Welcome from PCAST Co-Chairs

>> JOHN HOLDREN: Good morning, everybody. Let me welcome the members of PCAST to this third from the last meeting of President Obama's PCAST. We will meet again in November and meet again in January. And after that, there will be a new Administration and presumably a new PCAST. But I would like to begin by observing a couple of milestones and one passing. Today the 30th of September happens to be the birthday of our colleague PCAST member Professor Rosina Bierbaum. Happy birthday Rosina.

Today is also the final day in office of our member Dr. Wanda Austin, who has been the Chief Executive Officer of the Aerospace Corporation for the last eight years. Enormously important company, enormously important role. She retires from that position at the end of the day today. She has chosen to spend her last two days in office with PCAST. I think that underscores the importance that PCAST has in the lives of all of us who are fortunate enough to be members. Dr. Austin was with the Aerospace Corporation I think for 37 years, is that right? And it's CEO for eight. Fabulous achievements. So congratulations, Wanda.

(Applause).

On a sadder note, I want to mention the passing of our former member, Dr. Ahmed Zewail, professor of chemistry at Cal Tech. PCAST member in the first term, Nobel Laureate in chemistry, a real pillar of STEM education in developing countries. He was one of the first Presidential science envoys, his mission was to the Middle East where he continued a long career of inspiring young people in building science education in developing countries, particularly in the Middle East, in his home country originally of Egypt. He passed away on August second, since our last meeting obviously. And I would suggest a moment of silence in memory of our late colleague.

(Moment of silence).

Thank you very much.

Forensic Science Update

>>JOHN HOLDREN: We will now move into the agenda for the morning. And I want to turn the microphone and the platform over to my distinguished co-chair Dr. Eric Lander, who also happened to be the Chair on the study on forensic science that was recently completed, transmitted to the President and made public to talk a little bit about that forensic science report.

>> ERIC LANDER: Great, well, thank you, John. Let me add my welcome to John's to everyone in the room, everyone on the web, and again my thanks to all of the members of PCAST who have not let up one bit in the work that is going on. With a study approved already in September, another study coming forward for approval today, and more studies underway. I suspect PCAST will be working up until the very end of the Administration as the President has requested and I just want to thank everybody for their continued service and energy.

So I would like to briefly -- if we can bring up those slides, that would be great.

I would like to briefly review the report that we approved and released on forensic science It's entitled, "Forensic Science in the Criminal Courts; Ensuring Scientific Validity of Feature Comparison Methods". We reported on this at public meetings of the PCAST on several occasions before. And then -- let's see, I'll -- I have the clicker right here so I'm not going to go through all of the process and all of the background. It's all available on previous discussions on the PCAST Web site as well as on the report. I just want to briefly summarize where we are, what were the key points from the report. And the next steps going forward importantly at the end.

So we started this work a little more than a year ago. We thought about starting it in the spring of 2015. Began to seriously get underway about a year ago September of 2015. On September 1st, the PCAST in a telephone meeting, public meeting, voted approval of the recommendations and the substance of the report and then we released the report on September 20th following our usual practice of clarifications and copy editing and things like that. I noted 125 drafts. And in fact many subdrafts because there were decimal points attached to those things, as well, but 125 significant drafts.

It weighs in at 173 pages which I think set a new record for PCAST, 399 footnotes which again set a new record for PCAST. It involved a review of 2100 scientific papers which I don't have an exact count but I don't think anyone will argue it too set a record, and for the first time we opened to public comment early in the process last fall and we're tremendously grateful to the public for 70 really lengthy thoughtful comments addressing questions PCAST posed to the public at large, in particular intended to the scientific community and to the forensic science, law enforcement community. People took a lot of care to provide material to PCAST.

Such a report would not be possible without enormous help. Although the PCAST members themselves rolled up their sleeves and did a tremendous amount of work, I want to specifically acknowledge three people. We were enormously lucky to have the services of Tania Simoncelli who is herself a world expert in the field of forensic evidence, has written a book on the subject. And we're very lucky a former member of the staff of OSTP, currently working with me on my PCAST work and was secunded to the PCAST Working Group for this purpose, and being able to draw on her many, many years, decades of experience in this field was invaluable.

I want to thank Kristen Zarrelli an incredible researcher who went through a large number of these papers, synthesized them, and prepared many notes along the way and made sure all of these drafts proceeded toward a final report, amazing job of research there, and then our own PCAST staff member Diana Pankevich who had no idea what she was signing up for when she got involved in this report and organized countless phone calls with members of the forensic science community,   Had many meetings. Went through all sorts of communications. It's really lucky we didn't let Diana know in advance what this was going to entail but she was the one personally responsible for example corralling this online appendix of 2100 papers that were reviewed. So I want to give thanks to Tania to Kristen and Diana for their amazing partnership in this.

(Applause).

>> ERIC LANDER: So at 173 pages and 399 footnotes you might think it's really complicated but the truth is the entire report can be described in three tweets. The tweet version of the report for the busy person today says as follows; tweet No. 1 for a forensic feature comparison method to be foundationally valid, there needs to be actual empirical evidence of its reliability and estimates of its accuracy.

Tweet No. 2: for a number of current methods, there is little or no actual empirical evidence of reliability or accuracy.

Tweet No. 3: some, not all, in the forensic science and law enforcement community see no need for empirical evidence.

The report is the long form version of those three tweets, but if you just want to take away those three tweets, that pretty much says it.

Forensic science is a science. It comes forward into the courtroom saying -- wearing the mantle of science, we bring forward scientific evidence that should be taken very seriously. If it comes forward as a science it of course must meet the criteria of scientific validity for a science and for the last 400 years those criteria are you have empirical evidence to support your claim. There are many in the forensics science community who know this and absorb this and work toward this, but historically this has not been the case always. Forensic science grew not in its earliest days from the scientific laboratory, but rather from practitioners who in very good faith felt that by looking at a lot of evidence, they could draw meaningful and accurate conclusions. We have seen over the course of the last several decades a recognition that that is not a foundation for reliable scientific evidence being brought forward to the court and being treated that way. I want to underscore. I've said court multiple times. There's a big distinction between scientific insights and ideas being used in the investigation of a crime. PCAST did not in any way look to the question of what should or shouldn't be used in an investigation. We very clearly said the report does not touch on that and we have said a much broader standard should be used for how you investigate. Just like in science, nobody says what

you're allowed to do to formulate a hypothesis. Hypotheses can come and have come famously in chemistry from a fevered dream. That's right of the benzene ring. Hypotheses can come from anywhere. What makes science great is you can come up with an idea, hypothesis, from any direction and then you must subject it to proof, so we do not in any way wish to limit how you might do an investigation, exonerate a subject in advance, exclude a subject in advance, reach the judgment of what you wish to bring to court. We're only addressing the question when you come to court wish to prove something and the standard here is that the full package is proved beyond a reasonable doubt, what are the requirements to say something is scientifically valid

So that's been the issue. I've got to say there are folks in the forensic science community who have continued over the years to meet the call. To go and collect evidence. And find, yes, we can support that this method is valid and we can tell you how accurate it is. Something doesn't have to be perfectly accurate, but you have to know how accurate it is if something is wrong 1 in a million times or 1 in 10 times that's pretty relevant you need to know.

But there remain many people in the forensic science community who don't really yet get it. That you can't come with scientific evidence unless you can come with a demonstration of its accuracy. And there's that tension playing out within the community. It's going in the right direction. But it continues to need to be propelled by people saying things in the clearest, simplest terms. The tweets should be kept in mind by everybody in that community.

So that's really what we tried to focus on is where are they. Now we are not the first to touch this question. This was touched in the 1990s extensively by various National Academy reports having to do with DNA and compositional bullet lead analysis and other such fields, and reports in the past decade, most notably an overall report by the National Academy in 2009 in an NRC report about the overall state of forensic science, which noted very clearly essentially these three tweets.

It was a very influential report. It led to the Obama Administration adopting various policies including creating a National Commission on Forensic Science and NIST, creating a process for standards development, all very good. The President asked us last year asked to address the question what else is needed and that's what we sought to do in the report.

So very briefly, and we've covered this in our public phone call, the PCAST made eight recommendations. I have not put the full text up there because we have ever covered them and they are already in the public report. I'll just briefly say the first and perhaps most foundational of it is that NIST should perform ongoing evaluations of scientific validity and reliability of forensic feature comparison methods. It's got to sit at a science based agency. It's not appropriate or for it in any way to sit in non-science based agency. I think there were some people say the Department of Justice can do this, and the answer is of course it can't do it, it's got to be a prosecutor, it has got to be a user of this we have to separate the scientific evaluation of this to the people who have responsibility to use

the evidence. You can't do both simultaneously. This in no way impugns the role of DOJ. In fact I think it elevates the role of DOJ; it must be an active user of these technologies which means it can't be the scientific evaluator of those technologies. NIST is the right place from the Federal Government to do it. NIST has the important role to move us from subjective methods to objective methods. Many of these methods today remain very subjective, and examiners sit there and compare patterns saying I think they match. There was a time that was okay, but technology has moved on. Image analyses are quite good now. We can do facial recognition. We ought to be applying it to latent fingerprints and firearms and we think it's a great time to move that forward and that will advance the cause of justice in being able to identify with higher accuracy and correctly identify perpetrators, exclude innocent people, raise the level of science and NIST should play that role. NIST should also improve that standards development process I referred to and we make specific recommendations about how that should be done.

We think because there's a movement of forensic scientists toward a more and more scientific basis for forensic science, we think it's important to have a national research strategy we call on OSTP in collaboration with multiple agencies to lead the development of that strategy. We think the FBI has a very important role to play. They have simply been world leaders on their work on latent fingertips. My hat and I think all of our hats are off to the FBI for a brilliant set studies of latent fingerprints, what are called black box studies to see if they get the right answer, and white box studies to ask what are examiners thinking when they are comparing when they look at things. You can learn a lot from that. They are simply a brilliant studies. They are a model, the lead black box study was published in the proceedings of the National Academy of Sciences, it's what needs to be done in going forward. FBI has an important role to play. They need our support and increased funding to do that and we call for that.

        The next one is sort of I guess obvious but we say it anyway, of course the Attorney General should ensure that the Department of Justice uses scientifically valid evidence. The responsibility of all prosecutors is not to win a prosecution. It's to get the right answer. That's what we ask the Government to do. The Government's interest is in getting the right answer and the only way to get a right answer is to ensure to use scientifically valid evidence. It almost doesn't need to be stated but should be stated that of course the Attorney General should only use scientifically valid evidence.

        We note that the Department of Justice in particular issued some guidelines about the testimony examiners can give, and the guidelines do one very good thing. They forbid examiners from making the kind of inflated claims that had been made in the past, that things were perfect, zero error rates. There's a long history of examiners having told juries things that were just way beyond what the evidence supported and the Department of Justice rightly and we saluted said those kinds of over claims are not allowed. Unfortunately in writing the guidelines they went too far. They actually said accurate claims about the accuracy of a method are not allowed. Indeed examiners aren't allowed to make any statements about accuracy of a method, and that's simply not okay because you can't come

in and support a scientific method unless you can actually state the accurate facts about its accuracy, so we recommended the department withdraw and reissue those guidelines to be able to come down the middle correctly.

And then finally I note we say judges should take account of the scientific criteria for scientific validity. It isn't PCAST's job to tell judges how to do their job. But the law says judges are to act as gatekeepers with respect to the reliability of the methods that come before them. And particularly the Supreme Court says the job, the overarching subject of the judge's inquiry is scientific validity. If judges are to do their job, the scientific community has a responsibility to make clear what does scientific validity mean, so we have tried to lay out clearly in the report so the judges may use it when they wish to make admissibility decisions. The scientific criteria for scientific validity while respecting the line that the scientific community defines scientific validity and scientific criteria the legal the judges themselves define the legal application of these things and I think it's an important distinction we try to make clear in the report.

In the report, in addition to specific recommendations, we make findings actually No. 8 is not a finding it's just a topic there we make findings with regard to 7 topics, we try to lay out what is scientific validity in terms that are clear and simple and useful. There's no shocking news under what it is to have scientific validity, it means empirical evidence. If you want to claim you're able to accurately tell that a bullet came from a gun you have to show me you can do it, we write that it takes about a page to lay that out clearly, to explain what are the components to know, what are the things you have to measure. It's kind of a form of metrology, the science of measurement and comparison, and I guess that's why NIST has been assigned the responsibility within the Federal Government because it's the world's metrological organization. We look at DNA analysis of single source and simple mixture samples, and complex mixtures, bite marks, latent fingerprints, firearms and identification, footwear, DNA, we determine which one has adequate evidence of scientific validity. We do not do a full analysis of hair analysis. What we do is examine a recent document released by the Department of Justice but we didn't in the report do a full analysis of that subject and the details are all there.

Now, a report was -- our report was released to the public on September 20th. We've been tracking reaction to it. Lots of people said many things. I wanted to highlight one in particular. Because I think it really underscores why people should read the report carefully. The National District Attorneys Association said in a statement that I might be allowed if I were to say is slightly hyperbolic, that adopting any of PCAST's recommendations would have a devastating effect on the ability of law enforcement, prosecutors and the defense bar, to fully investigate their cases, exclude innocent subjects, implicate the guilty and achieve true justice at trial.

I just, you know, tend to want to keep things, you know, carefully laid out here. Any of PCAST's recommendations seems a bit extreme. We recommend increased funding for the FBI. We recommend all sorts of things here I think that might be a bit extreme but far more important, the

devastating effect on the ability to investigate cases and exclude subjects, I would ask people making statements like this to reread the report and it's very clear statements we are in no way limiting what might be done in the form of an investigation or excluding subjects. The report is really clear, in fact it says the opposite so I want to put people at least that the report makes no such claims. We're merely saying when you want to come to court and you wish to call something scientific evidence, you need empirical evidence that it's accurate. It's nothing very controversial. I think this is in a way the least controversial conclusion you might imagine.

So the question then is what are real concerns about the report? We noted that the Department of Justice said the following. The report does not mention numerous published research studies which seem to meet PCAST's criteria for appropriately designed studies providing support for foundational validity. Now, that is not a hyperbolic statement. It's a measured scientific statement. And the right response to a measured scientific statement is to look closely at it. So we have asked the Department of Justice to please let us know what are the numerous published research studies that we might not have identified and might not have mentioned. Because it's very important. That's what ongoing scientific evaluation is, to be able to examine if there are such.

So we've contacted the DOJ. The DOJ, it's been a week and a half hasn't had an opportunity to get back with us yet with any of those studies, but we're looking forward to that we think because we take it very seriously, we should take one further step. So Phase 2 of the PCAST forensic study that I'll announce right now, is that we'll issue next week an RFI or request for information that we'll hold up through some time mid-October, where we'll ask the public for each forensic feature comparison method. The PCAST report found not yet to be foundationally valid. Please tell us if you can identify published appropriately designed research studies that were not mentioned in the report, that provide empirical evidence of the foundational validity of the method by examining the reliability and estimating the accuracy of the method as it is currently practiced. We will when that RFI closes review those studies and we will issue if necessary an appendix to the report, that's how science works. That's how scientific evaluation must proceed on an ongoing basis, particularly in regards to these areas. DNA beyond the stated we thought were possible for DNA some things we said are clearly foundationally valid, others have not yet been proven for example four person mixtures. There were three person mixtures with a minor contributor. Bite marks we said aren't foundationally valid and haven't been shown to be foundationally valid, and we expressed great skepticism it could be. Firearms with regard to whether you can individualize the source of the bullet not the class of the gun, but the source of a bullet to an individual gun. Footwear, we didn't fully analyze hair analysis we would be grateful to see papers people have although we didn't take up a full study of that.

We'll -- we'll put up next week an RFI on that because we think it's important we as PCAST model the behavior of what scientific evaluation must look like to get forensic science to the high standard that we want it to be throughout our courts and for the country.

