President's Council of Advisors on Science and Technology (PCAST)
Public Meeting Transcript
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Human Space Exploration

>>John Holdren: Well, welcome, everybody, to this bimonthly meeting of the President's Council of Advisors on Science and Technology—great pleasure to welcome back the members of PCAST, the members of the wider science and technology community who joined us in person in these meetings, and, of course, the audience who watched the live stream on the web, and welcome, as well, to the members of the OSTP staff, including the all important PCAST Executive Office which organizes and supports these meetings. Eric, do you have any word of welcome that you would like to add before we launch into the program?

>>Eric Lander: No, just very briefly, to offer my thanks to all the members of the President's Council. There is still so much work going on, in PCAST. It's fantastic to see. I think we have six or seven different projects underway and it's just a great thing. I want to thank everyone for their continued service on the council, everyone who is here in the room today watching, those on the web, and our guests, and I'll turn it back to John.

>>John Holdren: Okay, and speaking of our guests we start with what I'm sure is going to be a fascinating session on human space exploration. We have on our panel top leaders from NASA and from the commercial space industry, both SpaceX and Boeing represented here. The members of PCAST have the bios of our guest speakers in their folders, but since not everybody does, let me say just a word about each. Charles Bolden, the Administrator of NASA, the 12th Administrator that NASA has had has been serving for the entire duration of the Obama Administration. He has an amazing history as a Marine combat pilot, a test pilot, and astronaut, twice pilot, twice commander of shuttle missions, helped put the Hubble space telescope up there, but, as I like to say, after six and a half years ever working with administrator Bolden, the most impressive thing about him, notwithstanding his many, many achievements in space and in the air is that he has his arms around every aspect of NASA's enormous, and enormously important portfolio. He understands that agency top to bottom, oversees it with tremendous skill, and explains it with tremendous skill. Bill Gerstenmaier is the Associate Administrator for Human Exploration and Operations at NASA. He has been at NASA since 1977. He has run the shuttle program. He has run the International Space Station Program. He has been Associate Administrator for Space Operations since 2005. He is the face and in many respects the brain in the human space exploration program at NASA. Garrett Reisman is himself a two time

astronaut, logged over three months in space, including 21 hours in space walks, three different space walks. He has a Ph.D. in mechanical engineering from Cal Tech. He is Director of Crew Operations at SpaceX and has had leadership roles in that company for some time. John Elbon is the Vice President and General Manager for Space Exploration at the Boeing Company, responsible for the strategic direction of Boeing's civil space program and support of NASA programs including the international space station commercial crew development and the space launch system. He has been in that position since 2011, has a long previous history at Boeing. So we're just delighted to have all four of you with us today. This promises to be a fascinating discussion. I turn it over to you. I assume you've worked out an order. I suspect that Charlie Bolden is going to go first.

>>Charlie Bolden: Since I know the least I'm going to start, and then I'll hand it off to the experts, but thanks very much, Dr. Holden, for inviting us to appear before this group today to discuss NASA's plans for our journey to Mars, and I want to start by saying before I get any farther, I hope everyone in here is aware of the fact that this is a huge day for exploration, for exploration for the nation. I had an opportunity to spend an hour and a half on radio, television, all kinds of stuff, before coming over here this morning talking about Pluto new horizons and it's close approach to Pluto which has now occurred, although it will be eight or nine hours before we get evidence of that and evidence it has survived its journey through the Pluto system because it's not going into orbit, it's just going to keep going. Somebody asked well, what's it going to do after that? I said, I'm just worried about making sure that it got there safely and that I have evidence that it got there safely. So, today's a huge day for those of you sitting around who look a lot younger than I am, if you're students, try to remember where you were it this morning because this is—it's not like Neil Armstrong walking on the surface of the moon, but this morning the United States became the only nation in the history of humanity to visit every single planet in our solar system. That's a big deal. If you don't think so, I get emotional about that because that's a big deal, and you need to be able to tell your kids, you know that you were sitting in the room with people that made that happen. So, we're excited about the rest of the day. But NASA's a multi-mission agency. We do lots of stuff. We can walk and chew gum, and we have four big directorates. There's Science Mission Directorate. There's Space Technology Mission Directorate, the Aeronautics Mission Directorate, and Human Exploration Operations and Mission Directorate, and this chart in front of all of you, what Bill Gerstenmaier and I hope to do over the next period of time we have with you is help you understand how we're now intertwining those four directorates, as it has never been done before, into a singular effort to get humans farther into the solar system than ever before to get humans to Mars, and, if it works, get us there in the period of the 2030s, and we've got a stepping stones approach to doing that. The reason it's critical, I think, to have, you know, Garrett and John here, is because they represent the foundation for our ability to do this. Bill

will talk about the incredible value of the international space station. It is a unique orbiting laboratory. It is a one of a kind laboratory, but it has finite lifetime, and, you know, we've established that by 2028 the International Space Station just is gone, you know, it just, from an engineering perspective, as it stands today, it will no longer be able to be sustained. Bill and I will tell you that we think you'll never see anything like the international space station again in its size and structure, nor should you see that, because our purpose in life is to try to facilitate the success of a commercial space industry that takes over and allows NASA to take the step away from being Earth reliant to becoming an organization that's in the proving ground, that's operating for the next ten years in the period of the 20s in the lunar vicinity trying to perfect the technologies that we need to get the courage actually to say, okay, it's time to launch off from here and send humans onto Mars. Now, I want to try to introduce this today by talking about—describing several things. What are our goals and rationale? What are the challenges we face as we move humanity out? What are the principals that guide this development? What's our approach? And then, finally, our progress today. The ultimate goal, as the President has said numerous times, reconfirmed it in the State of the Union Address this year when he said the United States is about exploration. We are going farther into the solar system, except this time we're going to stay. This is not about sending a man to a body and bringing them safely back to earth. This is about moving humanity farther into the solar system and establishing a foothold where we can remain time in memorial. So, we are really moving humanity out to the next place where we believe that a multi species environment should survive, and that, we think, is Mars. Through the history of humanity, we've always been confronted with crossing the next river, or crossing the next mountain, or going beyond something. That's our heritage. Everyone sitting around in this room—I think most people are American citizens, but we understand that very fully. It is the story of the journey West, you know, of the early pilgrims and other people landing on the shores of the United States, but then just not being satisfied and continually moving west and exploring, and so, we're now trying to get us off this planet and farther out. Mars is our first destination for humanity, and I say that because I have three beautiful granddaughters, and they're 15, 12, and 9, and when I talk about Mars as the ultimate destination, they always stop me and they say, why do you say that? You know, where do we go next? And so, I say Mars is the first destination for humanity off this planet and out into the solar system. I don't know what the ultimate destination is. We may learn stuff about Pluto over the coming weeks and months that makes that enticing as Europa has developed to be over just the past few months. So it's up to most of the people sitting around here to determine. Our first steps are going to be exploratory in nature, as they always have been, trying to take advantage of the International Space Station, as we have done for 15 years now. For those of you who may not realize it, there has not been one second, not one second, in the last almost 15 years that humans have not lived off this planet on the international space station. It's been permanently occupied for the last 14 plus years, going on

15, and that has also not been a period of time when there have not been at least two nations represented on that orbiting outpost, at a time when those two nations don't happen to be getting along very well, at times down here on Earth and yet we demonstrate that when you have a singular mission and a focus you can do anything together, so, we think it's very important there. Each mission puts us in a place, you know, where we begin to establish another element of infrastructure that's going to be important for humans to subsist there. So, the journey to Mars is not only something that NASA is undertaking, it is an international effort as I have said before. So, there will be multiple nations that participate with us. We have a starting group. If you want to say everybody has a starting team, if you're a basketball fan, the starting five is the five nations that run the International Space Station today or the five entities, the European Space Agency, the Russian Space Agency, ROSCOSMOS, NASA, representing the United States, Japan, represented by Jackson, and the Canadian Space Agency. So that's our starting five, but we've got an emerging bench of what the President refers to as what we call nontraditional partners, nations that heretofore would not have been considered to have an interest in human space flight. India, China, you name them, on and on and on, that are beginning to come into the fore and with our leadership and our assistance can become effective members of the team, if you will. There are several principles that guide our approach and the first and foremost is proceeding with a program that's implementable with a stable budget. Well, you say, okay, then the first thing's gone because there is no stable budget, but we continue to work with the Congress and The Administration in trying to establish what we believe is a workable budget to sustain this program. So, we want a program that's sustainable, affordable, and realistic and we think that the exploration program that Bill is going to talk about in a little bit are all of those. We want to exploit modularity and commonality. So, we're bringing other nations in. If you look at the international space station today what is considered to be the premier module is not the American module, it's JEM. It's the Japanese Experiment Module. That is the state of the art module that does more things in more different ways than any of the other modules. Garrett can even talk about it some. So, we're looking at getting the best of all worlds and bringing other nations in, but also bringing in entrepreneurs and American industry as a part of the team, and instead of trying to define, you know, some definitive set of intermediate visits, we, you know, we think that there are a number of different paths that we can take to ultimately get humans to Mars. We have an asteroid redirect mission that we are undertaking right now, or would like to undertake, that will help us establish some of the technologies that will be required to get humans to Mars, whether it's increased efficiency in our solar electric propulsion systems, increased ability to operate in low gravity or no gravity environments that we don't know exactly how to do with humans today. So, there are a number of things that go along with this, and then, proactively designing the ability to adapt as we go along, to adapt to new environments and surprises that we will find along the way, disappointments that we will find along the way, because a partner drops out,

or a partner doesn't live up to their commitments. So, those are the kinds of flexibility we have. So, with that, let me turn over to Bill to talk about the journey itself.