That's pretty much it. It is an ongoing process. It may be that any of those methods four years from now there's evidence for foundational validity, that would be great or maybe those methods are discarded because it's recognized you can't get a valid method here but some other way like automated analysis of firearms. Ideally NIST should be continuing this. That is the real responsibility. PCAST isn't an ongoing mechanism to do it. We will still do this while in the Administration with you it should be picked up on an ongoing fashion by NIST. That's it. I will at this point throw it open to PCAST. I want to thank again the members of PCAST I want to thank the many, many people in the forensic science community with whom we spoke who helped us along, and particularly the whole movement of people within forensics who see the importance of empirical evidence and are pushing the field toward empirical evidence. As happened with DNA some decades ago, everything will get better once you turn the spotlight of science on it. It can be uncomfortable because you find things aren't perfect. Nothing is perfect. Things only get better, though, when you note their imperfections and then you begin to go to work on them. I see a flag up from Chris Cassel.

>> CHRISTINE CASSEL: Thank you, Eric. I want to congratulate you and Tonia and Diana and all of the colleagues who worked so hard on this. I think it's a real important contribution.

I just wanted to ask you about I think it's wonderful to do this RFI to really ask. I mean you guys did extraordinary literature review, unprecedented in PCAST history I think. But I think that's a really good idea. What do you have in mind, given our sort of timeframe, what do you have in terms of being able to -- will there be an addendum to the report. Will there be another public report.

>> ERIC LANDER: We'll do a public addendum and we'll open it for two weeks. Folks have been reading the report for a while if there are numerous studies that in any way should still be read we'll open it for the next two weeks and spend the three weeks after that reading those studies and seeing which of them are empirical studies. I must say since the FBI and many other groups sent us these lists over the course of the last year. My guess is there are not lots of additional studies that weren't already caught by the Department of Justice and others and sent along, so it could be we get none. But nonetheless the fact that we are as PCAST open to hearing those things models what we must do in science. And if appropriate, it won't be hard for us to prepare an addendum to or appendix to the report that we can present at a future meeting. Jim?

>> JAMES GATES: Thank you, Eric. First of all, I would like to in this public session, recognize the extraordinary leadership that you and Dr. Holdren have shown throughout this process. As many of the people in this room know I've actually been embedded in the National Commission on Forensic Science for about two years

>> ERIC LANDER: Close to the mic.

>> JAMES GATES: I've been in the embedded in the National Commission on Forensic Science for two years, and so I've watched this problem I can't say at ground level but at the level of the

Commission. And the report that PCAST has put together responds to one of the challenges that I recognized in the forensic science community.

The community, as Eric quite properly described, it's variegated, not of a single opinion. And in fact there are forensic scientists who do heroic work in delivering a higher quality of scientific evidence to the courtroom. As Eric said, I commend these folks. They are doing work that's just like the work of doctors. Doctors in medicine also have a similar history. For the members of the forensic science community, it's in a state of ferment, some of the quotes that Eric illustrated for us showed us, but it's ongoing ferment, and the most important thing this report does is answer a challenge I described in a paper that was published in a National Institute of Justice piece about a year ago. In fact I claimed this is the metachallenge, namely shall the standards and practice of forensic science be aligned with other sciences or not. I think that we in this report have in complete and strong terms has to say the answer is yes. When you use the word science there's no special dispensation that will be given to the community of forensic science. In the Commission I've made this statement if it's not science don't call it science. This doesn't necessarily win one a bunch of friends. But the report I think it does a remarkable service in enunciating this in a limited way where we are confident how the science would play out if it's given a chance, so that's my first statement I find it extraordinary and I'm grateful. I'm going to continue to engage with the forensic science community. I took on the responsibility to join the OSAC process with NIST as you recognized the scientific agency in Government that's probably best situated in order to continue to drive this process This process is not going to be done in a decade, in my opinion this is at least a decadal process.

So that brings me to the other thing that I think is an implicit message of our report, that the larger scientific community has got to engage forensic science itself. We cannot sit back in the playing field and simply lob in criticism if I may use that analogy. We have to engage forensic scientists, and I can tell you from my interactions with the community there are forensic scientists there who would love to have the stovepipe come down, so it's incumbent on us I think it's a challenge we didn't state in the report explicitly but I think this report really emphasizes we who are scientists outside the discipline can't remain silent. So that's the last comment I would make.

>> ERIC LANDER: Bill the last comment

>> WILLIAM PRESS: Eric you didn't note that immediately after our report was issued, the Attorney General issued a fairly negative comment at least as reported in the Wall Street Journal in which she said that the Department of Justice would not be adopting the recommendations related to the admissibility of forensic science evidence.

I think we all saw that and were rather disappointed as a kind of snap judgment, because it didn't seem likely the Attorney General or anyone really would have had time to study our study in any detail, but that's not my question, My question is do you think a statement like that coming from the

top sends a chill down the organization in DOJ and FBI that will affect exactly the forward looking forensic scientists that we hope will implement some of our recommendations or do the research necessary to implement some of our recommendations.

>> ERIC LANDER: That's a great question. I didn't really raise the Attorney General's statement about saying they were not going to adopt the recommendation to the Department of Justice on the admissibility of evidence because I think somebody simply in haste misread the recommendation. The recommendation doesn't say anything about admissibility. The recommendation to the Attorney General is that the Department of Justice use scientifically valid evidence. I can't imagine that the Department of Justice could in any way reject the idea that they should use scientifically valid evidence and support the idea that they should use scientifically invalid evidence that would have to be the conclusion so I'm simply guessing somebody reacting quickly and having to react to some newspaper reporter issued a statement that the Attorney General is rejecting the recommendation about admissibility misreading there is no recommendation about admissibility, we'll reach out to the Department of Justice, but I would be shocked if the Department of Justice took the position that they believe they should use scientifically invalid evidence so I would just suspend judgment on it and we'll have some back and forths. That's why PCAST isn't dropping the topic. Like I said, that Recommendation 6 about the need to use scientifically valid evidence is the greatest no brainer in the report, how could you do otherwise anyway I'm sure we'll clear that up.

Water S&T Update

>>ERIC LANDER: We should move on. I want to thank everybody. And let us turn to our next topic. PCAST is busily at work on water, particularly following Flint, Michigan and the troubling events in Flint. The President asked us to look at the much broader situation of safety of American drinking water and this report is in process.

We're not ready to have a report and recommendations. But we're going to get a short update from Chris Cassel and Rosina Bierbaum, and I'll turn to Chris first and then Rosina to tell us where you are and what kind of questions you're looking into.

>> CHRISTINE CASSEL: Thank you Eric, and thanks for this opportunity to give PCAST an update on this very important work we will make this brief because we have not concluded the recommendations yet. And because we want to make sure to have time for our distinguished guests following. But I do want in the public session to let people know that we have been hard at work in response to the President's questions, I think quite vividly in response to what we all witnessed in Flint, Michigan, concern about the broader issue of drinking water and drinking water safety in our country.

We put together, Rosina and I, have been chairing this Working Group. Rosina with the background in environmental scientist, me as a physician. So bringing those different perspectives.

We also are very pleased that we have four PCAST members who have been very active, including the President's science advisor John Holdren who has been deeply involved in this and made enormous contributions to it. Ed Penhoet who is a biologist and also public health expert. Maxine Savitz from engineering. And Dan Schrag also from earth sciences.

So we have I think a really good sort of and broad based interdisciplinary team. We have been supported by terrific staff Diana Pankevich PCAST staff who amazingly while she was doing this incredibly heavy lifting on the forensic science report somewhere in her spare time was finding time to help move this water study along, and Bruce Rodan from OSTP.

The Working Group members are really drawn from a group of people who are real experts in drinking water and water science and policy.

Matthew Davis, who is listed there at Lurie Children's Hospital at Northwestern, actually at the time he started working with us. And initial was at the University of Michigan and was the Chair and led the Government mandated local mandated review of the situation in Flint. A really excellent publicly available report. I recommend to anyone. Where he really, he and his committee really outlined the situation there.

He, interestingly, is a pediatrician, as well as public health expert. And then Bob Perciasepe a former EPA water administration, Oren Schneider from American Water, Chad Seidel from University of Colorado. Nancy Sutley, also previously with EPA and now with the Los Angeles Department of Water Nancy hosted a meeting for our PCAST group in Los Angeles and Paul Westerhoff from Arizona State.

We've had several meetings both in person and by telephone. And I want to thank the Working Group members for a lot of work, including preparing of documents, writing of text, and finding and soliciting important information for us.

These were the questions that we were asked to address. There are, I think I want to point out perhaps the obvious that there are a number of activities going on about drinking water safety, many of them in response to the events in Flint. Many Federal agencies are hard at work on this as well as state and local authorities. And public health philanthropies, academic groups, and others are working in these areas.

So our focus as always is very much on what can science and technology do and particularly at the Federal level to help the situation.

So the questions include what is the current state of scientific understanding of the risks associated with contaminants in drinking water? One of the unfortunate things that's happened in response to the appropriate and wide-spread news coverage of the situation in Flint is that a lot of

Americans are very nervous about their water and don't want to drink water and go to bottled water all the time

When in fact most publicly provided drinking water in the country is quite safe and actually quite good.

But the question that the public wants to know is, what about my water? And what about the water coming out of my tap? And we don't by and large have a good answer for that.

So that's part of what our study is looking at is how can we get better information to the public.

And then the fact is that drinking water has lots of different things in it. Not all of them are dangerous. Some of them are actually quite healthy. Minerals and things. And when something is considered a contaminant, what is the relative risk of that contaminant? Because there are many times people have hard water that's drinking water that has more certain minerals in it. It's not dangerous, it just maybe doesn't soap up as well when you're trying to wash stuff or things like that. So we really need to know not only chemicals, the comparative risks of chemicals but also biological agents. There are waterborne illnesses, probably legionella is one of the most well known. And how are those determined?

One of the reasons to understand comparative risks is to understand priority lists for public health and policy actions.

And then the third is improvement needed in monitoring data collection and data analysis on the contamination in drinking water and the factors that may contribute to it? I think without even going back to our committee we can tell you yes in answer to that question. And so we're really looking at this question of what sort of scientific methods can be applied to monitoring and within the source, within every aspect.

I think, just let me say that it's important for people who are listening to understand that unlike a lot of public health issues, water is really terribly complicated. And the distribution system. There are four different places where you need to study the quality of water. One is where it comes from, the source, which is of course now dramatically affected with climate change and drought in many areas reducing and changing the sources of water.

Then there are treatment plants. And there's a whole set of issues about what kinds of treatments and how those are used.

Then there are distributions, the pipes that go under the street and take the water to your house.

And then there's the premise plumbing, what happens in your house. Each one of those is regulated by different authorities, some like what's in your house, hardly at all and 50 million people get their water from wells which is not regulated in any of those traditional ways, so there's a lot of different factors making it a very complex regulatory environment that doesn't have a single sort of leverage point from the policy perspective would be easy to look at.

So we also were looking at what kind of technology could be easily and quickly implemented that could help with risk assessment as well as with reducing the risk. And also with helping with communication in these areas. So we're looking at all of the technology implications in that question.

And then of course, what additional research and development is needed to contribute both to better understanding, better monitoring, and also reducing what risks there are in the nation's drinking water.

So I'm just going to stop there and ask Rosina to just summarize kind of the areas that we're looking at for recommendations

>> DR. ROSINA BIERBAUM: Thanks for that, Chris. Yes, as Chris intimated we're busily getting our arms around all of the other ongoing relevant activities. So that we can really offer value added options although as we both answered Question 3 yeah lots more needed, I do want to say there are lots of things to build on and just to give you an example in this year's budget alone, the Department of Energy is starting a desalination hub that NOAA is trying to develop an integrated water predictability for algae blooms detections which was so important in Toledo. The Bureau of Reclamation has initiated a water technology solution challenge so lots of things going on but we are PCAST so we're thinking about the S & T particularly, so we will have a sharp focus on how well coordinated the Federal R&D effort is to deliver on all of these needs, and it turns out there are actually three interagency committees working on various aspects of water. One actually on water availability and quality. One on water technologies. And one on water issues that intersect agriculture and energy. So we're trying to get our arms around these three committees, what are they already doing and does this add up to a true water strategy for the nation so a lot of focus on that.

We do want to be sure that the next generation technologies are actually going to be developed and coming online and there are a number of very exciting areas including things like the microbiome of water systems if you think of that from the source to tap, can we do more with different sensors to tell about water quality problems quickly. How can we enable potable reuse so we'll have a class of categories that we think need to be begun and furthered quickly so they can be demonstrated and deployed? But similarly there's a lot of tried and true technologies that may not be used as well as they could so we'll have recommendations in that arena.

One thing we have learned is there are very exciting experiments going on in cities around the country, so we would like to highlight some of these model cities, if you will, and especially in three

categories that would be prevalent, so we were thinking we would focus on an inland arid city with unique water problems a city that's totally dependent on groundwater which offers its even problems, and then of course an industrial Midwestern city would also provide interesting possibilities. As we highlight best practices within those kinds of places we would also like to talk about how the new technologies that we think need to come online can be eventually demonstrated in those cities.

We'll talk about data. We can't help but talk about data and some interesting ideas about perhaps developing geocoded databases or data layers where you can identify vulnerable populations and vulnerable regions quickly, so we're trying to develop a recommendation in that area and then the workforce. Obviously the workforce for the water systems of tomorrow need to be different than those of today. There's a massive retirement in water system operators about to happen. EPA is thinking about perhaps revising their guidelines for operator certification which we think would be a good idea, it's been 16 years since that's been revisited. So making sure that we have a trained workforce will be a part of our recommendation suite we're pretty sure. And then we want to make use of an initiative that Dr. Holdren started a year ago today which is citizen science. And all sorts of very interesting citizen science efforts have sprung up but we're not sure there's actually one going on in the drinking water arena, but there could. And so we're looking into that. We will certainly also as Chris said be thinking about how the Federal Government can better communicate water safety and water risks. And then finally, since I think we're out of time, we will be making some recommendations on how the Federal Government can undertake human health and water quality risk assessments as well as the water utility system vulnerability assessments. And as we look at all of these recommendations we will be keeping the vulnerable populations front and center. And we'll be looking at whether there are existing programs in the Federal Government that can be used to perhaps test and identify the most vulnerable populations along the way.

So that just gives you a flavor of our ferment and foment stage we're at and we certainly hope to have the report finished and for review by the time we next meet.

>> ERIC LANDER: Excellent. Well thank you for sharing the ferment and the foment and the roiling and bubbling waters of your group. This is great.

We would have time for one brief question if anyone has one but since it's a report that's still very much in progress, I don't know if there's anything that's very much on peoples' minds.

All right. If not, keep going, I think this is just fantastic that you guys are going to get this done in the couple of months ahead. And will bring this forward to a PCAST for review and consideration and a potential vote for a report with these recommendations. Because it is an incredibly important topic. And I know as we have begun digging into it, it's more daunting than many people may realize on first notice. But so important. Because I suppose there's no other product other than air that you

can say all Americans use in the way that all Americans use water. So thank you very much for these efforts.

Agriculture Preparedness & Soil Science

>>ERIC LANDER: We're going to turn now to a panel on agricultural preparedness and soil science. I'm going to invite our three panelists to come up. And I'm going to turn to our co-Vice Chair Maxine Savitz who is going to chair this portion of our session. Maxine?

>> MAXINE SAVITZ: Thank you, Eric. We'll wait until the panel gets settled. While they are getting settled just give a preliminary several years ago PCAST issued a report on agriculture R&D, as part of the charge by the President is to periodically consider the implementation that has occurred during this report. Is Ann coming up?

>>ERIC LANDER: You're invited. Your name is on the program.

(Chuckles).