>>Bill Gerstenmaier: Alright, thanks Charlie, and again, I'll just talk a little bit from this chart. As Charlie described to you it really involves the science director which is on Mars today, obviously doing a lot of activities. We have an instrument on the curiosity rover, a radiation monitor that actually monitors the radiation environment every day on Mars. So that's a piece of this. On the 2020 rover there's going to be a device called Moxi that will actually pull oxygen out of the atmosphere, and the idea there is not so much scientific interest but more kind of technology interest, can we actually use the resources in the Mars environment to provide oxygen for either propellant systems or for life support systems. So, we're working actively with the science mission directorate to do that and also with the technology mission directorate to look at things such as the interheat shield that was used on curiosity rover. It was instrumented to look at the entry dissent landing conditions entering into the Mars atmosphere. We'll do the same thing on the heat shield that will be used on the 2020 rover. So, it really takes all of our directorates working together to achieve this activity we call the journey to Mars. I use this chart sometimes in public forums, and it's interesting when I talk in public forums. They tell me there should be another swirl on here and that's the public, and what they tell me is that they want to be participants in this activity and it's not just a NASA activity and it's not just NASA's three directorates. They see this journey as something that's bigger than all of us that we have to all work together and it takes the best and brightest of us, all as a nation, or as a global community to contribute to make this happen and I think that's a very interesting discussion and feedback I get from the outside. I'd be interested in your feedback as you ask us questions. I also stress very much the journey piece. This isn't going to happen instantaneously. This isn't a single mission, this isn't a single activity, this is a multi-decadal activity we're putting together. We're building first pieces of that with the SLS heavy lift launch vehicle, the Orion space capsule, the crew that goes to station and station activities. They all fit in this journey piece. You see down at the bottom and sometimes that gets lost are the three regions we talk about. So you see down at the bottom, and sometimes that gets lost, is the three regions that we talk about. We talk about Earth Reliant, that's where we are with Space Station. We need to use Space Station and its unique abilities to really understand what it takes to have long duration human space flight to make sure the human can actually tolerate the environments that are required for the human body to adapt. We have the one year expedition going on now between a Russian and a U.S. crew member where we're getting detailed information on how the human body survives or tolerates the micro gravity environment for the transit duration to Mars and that's a real piece and we need to do that in the earth reliant region. The proving ground region is around the moon and the key thing there is you see down at the bottom the return time. The return time now is days away on the moon. You go to the far side of the moon you lose

communications with the Earth. You now have to be more autonomous. It kind of stresses a little bit. We need to understand the risk reduction techniques, the risk reduction capabilities in the region around the moon before we're ready to commit to that third region which is the Earth independent region, and that's when we really need to be ready to go when we launch on that mission, we know return is now months to come back and we better be really ready to go, we better have the systems checked out, we better understand how the human will actually perform when we go commit to that. So, this is again a journey encompassing all three of those regions, and so I think that's where I'll leave it at this point and see if Charlie has any kind of concluding remarks and we'll turn it over to the other panelists.

>>Garrett Reisman: Well, thank you for inviting me here today. I'm here representing SpaceX and if we can go to the next slide. I got a clicker. Oh, thanks Charlie. Okay. All right. There we go. So, I want to give a brief company overview for those of you who may not be as familiar with the company as we are. So our company designs, manufacturers, and launches advanced rockets and space craft. We were founded back in 2002 and the whole goal, the whole reason the company was founded was to advance the cause of human space flight. It's not a typical way to start off an entrepreneurial venture. Usually, you're focused on the bottom line, but we had a much more lofty purpose and existence, and we're the world's fastest growing launch provider and we have over 50 missions on our manifest representing over $7 billion in contracts, and the majority of those missions are commercial missions. So we have brought the market share for commercial launches, launching satellites or other commercial payloads—the United States used to be a leader in this area. In fact, back in the '80s we had the vast majority of the market share. It went down to almost zero and now it's coming back up and we're very proud of the impact we've had as far as lowering the cost of access to space and bringing that industry, that market share back to the United States. We have more than 4,000 employees and we're growing fast. So I'd like to show a little video. I think I need a little help for this if you can start it.

>>Video: T minus five, four, three, two, one, zero. Lift off.(music playing) Here's a look at the Dragon Capsule, making its way to the International Space Station. Station, we see Dragon at 20 meters. And capture is confirmed.

>>Garrett Reisman: So close. We cut that video right at the right moment, but I'd like to talk to you a little bit more about a couple of those different things. Let's see. Okay. Our vehicles, you saw in the video a lot of shots of the falcon nine launching and attempting to land on an autonomous drone ship. I'll talk about that more in a moment. The falcon heavy is under development. We are bending metal as we speak and that will be coming to a launch pad near you very soon. That falcon heavy is going to have almost 4 million pounds of thrust. So it's going

to be really impressive. I mean, it's slightly greater even than the thrust that the space shuttle has. So, we're going to hear a roar down in Florida soon that we haven't heard in a while and that's going to be very exciting. We plan for that to be the first launch off of pad 39A under our auspices there. The Dragon Space Craft, we have delivered cargo to the space station seven times now with the Dragon that you see in the upper picture there and we're developing an upgraded version of Dragon much more capable that will be meeting NASA's requirements and part of the commercial crew program will be flying crew in the Dragon to the space station in short order. So we did back on the 28th of June, we did experience a failure of the falcon nine when we tried our most recent launch. We're working hard to getting to the bottom of that event. The root cause in determining the root cause is a very complex endeavor. I was talking to Bill a moment ago, that the tremendous amount of data we have based on all the modern instrumentation we had on the vehicle is both a blessing and a curse and trying to find one explanation that fits every single piece of data has been proven to be difficult, but we're getting closer. Day by day we're learning more and getting closer to making all the pieces of the puzzle fit. In doing so, we have strong oversight from the FAA who is mandated to oversee the investigation. We also have strong participation from NASA, all parts of NASA, not just commercial crew and commercial cargo, but also NLS is very involved, and the Air Force, another customer of oursand we're certified for on ramping with the Air Force, so they're very involved with the investigation as well. So we're confident that we will get to the bottom of this and we will find root cause and hopefully have some more information on that in the near future. As far as future developments, commercial crew I mentioned and we're one of two providers selected by NASA along with Boeing. I'm sure John will have more to talk about that, and the idea is that we're in the commercial crew program with these two providers. The goal is to restore the United States' capability to launch men and women into space and we plan to do that pronto. Reusability is a big thing that SpaceX is really working towards, and it's not just reusability, it's affordable and rapid reusability. That's our goal and we think that's necessary to achieve the infection major reduction in the cost of access to space. We're getting very close, as you saw in the video, so very close to recovering that first stage of the falcon nine, and as we go forward, we're going to be looking to reuse more and more of both our rocket and our space craft, and Mars, as Charlie mentioned, is the ultimate goal of the agency, also the ultimate goal of our company. Really, the company was founded to make Earth—I'm sorry, to make humans a multi planetary species. So, we have some pretty lofty goals. Commercial crew—I just wanted to talk a little bit more in detail about commercial crew. This program builds on the highly successful commercial cargo program that we partnered with NASA on for many years now. This program was characterized by a firm fixed price contracting structure as opposed to the traditional cost plus contracting structure, and It involved partner co-investment. So, private companies had skin in the game, if you will, and this created great value to the government. The cost to the taxpayer was much less, billions of dollars less than what would have been the

case for a traditional program. By taking this approach, I would say that this, you know, this frees NASA up to focus on all the stuff that Charlie and Bill just spoke to you about, going beyond low Earth orbit, the exploration piece. So, I guess you could say what we're trying to do is chew your gum so you can walk. I'm actually not sure if it's it was wise to extend that metaphor. Maybe run or fly. We want you to run and fly and we'll chew the gum, or something like that. Anyway, for over four years we've been partnering with NASA to take the next step and go from cargo to carrying crew and so, with dragon, you see the dragon here on these slides, we have the capability to fly the requested four NASA astronauts to and from the space station. We have additional capability in excess of requirements to carry up to seven people in the Dragon. The Dragon has a state of the art launch escape system which you see being validated there in the big picture. That's our test and that promises levels of crew safety never previously attained by human space craft. The crew missions we're going to launch from the historic pad 39A. That's where Apollo Eleven launched from. It's where—not to in any way denigrate the incredible achievement of a man landing on the moon but I should say it's also the pad that I think both Charlie and I launched from in the space shuttle. I'd like to put that out there. It's a great facility and we're well under way. By the end of the year we plan to be ready to launch out of that facility and put it back to good use. We have successfully completed our first milestones in the new program, the CCT cap, and that includes a certification baseline review. We just completed an avionics test bed activation. We have all the avionics boxes and the harnessing on tabletop and running flight software. So, we will later this year complete the initial propulsion module test. We'll do a propulsion land landing test. You've seen in the video how we intend to do propulsive landing with the capsule on land, and then we'll qualify our docking system, we have a launch site operational readiness review at 39A, and finally a delta critical design review. So that's what—we have a lot of work to do before the end of the year, but we're on track to complete all of that. The most complex and integrative test we completed this year was the pad abort test, and I'll talk more about that on my next slide, but all this is leading toward an end autonomous test flight test where we're going to take the dragon, fly it with nobody inside, all the way up to the space station, dock to the space station, come all the way home and demonstrate the entire mission, all phases of the flight, and once we have a successful test flight, then we will first put people inside, and we intend to do that first autonomous test flight in late 2016 and then fly people to the space station in 2017. We will be flying a test pilot crew consisting of NASA astronauts, derived from the pool of four astronauts that were just announced last week, and a lot of those guys are good friends of mine so I'm really happy to see. You guys have made some great choices there. Then I want to talk a little bit about the pad abort test. Back in May of this year, we completed the first major flight test for the commercial crew program and this validated some very important aspects of our abort capability. This is one of the hallmarks of the increased safety crew safety of the commercial crew program, the ability to get the crew to safety should there be a mishap during ascent, and

one of the most difficult times to do that is when you're sitting on the launch pad on top of a fully fueled rocket with no altitude and no air speed to work with. So, you have to demonstrate that you have enough gas in the tank, if you will, to get high enough and far enough away from anything untoward that is happening back at the launch pad, and that's tricky. It's a little bit easier once you have some energy to work with and less of a propellant in the tank. So, we built a test article which is very flight like, had the very flight like avionics inside controlling the propulsion system and we did it. We did this pad abort test. She went, you can see the pictures there, and she went from 0 miles an hour to 100. So zero to 100 in 1.2 seconds, which, you know, even the Tesla model P85D doesn't accelerate quite that fast. It had a max acceleration of 6G's exactly and exactly as we planned it to do, and reached a top speed of 345 miles an hour. It went about 1200 meters up and 1200 meters out. So high enough, fast enough, and far enough to get to safety, and come down in the ocean, and also high enough to deploy the parachutes as you can see and have a splash down in the water. So, this is a big thrill for us. We worked for a long time, our teams, and NASA, too, had a lot invested in this, and we're very excited about the result. So, I'll end with just a little talk about reusability, and, as I mentioned before, we're working really hard to recover that first stage of the Falcon 9, first on an autonomous drone ship like you see in the picture there, but then on land, and we've already begun construction of our landing zone at the Cape Canaveral Air Force Station. We have LC1, Landing Complex 1, and that construction there is in full swing. Again, rapid affordable reusability we think is going to change the economics of space flight and lead to the incredibly wonderful things in lower Earth orbit and beyond, hopefully enabling all the wonderful things that NASA is working on. So, thank you very much.

>>John Elbon: Good morning, Dr. Holdren and the Committee, thanks for the opportunity to come chat with you today. I've dedicated my career to working in this field, so, it's fun to talk about something you have passion for. So, thanks for that. So, you know, if I sit on an airplane and talk to people about what I do, often people think we don't have the space program now because the shuttle's not flying, and I think there couldn't be anything further from the truth. As the Administrator mentioned in a couple months we will have completed 15 years of continuous presence on the international space station, and at this point in time there are more vehicles being developed and capability being developed than ever in our history. The space station is up there. We have two systems to take cargo up there, perhaps more. Two programs for commercial crew are under development. We're building a huge rocket called the space launch system, a capsule to take us into deep space called Orion. All that's going on in parallel. Previous times in our history we were maybe building one thing, like the shuttle or station, but now we're doing that in parallel. So, it's just incredible the amount of work that's going on. Among the companies involved, I think Boeing is unique relative to the fact that we are involved in several aspects of all that, and we're also involved in programs that are traditional

NASA led programs, like international space station, and the space launch system, as well as programs like commercial crew where we have participation by what has been dubbed the new space kind of community. So, we kind of have a broad spectrum of things that we're involved in. I'll briefly just describe our involvement in those three programs shown there and then I've got a couple of things I want to say about why it's important to our country and a company like Boeing to be involved. The first in the top right is the International Space Station. Sixteen countries put that together. Took 41 shuttle launches to get it up there. It covers a football field including the end zones if it's laid out on the ground. The Space Station is just an incredible engineering marvel. It's now returning science that's having a real impact. There is a potential cure for Duchenne's muscular dystrophy that's being tested in Asoka, Japan. It's an awful disease. If we can cure that based on research done on-station, that's a big deal. There are water filtration systems that were developed on station that are deployed in remote areas to filter water for people. We've got new treatments for osteoporosis based on research done on station. So the science that's coming out is having a huge impact, and very important. I'll move to the left side of the chart and talk about commercial crew. Along with SpaceX, we are a company that's developing a capability to carry astronauts to and from station. Our capsule is called the CST100. It will launch on an atlas five. We chose the atlas five because it's a very dependable launch vehicle. It's had fifty four successful missions in a row now, and when you combine that with a robust abort system similar to the one Garrett was describing on top of that rocket, it will be a very safe, reliable transportation system to take people up to station. I think there's a lot of wisdom in moving the lower orbit Earth activity and transportation of cargo and crew to station and industry. That's a mission that's well understood. We've been doing that since John Glen flew over 50 years ago, and so, the challenges with that mission, the risks associated with it, are something that can be accommodated within industry with less NASA involvement than we have in things like SLS, the Space Launch System or the International Space Station. That leads to reduced costs for those missions and leaves funding within NASA's budget so we can do the really hard job of going back to the area around the moon and eventually onto Mars as Mr. Gerstenmaier described in the chart he had on the journey. The third program that we're involved in is the Space Launch System. Incredible rocket, bigger than the Apollo rocket. I think its merits can be measured in three ways. First is a way we typically measure things which is the cost, dollars per pound to take things to orbit. Because the rocket is so large, the recurring cost of the mission when you divide it by the payload will be very comparable to the cost of launching things on EELVs today. Perhaps more importantly, though, the payload shroud on the final version of this rocket will be 10 meters in diameter and about twice as long as the shuttle payload bay. To give you a sense of that, you could put three school buses inside that pay load shroud. Two next to each other, that's the diameter, and one on top, that's the length. If we have that kind of volume, things like, well, it took 41 shuttle flights to build a space station. We could do that in four or five flights with that kind of volume.

Something like the James Web telescope which is very complicated because it has to fold up and fit in a 5 meter shroud, could be launched deployed and it could be launched as a heavier machine. So, the risk in the program development of something like that would be greatly reduced, and the cost of the difference in the launch vehicles would be more than offset by the reduction in cost in the development program to do that. So, that's the second metric volume. The third metric, I think, is the delta velocity that a rocket like this can impact. The mission to Europa, for example, will take about two years to get to Europa, launched on an SLS, as opposed to over seven years if we launch it on an EELV. So the cost savings associated with five years less of a program is a big deal, and the science comes back five years earlier. So, three big things SLS does dollars per pound, dollars to orbit, and velocity to get to places. I wanted to show this slide. This is the cover of the Boeing annual report for this year, and so the point I wanted to make with this is the business that we do with NASA is about 2 percent of the revenue of the Boeing Company, but it's a huge deal for us from an identity of the company and the future of the company. If Bill Boeing started the company a hundred years ago, we're now moving into our celebration of 100 years, and if you think back what the aviation industry was like 100 years ago, he was building airplanes out of spruce and fabric to fly air mail across the country, and at that time, nobody could have imagined what the aviation industry would look like today. The division of the company that manufactures commercial airplanes is a 70 billion dollar business. It's the leading exporter in the United States, and it's just a tremendous asset to the country. I believe that where Bill Boeing was 100 years ago, right now, relative to space, and a hundred years from now we'll look back at this huge commercial space industry. It will be a division of the Boeing Company as big as the commercial airplane businesses now and we'll say, wow, we never would have imagined where we were in 2015, where we are today. So, I think it's real important that we keep going with human space flight and it's real important for a company like Boeing to stay involved with it. Thanks for the time and I look forward to answering questions.

>>John Holdren: Good. Well, thank you. We will use our usual procedure where PCAST members who have questions or comments raise their flags, and Jim Gates is the first flag that I saw.

>>Jim Gates: Thank you, John, and I'd like to thank the panelist force a great briefing. My question has to do with support. In low earth orbit there's great interaction between ground crew and the people who are actually flying the mission, and so, as one looks to these missions that are far out where you won't be able to have that kind of contact and support, what's going on in the domain of expert systems to support the astronauts as they're out there and beyond convenient communication range with ground crew?

>>William Gerstenmaier: We're doing demonstrations today onboard Space Station where we have several tasks that we used to have the crew do with the ground kind of following along and they're now autonomous tasks to actually be done by the crew, so, we have some maintenance procedures we do on the treadmill that are now totally autonomous. They have software that guides the crew through the procedure. We've also been experimenting with some kinds of heads up displays, some essential virtual reality systems that the crews can use on orbit so they can have a schematic in the upper left hand corner of some eyeglasses they wear, and that shows them what hardware they're working on. So, again, we're starting to just probe that area of research to understand where we can give the astronauts and crew members more tools they can be totally autonomous and break away from where we are. So, again station is a great place to go demonstrate some of those things.

>>John Holdren: I'm going to call on myself at this point and ask maybe each of the panelists for your thoughts on what the most important advanced technologies are likely to be, technologies, capabilities that we don't quite have today, but if we had, would greatly expedite and improve our capacity to carry out ambitious human missions. What specific kinds of technologies do we need that we don't have?

>>Charlie Bolden: I'll begin with what I think may be the costliest and therefore the last one we choose to undertake and that's propulsion, in space propulsion. We need game changing in space propulsion. Eight months to Mars is too long. We can do it better. We know what the technologies are that are needed. The nation has not made the investments in those technologies. We're looking at—in NASA we're looking at just rudimentary forms of nuclear propulsion right now, or Vasmer, or others, but from my perspective it's game changing propulsion.

>>William Gerstenmaier: I'll give some routine things and then we can think about those. We're experimenting a lot with the 3D printing. You know, we carry essentially an in-flight maintenance toolkit with a whole bunch of sockets and other equipment. We can all print those pieces now, and then what we're also looking at is actually recycling. We print a tool, we grind a tool back up, it makes more feed stock to print another device. We think that lowers the amount of mass, the amount of equipment you need to carry with you. Another area that we're struggling with a little bit with is things that seem simple, medicines have an expiration date, foods have expiration dates, how do we push that shelf life further, especially in the vitamin area and other areas when you're talking about a three year mission to Mars. How do you provide the nutrients needed for the crews in some kind of storable vitamin format? Can you even, maybe, print vitamins, or print food stock, and print other things as well for those journeys. So, I think we're pushing a little bit on looking at some of those technologies that

seem trivial, but they're things we really need to lower when we get this Earth independent region, break that tie back to the planet.

>>Garrett Reisman: Well, answering the question, looking through the prism of our common goal, which is getting to Mars and having sustained human presence on Mars, I agree completely with the previous comments but also I would add to that the ability to do propulsion—I'm sorry, propulsive landing, what we're finding is it's difficult. We've been successful in getting rovers onto the surface of Mars, using things like airbags and other entry and dissent and landing technologies, but a lot of those technologies are not scalable, and so, finding a good way to get something large, which we're going to need really big things, on to the surface of Mars, requires a new technology and NASA is trying various decelerators and looking at that, but we think the answer is propulsive landing, and that's really why you see all the work we're doing now using propulsive landing to recover our first stage, the drone ship and also moving towards propulsion landing on our capsule as well. We figure that if you can do that and master that technology here on Earth, it only gets easier when you go someplace that has less gravity, but is in fact, you just change the game set, and it's exportable to anyplace you want to go in the solar system. So, we think that's really important.

>>John Elbon: I would add to the list improved closed loop environmental and life support systems to reduce the logistics that you need for oxygen, water, things like that. Navigation systems, you know, GPS is a great tool around the Earth. Systems that can help us navigate in deep space are a big deal, just logistics in general. Mars is a long ways away. If we had a 12 inch globe of the Earth sitting here, the space station is three eighths of an inch above the surface of that globe on that scale. The moon's about 30 feet away on that scale, so the distance from me to you. Mars, depending on the relative orbits of Earth and Mars, is between a mile and 10 miles away. So, you know, just that logistics challenge that that distance drives into the system encompasses the things that were talked about, like 3D printing and the ability to do all that stuff.

>>John Holdren: Wanda Austin.

>>Wanda Austin: Thank you. Good morning. This question really is for Garrett. You know, SpaceX has a great reputation for innovation and we've watched the Falcon 9 evolve. I know that you're working on the full thrust vehicle, and all of this is building to being able to fly humans to space as you showed us today. Can you talk a little bit about how you develop the reliability, how you approach mission assurance given this innovative and rapid change in growth in your rocket?

>>Garrett Reisman: That's a great question. So, as far as how we approach mission assurance and reliability, we use a lot of the same traditional techniques that have more dividends so we use—you know, we do Formica's and probability safety assessments and hazard reports and all the usually safety system techniques and mission assurance techniques. But, I think as far as a philosophy, we are trying to new and innovative things. That's really important because we feel that if you use existing capabilities, you can achieve a certain level of safety and reliability but you'll never do better than that. You're essentially locking yourself in at the best that you can do today. So, we think that one of the keys to improving overall reliability and safety is continuous improvement. Constantly looking at the data, listening to your vehicle and figuring out what's not—what could be done better, and what should be improved. So that's a tenant, and the other tenant from a design perspective is, I would say, not making it overly complicated. I think we have a history of trying to achieve certain pre thought out metrics and trying so hard to achieve those across all different areas of the vehicle and with the systems engineering approach that starts out with subsystem specs from day one and locks things in and prevents the engineers from turning their knobs, and so, I think the important thing is when you can't turn a knob you tend to try to do things that are—make things complicated, use more expensive, you know, go to unobtainable materials and stuff like that. So, I think that the key is not, you know, simplicity as a design goal is a good thing because often that gets you improved performance, at the same time, increased reliability and better manufacturability.