>>MAXINE SAVITZ: Okay. Well, and as we were doing that report which was co-chaired by Barbara Schaal, Daniel Schrag, Catherine Woteki was very helpful as we went and prepared that report so she's here today as the Under Secretary for Research, Education, and Economics to give us an update and Ann is here to help answer the questions and make other comments. And you said air is important. Soil is equally important. How you're going to grow your products and be able to live and Jo Handelsman is going to tell us about it as a renewable resource and Jo is a Social Director for Science at OSTP. So I think Cathy is going first.

>> CATHERINE WOTEKI: Thanks Maxine and good morning everyone. It's a delight to be able to come back and give you a second update on the implementation that we have made on the recommendations from your report. That report Maxine did a real nice job in kind of summarizing. It addressed the challenges facing our food and agricultural system both domestically and internationally, assessed whether the R&D programs that we have underway in the department and also looked a bit more broadly across other agencies that are also engaged in various aspects of agriculture related research, whether those were up to the challenges that we're facing again, domestically and internationally. And called for a new ecosystem for research in support of sustainable agricultural systems.

What I would like to do today is give you an update on what we have done in further implementing the recommendations in that report. And also to let you know about another circumstance that I think is very much in the spirit of amplifying and creating that new ecosystem for agricultural research. And that was in the 2014 Farm Bill, which is the legislation that periodically authorizes and reauthorizes our research programs. In 2014, that Farm Bill called for the establishment

of a foundation for food and agriculture research. And Congress provided some seed money for that research, $200 million, to be used in the support of research and related activities, including some educational related activities. That could only be expended, though, if it was matched by non-Federal funds. So essentially calling for establishment of partnerships in support of agricultural research.

The mission that's described for the foundation is that it is to advance the research mission of the Department of Agriculture. But the work that it supports should be complimentary and not duplicative of the ongoing research programs in the Department. And it focuses, the research efforts, the mission of this foundation, along the priority areas that are also authorized for the department; plant and animal health and production and products. food safety, nutrition and health, renewable energy, natural resources in the environment, agriculture and food security, agricultural systems and technology, and agricultural economics in rural communities.

The foundation is up and operational. They managed to lure Dr. Sally Rockey from NIH to be the first Executive Director for the foundation. It has a very active Board and on that Board are currently, I believe it's 20 members, 5 of which are ex officio members, the Secretary of Agriculture, myself in the Under Secretary for Research, Education, and Economics role in USDA, the director of our extramural research program, the National Institute of Food and Agriculture and the administrator of the intramural research program at the Agricultural Research Service, and also the Director of the National Science Foundation.

So they have so far established a competitive grants programs to support new investigators as well as a program for rapid response to emergent problems in agriculture. And also with the National Academies established a new prize for agricultural science. So they are up and operational, and we're very much engaged in identifying what are new ways that we can be working with other colleagues, again with non-Federal funds and the match that's made available through these seed funds provided by the authorizing legislation.

About a year after the report came out, I met with you and indicated that we had implemented almost all of the recommendations, and one that was still on the to-do list was establishing a Science Advisory Council to advise me and the chief scientist the Under Secretary role and the secretary. We have done that. We have established the Science Advisory Council under our existing mandated Federal Advisory Committee that's called the National Agricultural Research Extension, Education and Economics, there's lots of Es in there Advisory Board so we call it the NAREEE Board for short, so we established this Council. It's chaired by a member of the NAREEE Board with strong scientific credentials, and they are able as they take on different projects, to bring in additional scientific expertise from the broader community, so they are able to amplify their own scientific backgrounds, depending on what the project is they are undertaking. They at this point have completed and are going through the final review of a report to us on rigor and reproducibility and the science that we support through our research programs. They are beginning work on a project on gene editing and

new plant breeding techniques. And also picking up on the comment just made about crowdsourcing and citizen science, we have also asked them to take a look at what we are currently doing in this area, and to make some recommendations about additional approaches we can implement that will still, that will be complementary and bring in these new ways to get more public involvement in our science.

So with that we have, I think pretty much, within the funding that we've had available responded to all of the recommendations that were made in the initial report. There was a theme that ran through your report, and it had to do with what should the Federal Government be doing as opposed to the private sector in our support of agricultural research? And although there wasn't a specific recommendation in the report about this, we have asked the NAREEE Board three years ago actually, shortly after your report was published, to review and to recommend to us what we should be doing with respect to rebalancing our portfolio, taking in mind what the private sector is undertaking. And the NAREEE Board recommended that we commission a set of studies to continue to provide additional new information about the private sector funding of agricultural science. That we host a continuing set of listening sessions to assess public opinion about this rebalancing. And also to host an Annual Meeting, a research roundtable, bringing in private sector to have those conversations.

We have moved forward on the first of these with the Economic Research Service. And they have considered how they will continue to monitor the private sector investment in agricultural science. We have under the NAREEE Board a mechanism for holding listening sessions, and have been particularly focusing on the fruits and vegetables. And holding listening sessions in various parts of the country.

And lastly, we're currently in discussions with the National Academy of Sciences about establishing a research roundtable. And we'll be holding a scoping session in about a month's time on that.

So that will be ongoing work

Finally, I thought I would share with you two pieces of information about the current status of our research investment in agricultural science. This slide shows you the appropriations for our mission area from 2010 to 2017. The 2010 through 2016 numbers are the enacted. And as you can see, we had a dramatic decline in 2011, 2012, and 2013 across the all four of the agencies that are within this mission area.

Partial recovery in 2014, 2015 and 2016.

The 2017 numbers are the ones that are in the Ag appropriations bill as it currently stands. It's not been enacted. And as you all know, we're on a continuing resolution. But in essence what this shows is that we have made a partial recovery. But the investment that's being made currently in our

domestic research is below the level of 2010. And these are in inflation adjusted dollars, all of these figures.

Lastly, there was a really interesting article that appeared in the September 15th issue of Nature by Phil Pardy and some of his colleagues at the University of Minnesota. And what they have done is to collect 50 years of information from 158 countries around the world about their public as well as the private level investment in agricultural research.

The bar, if you look at the two big bars on the left of this slide, the bar on the far left shows the public sector investment in all 158 countries in 1960. And that was a total of $6.2 billion. And the bar on the right reflects the 2011 investment, public sector again, and it had grown to $38.1 billion.

These bars show the proportionate investment by high income countries. That's the ones in pink, the middle income countries in blue. And the low income countries you probably can't see from the back of the room, it's the thin green line across the bottom.

Three observations on these two bars on the left, the middle income countries, the ones shown in blue, are investing at this point more than the high income countries. And a lot of that growth is attributable to investments that China and India have been making. And appropriately so, to feed their growing populations.

The U.S. role is showing in the bottom right hand corner of the pink part of both of these bars. And the U.S. proportionate contribution has shrunk considerably over that 50-year period of time.

And lastly, the thin green line across the bottom shows that the low income countries where the greatest expectation would be of increases in agricultural productivity from research and the transfer of that information and technology would make the biggest difference are just woefully small proportion of the overall global investment.

If you turn to the right hand panel in the center of that are two bars that, again, compare on the top 1980, on the bottom 2011 that show the public versus the private. So the cross hatched parts of the bars on the left-hand side represent the public investment. The solid ones on the right-hand side of the bars, the private investment. And what this shows is that the increase that's happened in the middle income countries is largely attributable to the private sector investment. And lastly, at the bottom of the chart, it shows the gap between the investment and the rich countries and the poor countries. In 1960, that gap was 7 to 1 on a per capita investment basis. And in 2011, it was 12 fold.

So I, again, want to thank all of the members of PCAST who were involved in doing the initial report on the challenges that are facing our food and agricultural system and as I said, I'm really pleased to say I think that we have done the best that we possibly could within our resource constraints to be as responsive to those recommendations. And the President's budget has each year

been very, very supportive of the recommendations, both with respect to the research funding in the department, and also in encouraging other departments to focus appropriately within their mission on some of the more fundamental questions that we can build on in our programs.

So we very much appreciate that strong support. The 2017 budget was for us a huge break-through. The President's budget for the first time requested the fully authorized level of support for our competitive grants program, 700 million. We hope that when we get a full appropriation for 2017, Congress might go back and reconsider that. But as you could see in the slide that I showed previously, the work that's been done so far on our appropriations bill does not reflect that.

So that's it for me. And do you want to take questions now.

>> DR. MAXINE SAVITZ: I think we'll have Jo talk even though they are complementary but related.

>> JO HANDELSMAN: Well, thanks, Cathy. And thanks, Maxine for chairing this session and having a part of it dedicated to soil. I was going to talk about our efforts in OSTP on a new soil initiative. It's not new anymore. But it was new a few years ago. And the progress that we've made and what we can expect by the end of the Administration.

I wanted to start by introducing my collaborators on soil, Parker Liautaud and Rich Pouyat who I'm not sure have been introduced to PCAST so perhaps you can just stand up. Two really important members of the OSTP team. Parker is in the science division and Rich is in E & E. And Tammy Dickinson has been kind enough to share him with his because he's a soil expert.

So this group has been working on trying to ask what we need to sustain soil.

It's interesting as you watch PCAST and just about every other scientific group that talks about environmental issues, how infrequently soil is mentioned in everything from food to climate change, to water purity, to ecosystem services, to the necessary features of life on earth. And soil is as fundamental as anything else, including water, to our existence. But it's something that we literally walk on and disrespect by calling it dirt and rarely appreciate for its richness and importance in human existence and the stability of the earth.

So just for those who are less familiar with soil I think it's worth reviewing what it is, It's one of the most complex systems on earth. Some people have argued that biologically it's the poor man's rainforest because it's so biologically diverse. It's a mixture of pulverized bedrock, so it's very ancient in some ways, more modern and weathered minerals that have been worked over by the environment, climate, and the biological environment of microbes, animals and plants for millennia. And it can take as much as 500 years to form even a couple of centimeters of top soil.

So this is a very slow-to-form product of very long geologic processes. But that process can also be sped up and I'll just mention that a little bit at the end.

The richness of biological life lies largely in the microbial world. There are about a billion cells at minimum for every gram of soil. And the estimates of the number of species in each gram range from a few thousand to 40,000. There was one estimate of upwards of a million. But that may have been an overestimate. It's always in a dynamic state. Soil is never stable or static. The water content is changing constantly. In the daytime, plants take water out of the soil. At night, there's a gush of water from the plants into the soil. The temperature is constantly changing. Microbial life changes the chemistry. And of course the rest of the environment changes it on a regular basis.

And so the combination of the plants, animals, microbes, and minerals, give us this complex and very rich source of sustenance on earth; it's critical for food security, obviously we grow our crops in soil. NASA has taken a very strong interest in soil as you may have seen in a recent film that NASA collaborated on, soil was the star of The Martian, and the reason is of course to sustain life in a long-term sense on Mars, we need a medium for growing plants and food.

Climate mitigation is also an important role of soil that's very often ignored. It's one of the largest carbon storage bodies on earth. It holds about 1500 gigatons of carbon across the earth. There's a range of estimates. But all of them exceed the estimates of what is in the atmosphere in terms of carbon and how much carbon is in the earth's vegetation. Water quality is dictated by soil because soil is the biggest filter we have on earth. We would all be drinking gasoline from buried oil tanks across the country if we didn't have soil to filter the water, and many other surface contaminants are removed by the time the water gets to our groundwater and aquifers.

Water manages, soil manages the movement of water when it's healthy. It keeps water moving downwards or into appropriate pathways. When it's unhealthy, water moves across its surfaces and is much less well managed for human uses under those circumstances.

And water availability is dramatically affected by soil. Healthy soil holds water and releases water in a very regular pattern. Unhealthy soil has much less water holding capacity and has less of a modulating effect on local weather.

We depend on soil for bioenergy fuel production. Drugs for humans. Most of our antibiotics come from soil bacteria. And for constant stream of discovery of biodiversity which continues.

So some of the challenges for soil are that we don't manage it in a sustainable way. And so there is ongoing degradation and erosion of soil. Salinization and desertification across the world are ongoing issues of ways we're losing productive soil. Land use has of course eroded our amount of soil through urbanization and deforestation. Which are both extremely damaging to soil and can cause the entire loss of the health of soil.

We have contaminated a lot of our soils with heavy metals and other kinds of contaminants that the bacteria can't keep up with and have not yet remediated, but over time they often will.

Acid deposition from acid rain and eutrophication have been two outcomes of human activity with regard to soil.

Climate change has been, probably has become the greatest threat to soil. And I think this is where we need a particular amount of attention in the future. Because this is where we're seeing the most rapid change in soil stability.

One effect is the heavy rains that we see associated with climate change, particularly in the Midwest. And that can result in the movement of soil. The erosion into, for example, the Mississippi River which then takes it down to the Gulf of Mexico, causing the dead zone in the gulf. And that can often lead to as much as 50% of the carbon from the soil being released to the atmosphere. And that varies depending on the soil, how it's moved, and how wet it is.

This is just an example which is probably no surprise to this group of the effect of the increase in extremely heavy precipitation that we see with climate change. And so this is a decadal portrait of the frequency of heavy precipitation events you can see since the '60s, there's been a very steady increase in the frequency of these events. In the 2000s we have heard quite a bit about these, and particularly in sloped agricultural areas in the Midwest, we see tremendous damage to the soil as a result.

The velocity of raindrops is one of the key elements that affects the frequency of erosion and the movement of soil.

These are some photographs from Iowa where soil and soil conservation are probably the best studied in the country. And the top photograph where you see each of those little light spots, the whitish yellowish spots, those are areas where the soil is entirely eroded and down to subsoil and bedrock. So those points of complete exposure of what's supposed to be under the soil with no coverage.

There are a number of elements of these photographs that are disturbing, one is how much soil is left exposed. And you can see, this shouldn't happen. But this is what a lot of the Midwest looks like for about eight months of the year. And that leads to very free movement of soil by wind and water erosion. But the outcome of the damage is probably the most disturbing aspect.

We see an average soil loss in the country and across Iowa for example, of about 5 tons per acre which while it's not devastating, is not really sustainable because soil is recreated at less than about a half a ton per acre. So the math isn't very hard to do there.

But that's getting to be a serious average. Because although it may average 5 tons per acre, there are areas being dramatically eroded at a much higher rate. In 2007 which was one of the recent years where we had some of those very heavy rainstorms in the Midwest, there were large areas of Iowa where soil was removed at 100 tons per acre in one rainstorm. So not in a year, which is the 5 ton per acre. But in one rainstorm in one day.

And I'll show you some numbers on the next slide. But that was thought to happen in about 138,000 acres across Iowa. So that's a vast land mass that lost 100 tons per acre in one rainstorm.

The loss of crop yield is estimated in many states to be quite high. There are parts of Ohio that have estimated at 40% reduction in crop yield. And in Iowa it's estimated to be about a billion dollar loss across the state.

This is a projection that we developed looking at, basically asking the question how long would our soil last at different rates of erosion.

And the top line you see is the blue line, is the average rate across the country of 5 tons per acre per year. And you can see that we would still have a fair amount of soil left by about 100 years from now. But eventually of course it would approach 0.

But it's unlikely that soil loss will continue at an average of 5 tons per acre. And in some areas, it will approach 100 tons per acre per year. And that's the most severe drop with the steepest slope that you see in the first curve, first line, which shows that we wouldn't have any soil left by 2025 in those areas.

So that's pretty near term. And I think is one of the greatest threats of climate change. Because although we don't expect all of our soil by any means to be eroding at 100 tons per acre, the land mass that is eroding at that rate is expanding across the country.

So these are the basic concerns. And the question is, what can we do about it. And we have a lot of tools to protect our soil.

A large amount of research over the last century has gone into understanding soil, and a lot of technology over millennia in fact has gone into preserving and protecting soil.