>>John Holdren: Barbara Schaal.

>>Barbara Schaal: Thank you. This was a really very interesting presentation. You were talking about making tools and using 3D printers, then had the kind of offhand comment about maybe even printing food and, of course, going out to space, going to Mars with a three year trip, that adds some really interesting challenges in terms of food and nutrition because you're not just dealing with calories on a day to day basis, but rather really thinking about over the course of three years what kind of consistent micro nutrients will an astronaut need. Likewise, there's issues related to long term exposure to radiation and then also to health issues, you know, the bone health and density that has been looked at. So, I just wondered a bit about how these issues are being approached and what kind of new technologies and innovations are involved for these really long term issues that we lately to astronaut health.

>>Charlie Bolden: Hopefully we didn't make it sound like an offhanded comment about making food. If you visit the Aims Research—printing food—if you visit the Aims Research Center, you'll visit the astrobiology lab, and actually there, they are looking at 3D printing food. You know, it's in its very, very, very formative stages. We're looking at how you utilize microbes. We have actually demonstrated that there are certain microbes that you can use to create concrete

when measured against secrete or Portland cement. You know, there are standards in the area of concrete. Some of the microbial cements that have been manufactured have been pretty strong. So, it's way too early to say, but when I talk to people all the time, I'm talking about the critical importance of finding microbes, whether it's on Europa or whether it's on the surface of Mars. If we find out that there are in fact microbes in these environments to which we are headed and we're able to develop a capability of taking those microbes and using them as the feed stock for 3D printing of food, or 3D printing of building material, or the like, then you get to the point where I am a firm believer that the first construction on Mars is not going to be done by humans. It's not going to be done by astronauts. It's going to be done by a small robotic army that's going to go and land in place all of the habitat that astronauts, the first group of astronauts are going to be able to live in. When you think about—I'm a military guy, a logistician, so when you think about how we go to war today, I'm a marine, but other than the marine core, not very many people send in the marines to build a habitat. It is usually a very good engineering firm, somebody like a Kellogg Brown and Root or Floor. They go in and establish the habitat and then the combat troops come in on the heels of that and I look at going to Mars or any other place not unlike that. So, I think it's not farfetched that we may one day be able to print 3D print food.

>>John Holdren: Chris Chyba.

>>Chris Chyba: I very much like your depiction of the human space flight program as being directed towards a goal, which is the expansion of human civilization into the solar system, and then there's a kind of near term destination, or perhaps midterm destination, which is getting to Mars. I also like the understanding of the space station as being in the service of deriving everything you can from it to learn about how you can do that kind of journey. I'd like to ask you to say a little bit more about that intermediate step because sometimes that I think that's the step that the public might have the hardest time understanding. What is the sequence of missions that you envision currently in that intermediate range, where we're first starting to learn to operate autonomously, but not yet taking on something like a two and a half year mission to Mars?

>>Charlie Bolden: Very quickly and then I'll let Bill and the rest of these guys talk about it, I think what we are doing is trying to work with industry. Every international space station forum that has been held over the last five years has gone into the public sector and said, what do you see as a future capability of something like an International Space Station, or what lessons can you take from the International Space Station? I'd be interested in seeing what our two industry partners say because frequently the answer we get back from people is we like things the way they are now. You know, we really like it with the government providing the facility and we can

go and do experimentation and the like. That's not the intent. The intent is for government to get out of that. You know, we constructed the International Space Station 15 years ago. It has been absolutely, incredibly successful. My team was startled about a week ago when we were talking budgets and Bill Gerstenmaier's folks were briefing me on the International Space Station. They said what is the sign that we are now moving into the proving zone and I said, well, the sign is that we can safely say that we now have a place for our astronauts to reside off the International Space Station and that's also the sign that we can now give up on the International Space Station as an agency because we are now moving to the next arena for us, which is the proving zone. So it's not, it's not, you know, the cart does need to come before the horse and for me moving out to the proving zone says we have sufficient sustainable ways to maintain ourselves and orbit around the moon as Bill referred to it habitats and they may be two dragon capsules, or they could be 2Signus capsules. That's a sufficient habitat, we think, to begin your, you know, your time out in space. Think back to when we established the International Space Station. We had two modules. One was a power and propulsion module and the other one was the U.S. contribution, was unity. It was one hab module in which the crew lived and that's the way it was for several years until we started building up the International Space Station. Look at Sky Lab. There are so many lessons to be learned from our past. We tend to want to forget about, but we've have been there. We've done this, and we know how to do it, and I think we need to learn how to rely a little bit more on American and international industry because we have some incredible international partners when it comes to pressurized modules. The Italians do absolutely incredible pressurized modules. You look at the permanent logistics module on the International Space Station today. That's an Italian module. That's not anything that we built. So, my caution is don't—being leaders doesn't mean we have to do everything. It means we have to recognize the capabilities that are available in the international and industrial and entrepreneurial community and try to pull everybody together. So, we're not able to answer your question just yet because I don't have a habitat in mind, but it's going to be a habitat of some type that Americans and astronauts of other nations will live on for some small, hopefully, short period of time as we develop an environment that operates around the moon for about a ten year period of time. You don't want to establish a big international space station in lunar orbit because you don't want to get stuck there. You know, you don't want to fall in love with the proving ground. I don't. I want to make sure that I use the proving ground as a place to continue to develop technology, to continue to get the courage to say, okay, humans can handle this and then send us off.

>>John Holdren: Great. We have time for one more question. Dan Schrag.

>>Dan Schrag: Thank you. Thank you to all of you. I think this is such an exciting time poised to send humans ultimately out to Mars and to explore the rest of the solar system, but at the

same time the Earth is going to be our home for a very long time and as these exciting developments and space exploration are allowing us to move outside of the Earth's orbit into other—explore other planets and planetary bodies, we are also, it's a revolutionary time in Earth observations as well, extraordinary new capabilities. But, of course, this has come under attack recently. The proposed science budget in the house subjects NASA to potentially a 32 percent cut in earth sciences, which would—devastating is a gross understatement for how severely this could impact our abilities to understand our own planet and observe the changes that are happening. You know, even if you're skeptical of some of the science that I work on in climate science, the idea that you would literally put out your eyes and cut off your ears is, seems insane. So, I know, Administrator Bolden, you're deeply involved in protecting this budget, but I'd love to hear what those efforts are, but I'd also love to ask Dr. Reisman, is SpaceX thinking about Earth observations as well as a capability, in terms of enabling new generation of Earth observations through your launch capabilities, and I'd love to know what SpaceX is thinking about in the domain of earth science. Thank you.

>>Charlie Bolden: Very quickly, if I can, you know, we are doing everything that we can in the power of my position to communicate with the powers that be, both on Capitol Hill, and in and around the White House, to help people understand the critical importance of Earth observations and earth science, and understanding the change that's occurring to our climate. You know, I don't—I'm not a global warming guy. I don't use terms like that, but the climate is changing, and we need to fully understand that. So we in NASA are trying to find more affordable ways to do the types of science, the types of data gathering that enables us to understand more. How do we understand the interaction of the oceans with our climate today? Well, we've got something called Rapid Scatt, the Rapid Scatterometer that is now an instrument on the International Space Station; unheralded because it is an earth science instrument that uses the international space station as its platform. Didn't require 500 million-dollar launch vehicle, didn't require 500 million dollar science package, but it's something that went up in the trunk of Dragon in two pieces and from the Marshal Space Flight Center or Houston, a ground team robotically removed those two pieces, put them in place and placed them on the International Space Station where today they do very valuable earth science, or something called CATS that looks at aerosols in our atmosphere. Same thing went up in the trunk and we pulled it out. So, I don't mean to steal Garret's thunder, but SpaceX and unpressurized capability of the Dragon Module and the same thing we will have with CST100, you know, yeah, we want to get people into space, but we also need to be able to carry experiments and cargo and supplies and the like, so I think they're doing an incredible job of enabling us to be able to do those kinds of things.

>>Garrett Reisman: So, I'll just answer quickly and say that, first of all, SpaceX—we're really in the transportation services providing business, not necessarily in the science payload or earth observation business, but we are very proud of the fact that, as the Administrator said that many of our transportation capabilities enable that type of research by having the ability with the trunk to bring unpressurized scientific payloads up to the Space Station. But, I can also tell you that we share the concern, you know, at large, if you will. I mean, my boss founded SpaceX to make human life multi planetary because he's concerned about all of our eggs being here in this one basket and, you know, he's not just doing SpaceX. He's concerned about what we're doing to this planet, and that's why he created Tesla to try to change our—go to a clean energy alternative for transportation here on Earth, and also Solar City which is another big emphasis of his to try to convert us to a green electrical source of energy. So, yeah, we're concerned about it as a whole.

>>John Holdren: Great, well we do now have to move on but I want to thank this terrific panel for your contributions for your presentation, and for all the good stuff you'll continue to do, and Charlie and Bill, special congratulations on new horizons in Pluto, today's historic fly by. There's already a great picture from yesterday that is posted, which is just fabulous and even better ones are to come. So, thanks again to all of you. (Applause)

Review of the Networking and Information Technology Research and Development (NITRD) Program

>>John Holdren: And we are now going to switch topics to a review of the Networking and Information Technology Research and Development Program, the NITRD program, and I think Michael McQuade is probably going to lead that off. So, Michael, the floor is yours.

>>Michael McQuade: Good morning, everybody. As he's making his way up I will introduce Greg in a just a moment. First of all, I'm here representing the review team for the National Information Technology R&D program, NITRD, and I would be remiss if I didn't immediately recognize Susan Graham, PCAST member, who, along with Dr. Hager, are the two co-chairs of the committee that's reviewing the NITRD program. Doctor Greg Hager is Professor of Computer Science at John Hopkins University. His background and specialty is, among other things, in image analysis robotics, robotic systems. He also serves a very important role as the Chair of the Computing Community Consortium which is an external group that provides valuable assistance, advice, and guidance to the NITRD program. So, I'd like to start off, just, if you'll allow me to just read two sentences from what is the beginning of the report that we're

here to discuss, and then I'll talk about the format going through. The United States has been a leader in networking in information technology, NIT, for over 70 years, which dates all of us I think. To ensure that the nation can advance its NIT capabilities and address important goals in areas such as defense, economic prosperity and inclusion, health and human safety, education and quality of life, continued investments in networking information technology research and development are necessary. That's why the NIT program, the NITRD program, exists as a cross cutting government initiative. That's why PCAST plays a role in periodically evaluating the health of that activity. So we're here today to discuss the report of that team. I'm going to turn it over to Greg to review the review process and a number of the findings and recommendations relative to the technical components of that. I'll come back after Greg to talk a little bit about some of the organizational findings and recommendations and then open it up for questions, comments. Ultimately, we are asking for PCAST approval for the recommendations and the report today. So, Greg?

>>Greg Hager: Great. Thank you, Michael. So I'd like to start out just by highlighting some of Michael's remarks. Really, the evolution of NIT research over the past 70 years is remarkable. Just to use one often overused example, the Internet was invented about 50 years ago today, or the predecessor of the modern Internet, and if you look at the world today, about 80 percent of the developed world now has access to the Internet. The developing world is growing quickly. In fact, just this year, we passed the 3 billion mark in terms of the number of users of the modern Internet. Just to give you a kind of interesting side statistic, the number of photos uploaded every day using the Internet is about 2 billion. So, if you haven't up loaded your photo today, you're already behind the curve. Now, the evolution of the Internet has, of course, been of enormous benefit to the United States. We've seen the creation of entirely new industries, the recreation of existing industries. I show here just an example of what's become the familiar hockey stick curve of growth. Now, in this case of cloud computing systems, which ten years ago really didn't exist as a service, and now is expected to soon pass a 50 billion dollar industry. This is also, of course, of great benefit to the workforce. This is a chart from the National Bureau of Labor Statistics in the upper right, predicting that of newly created stem jobs, in the next ten years, 65 percent of those jobs will be related to computing. Now, of course, with this globalization which has been of immense benefit both economically and socially to the United States, there are a number of threats. As many of you know, just by reading the paper, there are enormous challenges in information security and privacy today in our society. We see the growth of the loss of personal information, personal identifying information, in any number of sectors, and so, in addition to creating new opportunities, we also have to ensure that we continue to secure that prosperity through advanced research in security and privacy. So, just with that as a backdrop, let me give you a sense of what we were attempting to do in this review. Obviously, NIT research is an incredibly broad endeavor. It has been reviewed in the

past, both in 2010 and 2013, in the context of the NITRD program. The 2010 review was a very broad review. It was very much a forward looking review of the field and made a number of recommendations of areas of investment that would benefit the nation, as well as advance the organization and operation of NITRD itself. The 2013 PCAST report looked largely at the 2010 report for guidance and assessed the progress on those recommendations. Our report follows in this line. However, we tried to strike a balance between both assessing the response to the recommendations, as well as doing a review of the state of the field and the NITRD organization and making new recommendations in response to new challenges that we identified. Our working group consisted of seven individuals, myself and Susan Graham, as co-chairs, PCAST members Michael McQuade and Eric Schmidt as well as three external working members, Sarah Keesler, Bill Daily, and Eric Korevitz. We kicked off this review in about the middle of January with a first tele-con just reviewing the past reports. We commenced weekly phone meetings. Many of those meetings were interviews with experts from government, private sector, and academia. In April we had a face to face meeting where we had a chance to put together our first preliminary findings. We did an update to PCAST in May and now we are here today with the final findings and recommendations to that report. So, just at a high level, a few overriding observations that will come out I think as I review our findings as I've already indicated and as Michael suggested, networking and information technology research continues to be a strong contributor to our national economic and societal well being. It's a field that's growing rapidly. It's creating some stresses within the research and education communities. In particular competition for trained workers and, you know, relatively challenging funding environment for NIT research. One of the things we also found out about the field which is interesting, and the highlight is we're starting to see an enormous convergence of historically separate research areas, areas that typically, historically had worked really separately if you will when they're in their own silos are really now starting to thread together in a number of interesting and new ways. I'll highlight a few examples of that. And, in fact, at the end Michael will speak about the coordination operation and the continued need for coordination to maximize the impact of these federal investments. So, to frame a bit more the state of the field, I think it's important to understand—and our recommendations, it's important to understand how the field has evolved since 1991 when the high performance computing act was first passed. At that time, the computing research field really was driven in a three legged stool of computing software and networking, computing to build the hardware and software that created capabilities, software to create applications and access that capability, networking to exchange data between computing systems. As the world became increasingly digital, in particular with the growth of the Internet, we started to see an evolution where data started to play a larger and larger role in the field. In many ways software became, if you will, a mean to ab end instead of an end to itself. As we now look to today, the next evolution really has been the growth of computing in a very intimate contact with people. We all carry mobile devices. We interact now on a daily,

hourly, some of us minute by minute basis through the Internet, and at the same time an ever deeper integration of computing into our physical world, our cars, our kids' toys, all have computing inside much them now powering them and creating new capabilities through these physical devices. So, if we look at the world today from the world of computing research, we see now a field that's only driven by its own internal innovation and manifest destiny, but a field that's now deeply embedded in a variety of important societal thrusts, and really, we're seeing now a drive not just from computing but from external factors in terms of how we shape and develop computing research, and so, our report again reflects really this emerging ecosystem of the computing research field, and I would point out that this evolution has not diminished the important of the NITRD organization, but rather, it's increased its relevance. I think there's more and more a strong need and role for coordination among to enhance the federal investments of NIT research. So, let me now turn to a review of some of the findings of the report. We chose to highlight eight areas within the report. So, the first of these are two areas which actually were highlighted in past reports and I'll just give you both an update and a sense of what the translation of these areas could be. So, cyber security and health are both national priorities. Cyber security we already saw in that opening chart, essential to be able to build secure and reliable computing systems to defend against to attack and to be resilient in support, also not just defend but also attribution when the attack occurs. There have been great investments in this area by both NSF and DARPA. We've seen a number of interesting research progress in this area. I think that what we find as we talk to leaders in the field is that the next step is to start to understand how these findings should translate into application in computing systems, how to design systems at the outset so that they're secure and resilient, how to make sure that those advances are translated into practice. A second finding in cyber security is that while we think about the advances in the technology, we need to consider also the human element. The fact is that many security issues arise not because of technological limitations, but because of human limitations, and as we design these systems, we have to keep in mind, not just the technology, but, also, the human aspects of that technology. Health, likewise, there have been a number of responses to prior recommendations; both NSF and NIH have made investments in advancing NIT research in the health area. We're seeing a growing innovation community in that space. Like with cyber security, what is important is to ensure that we capitalize on those advances by connecting those—that research into practice. So, in particular, we highlight the need for open platforms and open standards to access data, to access technology. We also highlight the need for paths for translation, the ability to deploy, test, and revise innovations in the healthcare environment. So, pathways directly into a laboratory that really is our healthcare system. So, in both of these areas, they remain critical. Past investments have created progress. We need to capitalize in those investments by promoting collaboration public private partnerships and in particular paths for translation into practice. So, let me talk about too other areas that have actually have received federal

investment in response to prior recommendations, big data and NIT enabled interaction with the physical world. So, in big data there has been a big data initiative that has spurred advances in big data computing. Of course there is already a vibrant industry also that's developed in this area. In NIT enabled interaction with the physical world, there are programs in cyber physical systems and the national robotics initiative which was launched just over four years ago. So, both of these have created numerous advances in the field. Again, in both of these areas what we highlight in our findings are the needs for first creating open standards and open platforms so that as the industry advances the academic research field is able to have access to those advances and to build on to those advances. In big data, we highlight the need for continuing long term research, to look not just at analysis and inference, but to start to look at issues such as assessing the quality of data and what that leads to in terms of confidence and uncertainty, as well as moving from finding causality in large datasets to starting to understand causality and the causal relationships among activities or processes that are observed through these big data systems. In NIT interaction in the physical world, one of the interesting observations is as I alluded to earlier, a convergence. The convergence is that as we see more and more computing embedded in the physical world, we see more and more interaction of people with those devices, and so we're seeing more and more interest in need for research that advances not just the fundamentals of autonomy and developing autonomous systems but systems also that are able to interact in a smart way and appropriate way with people in the world around them. So, again, these are areas where we see a continued need for multiagency and multidisciplinary collaboration. These are both areas which cross multiple federal agencies, both at the fundamental level as well, in terms of mission research in many areas, and we need to ensure that we couple the basic research in these areas through those mission agencies with effective means of deployment and testing. Developing systems, but also testing them in sandboxes and on platforms that are appropriate to mission needs and appropriate to areas of endeavor that make use of these technologies. So, in my opening slides, I spoke a bit about the fact that we're seeing more and more intimate interaction between people and technology, and this is another theme we highlight in the report. So, what we find is that there are really two areas that we'd like to highlight. So, these are the areas of privacy in cyber human systems. So, privacy is an area that has been called out in past reports. In fact, PCAST itself has also taken on that issue and discussed it and issued reports. It's an area that continues to need attention. It's a difficult area because it is an area that is at the intersection of technology as we understand it but also of social science and of issues in regulation. How do you develop technological systems that enhance privacy and at the same time can be used in a way that conform to an agreed upon set of rules. So what this requires is really a bringing together of the technology community with social sciences, with cognitive science, with psychology, in some cases with anthropology to understand what is the meaning of privacy and how is privacy then reflected in technological systems. Cyber human systems is an area that is really exploding in many ways. It encompasses,

broadly, what we historically would have called human computer interaction, but now has grown to include platforms for social interaction, platforms for human computation, the ability to gather workers together from around the globe to solve complex tasks by breaking it into small pieces and having those workers collaborate to solve that problem, and more and more, it's starting to bridge, as I said earlier, into the area of physical intelligence. How do we develop systems that are socially aware and socially intelligent, able to interact with people in appropriate and safe and trusted ways? So, these are areas which deserve continuing investment. They require broad multidisciplinary research, but, they have the—they offer the opportunity to do advance—or address important societal problems. So, in our report we also would like to highlight the technology base. It's very easy in today's world to look around and see the immense advances in information technology and to lose track of the fact that, as I said at the beginning of my presentation, really the stage for those advances was set decades ago, and at the time that that stage was set, we did not know where the field was going to go. So, it's important, it's crucial, that we continue to invest in long term fundamental research in networking and information technology, in computer science, in electrical engineering, to ensure future advances of the field. One particular area we highlight is high capability computing. We are nearing what appears to be the end of what's popularly known as Moore's law. For years and years, we've always been comfortable with the fact that if it's not fast enough today I'll just wait a year or two and it will be fast enough then. It's not clear that the fundamental physical property that has supported Moore's law will continue, and so, there is an important need to understand new research directions in architectures, algorithms, and software that will continue to advance high capability computing for both computing intensive and data intensive computing systems. So, again just highlighting the need for long term research in NIT, as well as in particular the need to continue to support high capability computing systems. Last, I'd like to highlight the workforce development in that opening chart. I pointed to the huge need for skilled workers in the NIT space, and we find that there are numerous opportunities to enhance the pipeline to build new skilled IT workers, to identify them very early. In many countries it's now common in high school or even earlier to identify students who are skilled and are capable and interested in NIT and to nurture them and to move them into the pipeline, and it's important that we continue our investments and to develop programs in this area. It's also crucial that we pay attention to diversity of the field. In particular, for example, women continue to be largely underrepresented in the networking and information technology field. It's crucial we design programs to capture that capacity in our workforce and bring them into the fold. So, again, we find that we need to develop programs to grow the pipeline, to retain students at all levels. We need to train and retrain workers, and we need to pay particular attention to diversity to develop the capacity we need to continue to advance the field. So, those are the technical findings of the report. What I'd like to do at this point is to turn it over to Michael to talk a bit about the NITRD process itself.