We use incentives to farmers to practice good soil management. And there's a lot of interesting research at USDA going on right now about in behavioral economics looking at what does it take for farmers to adopt practices that protect the soil.

Some have suggested consumer pressure. We have been in conversations with some of the consumer advocacy groups that are thinking about labels, and that kind of thing, for safe soil practices applied to food. Education and training and public sizing the message about soil that it's an important

resource that's under threat I think is an important means to engage the public, and citizen science research has become an important part of our research enterprise in soil, partly because soil is so heterogeneous and we need such a fine grain sampling strategy in order to get a complete picture of soil, citizen science and using kids and students to sample soil much more intensively than we could do from a scientific, standard scientific way can be really important for gathering data

Data sharing is becoming a large issue because the size of the databases that are needed to maintain soil data are enormous. And sharing the data has become a political and privacy issue because a lot of the data are collected on private farms, and in some cases by farmers, and it's not clear that all of them want to share their data or clear to them why they should.

And then we have policies, regulations, and legislation that have been absolutely critical to the health of our soil and I just wanted to spend just a minute reviewing some of those.

One of the most important acts, well it's not on here was 1936, President Roosevelt signed the legislation that started the Soil Conservation Service but more recently in 1985 the Food Security Act reduced erosion, it's thought to have reduced erosion about 40% in its first seven to ten years after being enacted.

The 1990 amendments to the Clean Air Act also had a big effect largely because of the reduction in acid rain damage. Under Secretary Vilsack, the conservation programs have vastly increased the number of acres that are in conservation between the beginning of his tenure and this year, but the problem is the Federal Government's authority is limited by many, many aspects of the legislation. And the fierce independence of our farmers and many of the legislation has been changed over the years so it's now up to farmers to self-certify, and there's very little outside accountability, and that has created a problem because we don't know the quality of the soil preservation methods that many are using.

So the bottom line is that soil is eroding across our country at 10 times the rate it's produced. In other countries like China and India these numbers are 30 and 40 fold greater. So this is a global issue. And one that we need to pay attention to before it's too late. We in OSTP developed a soil workshop that provided the basis for a new interagency Working Group that is focusing on soil science. And the workshop in August, where it is and where we're losing it, how we're managing it and methods to sustain it. Then we obtained very broad input from an extremely diverse group of stakeholders. One member of the community garden community said that, and he's been in a lot of meetings about soil and about many other things, he said he had never seen such an eclectic group brought together to discuss soil. And it was very, very stimulating and productive process. And we've been reviewing the products of that and passing those onto our new Working Group so they can begin to think about the role of the Federal Government in the future of soil.

We focused in that group on all kinds of soil. This was not just agricultural, we focused on urban soils and the so-called vulnerable soils and forest and range land.

Some of the opportunities that were identified in the workshop were new incentives. For example, the idea of consumer-driven food labels that would tell consumers that soil friendly practices had been used in the production of their food.

Developing a messaging campaign, for example, extending the concept of Tree Cities which are across the United States, to develop Earth Cities where cities could sign up to become Earth Cities if they met a number of criteria.

And then working on entrepreneurs. This is an ongoing discussion with entrepreneurs who develop composting companies locally. And developing more of a network of those, replicating them across the country. And then finally galvanizing the research community to develop even more innovative and creative ideas for preserving soil and hopefully building soil so we can increase the rate at which soil is produced.

I thought I would just end on the idea that, the idea that soil has been considered a precious and determining resource for a very long time, long before 1936. But one quote that I think is worth remembering from President Roosevelt as he signed the legislation that created the Soil Conservation Service in USDA, he said, the history of every nation is eventually written in the way in which it cares for its soil. The United States is now emerging from its youthful stage of heedless exploitation, this is just following the Dust Bowl, and is beginning to realize the supreme importance of treating the soil well. And here we are most of the way through another century. And I think we need to consider those words as we go forward with not only agriculture but the rest of our environmental management strategies.

>> MAXINE SAVITZ: I want to thank you both we're going to run another 15 minutes so we have a chance for questions, and we'll shorten the break a little Thank you, Cathy's conversation was sort of more uplifting because she's been implementing this research. And then we hear this soil, very scary. And action needed now. So James Gates you were up before and put it down and so I'll go first with you.

>> JAMES GATES: Thank you very much I have to, first of all commend all of the briefers, because as Catherine was speaking, I had a question about the interplay between this new foundation and agribusiness and you dispensed with that question And then a second question came to mind about as you know PCAST has done a report on cities. And so that naturally raised some of my, in my mind a question about urban agriculture. And then at the end of Jo's presentation I heard her also mention that there was this workshop.

So let me go to the second question which is on urban agriculture.

In my mind, urban agriculture to me looks a little bit like distributive generation of power. It's one of these things that people talk about. It's out there. But do you really think it's going to play a substantial role in meeting the needs for food security into the future?

>> JO HANDELSMAN: I can start and Cathy can pick it up. When you look at the numbers in terms of the proportion of food that was provided by the victory gardens of World War II, it's actually quite remarkable I think at some points people estimated it was about 40% of the food consumed, so yeah I think local agriculture and very small scale agriculture, intensive agriculture can be really important. As we begin to see more modern techniques like vertical agriculture and using land in completely new ways, I think that productivity will increase. And I think the intensive interest in this, in urban environments partly for improving local nutrition, has really sparked some interest. So yeah, I think this is a very, very important area. And as we heard about yesterday, land use is changing in urban environments in so many ways. What if we turn some of those parking ramps we talked about into agricultural production sites.

>> CATHERINE WOTEKI: So I would echo what Jo has just said. And amplify it by saying urban agriculture is already making a contribution to food security here in the United States. And through our statistical agency, the National Agricultural Statistics Service, they are attempting to develop the sampling frames so that we can actually begin printing reliable statistics about how much food is being produced in urban areas and coming into the food supply.

And it turns out to be a very considerable sampling challenge. So it's a research project at this point to develop that sampling frame.

And then I regret that I didn't introduce Dr. Bartuska to you at the beginning of the panel. Ann is Deputy Under Secretary in the department, my very relied upon deputy. And she has been working with a Working Group on urban agriculture that we have established within the department. And you might talk a little bit about that.

>> ANN BARTUSKA: I'm always pleased to talk about urban agriculture. It's one of these actually urban systems in general from an ecological perspective has just really taken off, and those of us involved in ecosystem research have seen the resurgence of looking at urban systems in an integrated way. In urban Ag space one of the things I've been privileged to do is get out and about over the last six years to a lot of our funded projects. And the community foods program is my -- this is my long introduction to the answer in the Community Foods Program sponsored by NIFA, I've had chance to see a lot of different community agricultural activities, and it's been clear that urban ag is just blossoming everywhere in all sorts of manifestations A lot of it to do with community security, and this is one of the things since we were talking about social science earlier, there's a very strong tie to social sciences in urban ag that you don't see in rural ag. It's a very different manifestation of how food brings people together. It really hits the sweet spot in nutritional security and addressing food deserts,

and Cathy is right we really need to get the data because right now it's very anecdotal. I was at a farm in Cleveland one of 40 urban farms that produced 22,000 pounds last year. Well how does that contribute to the overall production in the Cleveland city itself.

This is the long introduction to what USDA ended up doing, because many of these county extension agents I would meet out there would say, is there an urban Ag program at USDA? No there's not, however every single agency has urban agriculture activities, and we have produced a toolkit called the Urban Agriculture Toolkit. It's really accessible, we have validated it with people who are in communities, and it tries to convey all of the different questions somebody might have in venturing into urban ag, how do I set up a farm stand, how do I get access to composting, where are new and emerging composting research, which we actually have an ARS in Beltsville doing that. How do I start an urban farm, where are the financial mechanisms, what are the conservation practices? So I think we have in truthfully in less than two years gone from a not talking about urban ag to fully embracing urban ag to the point where we now, there's been a piece of urban ag legislation introduced to set up an Office of Urban Agriculture at USDA. I don't know that with we need that, because I know we have a lot of programs, but I think it's an incredibly powerful growth area which gets to my last point in that in touching where Americans learn, it is in urban areas because that's where 80% of the American people are. This whole vast pipeline that we have been struggling with, if we can touch urban youth through agriculture and these kinds of food production systems, then that actually helps contribute to our overall pipeline.

And since I have the microphone I did want to throw one little bit of factoid for the water piece, that 85% of the service derived drinking water of this country comes from our agricultural lands and forests for the 2005 RPA assessment analysis. We have a role in sustainability of water through our sustainable agricultural and forestry practices, so the connections are really, really strong. Thank you for the question.

>> MAXINE SAVITZ: Thank you and interesting the British had these local settlements all the time for farming they decreased, and now they are back again, and it's the same kind of cycling. John

>> JOHN HOLDREN: I have two quick comments one I wanted everybody to know that Dr. Ann Bartuska in addition to her extensive responsibilities in USDA, has now taken on the chairmanship of the Subcommittee on Global Change Research under the Committee on Environment Natural Resources, and Sustainability of the National Science and Technology Council and in that role she is overseeing the whole US. Global change research program, a 13 agency, a $2.7 billion operation, so I wanted to thank Ann publicly for taking on that very important responsibility. She is the first biologist to chair that very important committee. My second observation is I was just struck by Dr. Handelsman's initial description of how complex soil is. I remembered being in the audience for a lecture on soil and sustainability by a very distinguished biologist 48 years ago when I was a graduate student at Stanford, and the distinguished biologist began his remarks by saying, too many people

imagine that soil is just a collection of crushed rock that keeps plants from blowing away in the wind. And then he said, it is not. And proceeded to give remarks about the complexity and importance of the soil ecosystem, much along the lines of what Jo just delivered, although much less informed by details that soil science has produced in between, so thank you Jo for that very informative presentation

>> MAXINE SAVITZ: How much more erosion in the 50 years since then has occurred since that talk. Barbara?

>> BARBARA SCHAAL: Thank you for the presentation. When we initially worked on the agriculture project for PCAST, we had a number of workshops. And one of the most interesting was something that you touched on, Dr. Woteki. And that was the relationship between basic research and applied research. And the relative roles of the academic sector and extension agents and research stations and the private sector. And one of the most remarkable moments to me at one of those meetings was the statements from folks from some very large corporations. And their comment was that they no longer do basic research. That they rely on the research operations of the Government and of universities.

And of course what they do superbly is some of the breeding studies and some of the applications. We just talked earlier this morning about the challenges of moving basic science through into practice, and of course when you have different actors doing these two different things, that becomes even more of a challenge. So one of the things that we talked about was the public private partnerships. Now we see that in FFAR's work where you have the private sector supporting agriculture research in some very interesting areas. But that doesn't really get at moving the basics, from basic science to practice. So I wonder if you could comment on that.

>> CATHERINE WOTEKI: I certainly can, and as you were talking what I immediately thought about was with respect to agricultural science, the United States traditionally has been where that fundamental science is done by and large. Northern Europe, another major contributor. And if you looked closely at those two big bars that showed the wealthy countries' contributions, the places where that fundamental science and agriculture and it's immediate applications at the beginning of the applied part of the pipeline have been made have been in Europe and in the United States. And that's where the investment has gone down.

About a year ago, OECD asked if we would be, volunteer to be the subjects of a study. They have been doing a series of case studies of agricultural research in different countries. And we agreed to do that. Their report is going to be coming out in November. And this question of fundamental science in agriculture and how it gets applied is one of the things that they have looked at now in six different countries. So U.S., Canada, Australia, China, they are going to be finishing up a couple of other countries. And for me, a big question and going to the really the thrust of your report, is where is that fundamental science for agriculture going to be coming from in the future. Because most of the

other countries are more in the applied locally adapting plants, animals, and systems to their local conditions. So I think that is a challenge for us.

Domestically we have established and really strengthened building on existing working relationships, both with the National Science Foundation and with the Department of Energy on the plant sciences. And with NIH on the animal sciences.

So there's a very strong collaborative research community and a set of programs. And I think that transfer of the fundamental science, like the Department of Energy and ARPA-E has been funding, and we actually meet with them regularly about the transfer of the findings from that into our own research programs, and then building on those. So I think that's strong.

And ongoing with the private sector, built into our planning programs, both for the competitive side of the house and the intramural side of the house, are regular consultations as those programs are reviewed and evaluated on about a five-year basis. So I know that that is ongoing. But to the roundtable we're talking about setting up I think the question of where should the Federal USDA research investment on the more fundamental side go is going to be one of those key questions for that further discussion.

>> MAXINE SAVITZ: We have less than five minute, and we have three questions coming so if each of the people would ask their questions quickly and then answer them all at the end. Daniel Schrag?

>> DANIEL SCHRAG: Thank you I just want to quickly follow up on Barbara's question. Cathy, when we worked together, first of all, when we did work together as co-chairs of the agricultural report, I have got to say you were just an incredible partner in that effort and really a model for how PCAST could work effectively with the departments to really figure out how to make the report best perceived by the agricultural community. Because I think you used the word tough love for our report. There were some, you know, there were some, some tough things, wet some carrots but there were some tough recommendations and you really helped us translate to be able to be heard in an effective way.

My question really is about the agricultural research community. One of the challenges we saw was the, what we call the balkanization of agriculture in this country that the agricultural research communities are generally separated from the rest of the science, they are different institutions. Even when they are in the same institutions they are at different parts of campuses, and our hope was among other things we didn't have any specific recommendations for that, although certainly the increase in competitive funding which we thought was critical, could help that provided it didn't all get scuttled to the existing community.

The question is, over the last several years now, have you seen any progress in that, in the recognition that the broader chemistry, biology, earth science communities have gotten more engaged in agricultural science, viewing it as a fundamental area?

>> MAXINE SAVITZ: Just hold the question and we'll get the other two.

>> MARIO MOLINA: Thanks a lot for the presentations. My question has to do with a part of Jo's presentation on the effect of climate change on agriculture. But there's the other side, which is the potential for agriculture to capture carbon. And that's something potentially very important. In fact, it came out in the Paris accord as you know last December, and the United States made commitments related to that so my question is to what extent is that really part of the research agenda? Because it's not obvious that the carbon will stay there. But yet the potential is enormous. And a related question is there's another worry with agriculture and climate which is emissions of nitrous oxide which could be also limited quite a bit from excessive use of fertilizers that also have pollute water and so on.

But there are these other connections which I believe are a very important component of the research agenda. So I was just wondering to what extent this is actually happening.

>> DR. MAXINE SAVITZ: Bill, last question.

>> WILLIAM PRESS: So my question is also to Jo. It sounds like soil is in some sense nature's original smart material, and I wonder in that sense has there been any attempt to interest material scientists in interventions in soil that one might make to improve the smart properties of it as you discussed, you know, absorbing, releasing water, erosionbility and so on and so forth.

>> MAXINE SAVITZ: Cathy, John, I assume you made your comment?

>> JOHN HOLDREN: Yes.

>> MAXINE SAVITZ: Cathy do you want to answer Dan.

>> CATHERINE WOTEKI: Yeah so quick response, I think that, yes there has been progress made on breaking down some of those barriers. I can point to specific campuses where that is occurring. And largely it is being driven by the emergence of agriculture and food systems as being critical in long-term sustainability of the planet. It just keeps emerging over and over and getting more and more public scrutiny. So I think that is definitely happening.

There remains one key barrier to non-land grant universities participating in our competitive programs. And that is the cap that's imposed by the Congress on indirect costs, so we have a cap at 30%. And there are many universities, as I understand it, who say that they don't want their faculty applying under those terms.

>> MAXINE SAVITZ: Interesting. I didn't know that there was a difference among departments.

Jo, on the two.

>> JO HANDELSMAN: So on the COP 21 agreement, as you know France introduced the idea of the 4 per thousand that we all increase the carbon content of soil across the world by .4% which would mitigate all of our emissions, the US. did not sign onto that because there's concern it would not be measurable, we couldn't hold ourselves accountable, and we couldn't study progress but that doesn't mean we're not committed to the basic concept. There's an enormous amount of research going on in that area personally I think of course there should be more but that's an area both the emission of greenhouse gases as well as carbon capture.