>> Michael McQuade: Thank you very much, Greg. In addition to reviewing the technical components, research components of the program, as we always do, we reviewed the coordination aspects and the way the program itself is run. So, first of all I think our findings are that the program continues as we have said to be vitally important as a national investment and that the budget reporting and coordination mechanisms that are used for this kind of crosscut initiative are appropriate and continue to be important, that the model of coordination that occurs through the NITRD subcommittee, the NCO and the NITRD groups which I'll talk about in just a moment, is both appropriate and beneficial to the community. It's also a very good example of government initiative, crosscutting initiative that has significant outreach in connection to the external community. We find that very positive. We do note, if you can click one more time, that our previous recommendation from the previous reviews that the budget reporting structure and coordination modernization has not occurred. There has not been major progress in that area. So, if you go to the next slide, in particular as many of you know, the government investments in NITRD are tracked through a series of what are called program component areas. These are broad areas that are used for accumulating budget categories and tracking investment over time. Those have not changed substantially since the beginning of the NITRD program, and over time, as various research themes have progressed to the point where they are now commercial or whether new themes have arisen. We have significant misalignment between the PCA's and the day to day operation of what NITRD is going on. So we recommend specifically that OSTP, NCO, and the NITRD subcommittee in direct collaboration with OMB create a process for periodically reviewing the PCA's, revising those as appropriate, and that that be done on a periodic basis, something in the range of five to seven years seems to be an appropriate task. We did take a look in the review process at the current PCA's and do make a set of recommendations on which ones should be put in place for the 2017 budget cycle to reflect the state of the industry, the state of the research agenda, that we have going forward. Next slide. The NITRD program is accomplished through a series of groups of various scope and sizes, special working groups, community groups, groups of practice, communities of practice. That coordination process for the creation, operation, and potentially sun setting of those groups, appears to be opaque at best, and not particularly rule driven, so we do recommend that the NITRD subcommittee in collaboration with NSTC and OSTP establish specific language that describes the purpose of each of those groups, both the purpose of the hierarchy of groups and the groups themselves and what the mechanism should be for establishing monitoring and terminating a particular group over time, that the NITRD subcommittee in collaboration with NCO and OSTP set up a process for periodically reviewing the groups and that each of the senior steering groups which are the highest level aggregation of foci within the NITRD program, establish a process to periodically publish the results, the direction, and research and coordination plans in each of those areas of interest. So, strong

endorsement of the structure, strong endorsement of the way the structure accomplishes its work. Some very specific recommendations on how that structure should be kept live and vital, how the PCA should be reviewed and upgraded on a periodic basis and those are consistent with past recommendations that PCAST has made in its reviews. Greg, back to you.

>> Greg Hager: All right. Thank you, Michael. So, let me just briefly close by saying, you know, the U.S. information technology industry continues to be an industry that is the envy of the rest of the world. We continue to be a world leader in many, many areas. As we have seen the research community continues to grow and evolve and NITRD, I believe, we have found in this review, plays an important role in helping to guide a strategic federal investment to continue that innovation to create new ideas and continue progress in this area. So, with that, let me close and I'm happy to take questions.

>>John Holdren: Good. Well, thank you very much, Greg, and Michael. A couple of flags up immediately. Chris Cassel is up first.

>>Chris Cassel: Thank you, and thanks to everyone who contributed to this report. I'm struck by the growth of the recommendations about healthcare, which is an area that I'm very involved in and as Michael knows and PCAST knows, PCAST has made numerous recommendations towards accelerating access to healthcare data in more usable and fluid ways and so you rightly emphasize big data, the explosion of sources of data for healthcare, including but not limited to what we think of as health information technology. And, you know, the uses of this is for health monitoring, for all kinds of reasons including public health issues, both in the United States and globally, but also research and decision support and performance measurement for the health system as part of systems engineering in healthcare delivery and sort of a whole range of topics. My question is, just yesterday, and again later this afternoon, we're going to be meeting with people who are leaders in the national effort to accelerate progress and health, specifically in electronic health records and the way in which that data is used. Do the groups that you're— and I guess this is a question, Michael, for you, because I don't really understand the structure of NITRD and how it works. Do these recommendations have any landing place or receptor site in HHS and how—because this is a very strong set of recommendations. How does this have impact with the people in HHS who are on the ground trying to make this thing work?

>>Gregory Hager: All right. Thank you. So, one of the things we try to do in our recommendations is to target those recommendations. So, clearly Health and Human Services, NIH, NSF, all play an important role in the development of this ecosystem. What we've tried to do in the report, as you said, is to highlight really both the opportunities and the barriers and the barriers really exist. There are obviously many sources of barriers, the regulatory and

personal privacy barriers. There are also interesting barriers simply in the fact that we do not at this point have broad standards, broad open interfaces that allow access to data. So, what we've tried to do is to really highlight, I would say, the bookends and focus is on the agency. So one book end is how do we provide the best possible access to data and to technology so that researchers can actually connect to the real world problems, and those recommendations are targeted again at NIH, NSF, HHS, and also as I suggested in my presentation the landing place for that technology. I think, you know, we talk a lot about getting access to, if you will, the inputs to the system. We don't talk a lot about how do we actually realize the outer puts of the research system and I think a lot of what we tried to highlight in the report is the need for the ability to rapidly deploy, to rapidly test, to rapidly innovate, as we're familiar with in the IT industry, but we're not familiar with that in the healthcare industry, and that's really one of the, I think, key recommendations I'd like to highlight in your report. Thank you for your question.

>>John Holdren: Good. Maxine Savitz is next.

>>Maxine Savitz: I want to thank the committee for doing this review. You've done very well. One of your summaries is that the U.S. continues to be world leader in this area. Doing this assessment, did you since the last review, are there any areas where U.S. leadership is at risk? Did you look at that?

>>Gregory Hager: Thank you. Yeah, when we started the report we actually specifically tried to look at that question and I think there are a number of new emerging trends that we really should pay attention to. I'll give you two examples. So, first, in the area of computing in the physical world, the European Union just announced a 2.1 billion Euro initiative. That's billion with a B, initiative in robotics, called the Spark Initiative. It is a public private partnership. It is one third federal investment and two thirds private investment. But it obviously dwarfs any investment that we in the United States are currently committing to that particular area. Another area that's worth highlight something high performance computing. So, we no longer have the fastest super computer in this country and in fact there are, you know, unnamed countries in Asia who are continuing to invest to ensure that they do. Another important, but more hidden, fact about that is the question of the capacity of the system. So, it's easy to identify the fastest super computer and say are we winning, but if you look at Japan, for example, they made an enormous investment in developing the broad capacity of computing systems, and so these are, I think, two examples of areas where if we look around the world there are other countries that are investing heavily, looking, in many ways, for that next great innovation that, in some sense, leap frogs where we are today. Thank you.

>>John Holdren: Good. Dan Schrag is next.

>>Dan Schrag: So, you mentioned the public private partnership in Europe and clearly this is an area that U.S. dominance is partly because of the incredible achievements in the private sector as well, and the report discusses the intersection between the public and private investment here in the U.S. I wonder if you could elaborate more just a little bit more on that relationship between the private sector and public sector and how the public investment takes advantage of the huge private investment in the U.S.

>>Gregory Hager: Thank you. So, you know, one of the things—so, I've been a department chair in the past, and so, I've started to, you know, in the process of recruiting faculty started to think exactly about this question of what is the leverage that federal investments can gain through the private sector and vice versa, and I'll highlight that in fact next week. The Computing Community Consortium is leading a round table on this very topic. One of the things we're seeing more and more within the academic research community is there are many areas of computing research where advances depend on collaborations with the private sector. So, as you see the information industries, for example, develop, more and more they're capturing data that there's simply no way a public university or a researcher could have access to except through a partnership with private industry. If you look at the growth of cloud computing and computing capabilities, those are enormous capabilities that, again, if you're doing work not just in the use of computing capabilities, but in the development of new computing capabilities having access to those facilities is a crucial part of being able to advance your research, and the relevance of your research depends on that advance. If we look a little bit further ahead, we look at, for example, computing in the physical world, we're starting to see, you know, the emergence of an industry. I think the opportunity there is a dialogue between industry and academia to create common standards, means of transferring new technology innovations from industry back into academia as a platform to build on so that academia can now transfer new innovations and ideas back into industry. So I think this notion of collaboration through common standards, through, you know, sharing of data and capabilities, and also through new programs that allow movement of people from academia into the private sector to learn about problems at the cutting edge in industry, but also moving back to academia to then advance their research in those problem areas, I think these are all huge opportunities that could really advance the computing research field particularly in a time of relatively flat federal funding when, you know, the only real way to grow our innovation capacity, I think, is to look at new funding models. Thank you.

>>Michael McQuade: If I could just have one comment. I think it's what makes the whole discussion about human resources so vital and so complicated here because this industry is so important from an innovation point of view and the sort of historical models that say all the

science is done in University and then that gets translated to somebody who innovates a new product, just isn't the model, and so, when we talk about the need for people, we need people in so many different categories. We need people who just do the stuff that needs to be done to keep the water flowing. We need people who are deeply involved in fundamental research. Some of those are going to be in University. Some of those are in the practicing community itself, and then part of the focus that we have on making sure younger people engage as diversity as possible is because the innovation criteria that comes from people thinking not just about the science, not just about the underlying computer signs, but what's the next big thing, and so, this challenge around human resources—it's a wonderful opportunity for us, but it's a very big and broad challenge we have in front of us.

>>John Holdren: Jim Gates.

>>Jim Gates: Thank you and, again, kudos to the team for putting together the NITRD review. It's been very interesting over the last several years here on PCAST as we watch the evolution of these reports and also very encouraging to hear from this report that part of your effort was to look back to see what was effectively implemented from past reports. So, I thank you all for your efforts. Your last transparencies spoke to, again, this issue of people problem that Michael just alluded to and it's, you know, PCAST has looked at stem education on a number of scales the last several years. Part of your problem is actually a very different problem. It's something that one of our colleagues called the gazelle problem of actually identifying the gazelles early enough to actually pull the system forward. That's not something we've had a chance to really delve very deeply into because we've been talking about lifting the entire ship because this Administration as well as this PCAST is particularly focused on the leveraging of science and technology for the benefit of the American economy and the American people. So, are you and your colleagues thinking a bit more about what might be the final word in your report in this domain of stem education as it relates to both the gazelles, as well as the broad need for more access among the workforce to make this, to continue to make this be a jewel of American innovation?

>>Gregory Hager: Thank you. Yeah, so you're absolutely right, there is really both the broad, as you say, bringing up everyone, making sure that we have the broadest possible workforce but also identifying future leaders, and we do call that out as an important challenge for the field in something where there are a number of opportunities for progress, and so, there are both findings and recommendations related to that.

>>John Holdren: Well, I see no further flags so it's probably time for us to vote on whether to accept, with the usual provision, subject to final edits, the recommendations of the NITRD

panel. Can I ask all the PCAST members who are in favor of accepting those recommendations to raise their hands? All those opposed? Abstentions? Seeing none, the recommendations are accepted, subject to final edits. Let me again thank the team—Greg, Michael, Eric Schmidt, in his absence, and Susan Graham, in her absence. But, great job. Thank you for that.

Technology and Aging: Innovators

>>Eric Lander: I'd like to welcome everybody back for the continuation of this morning's meeting, The President's Council of Advisors on Science and Technology. I will chair the second half of our meeting. We're going to be focusing on the topic of aging and technology. The PCAST is engaged in a study about the interaction of aging and technology, ways to use technology, ways in which the nation can use technology to really support the needs of a growing population of Americans who are living to older and older ages, and make it possible for people to have the autonomy that they very much demand and the health and the other services, taking into account the very different experiences for people as they're older. Now, the idea that aging and technology go together is not necessarily obvious to everybody. Many of the technology applications over the course of the past decades, the transformative things that you think about on the Web are often associated, at least in the first instance, with the needs of say 20 somethings. I think you can think of many examples of innovative companies that have done that, but in fact, we have with us today two innovators who are thinking about using really quite advanced technological approaches and thinking about remaking the social support network to provide services for elderly Americans or older Americans and I think it struck us all that this is just an area of tremendous unmet need and tremendous business opportunity, and so, we in the course of informing ourselves about these things have invited today Seth Sternberg and Kai Stinchcombe. Seth Sternberg is the co-founder and CEO of a company called Honor, and he's going to tell us about how Honor is involved in helping to rethink the provision of services for older Americans and before that, I think characteristic of people who are involved in creative things on the Web, he was the CEO company of Meebo which brought instant messaging to the web. Kai Stinchcombe is the CEO of True Link financial, and he has founded and led companies across the financial services and tech industries and given that experience, he's now looking at the experiences of financial services, particularly to older Americans, and so, welcome, to both of you. I'm going to ask you each to present briefly and then we'll have an opportunity for the PCAST to present and for that general discussion. I'll ask Chris Cassel who's been leading our study to lead the discussion. I don't know if you guys have agreed on an order, yes, we have it looks like. Seth Sternberg is up first. All yours.

>>Seth Sternberg: Cool. Well, thank you, guys, very much for having me here. I really appreciate it. This is a pretty important topic. Okay, I'll get closer to the mic, closer to the mic, and I'm going to grab this. Okay. How's that? Does that work better? Alright, so, thank you all for having me here. I really appreciate it. I'm really psyched that you guys are actually looking into how technology can help our older Americans stay in their homes as they age. It's not something, as you said, that people naturally go to, but I think it has a lot of relevance. I think there's a lot of innovation we can accomplish there, so let me take you through some stuff. First, I want to talk to you a little bit about just how I got to this, like why I'm doing Honor. So, that's me when I did not have gray hair. I had more hair and I was 18 years old and that's my grandmother, and I recently flew to Connecticut which is where my mother's from, and I grew up there too. My mother, you know, picks me up at the airport, Bradley Airport, for those of you who know it, and she started driving me home to my home in West Hartford, and as she was driving me home I just noticed that she was driving a little bit slower than she used to drive, and I was like, Mom, why are you driving this slow, and she's like, well, driving's just harder than it used to be, and so, then I started thinking like five years from now, my mother loves her home, I don't want to be the son who has to say, hey, Mom, it's kind of time for you to, you know, leave home and go somewhere where, you know, you can be better off because I actually think she'd probably be worse off anywhere else other than her own home, and you can say Honor is a way for me to avoid ever having to have that conversation with my mother. I want her to be able to stay in her home. So then, I started doing research, right, and I looked into, well, you know, how would I help my mother stay in her home and what it showed me was 20 years after my grandmother passed on, basically, the world hasn't changed. Like, to keep seniors in their homes, we really haven't done very much. We haven't innovated. So, our mission is to bring joy, comfort, and grace to people as they age, right, and we put together an amazing team, I think, to make that happen. We also took one of the largest fundings in this space in order to accomplish this goal. So, Mark Andresen, who you guys met on this panel, I would imagine know very well, led our fundraising, and then, we raised—he put in $15 million, then we raised another $5 million from a whole host of folks across the spectrum from you know, Ben Jealous, who ran the NAACP for four years, to from Bob Kerrey, the former Governor and Senator from Nebraska, to, you know, Max Levchin, and Jeremy Stoppelman, who did PayPal and Yelp, respectively, because we really wanted as many smart brains on this problem as we could possibly get. Now I want to talk to you a little bit about some stats I found as I started looking into this problem. I initially was just looking into it for myself, right, like, how would I help my mother stay in her home, and then, these are the kinds of things that convinced me, wow, like maybe I should work on trying to solve this more broadly for, you know, the country and then hopefully the world. So, everyone knows that the percentage of our population that's over the age of 65 is expanding very quickly. The projections are that our society will invert, right, which it to say over 20 percent of our population will be over the age of 65 by, I think, it's 2035, right? So, that's pretty soon.

Germany, Japan, Italy are already there. Northern Europe, for the most part, is going to get there before we do. Now, the other two stats that people ignore, right, on how significant this problem is, of how we're going to care for our parents as they age is, one, shrinking families. So people have less children than they used to have, and, with less children, it's just less likely that one of your four or five kids are going to stay around when you only have one or two, right? So, if you only have one or two, what's the likelihood one of them is living in the same hometown as you are, to help you as you start to need help in the home? And then you cross that with urbanization, right, so if you look at percentage of society that lives in the urban core, you discover that's going up, and people are buying or renting very small apartments that cost a lot of money that don't have enough space for your parent to come in and live with you. So you cross kind of a graying society with sub replacement fertility, with urbanization, and now you've got the makings of a really big challenge we have on our hands as a society. So then, you look at the innovation in the space, right? You say, well, okay, jeez, I hope we're working to solve this problem, and as I said, you know, what I discovered is there are various plays, very little innovation around actually helping seniors stay in their home, and the question is why, right? Why have we not innovated? And I think the dominant one is probably the first bullet here. So the belief is that innovation comes from technology, right, and then, the belief is technology and seniors do not mix and therefore, and Kai is shaking his head because he knows this is true because he's been attempting to innovate in the space as well, and so, therefore the investor class and entrepreneur class says, well jeez, we're not going to solve this one, right? It's too high risk because we'd solve it through tech and we don't believe that the population we want to use that tech for will actually use it, and the point I make to people when they say that is, well, the funny thing is that, you know, I know a lot of seniors who drive cars, use microwaves and use cell phones, and it's because those are pieces of technology that don't feel like technology, right? Technology for the sake of technology is kind of useless. It should really be technology that delivers an amazing service to someone, like getting them from point A to B. There are a couple more minor ones. I'm going really fast because I don't want to run out of time here, but entrepreneurs, oftentimes, their parents are their solution. If you look statistically at entrepreneurs they tend to come from upper middle class families. It's a psychological thing. You weren't so wealthy that you had just had your life kind of taken care of for you, but you have enough protection that you know you were always going to have a roof over your head and dinner. So, it's really your parents that actually enabled you to be an entrepreneur. This is like a statistical fact. If your parents are a solution you're probably not going to design for that problem in your life, and there's this fear, and this is the craziest one, so I do want to talk to it, that there's too much natural churn if you sell products to seniors because they're too old and they'll pass on and I say, well, that's funny because products for teenagers have this natural churn problem too, where teenagers just stop caring about your product in three years, but the nice thing about senior space is, well, at least you can look at the

present day 55 or 60 years old and know what they're going to want when they're 65 or 70, and so, I actually think that you have much less natural churn in the senior space than in, let's say, the high school student space. So, just really quick on how we're designing to fix this problem, at least on in home care, and then I'm going to talk a little bit about some recommendations that I would kill for you all to bring to President Obama. So, our approach is to completely remake private duty home care from top to bottom. In case you don't know what private duty home care is, it's when someone goes into a senior's home, so a human goes into the home, and they help the senior with what's called an activity of daily living, or an ADL, and these are things like getting out of bed, getting food, right, bathing, getting dressed, right? So, it's the things where if you cannot do one or two ADLs, you can't live alone anymore, right? So, private duty home care helps you accomplish these goals, and so, our approach is to say, well, the current state of private duty home care, charitably, is not very good. The product really needs a lot of help. So, we're going to remake that. Here's how. First is that we really focus on the three actors in this system. So, it's not just about the elder. It's also about the care professionals who are caring for that person and it's about the children, right, the adult children of those elders who are caring for that person. If they're not in good places in their own lives, it's very hard for them to be able to help take care of a senior, and so, the way we do this on the care professional side is two things: One is we give them the tools that they need to provide amazing care, and that really breaks down into two pieces. One is a lot of information about the senior before they ever walk into the home. So, an app on their phone that says, you know, here are the kind of basic conditions of this person, but here's who this person is as a human. Here's what their career was. Here's their proudest moment in life, right? So, you can really help that person as a whole human, not just as kind of a random number. Other tools like a care plan, right, on a phone, so that when you walk into a home you know check the boxes, right, here's this—it's not this screenshot, but here are, you know, here are the things I'm going to attempt to accomplish today in the home. We even monitor on the care post side for fraud and abuse, right. So, their phone looks at when they, you know, say I'm in a given job, well, are they actually geographically in the geo fence of the home that they're going to be serving that senior in. If yes, that's great. If no, then we have to get a human involved to figure out why there was a mismatch between where they checked in, and where they physically are, and then, the final one for care professionals. So, on average, this should blow your minds, on average they're paid $9.50 an hour. On average, the official stat is they get 34 hours a week, but we've done a lot of math and we believe it's more like 20 hours a work a week. So, their full time equivalent wage is $4.75 an hour. 56% percent of them are on government assistance. How can they take care of our seniors, if they're really put into a place where they can't take care of themselves? And so, on our platform in the San Francisco Bay Area they can earn $17 an hour, right, which, in Bay Area, $12 is the average, and we're doing $17, and it's our belief that that lets us get the best people and then let's us be the most selective about who we allow onto the platform, and then