One of -- and one of the I think the happy coincidences is that things that help with soil protection are also the very practices that will increase carbon capture such as using cover crops and having more photosynthesis going on overall, so I think that's an area of interest and Ann might want to add something to that. On the material science, I think that's a very rich area, Bill. There's a lot of new nanotechnology looking at how to recreate the best properties of soil more rapidly. And that's one of the goals that we have set in the discussion of our Working Group is how can we, or can we create soil? And is that a reasonable grand challenge for example to speed up the rate of soil production, which can be done with compost and other substances that are much older, but nanotechnology in particular and other material sciences I think are going to be critical.

>> DR. MAXINE SAVITZ: Ann, did you want to add?

>> ANN BARTUSKA: The one thing I might add that answers a couple of the questions or contributes to that is USDA, our secretary charged us to establish the building blocks for greenhouse gas emission mitigation which are ten building blocks a couple of them have to do with science but a lot of it has to do with carbon smart practices in agriculture and forestry. I think the building blocks is actually online at the USDA site but it is stimulating additional research and carbon capture in soils, including biochar and the potential of biochar and there have been some biopolymers that have been looked at from some material scientists as a mechanism to enhance the biochar, so it actually has accumulative processes. So I think we're trying to hit it at various places and of course it comes back to how do we inform the conservation programs to make sure that the users of conservation programs apply those practices which gets to our earlier discussion on this translation.

So, but the building blocks I think gives us a really good framework on greenhouse gas mitigation and that's balanced by our climate change research portfolio.

>> DR. MAXINE SAVITZ: Well I want to thank the three of you for all of the work you're doing and also the excellent presentations.

(Applause).

>> ERIC LANDER: We will take a break and we will be back, let's say about 10, 12 minutes and we'll be back for the second part of this meeting.

Biodefense Update

>> ERIC LANDER: So I'd like to welcome everyone back. The next part of our meeting we are going to address a topic of biodefense, biosecurity. PCAST has had a Working Group addressing this topic, and it's been co-chaired by Wanda Austin and Christopher Chyba who are ready to bring us some recommendations to PCAST for considerations to PCAST, so I'll turn it over to Wanda and Chris to lead us through a brief reminder, and then tell us about the recommendations coming forward.

>> WANDA AUSTIN: Good morning and thank you Eric Chris and I have divided the labor here so I'll get us started and Chris will back me up. So let me just remind PCAST that we started this Working Group about a year ago with a focus on trying to identify what actions are needed to protect against biological attack, and the Working Group was focused on trying to decrease the probability of or be able to preempt the biological attack, and to understand what we can do from an S & T respect in this area. So our chart shows the formal list of members. There are a lot of covert members who have been extremely helpful on this effort, specifically on PCAST both John Holdren and you, Eric have been extremely helpful as we've been going through this process and understanding what kind of recommendations we could bring forward that could be actionable, and move the ball forward in terms of our accomplishments here. I also want to recognize the PCAST staff members, the White House staff members, Jo Handelsman is another person who really contributed quite a bit to our progress on this.

And there were just many, many people. Over 100 interactions, phone calls, meetings that were held with quite a few different agencies, including DHS, HHS, Department of Agriculture, the Office of the D & I, the DoD, the NSC, in addition to the organizations that you might anticipate. Plus we had a session with the United Kingdom Prime Minister's Council of Science and Technology Advisors so this is a global issue that we are trying to get our arms around.

The specific Working Group members are highlighted here. They did an outstanding job. Even beyond the point where we stopped our formal Working Group meetings they have been actively engaged by email with helping with edits and write ups that have been required so special thanks to Roger Brent, Mark Buller, Tom Inglesby, David Relman and Tim Sterns.

So couldn't have done it without them. And of course Jerry Epstein has done a Yeoman's job for us from a staff perspective. I want to remind PCAST of the study goals. There were two primary goals we focused on; the decrease in probability of an attack and also decrease in the probability of/or

preempting a biological attack not only within the US. but worldwide because as I mentioned this is a problem that crosses boundaries very easily.

The challenge here is naturally occurring infectious disease, accidental releases, or intentional attacks. As you think about our current approaches of either stockpiling vaccines given today's technology, we realize this may not continue to be an effective approach. Considering when you look at the technology available in bioengineering for genome editing, there are lots of things that can be done that are beneficial to the country, but there's also the potential for misuse, and so we had a lot of interesting discussions about the range of possibilities there.

We also had the opportunity to observe some recent outbreaks, and how it was addressed, specifically if you look at ebola, influenza, even zika, and the impact it can have and how it can undermine the trust of the public. You can understand why this is a really critical issue at this point today. So what I would like to do now is focus on describing the recommendations. I will describe the first three. Chris is going to describe the subsequent recommendations. And then PCAST will see a full report write up on this before the next meeting. But today we want to focus and ask for approval on the recommendations themselves.

We've had a lot of comment and feedback from the team in the last, I would say couple of months. And we think we have reflected those changes in the words that you see represented on the charts today.

So Recommendation 1 is a near-term recommendation. And it's focused on the creation of a new interagency entity that would be charged with the planning, coordination and oversight of our national biodefense activities.

This would be across the Intelligence Community and the DoD. Departments of Homeland Security, Health and Human Services and Agriculture.

Other agencies could obviously and would obviously be drawn in as needed. The key thing here is on the leadership of this effort, we would expect and suggest that it be co-led by the assistant to the President of Homeland Security and Counter Terrorism the Assistant to the President for Science and Technology and the Chair of the Domestic Policy Council. This would be senior level representation that could, would also tap resources from agencies, including HSS, the Center for Disease Control and Prevention, and BARDA, the Biomedical Advanced Research and Development Authority, and the National Institutes of Health.

The things this entity would be charged with doing, first we are asking that within six months they would develop a national biodefense strategy, which would have both short, medium and long-term components. To really think forward about how to anticipate, prepare for, and respond to the issues that would arise from the biotechnology that continues to advance.

One of the things that we really want to stress here is that this landscape is changing dramatically on a very short timeline, so the second option here is to suggest that there be annual public updates, which could be in the form of a report. And that would necessarily include a classified annex because what we didn't want to do is provide a recipe here for someone with nefarious intentions, and the intent would be to give that to the President to track and measure the progress to achieve that strategy and if necessary, update that strategy. Also this entity would be charged with overseeing the execution of the national biodefense strategy and holding all of the agencies accountable for progress.

I would refer to the fact that we did present in a classified form, some classified recommendations that also align with the recommendations that we're presenting today.

Specifically there are some guiding requirements and tasks for the Intelligence Community and they, too, would be held accountable for adequate collection and analysis of the current and future biological threats. And have the right expertise to do that.

And then the final element of this first recommendation is to ensure the coordination of the efforts against new and emerging infectious disease, antibiotic resistance and intentional biothreats, including through the development of biosurveillance systems and new medical countermeasures.

This is something that we recognize that as this entity is formed and coordinates with all of the relevant entities, that they will have some specific suggestions on how to begin to get their arms around this very significant challenge.

So that's Recommendation 1.

Recommendation 2 is focused on the establishment of a public health emergency response fund. At least $2 billion. And the purpose of the fund would be to support the mobilization of rapid federal responses to serious rapidly emerging natural or intentional disease events. Public health interventions, scientific research, regulatory activities and global response. When I think of this the good analogy is the FEMA Disaster Relief Fund and the expectation would be that these funds carry over across years and can easily be replenished through routine and emergency appropriations.

The access to the funds would be contingent upon the expressed authorization of the President or a joint agreement of the Secretaries of Health and Human Services and the Department of Homeland Security.

So as we have seen and learned from recent outbreaks, one of the challenges that we have as a nation is being able to fund the relief and emergency response efforts in order to get on top of the issue as quickly as we can.

And then quickly let me turn to the third recommendation. Now, this recommendation is viewed as something that's more in the medium term in terms of a recommendation where the two earlier ones were more near-term, things that could be accomplished but this is focused on development of the capability for disease surveillance. And what we recommend is that the White House should act to substantially strengthen Federal, state, and local public health infrastructure for disease surveillance, as well as promote a stronger international system of disease surveillance.

So the point here is that when disease spreads, it really doesn't carry a passport. It's free to go wherever it wants to go and can migrate very quickly. In the same sense, if you take the flip side of that, the indications and warning that you have a problem or even something like fevers of unknown origin, that you want to have those sensors out very broadly looking for those indications so you can respond in a timely manner.

So the point here is that disease surveillance and maturing the capability to do that is something that's really important so there's two aspects of this recommendation. One is the laboratory networks in the U.S. and abroad with the capability for early detection and rapid monitoring. Both the man-made and naturally occurring infectious agents, and the second one is to rapidly be able to employ advanced biological tools. And the details of those recommendations are included. With that let me turn control of the charts over to Chris.

>> CHRISTOPHER CHYBA: Thank you, thank you, Wanda.

Our final three recommendations are medium to long-term recommendations and all of them have to do with medical countermeasures. What I want to do is describe those last three recommendations and then make a few concluding remarks.

So our fourth recommendation is for the White House to set an ambitious ten-year goal, and we recognize and the individuals within the agencies with whom we spoke to about this, recognize how ambitious this goal is but we think it's necessary as a ten-year objective and it's a goal for medical countermeasures preparedness, and it has two parts. One is that for infectious organisms for which there exist effective approaches to creating vaccines, we want to be in a position in a decade to have the ability to complete the development, manufacture, clinical testing, and licensure of a vaccine on a six-month time scale. A radically different position than the one we're in today.

In the second, and the second objective is for infectious organisms that we can reasonably anticipate could lead to a sudden epidemic spread to the United States, we want to have pretested vaccine candidates up through safety and immunogenicity studies. As a form of accountability, the Secretary of Health and Human Services and the Secretary of Defense should report annually to the White House on progress towards this goal.

Our fifth recommendation is one that reaches back to PCAST 2014 antimicrobial resistance report our report on combating antimicrobial resistance which this group will remember was released along with an Executive Order by the President on combating antibiotic resistant bacteria and a national strategy and ultimately national action plan so the recommendation begins by calling for full implementation of the recommendations PCAST made in that report with respect to combating antimicrobial resistance, in particular for antibiotic development to expand fundamental research, to establish a robust national infrastructure to support clinical trials, to strengthen and expand the existing regulatory efforts, and to significantly increase economic incentives for antibiotics.

In addition to reiterating those goals for antibiotics, there is a kind of parallel set of goals for antivirals that would address the viral part of the problem. That we did not speak to obviously in the antibiotic resistance report that could only enter as bacteria and fungi, but we're now expanding that to look at viruses.

In addition, we call for the United States to support the development of platform technologies that could allow a rapid response to agents of biological attack through a variety of technologies that we identify that should be examined, including, for example, engineered antibodies. So again, an effort towards increasing the rapidity of our response in the event we do face an outbreak.

Recommendation 6 is our single long-term recommendation in the study. And you can think of it as in one sense a kind of call to the scientific community. It's a call for a basic and applied research, for the Government to support basic and applied research and as with Recommendation 4, we have a suggestion on the amount of funds that should be made available to support this work.

But this is really with the intention of taking us into an altogether different realm as a long-term objective. Maybe this is two decades in the future. But down the road in the future, given what we may be facing both with respect to emerging infectious diseases which seem, it's a drum beat that seems to get ever more insistent but also with respect to the explosion of capabilities for the intentional manipulation with microorganisms, given what may be coming to us down the road, we want to have the ability, we want to put in place new types of countermeasures that will give us the ability to deliver those countermeasures within days of detecting and identifying or characterizing a disease agent.

That's at this point, I don't know that PCAST can even say what the approach would be to take to such a capability. We list a number of approaches that should be explored. But that is after all the point of a basic research program.

Those are our six recommendations. I would like to make a final set of comments and then it may be that other members of the Working Group or PCAST leadership would like to add some remarks and we can open it for questions.

Our first recommendation that Wanda highlighted calls for a national biodefense strategy. And that has to be a living document with metrics and accountability. What PCAST report is obviously not meant to be that comprehensive strategy. Our group was too small and our time was too limited. But our report, if you look at our recommendations, you see that our report has the representative elements of such a comprehensive strategy, it has to look at short-term, medium-term and long-term issues. It has to understand the kinds of evolution of biotechnological capabilities that we're facing. And that we might face in the future as those technologies continue to evolve.

It has to look at preventing attack, and understanding what capabilities of adversaries may be what their intentions and motives might be so for the prevention of attack, but also in the event that we do face an attack or a natural disease outbreak, it has to address countermeasures to such an event.

And it has to think seriously about the connection between addressing a natural disease outbreak, and learning from addressing natural disease outbreaks to help us prepare for the next natural disease outbreak, or should it happen dealing with a human engineered attack.

So our recommendations can't be as complete as would need to be those of a comprehensive strategy, but they span what's needed in that strategy. They address threat awareness so that we can improve our ability to see what might be coming. And also that we have a greater opportunity to prevent, interdict, or deter such an attack. They address surveillance so that if an outbreak occurs, natural or human engineered, we're, we detect it as quickly as possible so we can mount as quick a response as possible.

They address, as I've already said learning from infectious disease outbreaks.

And then they address the need for response capability, both this fund so when there's a flood in the United States, FEMA doesn't have to go to Congress and apply for funds to address the flood. We want a comparable capability so the next time there's a serious outbreak, the relevant agencies can move out immediately to address that outbreak.

And what are they going to move out with, well, those will be medical countermeasures, and we list as you just saw a set of areas where we think there's need for improvement, and looking into the future where there's need for substantial improvement if we're going to meet the future that may be coming at us.

Above all, perhaps, though what's needed is leadership. Leadership, accountability, and planning. And that planning needs to take into account the trajectory of the technology. And I think this is the most challenging aspect of it. It needs somehow to maintain focus on this issue. Even if, as we all hope, we continue to move in a future in which attacks keep not happening, in which intentional

attacks don't happen, but nevertheless the focus is maintained because the capabilities have to be advanced and have to be ready.

Those are my final comments in what has been a challenging year and a half, and I would like to ask other members of the Working Group or PCAST members if they have any comments to make.

>> ERIC LANDER: I want to thank both of you, Wanda and Chris for your leadership on this. It's a complex topic. And yes, you haven't laid out a whole national strategy, but what I think you've done is you have really identified that the landscape has continued to develop and that we're going to need to think differently about a national strategy, and provide the elements provided the elements for that and provided a framework for ensuring we do that in a thoughtful and ongoing way, so I think that's a major contribution there.

I would turn to PCAST for questions. I see Bill has his flag up and Susan has her flag up. Bill.

>> WILLIAM PRESS: Thanks, Chris and Wanda especially for your leadership on this. It seems to me the headline, or at least a headline in your recommendations in the sense of what's being unexpected is your recommendation that a strategic plan incorporate both natural outbreaks and attacks against the United States. And I understand that the biology is closely related in the same in that there are synergies there. But it's also true that the way our Government is organized is not along those lines. It's organized so that public health is in one set of stovepipes, and defense is in another set of stovepipes, so I was wondering if you could comment on the difficulties that you could foresee in trying to bring those stovepipes together to reach this kind of unified approach.

>> WANDA AUSTIN: So one aspect of this, Bill, that we had some presentations on, which I thought was very insightful was that one of the things we're charged with is protecting the health of our warfighters who would be logically maybe the first line of attack here in terms of being exposed to some horrible agent.

So I think it's in the interest of being effective on both sides of that ledger that we figure this out. Because it isn't going to be a serial process that we potentially are exposed in. I think that the natural occurring diseases is something we worry about as we send soldiers into harms way in foreign areas and also the fact that if someone were looking to, how could they have a significant impact, again, it might be our Department of Defense that would be front and center on that, so I think there are some forcing functions that would say that everybody needs to come to play and have a vested interest in addressing this issue because it's not going to be compartmentalized in a way that says you get a pass.

>> CHRISTOPHER CHYBA: I might add just a few comments to that. The first is, I think it's important, while clearly this report is informed by a sense that we need to learn everything we can from dealing with infectious disease outbreaks, both for the next outbreak of which there will certainly

be one, or for preparing for a human-made event, I think everyone also recognizes that a human made attack could be very different from a naturally occurring outbreak, and in particular with respect to the rapidity for which it could develop, the ability, the possibility that it could be launched in many locations simultaneously, and frankly the way the disease can progress could be quite different even if it was a natural occurring organism because of the way the disease could be deployed.

So there are important differences but nevertheless as you say all of this has to be brought together somehow into a comprehensive approach and I think that's one of the challenges, the challenge there is one of the reasons that the recommendation, the first recommendation that Dr. Austin presented talks about the need for this entity that combines the need for presence of the assistance of the President for Terrorism and Science and Technology and the Chair of the Policy Council because all three of those prongs have to be well coordinated.

If you go down into the weeds, the coordination continues. Somehow the strategy has to look both towards counter proliferation and also towards counter terrorism. There are many pieces of the security puzzle that have to be brought together, which means there is going to need to be some kind of dedicated staff, this is now me speaking beyond what's in the text of this recommendation. I want to be clear about that. There needs to be a dedicated staff at the White House that spans, that either spans that range or if they are in separate places or in regular frequent communication. And that are primarily committed to this set of studies. Another challenge we face is that because, fortunately intentional attacks don't happen frequently, anyone addressing these issues is naturally going to be pulled off into other crises that are occurring.

And yet that risks removing the ability to maintain a kind of strategic focus to continue the kind of tech awareness and the way the evolution of the technology is proceeding and so on.

So I think that there will also need to be a dedicated staff that supports this triumvirate of people that span the agencies.

>> SUSAN GRAHAM: You've talked so in the report and in the recommendations about the longer term and thinking about ten years out at least, and I'm thinking about the pipeline. Do we have the right educational programs in place so we'll have a continuing supply of people with the expertise we need?

>> CHRISTOPHER CHYBA: Our report did not address pipeline issues, although there are several reports by this body that have looked at significant pipeline issues, and it making that Jim Gates or others around the table should also chime in.

We heard PCAST has had just a recent briefing on the importance of ensuring that our scientific pipeline takes advantage of everyone in the country. Including underrepresented groups and women, and there are some areas in science that do a better job with that than others. But clearly if we're

going to the most competent national response to this challenge we need to take advantage of everybody in the United States, and ensure we are not leaking out of that pipeline individuals that have every bit as much capability as the more traditional people in those fields, but for some reason or for a variety of reasons, some of which we cannot identify, aren't making it all the way to the end of the pipeline. So that's one topic. If I could, I would expand just a little bit and ask whether people that are coming through a traditional education in molecular biology or microbiology, or any of the associated disciplines, are along the way being tuned in to these issues, or being taught to think about these topics and at least mentally prepare themselves. I think we're doing a bit better for that now than we used to. And I think this is, this is now a personal comment from what I've seen I think there's an enormous hunger for that. When we ran a seminar series at Princeton on these topics we ran it in the genomics building. Every seminar we held was packed, packed out. The room was overflowing, and that started with the undergraduates all the way up. In fact I wound up being invited by the professor who gives the big undergraduate introductory biology course to come and give one of the lectures on this set of topics. There's a clear hunger. I don't know whether it's always broken through to the faculty, though it's clearly broken through to some of them, but the students I think this is my anecdotal impression are seized with some of these issues, they recognize, I think there's a thirst for more knowledge.

>> ERIC LANDER: Jo Handelsman?

>> JO HANDELSMAN: Does your group envision the same office handling agricultural biosecurity as well as medical?

>> CHRISTOPHER CHYBA: So there's not really an office. What we propose in this recommendation is one that's a three-headed structure. But, it's not as apparent in the recommendations of the report and Barbara Schaal can speak to this, the report does contain some discussion of the agricultural challenge. And agricultural, the potential for an agricultural attack would certainly need to be included in the purview of this group.

>> JOHN HOLDREN: I would jump in and note the recommendation 1 includes specifically the Secretary of Agriculture as a member of the group.

>> WANDA AUSTIN: I think the agricultural challenge, and maybe Barbara is about to chime in here, is really key to biosurveillance as well.

>> BARBARA SCHAAL: If I can comment, yeah, the agriculture is very much represented in the biosurveillance. The nature of an agricultural attack would be quite different and consequences are quite different, and this report focuses a lot on human health but there are some very interesting issues, and I think in a committee where you have the Secretary of Agriculture, those would be very easily brought out.

>> ERIC LANDER: Indeed I think what you're doing, if I understand the recommendations correctly, is setting us on a course that we'll continue to be able each year to assess how things are changing, see the development of the science, see the spread of ideas and information, see the potential issues that arise in human health, both in disease and intentional uses and agriculture. There's a long future ahead. Most of these technologies have tremendous uses for human benefit for health and food, and you're prudently telling us that we have to have a mechanism in place to continue to watch it as it evolves, and develop clear national strategies to make sure we know what's going on and we can respond if we needed to, and the added benefit will be that in some cases, we'll be able to respond to naturally occurring outbreaks. Some of which may be far more clever than man-made outbreaks because nature tends to have a lot more experience in this game.

>> CHRISTOPHER CHYBA: If I may, I might add to this having metrics to accountability is essential. That is true not only within the Government. It will never be the case that the, that however dedicated that they will be able to stay on top of a field that's moving as fast as molecular biology is by itself. This is also Eric, your comments are also a call to the community. There has to be some element of the community outside the Government that's well plugged in that ways attention to what is happening and helps make sure that the Government is thinking about the evolution of these technologies is wise, prudent, and on track.

>> ERIC LANDER: Indeed it is a call to the rest of the scientific community. All right. I see no further flags up. I'll take it as a sign that we're ready to call the question and ask are we ready to vote on these recommendations and an underlying report in substance as always once we have voted on a report we go back to make sure it's clear and we copy it and it's my guess it will be several weeks of getting the final report out there is completed, but we want to vote on these recommendations today, and on the basic substance of the report.

If there are no objections, I'm going to ask for someone to move the report? And a second? All in favor? Any opposed? It's approved unanimously with our thanks and congratulations to Wanda and to Chris for guiding us through this lengthy process, well done.

(Applause)

Data, Technology, and Justice

>> ERIC LANDER: We are going to move very briskly to the last main section of our meeting today on data, technology, and justice. I'm going to invite the panel members to come up if they would right now and flags at the front to be changed to reflect the new panel members.

So in all areas of human life, it's important to be able to use data to improve outcomes. We think about it in medicine, we'll think about it in aspects of our economy. Obviously there are many, many places. I think we don't think about it with respect to justice as much as we should. The role of

data and technology in justice. To gather information. To make more perfect our process of protecting the safety of the American people, and along the way respecting the American people.

Balancing all of that with information that can be gathered by police departments is a very important thing, so that one can learn what works, one can learn how to be effective in protecting communities.

So I'm thrilled that we have three speakers today who are different than the speakers we usually get. We have Brandon Bouier, if you haven't read his bio sketch, you should. I won't read the whole thing. But it does talk about driving all the way across the country to work with this awesome group of extremely smart and motivated people here at the US Digital Service. And the other end of the country from which he was driving was Seattle where he was the lead GIS analyst for the Seattle Police Department. We have Maggie Goodrich who is the Chief Information Officer of the Los Angeles Police Department which is a very large Police Department. And I bet most of us don't think about it's Chief Information Officer. We always have other faces that we may attach to police departments and it's going to be very exciting to hear about the way that you're thinking about using information. And we have Luke Larson, the president of TASER. I think we all do think about TASER because everybody knows the word taser. But I don't think that's what Luke is going to talk about. I think he's going to talk about other things that a technology-based company that works with the policing function in the United States is thinking about in terms of being able to capture and provide information that will help us improve the function of protecting public safety.

I don't know the order in which you guys have chosen to go but our usual process is to have some brief presentations and then really throw it open to a discussion so I'll ask you to keep it brisk because I think the discussion will be very good. Are we going to go starting from the left, my left and moving to the right? So I'll ask Luke Larson to start us off.

>> LUKE LARSON: Great, good morning, my name is Luke Larson. I'm the President of TASER International. TASER is most well known for our smart weapons, we're in 95% of the police agencies but over the last eight years we've been become the market leader in wearable video cameras and digital evidence management software that I'm going to talk about today.

A few weeks ago we started a discussion with some of the folks at PCAST and specifically with Dr. Gates. Shared some of his personal experiences growing up. And his interactions with law enforcement. And he tied that to what's going on in society today. And you cannot open up a newspaper and see some of the events that have been happening over the last weeks, and really the last two years since Ferguson. And we see a couple of key themes that's going on. The first is we've got this societal distrust of police and communities. And that's something that we need to address.

And underneath that, we have the police community are being very, very underserved from a technology perspective. They have extremely antiquated systems. One of the largest police agencies in the country up to two years ago was still using typewriters.

So when we look at the scenario, we ask ourselves, what can we do. And at TASER and Axon, we think we can do much better, and the question is how can technology affect this? Eric Schmidt who sits on the PCAST with you, in his book, "How Google Works" identifies three technology trends that have driven transformational change in a lot of industries, and he talks about the convergence of the Internet where you have ubiquitous access to information. Mobile, you now have this on your fingertips on a handheld device, and cloud computing where you have massive computational and storage power, and when you bring all of these things together, you give humans also superpowers that they didn't have before. If I'm on my way to the airport I can get an update on what seat I'm in, what is the weather like in the city I'm going to go to. If I hear a song I like I can hear the mobile phone and identify it, and these are literally things that probably six, seven years ago would have been unthinkable, and we have seen these massively transform our personal lives as well as enterprise software, but we haven't seen that same adoption of technology in the Government space, so what we have focused on at TASER and Axon in the last, 8 years or so, really in the last 20 years with our smart weapons and in the last eight years with our newest division, is how can we use technology to solve this problem and it's something we're extremely passionate about. So over the last eight years we have built up a network that we call Axon and Axon is a network where we connect smart devices, cameras and smart weapons gathering information to applications, mobile and cloud based application systems, and really we want to use this information and serve it back to both police officers and communities so they can create safer communities.

On our devices, we have really, really intelligent wearable cameras these actually have microprocessors inside of them, they are capturing lots of information. It's a closed loop where we're updating the firmware on a regular basis, and to date we have over 100,000 cameras in the field, and I'll talk about the results of that a little later. And we have built up a great team. One of the questions that Dr. Gates asked us on the call is how do you get the best minds in tech working on this? And we have really built a phenomenal team at Axon. We have top grads from Stanford. Andy Peabody is one of the project managers working on the devices. Axon fleet is a new product we launched where we are really focused on how do we make the police car smarter. We have a great engineer Ray Farthna who comes from the consumer tech space helping us on that, and on the smart weapons we have Max Nerheim that came to us from Intel, and I say the names because we're proud of the team we assemble, but I also want to highlight we are bringing the best minds in tech to tackle these challenges. And on the software side, we have built an incredible team in Seattle led by Markus Womack and Jay Wright who come from consumer tech backgrounds, and to date we have collected over 4.6 petabytes of data on Evidence.com which is a massive amount of information and to put that on perspective Netflix today we have more data on evidence.com than Netflix has on their entire streaming catalog,

so I think today we're just accessing the veneer of what's capable with all of that information. We also have millions of videos and photos. And then finally, the whole purpose of using this technology is to bring it back to the frontline officers and the communities so they can use it in intelligent ways.

We have got over 50% of the major cities, 34 of the major cities think major metropolitan areas in the United States, the majority of them that have adopted the technology like LAPD with our friend Maggie Goodrich, have gone with the Axon network, and the reason that they have is with the network, you can imagine the value that families get being on Facebook and Twitter, being able to share photos of their children to family and friends, that same power of technology can be used in a secure way in law enforcement to move around secure digital information.

So the results to date have just been really phenomenal. Just yesterday, the University of Cambridge released the most comprehensive scientific study on the impact of body cameras to date. They studied thousands of police officers wearing the cameras in a controlled study and they found 93% fewer complaints when officers wear the camera, which is a great statistic, and even more statistic out of 2012 University of Cambridge study done with Realto PD where they found a 60% drop in use of force. A 60% drop in use of force and we know when video is present, it improves behavior on both sides. And then with smart weapons, this is the most effective use of force that's out there, and actually our long-term vision at TASER is we want to make the bullet obsolete, and we're not anti-gun and we're not anti-NRA but we think we can make a device that's so good, that's so effective that law enforcement would say, why would I ever go for a lethal device? When we say that, people usually think we're crazy but I use an analogy and our CEO and founder, who is actually here via robotic if you want to talk with him later, talks about 5, 600 years ago if we were in a bar in London you might see somebody, most of the men would be carrying swords, and technology pushes these weapons and everything we do it advances and we believe in the next 50, 100 years, the thought of using a lead bullet to kill somebody will seem barbaric and archaic and we want to be the company to push that technology forward.

So where is the future going? We believe these devices will help us collect information. The software will help us analyze that and serve it back to communities. And the future possibilities are really, there's a lot of low hanging fruit in law enforcement today. Because of the amount of paperwork that they do. And so if you ask police officers around the country, and there's data that shows they spend more time doing paperwork than they do doing police work. And we think with these new technology advancements in wearable sensors and machine learning, we can reduce that paperwork by 35%.

Now, if you think about that, that's going to double the amount of police that we can put on the street. And you heard one of the speakers talk earlier about the moon shot, a ten year bold vision, our bold vision in the next ten years to reduce that paperwork is by 80%. And it might sound like a

mundane task. Until you start to think about what can be freed up when we give these officers more time.

And the White House issued a paper where the 21st century policing committee said, we really need to shift the mindset of law enforcement from warriors to guardians, and one of the key themes is technology. Technology is not a silver bullet, it's not going to solve everything, it's technology combined with training so if we can free up these officers from doing paperwork, we'll give them more time to do training in things like unconscious bias and how to deescalate situations, and also be out in the streets interacting with their communities, which is something that technology is not going to solve. But it can help them enable that.

So this is a topic that we're really passionate about today. And look forward to having a great discussion with you all. Thank you.

>> ERIC LANDER: Thank you. That was very interesting indeed and I'm sure there will be a lot of questions on that. Let's though hear from each of the panelists and we'll do one discussion together and I turn to Brandon Bouier.

>> BRANDON BOUIER: Hi, can everyone hear me? Thank you for having me here. I really appreciate you guys giving me the opportunity to speak. I'm Brandon Bouier. I'm currently an engineer with the Defense Digital Service which is an offshoot of the United States Digital Service. Prior to that I was the lead GS analyst for the Seattle Police Department for almost seven years I have a bit of unique perspective on police and technology and I'm glad to be able to share some of it with you. So I want to talk to you a little bit about technology and public safety specifically the Police Department and some of the technology tools that we have looked at and used, and some that we would like to be able to use if available going forward in the Seattle Police Department.

As a GIS analyst and a data analyst, I've had the opportunity to look at a lot of data related to police interactions with the public and how that data gets back out to officers and how that circle of data collection and use of the data works. And one of the things I can definitely say is that while the data itself, and by data I also include the transparency of that data to the public is very important, the context in which that data is sits in is even more important. I can't tell you the number of times I've seen instances where advanced tools or algorithms for processing data have been used, yet the simple context of how the data was collected or what it's being used for was lost. And I can tell you as someone who has done this work, the best tool sets in the world won't help you if you don't understand the data you're working with.

So as far as dealing with technology in relation to patrol officers themselves, I put together what I consider to be the core four things that patrol officers are really looking for. Obviously the devil is in the details, but when you break it out to a high level these are four main things. No 1, an officer typically want to be where do they need to go and when do they need to be there, because they have

an area to patrol, so if you say you have to go to a specific area they want to know when. When they get there, who do they want to look for victim, potential suspect, a witness, anything, they need to know who they are looking for. And additionally, which has become more and more prevalent in recent years, what precautions do I need to take.

Each one of these core four have technology and tools that can be used to aid in effectively and efficiently answering each one of these particular questions. For example, with where to go, it really starts with the 911 call takers and dispatchers who receive the 911 calls and dispatching that information out to officers. They are the true first line so to speak as far as collecting the information and making sure it's out to the officers and they usually dispatch to the officers, this is where the call came from, this is where you need to go and they are crucial. So the technology for their computer aided dispatch systems, CAD systems for example is extremely necessary and extremely useful. It's also in most police departments relatively archaic and is in need of upgrades in many instances.

In addition to that, there are additional tools that have been making their way into police departments over the years, such as advanced analytical tools and real-time tools using places like real-time crime centers and things like that, that can help detectives, crime analyst units, commanders, identify where things are occurring and where they need to be in a near real-time basis without having to go through the 911 call dispatchers who are already busy answering 911 calls. So for example on the left side you have an interactive mapping tool that's showing updates of locations as they come in in real-time. In the upper right you have a social media tool that's used to allow the public, through social media, to be able to identify and communicate with the Police Departments as to what's going on in their particular neighborhood. And if you have public media relations folks within the Police Department, which Seattle was fortunate to have, they can identify that and get that information out to officers, as well.

On the bottom right there you have an application that's used in Seattle that identifies locations of where calls and incidents took place. So that the public themselves now have awareness of what was going on in their area. It's been very useful and very well received by the public. It provides brief information to allow the public to have that context as needed. Not just scaring everyone saying there's a lot of stuff going, on but here are exact things going on and when they occurred. As far as when to go there, that's when the stronger analytical tools start to come into play, and Seattle and most other major cities are usually fortunate to have dedicated analysts on staff that can analyze historical information and records management systems to deduce patterns and identify trends over time to help aid the question of when they need to be there, especially when officers are patrolling in between calls, so you have a combination of commercial off the shelf and also homegrown systems that are used to analyze and provide visualizations that range from technical visualizations for crime analysts themselves, all the way up to more user specific visualizations for officers out in the field, that can help officers and the detectives from tactical up to a strategic level when they need to be available

when does an officer himself need to be in a certain area or around a certain area and when does the department as a whole need to staff up their staff or reduce the staff when things are going on.

Now as far as who to look for, that's the magic bullet. That's what really kind of separates reality from say minority report for example.

Who to look for is who to look for is a situation where you usually start delving into the records management systems. When you've made contacts with individuals and that information gets stored in the record management systems. Having an easy ability whether it's through records management system itself or through additional systems that hook into that data having the ability to refer back to that information to provide that context preferably to real-time to officers while they are in the field is crucial, that's a large part of the reason why if you ever see a patrol car, officers have mobile data terminals if those units to retrieve information to give them a better understanding of who it is they need to contact and provides that additional context.

This is where in some instances the technology that currently exists still has a lot of room for improvement.

Because most of the technology that makes it really easy and effective to do that, like for example the bottom picture it shows the type of link analysis, id to a large degree is outside the grasps of a lot of police departments for various reasons, not the least of which being usually there aren't that many people with the expertise and the time to go in and do that type of work because it takes work to do so.

And in Seattle and in other places, the ideal scenario would be what you see on the far right there where you have that information at a fingertip, easy interface, easy to use out there for the officers out in the field.

There are in places like Seattle and other places technology like that is in place. Whether it's exactly like you see there or in some form. But the idea of making it more ubiquitous and what it takes on the backend to get that working is an undertaking to say the least.

Now, here is where things get interesting, when it comes to, okay, if I know where to go, when to be there, who to look for, what precautions do I need to take. There's a difference for example between telling an officer to go to a certain location, a certain residence at say 11 a.m. on a Tuesday and look for a person named Steve, well the officer would like to know is Steve say a witness, or is Steve a single person who is just there to provide some basic information, or does Steve have a known history of being very antagonistic towards police officers. That type of information can deescalate a situation well before an officer even gets to the location. And the technology that can allow things like that to happen would be very useful. And it's great to see that there are inroads towards that type of technology being made available. It can be as simple as just making the basic records management

information available like what you see in the upper right there available to the officer in a mobile data terminals, to more advanced tools, taking advantage of things like machine learning and other things that can provide that kind of trend, especially towards relatively newer encounters with people that can make it easier for an officer to recognize whether or not should, I knock on his door myself or wait for backup to arrive, or so on and so forth, or should I not show up with three or four police vehicles or just with a single public information officer to diffuse the situation earlier. That type of information is critical, and to a large degree a lot of that in most police agencies is still being performed as you see in the upper left there, by the 911 dispatchers who have access to a good chunk of this information when it's available to them, and try to make that available to the officers over the radio.

What you see in the bottom left there is a situation whereby by increasing community engagement, officers being in communities, just to engage with the public and in non-legal situations so to speak, can go a long way towards building up that trust to make it easier for an officer to understand when they arrive in a situation what they are arriving into.

In addition, the use of body worn video cameras has been from my standpoint at least a double edge sword. On one hand it's been huge towards, as was explained earlier, reducing complaints and issues over time. However, on the other hand, from a technological standpoint in many agencies Seattle being one of them, it's been a bit of a nightmare trying to handle and deal with this data and figure out how to handle it, especially and I've been involved with this when I was there how do you manage privacy when you're dealing with this video. There was a strong push to make this available on all officers, it still is, but when an officer has a video camera and he shows up to a home and he walks inside, he now has video of the home and everyone in it, those are privacy concerns.

So of course the natural reaction is, let's redact the video blur faces of video the officer example like that but when you are dealing with as much video as we're talking about and you're dealing with police departments, not huge I.T. organizations, how do you make that work? Who is going to watch all of this video? And who is going to redact all of this video? That's a lot of work.

And in Seattle alone, there's approximately 2 million videos that's Seattle alone is dealing with. Over a petabyte just in Seattle. I bet LAPD and other agencies have even more and growing. In Seattle, through the technology that we currently have in place, it takes roughly four hours to redact every single hour of video, and that's with dedicated staff and technology currently in place. And we're fortunate we have dedicated staff to work on this most police departments do not. And oftentimes the body worn video system, and I know this is improving, but oftentimes the body worn video systems are not tied very easily with the current CAD and RMS systems, and that's usually due to the fact that CAD and RMS systems are legacy and out of date before body worn tying those two together is key but also very hard. And the process of automatically redacting video quite frankly is hard. It's not really a solved problem yet. It's been easier to do with steady cam videos like the cameras you see here are steady and identifying faces and pictures and video and blurring that, but when the camera itself is also

moving so now you have a moving frame of reference with moving people in it you have just exponentially increased the difficulty of the problem and I know this firsthand.

So in addition to all of this, how can you go about bringing more tech talent into the justice space? How do you convince the people who work at the high tech organizations that are so easily going to places like TASER and everything which is fantastic, but how do you also convince them to make a commitment to work in the public sector.

I have a few recommendations. First, work to strengthen connections between the public sector and the academic institutions. Oftentimes people in my generation, people who do this tech stuff for a living, are simply unaware of the opportunities that present themselves in the public space. That's one of the things that makes the work I'm currently doing with Defense Digital Service is so engaging, I work with people in the public sector who literally come to me and literally say I didn't know this stuff was available to us and it's great. Have interesting challenges to work on. Oftentimes, people in the private sector and the tech world don't think that cool technology problems exist in the public sector they think it's boring bureaucratic stuff I have to upgrade this HR system for example instead of creating the next great app. I know from personal experience that nothing could be further from the truth. There are serious challenges all over the public sector that can make this really available.

The third thing which is difficult, but very important, is to provide autonomy when you get that tech talent if you're lucky enough to get the tech talent in place to come work on your public sector and public environment work, give them the autonomy to get the work done. Don't layer them in bureaucracy which they are not accustomed to, trust me, and expect that to be super effective. Tell them what you need and let them tell you how it's going to be done. You will be surprised and amazed at the results you get.

And meet the tech community on their terms. I mean this from basic technical standpoint. If the technical community at large is using certain technologies or certain communication systems to get their work done, maybe Open Source tools, things like that, allow that to happen. If they have comfortable tool sets that they are familiar with in the public sector environment they are much more likely to get great work out very fast. And the last one and it's the biggest, figure out how you're going to be able to change the culture. Not just the culture itself but the perception of that culture, and outside looking in, the perception of the culture is that governments are big, stuffy, and bureaucratic and that's culture and the perception needs to change, so I want to leave you with one last thing. HackAThons don't hurt. They are actually pretty awesome. In Seattle in 2014 we had a Hackathon to try to solve the very problem of redacting video. We got very good responses there, and we continue to work with some of those people to those very day, and here at Defense Digital Services we're also working with not necessarily a Hackathon, more of a bug bounty with half of the Pentagon, the first bug bounty in the U.S. Government where we actually allow the public sector to authorize them to

hack and find vulnerabilities in certain Government Web sites, including DOD.gov, and they found more vulnerabilities in a shorter period of time than professional organizations did that took a lot more money.

So don't be afraid to reach out. This is also a great way to reach out to the tech community and meet them on their terms. So I really want to leave you with that last question. How do you change a culture, because one of the interesting things I've found is someone who delves into the tech and data, the most important thing to make these changes persist is the cultural change. How do you convince these organizations, especially police departments, that this is the direction to go and this will be beneficial in the longer term. So thank you all for letting me speak.

>> ERIC LANDER: Great if we can turn finally to Maggie Goodrich. We look forward to your comments.

>> MAGGIE GOODRICH: Thank you for having me. I'm Maggie Goodrich I'm Chief Information Officer for the Los Angeles Police Department. I'll give you a little bit of perspective of technology, the use of data, and where we would like to see it go in terms of our experiences at the LAPD.

First and foremost, I think we all have to recognize that policing is changing. We're at a critical juncture I think. Where the idea of what a police officer is responsible for is transforming. And police officers are not really seeing justice seen as just first responders any more as they were many years ago. They are providing a service to the community. They are often responsible for engaging in other services that you wouldn't necessarily have thought of maybe 20 or 30 years ago in policing when you were just responding to those calls for service.

And the technology, the hope is that technology can really serve as a force multiplier for officers who have limited resources, but you know we have to recognize the challenges of implementing technology. And I think Brandon just articulated them very well. The focus for us at LAPD, No. 1, is about going digital. Luke mentioned a large agency using typewriters. I'm proud to say that's not the LAPD, but we are using a 30 year old mainframe as a records management system today. And it's been years in the making to get us to the point where we're just to the point where we can start implementing some modern technology in that regard, and there are a lot of challenges that have basically led us to where we are today. Which I will get to. But the reality is is that more and more data is coming in every day. I have a good friend who likes to joke that I actually work for a Big Data company that's disguised as a law enforcement agency. The amount of data that we collect is really incredible on a daily basis. And you know, video and the advent of the body camera has really just multiplied that by X. But the amount of data coming in, and how we handle it and how we leverage it is really a challenge for us, and the other challenge is we're doing this in a mobile environment.

On horseback, and on foot. So how do you make technology available to an officer, how do you not only collect the data that is out there as an officer does his or her job, but how do you also get data

into the officer's hands. And Brandon spoke to that very well in terms of officers want that information on what they are coming upon. And they need the right data at the right time. We don't want to flood them with data. We don't want to turn it into white noise. We need to figure out how to get them the right data at the right time to help them do their job, and to help them serve the community.

Here is a little bit of information on data in the LAPD. We have had in-car video since 2010. We've got 18 million videos stored today. Body cameras, we've got about 1100 cameras out. They have been for about a year. That's 83 terabytes of data. We're about to begin in another week the deployment of another 6,000 cameras, so this issue is only going to grow. We're talking about all of the CCTV out there, license plate recognition systems. And then something else we're diving into is Telematics on the police vehicles. There's a lot of information stored in that black box in the car, in the computer in the car, that can tell us a lot about how an officer is driving that can lead us to things like how can we improve driving so we can improve officer safety. More officers die in vehicle crashes than they do from bullet wounds. How can we make it safer for the officer as they do their job in that mobile environment? That's one of the things we've struggled with.

And are really tackling today.

And then how can we make the data available to the public in a useful way. And again, in context.

We've been an early adopter of the White House Police Data Initiative. We've made our data available via an open data portal. Keeping that up, putting it in context, and making it public we think is really important, to have individuals out there who are not necessarily in public safety participating, as well.

The other thing we have really looked toward is the analytics models out there. Machine learning, predictive analytics. How can we take what's happening in tech out there in areas such as media with Netflix or whomever it may be and apply it in public safety, and I think one of the struggles is is that so many times the leaders in technology out there are focused on sort of a commercial market and don't have an understanding of how their technology may apply in a public safety environment.

The challenges of all of this are pretty apparent I think, but I'll hit on a few of them. I also refer to the confines of the Government and how we innovate within it. Dealing with acceptance and adoption of the technology. We're talking about officers who range in years of experience. We're talking about officers who are 21 years old and expect to have that mobile device in their hand and expect it to do everything for them because that's what they have grown up with, and they are coming into what is then a very antiquated environment in terms of technology, and you're dealing with officers who have 30 plus years on and maybe wondering why you're handing them that mobile device. So our audience is very wide. The other thing I'll hit on, and it's not necessarily a technological issue, but it is a huge barrier to implementing modern technology, and that's just the procurement process

itself. The procurement process, as it stands today in Government, effectively takes a good 12 months to get through from RFP, to selection, to contract negotiation, to actually getting approvals through the various Government entities that have to make those approvals. By the time we're implementing, we're talking about an RFP that was issued a year ago and was probably soliciting technology that was created a couple years before that.

So many times we're implementing the last great version. Not today's great version unfortunately.

Coming up with a better way to procure that allows the leaders in the market to come in and prove it. Not on paper with written, we always start with written specs. And I completely agree that that's where you start. But they've got to come in and show us that the technology works. And I'm a big believer in bringing them in and doing proof of concepts and letting the market really compete against each other and walk the walk. And that's just a huge challenge for us.

And then the other thing is with the advent of new technology, the discussion we don't always have is what about the resources to support it? And Brandon mentioned redaction. And the privacy issues. And I'll go back to something even more fundamental before we get there. And that is who is watching the video on a regular basis? When it's a routine public encounter. If it's a use of force, if it's a complaint against an officer, someone watches that video. Someone is doing an investigation and that video is being looked at but think about all of the other routine vehicle stops or interactions with the community that just aren't being watched because the resources aren't there. Luke mentioned intelligence in the camera, and I agree, there's intelligence in the camera. But what I want is a smart camera. I want a camera that knows when to turn itself on so the officer doesn't have to worry about when to turn it on. I want a camera that can tell me when a use of force happens in front of it, when a pursuit happens in front of it, and I know we're not there yet but I think we should be pushing the technology providers out there to think about those analytics. Today let's call it a routine vehicle pursuit with, and a routine say use of cameras would be an officer goes to pull over a vehicle. That vehicle decides it's not going to stop. A routine pursuit means you've got that vehicle, that police officer that's trying to stop the car, you've got probably one more in backup following that patrol car, so you've got two patrol units now, and then you have a supervisor that typically comes on, as well.

So in those three patrol vehicles that are now in pursuit, you have an in car camera in each of those cars. And you have a body camera on each of those officers. And we patrol with two to a vehicle. So you can see very quickly that even in a routine instance, and I'm using a real life example where we just had in car video, we didn't even have body cameras on everybody yet, we had 100 hours of video in a routine pursuit that had to be reviewed, and that was a pursuit that was reported and we know about and we have to investigate it. The routine just average community interaction that is maybe 15 minutes and thank you, ma'am or sir and move on with your day, that video has to be watched, as well because we have to ensure that officers are complying with the policy, they are

turning the cameras on when they are supposed to be. That they are turning them off when they are supposed to be. And they are behaving appropriately in between. And the person power it takes just to watch that routine video outside of all of those specialized investigations where you have 100 hours of video to watch is really, you know just tasking on resources.

The other thing that I'll mention is that, particularly at LAPD, but I think really across the country now the push is to not only implement technology but then to measure the outcomes. We feel strongly that any time we implement a new technology, we involve a third party research partner who can help us study this properly. Do some sort of controlled implementation and controlled test so that we understand those results. We're doing that now with body cameras. We'll have results out probably in the early part of 2017 to understand the impact of those body cameras on our officers on the department and also on the community.

We are doing that, as well, in terms of risk data. All of the data that presents risk and liability to the city, whether it be a use of force or pursuit or complaint or claim or lawsuit, understanding what that data means and how that technology we have implemented to mitigate some of that is going to help us is really important. And I think, also bringing in third party researchers to help us do that. I think brings credibility to the message and the outcome provides another voice to the community that isn't just from the law enforcement agency, so I think that's important, as well. Thank you for having me today.

>> ERIC LANDER: Great. All right. We are really grateful to the three of you for just an eye-opening set of presentations. We have not heard about any of this in the course of our PCAST work before. And it's just great to hear about the depth with which these ideas are penetrating within police departments. We don't have that much time for questions. But I do want to make sure we get some time for discussion with PCAST. We have James Gates with his flag up and William Press is putting his flag up, I think this is really interesting to get into, thank you, Jim.

>> JAMES GATES: Thank you, Eric and thank you Luke and Brandon and Maggie for being willing to come before our group and inform the rest of the group of the things that I heard about on our call on September 20th. As our briefers have indicated, there are I think a lot of opportunities in this space for using data to reach better outcomes in law enforcement. And so I'm very enthusiastic.

Now, we have a constraint, and I have to tell you folks about our constraint, it's called time. This Administration will run out shortly. So what I have suggested to PCAST, and what we haven't actually decided is that the most effective way for us to leverage the expertise that you represent and of course I don't know if you've met our colleague Megan Smith who is sitting here, but the most effective way that I think we might proceed which I suggested yesterday is to model this after a report that we did earlier on Big Data and privacy which some of you folks mentioned because there were

actually two such reports, and PCAST provided the technical sort of foundation to the other report which was non-technical.

So I think that that may be a model that we might be able to squeeze in under the finish line as it's rapidly approaching us, so I just wanted to again thank you. And also wanted to ask you, well, let me make a statement. On the call I explained to you how we got here, namely that I had an encounter with a police officer many years ago that could mean I would not be here today. But I also have a brother-in-law who has been in law enforcement for about 15 years. So I understand the duality of this from a very personal viewpoint about I don't want anything to happen to my brother-in-law, but thank goodness I'm here to say this. So these are things I'm rather passionate about, and my colleagues have empowered us to go into this domain and I'm very hopeful that even though time is short and resources are short and bandwidth is limited, that we can get a very good short report that will try to move this issue forward. So that's my comment, thank you.

>> ERIC LANDER: Bill Press.

>> WILLIAM PRESS: Thanks. Let me just repeat the thanks that you've already heard. I think it was a very interesting set of talks.

My question I guess is about procurement. But more generally it's about the marketplace for this kind of technology for law enforcement.

A good friend of mine, I live in Austin, Texas, did the 60 hour civilian police academy training, which is really an outreach of the Austin police so people in the community really knows what it is they do really at some level of detail. And she was struck in many different presentations about technology that either they have or they would like to have, that it's very hard for them and they admit this, it's very hard for them to be smart consumers, and at the sort of shady end, it's consumer electronics that somebody slaps a law enforcement label on and sells for 10 times what you could buy it for in the consumer marketplace, and they know they are getting taken. Now we're hearing from TASER which is the elite highest end tech in law enforcement, but I wonder if there are things that could be taken for the benefit of law enforcement to make that a more informed marketplace with less shady stuff and more real stuff in it.

>> MAGGIE GOODRICH: Absolutely I call it the shiny object syndrome. There are a lot of vendors out there that are good at coming up with something that looks and sounds like magic and it is going to work for you, and they have slapped something related to public safety on top of it, and when you get it into the hands of the officers, it's practically not going to work or it may get you 75% of the way there, but how do you close that gap. One of the things we do in LA, is I have a group that are sworn who are responsible nothing but research and evaluation of new technology, we do outreach to the vendors on a regular basis in various areas of technology not necessarily in public safety. We look at the financial industries, we look at health care industries, any industries that have security concerns

that wrap around technology as well, and see what they are doing. And we really encourage vendors to come in early before they have produced whatever it is that they are going to sell us, and not just drop it on the table saying hey you can use it, but talk to us very early on about how we would use it, what are the use cases, practically how it would work. UI is very important when you're talking about an officer in the vehicle they don't have a lot of time to be looking at something or grabbing at something, pushing buttons whatever it may be so we have those conversations very early on. In fact our first meeting with TASER on the body camera, the body camera was essentially a paperweight. They put a plastic box on the table and said would you wear that, and our response was no. With the first version, sorry Luke, but it came a long way in a quick time because TASER and there are a number of other vendors who are very willing to participate very early on with us in those conversations, so we get something ultimately that works for us, and we have sworn officers participate in that process very early on, and I think at LAPD, I'm fortunate enough to have a dozen or so individuals who participate in that process really in a full-time capacity. Other agencies not as large as LAPD are not going to have those type of resources and those type of capabilities, so coming up with maybe a national model that could look at technology and participate in these partnerships with vendors early on, so that even the small agencies out there that were mid size that don't have the resources to partner with those in the private sector have the opportunity of a voice in that.

>> BRANDON BOUIER: I want to second what Maggie is saying because I dealt with this as well at the Seattle Police Department. One of the things I kept trying to stress and we did to an extent, was to make sure when we are looking at procuring a piece of software let me walk you through the basics of how it usually happens, the Police Chief goes to a conference and comes back and says we're going to use this software. So we have to figure out how to make it work. What usually ends up happening is we ask that the vendors not only demonstrate their software ahead of time, but what we have tried to do in recent years is give them a sample of our actual data because we have seen many cases in the past where the vendors show their software using this perfectly, absolutely immaculate set of data in a perfect system where everything is just perfect, and it's not like that at all in the real world, when we go to implement it you end up with issues. So we usually have them use a sample of our actual data and we give them some context and we say, now show us in a certain amount of time come back and demonstrate your software working with this stuff and we have prepared questions. We have dedicated I.T. staff, and we will sit there in a demo and actually evaluate them because to try to mitigate that whole shiny object syndrome that Maggie was talking about. It's worked out very well. You get to quickly separate the wheat from the chaff and we do those processes. For the agencies not fortunate to have dedicated staff that we do, partnering with local universities or colleges to bring in their technical expertise, or maybe even students for example can go a long way and getting more hands-on with those members of the civic tech community can also be very useful in these regards.

>> LUKE LARSON: One final comment from me on that, with advancements in technology like cloud computing, what we've seen in the enterprise space as a large corporation, we're buying

software from large companies like Salesforce and Marketo and others, and we basically adopt some of those best practices from enterprise, and try to introduce them into the Government space, so with the cloud application, you don't have to do a huge implementation on Day 1 with a smaller subset maybe five, ten officers, you can go live on a trial much quicker and that way the agency can agency see is it there, is the technology actually working the way that they say.

>> ERIC LANDER: Great, we have really come to the end of our time so I'm going to ask Dan and Megan if they can very quickly if they want to say something, and we'll get very quick answers.

>> DANIEL SCHRAG: Very quickly I want to drill down following Jim's question and Jim's experience. A lot of the work on body cameras and monitoring has been really important unfortunately what we have learned is people without monitoring don't always behave the way we hoped they would. We wish everyone would always behave the same whether they were being monitored or not and we have discovered that's not true and that's a shame. But what about on the weapons side? We have the gun, the taser, which is, it's been improved but it's old technology, and we have a night stick, and the reality is most officers, and when we read about these descriptions of these terrible situations that are occurring all over the country, there's the officer feels threatened and their only choice is to then shoot with lethal force and they empty their revolver into the suspect. Surely it's not clear that technology is coming to bear on the non-lethal weapon development side, and the question is, how do you increase the market forces that encourage investment in R&D in that space, because it seems like that would change the nature of this problem profoundly.

>> MAGGIE GOODRICH: I certainly agree. I don't think there's any officer in this country that wakes up in the morning thinking, I'm going to take a life today. And I think the officers welcome the introduction of less lethal weapons. I think the reality is, is that there aren't many others in the market that are focused on this. We evaluate tasers on a regular basis. The taser weapon itself. And TASER International comes out ahead because they really are the product out there.

And so I think there has to be a call nationally to push the technology industry out there to understand that this is important. That there's a large market for it. And get some talent on it maybe out of other industries to help us start focusing on how we could develop other solutions.

>> LUKE LARSON: I would just comment, at TASER has introduced different variations of the taser over the years and we spend millions of dollars in R&D improving those products. Our last product is called the X2, so we now have dual shots and we also have a warning arc. So we're improving the technology. Technology is not a silver bullet, though. You're going to have physical limitations. You're going to have environmental limitations. And so we've kind of identified four or five key areas that we think we can improve on. Multi-shot, distance, effectiveness, safety, the ability to measure data, and we're advancing all of those technologies. I would just want to reiterate, technology is one component.

The other component is training. And so today, the way a lot of our law enforcement officers are trained is in kind of a binary response mode. So I go into a simulator, I go on to a rifle range, I go onto a pistol range, the name of the game is if I feel threatened that person wins or I win. It's binary. The reality is, that's not the situation. It's very dynamic. And so I think we need to address the technology. And we also need to address the training. And give them the right tools for that.

>> ERIC LANDER: That's great. Thank you. I know that this could go on because it's such an amazingly interesting topic, but we'll have to call it to a close now I really want to thank our three speakers for some pretty fascinating presentations.

(Applause).

Public Comment / Adjourn Public Session

>> ERIC LANDER: Our last order of business is public comment. I believe we have one public commenter and Maxine will,

>> DR. MAXINE SAVITZ: We have one public commenter. We have Kay Chopard Cohen, Executive Director of the National District Attorneys Association is going to speak on forensic evidence in the courtroom, and while you're taking your seat, you have two minutes to talk. And we'll give you a 30-second warning before the end of the two minutes. Thank you. And we did receive some written comments from you. Thank you.

>>KAY CHOPARD COHEN: Co-chairman Holdren co-Chairman Lander and members of the counsel, the National District Attorneys Association has significant disagreement with the logic and manner in which the PCAST report portrayed the pattern analysis and comparison disciplines of bite marks, firearms, tool marks, tire tread, shoe prints, and DNA complex mixtures. First, we are concerned about the pervasive bias apparent throughout the report. The majority of the Working Group is composed of well known critics of forensic science and of the pattern analysis in matching methods in particular. Second, it must be pointed out that the Working Group and PCAST at large contains not a single working forensic scientist. And this lack of scientists with real world experience is shown throughout the report.

Third, PCAST without a single citation to scientific authority, unilaterally declares that forensic feature comparison methods belong to the scientific field of metrology, including statistics. It should be noted that no metrologists were included on PCAST's Working Group.

PCAST urges courts to exclude important forensic evidence by appealing to its own authority. However, PCAST is merely a temporary advisory body whose existence expires at the end of this Administration. It should be noted that Dahlberg and Fry evidentiary hearings remain the legal standard upon which judges acting as gatekeepers determine the admissibility of scientific evidence

with well trained and experienced advocates as experts on each side of an issue. Prosecutors ultimately serve the Criminal Justice System and the public at large. Forensic evidence and forensic experts are called to testify by prosecutors and members of the defense bar every day, both to exonerate the innocent and prosecute the guilty. Judges have the ultimate authority to determine whether or not a forensic discipline is valid or lacks the requisite foundation, not the PCAST report. Thank you.

>> DR. MAXINE SAVITZ: Thank you. We do please remain seated because we can go beyond the two minutes.

>> ERIC LANDER: We just have a few questions. First of all I really want to thank the National District Attorneys Association for its interest in the topic and for actually managing to release a statement about the PCAST report earlier in September. So we thank you for your interest in that very much. It was the eagerness of doing it even three weeks before we released the report was appreciated.

We had some particular points that I did want to raise because this morning in the session you may not have heard, there is a second phase of the work, where we are putting out an RFI. Asking for now any further comments and things about studies that might have been missed. So we very much would love if the District Attorney Association would point out scientific studies you think were missed in some way. That's the way science works. So I mean I'm hoping that the NDA would be willing to write to us and let us know. Would that be something you guys would be willing to do?

>>KAY CHOPARD COHEN: Absolutely and in fact we started on something like that not knowing you were going to do that.

>> ERIC LANDER: Fantastic this is how science works. We want to hear if you think there are specific, so I noted in your written statement you noted that even highly complex DNA mixtures can be interpreted by lots of computer programs. I was wondering if you could, had any scientific evidence to support that claim.

>> KAY CHOPARD COHEN: I didn't come prepared to answer questions.

>> ERIC LANDER: Okay then I would ask you to write to us.

>>KAY CHOPARD COHEN: But I certainly have that.

>> ERIC LANDER: Please if you have scientific papers, published papers we want to hear them that's No. 1. No. 2 on bite marks, do you think bite marks are scientifically valid, have they been scientifically validated?

>>KAY CHOPARD COHEN: Again I didn't realize you would ask us questions but we have information on that.

>> ERIC LANDER: Fabulous we're looking forward to hearing about that. We did note in your statement that you said the PCAST report made it difficult to do criminal investigation. And I would ask you to go back and look carefully at the report. I think we were very clear to say, not in your statement here, in the statement that was published about three weeks before we released our report, it noted that you said that it would affect criminal investigation. I would ask you to go back and figure out why you think that since the report says the opposite, that we are really not talking about criminal investigation. While I'm just ticking off things because we're eager to hear from you, you mentioned that PCAST urges the courts to exclude evidence, and it would be great if you could point to places in the report where we say that since I think what we spoke only about was foundational validity. We agree that judges are the ones who exclude evidence, but that would be awesome. And finally in your written statement you mention that PCAST made statements about cognitive bias, sweeping broad statements. It would be great if you could point them out to us because in the report I think what we say is that cognitive bias may be a problem, which seems very different than the idea that it is a sweeping problem across the whole discipline.

So as I think it's fantastic that you're coming and you're disagreeing, you're criticizing, that's the basis of science. We're thrilled you're here. I'm pressing you because we want to know if you have real scientific answers for those things, we're eager to hear them and we will be producing an addendum to the report based on it. It will be about a two-week turn-around period it will be do you think you'll be able to do that.

>>KAY CHOPARD COHEN: In the next two weeks is what you're asking for, I think we can we've started working on it.

>> ERIC LANDER: Fantastic we look forward to getting your scientific input from the NDAA, and we appreciate you being here.

>> DR. MAXINE SAVITZ: Thank you and I turn it over to John.

>> JOHN HOLDREN: My thanks, as well to our most recent presenter, but also to everybody who presented. And engaged in discussion at this PCAST meeting. As always, we're grateful for the wider interest in the community represented by people who are watching on the web, and by people from the wider community who took the trouble actually to be with us in the room. And again, I thank the members of PCAST and the staff of OSTP and the Secretariat of the PCAST for their continued engagement and incredibly hard work. It is a continuing pleasure to work with all of you. We are now adjourned.