we give them the tools, and put them in a better place in their lives so that they can deliver amazing care. Let's switch over to the other side, the adult children. So this is actually a picture of the adult child app, and the adult child app is really important, because when you look at the psychographics of the unpaid caregivers for seniors, and where they are, there are 40 million people in America trailing 90 days who say that they are caring for a senior because of elderly issues. 40 million, and, if you look at their stats they self-report over time that their health degrades because they're in the sandwich generation, right? They are caring for their parents at the same time that they're caring for their kids and they feel like they are kind of losing control, right, and there's actually a feeling of guilt. Like am I doing enough for my kids, am I doing enough for my parents, this is stuff I guess you've seen too, and so, our app for them, which they can get in the, you know, the iTunes app store, is designed to give information and control so they can see, you know, this is who's coming to help my mom today, this is what they're going to do, here's a personalized note, right, about what this person, what Janet did in my mom's home today. They can press a button to text Janet. They can press a button to call Janet. Today, that's literally discouraged by the existing industry because they're worried that the care giver, that the paid care giver that they've introduced into that home, might work with that family outside of the relationship of the agency and the agency would then be cut out, and so, they discourage direct communication. So, we're, and obviously, as you can see, we're encouraging it. So, this is about information, right, which drives control, and more knowledge about how your parent's being cared for. So, what does this all do for the seniors, right, and how does the technology help? I'm just going to talk a little bit to kind of implications behind some of these kind of high level statements and give some examples. So, senior and caregiver compatibility. There are 50,000 agencies across the United States doing private duty in home care. There are 2 million paid care professionals across the United States. Do the math, 30 care professionals per agency, right? Now, if you're not using technology to match the capabilities of a care professional with the very heterogeneous needs of a senior, right, then 30 is about where you scale out. Like how do you manage more than 30, right, by pen and paper? But a computer can do an amazing job of saying this senior speaks Mandarin, has cats in the home, and has dementia, and so, therefore, we need someone who speaks Mandarin, is not allergic to cat, and has dementia training, right? And you can do that at massive scale, and you can have much better matches between the needs of a senior and the capabilities of a care professional. Visibility involvement by the family, I already talked about that, so I'm going to skip over it. Care pro earnings. So, technology fundamentally is making us more efficient, right? We can look at, like, let's make drive times between different homes shorter. Let's, you know, scheduling is done by a computer. Literally today it's usually a phone tree if a care professional is sick on a given day, you find actually in today's world, it's either the care professional is told, sorry, we know you're sick but you still have to go to the home because we can't backfill you and believe it or not that happens a lot more than you want to believe, or it's a phone tree of literal—

there's a scheduler in the agency that dials down their people who says, hey, can you go, can you go, it's last second, I know, but we need someone there. So, that goes to quality, quality, sorry, for the senior. Care pro earnings I talked about but that efficiency, right, we can use to drive better earnings and accessibility right for the seniors. Finally, of course, if you bring data to this problem you can create a specific care plan for a given senior. I think you can drive down admissions and readmissions into hospitals if you bring in data intelligence. Clearly, cost and fraud, like I said, we are monitoring one example. We do a lot of stuff but one example is GPS. Finally, so, recommendations. First thing, please shine a spotlight on the opportunity for older adults, right, for investors, for entrepreneurs, for innovative large companies, right? We can—this is a massive opportunities. Seniors spend, people over the age of 65 spend a trillion dollars a year in America. That's a huge market, but, it's completely under innovated in. So, let's shine a spotlight on that opportunity. Second, the CMS is very innovative these days. I'm really impressed with CMS, and I think they should start looking at whether we can drive down cost for CMS in terms of hospitalization readmission through private duty home care, even something as simple as a safety check, right, a once every two weeks, once an hour safety check, right. That could drive down costs. Medicare does not fund private duty home care today. Medicaid does, but Medicare could cover it. This is a classic the middle gets squeezed in America problem. Finally, for all three participants, we need programs, right? There are 45 million people over the age of 65, there are 40 million caregivers, 2 million care professionals—we need to think about all three of those individuals. That's it. Thank you, guys, very much. I appreciate it.

>>Eric Lander: Thanks very much. We'll go directly to Kai, and then, we'll take questions together.

>>Kai Stinchcombe: I should be able to figure this out. So, I'm the CEO of a company called True Link Financial. We do credit cards for grannies. Which, there's sort of a moment when everybody's like, wow, this is going to be kind of out of left field so this is like the flight attendant warning, you are on this flight. If you're not intending to go there—well, here we are. So, we've done a lot of research on fraud targeting seniors, financial abuse of seniors. The thing that we found is that it is not like normal fraud, that you cannot just increase your fraud detection algorithms, because a lot of it stems from, you know, sort of error proneness or vulnerability on the part of seniors, that the mistakes that seniors make are different than the mistakes that other people make, and that there's a whole industry around teeing seniors up for mistakes, right. That we looked at sort of entrapment, or gas lighting, and we decided that we didn't have the market power to introduce that into the vocabulary, but that that's actually the bulk of the problem and, that it's almost impossible to get people to focus on that. So, let me offer an example. Suppose at 9:00 a.m.—suppose you have the inability to translate

working memory into long term memory, to form long term memories, which, you know, is a prevalent problem. It's not a small number of people who have this problem. You know, it's not a small number of people that have this problem. If at 9:00 a.m., I call you and persuade you to donate $20 to my non-profit; I can call you at 10:00 a.m. and say literally the exact same words and you will donate again because nothing has changed in your mental environment, right? And if I can make $20 an hour on five minute phone calls with this senior, you can really go to town on that. And it was precisely that experience with my grandmother, incidentally, that caused the formulation of the company. That you go to the financial system and you say we have this charitable contributions, what can you do about that, and the response will be, well, it sounds like she's having trouble managing her money, have you thought about taking away her access to her money, which is, you know, sort of devastating if you think about the range of actions that are curtailed by not being able to spend your own money. And so, there's this sort of category of what seems to be legal transactions being done by people whose business model depends on taking advantage of vulnerable seniors. The thing that we offer is a debit card that has specific protections against this type of predatory behavior so that you can still spend your own money as you age. And the underlying thesis is that seniors are differentiated, you know, sort of—how would you say that word? Well, you can recognize the market, right, that they have certain characteristics in common and so in the way that USA serves military families, or American Express serves business travelers, that there's an opportunity for financial services specifically targeted towards seniors, and, you know, as Seth said, the role of the adult child or responsible caregivers is really critical to our ability to do this also, and I'll just sort of dive into some of the stuff that we've learned over the course of doing this that I think might be relevant to this group. The first thing is, at the 99th percentile of making mistakes, it is just all seniors that are out there, right? So, you think about, you know, sort of a time that—the word senior moment, right? A senior moment is when you do something dumb and it's not like really dumb, but it's like a little bit dumb, and so, you think about people that are buying all in one vacuum cleaners and mops on TV, or, you know, being taken in by somebody calling on the phone posing as a family member, you know, you sort of did something a little bit dumb.

>>Eric Lander: Is that data, or rhetoric, the 99th percentile?

>>Kai Stinchcombe: It's rhetoric.

>>Eric Lander: Okay, because there's a whole consumer protection bureau that worries about other people being taken advantage. I just wanted to check. Thanks. Carry on.

>>Kai Stinchcombe: Yeah, the framework for thinking about the problem.

>>Unidentified Speaker: Okay. It just had a number in it.

>>Kai Stinchcombe: Yeah, it's a fake number. Yeah, I think I read that in the economist.

>>Unidentified Speaker: But it's hard to get the denominator for that number. That's one of the problems.

>>Kai Stinchcombe: Yeah, it would be pretty impossible. So, you know, the second thing is that, and this is like philosophical, and there's nothing really to be done about this but since the enlightenment the legal system is based on this sort of either you're a rational act capable of making decisions for yourself, or you're incompetent either because of a minor or because of, you know, a judgment of conservatorship and that there's this whole class of people that is somewhere in between, right, that there are some decisions that they are competent to make, and other decisions that they're not, and so, this was why the bank said you have to take away your checkbook and credit card because if you say that when she authorizes a payment, you know, she shouldn't—she isn't really capable of doing that, what you mean in our legal system is she's unable to authorize any payment. Her signature doesn't mean anything, and the fact that there's no middle ground in between where you can say, you know, this agreement is wrong for her, this agreement is right for her, it just—there ends up being a whole group of people that falls in between that crack, and so, if you think about consumer protection, you know, sort of philosophically as helping people avoid errors, right, that in so many cases, you know, you are in a bank signing a predatory mortgage, or signing up for a predatory investment vehicle, or you are buying something where, you know, if you did a full set of research you might realize that the product is inappropriate, or dishonestly marketed, this is the type of error that is made very, very frequently by seniors, and so, when you think about consumer protection, thinking about somebody who has mild cognitive impairment and whether our consumer protection laws which are, you know, sort of not strong enough to protect the mainstream, you know, what is a person with Alzheimer's or dementia, how are they going to be protected, and then, the second thing, you know, you talk a lot about caregivers, and this is something that, I think, again, the legal system is bad at, right? So, finding the responsible caregiver. You know, often you turn to a probate court or something like that as a way to sort of identify who are the good actors and who are the bad actors, and if SLS there isn't an advanced directive or, you know, power of attorney or family member that initiates conservatorship often it will be, sort of, the person that is closest to the action, right, and so, there was a story about retirement homes putting people under conservatorship and then milking them out of their money. Often, if you end up being a conservator of the court which, you know, you think about the sort of social services staffing that's available to them, they're not beautifully positioned to take on the responsibility of a caring family member, and so,

thinking about what's the process for identifying this person in advance, and then second how do you empower them, right? So, for example, in the banking sector, if somebody, you know, in sort of the golden age that maybe imaginary of community banking, you have somebody that comes into a bank and says hey, I need a $50,000 cashier's check, and you know, you would imagine the teller saying, well, Harold, what's that for and they say, well, I'm investing in a horse rescue farm. You say, well, why don't we call your daughter and see if that's, you know, a wise investment. And now, you know, in the age of sort of banking at scale and also with privacy rules, you can't actually call the daughter, and it would seem entirely common sense that you would contact a family member, but there's no way to do that, and so, thinking about sort of what are the appropriate protective roles that a caregiver can play and how do you, you know, sort of build that into the legal system so that it can be done sort of systemically, and then, what do you do about bad caregivers, and this is something that, you know, we found that everybody's obsessed with because it's so lurid, right, you think about the nephew who stole all of his mother's money, you know, that's a much better headline than the hundred other nephews who are out there caring for their, you know, aunt as she ages. And so often this takes the lens of prosecution, and the number of times prosecutors have complained to me that they can't get, you know, Grandma to testify against her grandson and you think about, you know, this is somebody that you tried to raise and you're sort of last act on this Earth will be putting them in jail and, you know, you did your best to raise them right, they went astray, they did something, but it's this totally implausible to ask of legal system to say well, oh, you know, probably the best answer is to try to put these people in jail, and so, you know, I don't have a better answer, but it seems like something that is cooperative and is focused on what does the senior actually want and how do you make sure that they're in good hands primarily, rather than, sort of, how do you punish this person for this, you know, admittedly quite evil deed. And then, you know, sort of zooming out to our particular policy wish list. Almost all fraud against seniors is processed through the financial system and any time you want to apply pressure, you know, going after the people that are processing the transactions is much easier than going after the people that are taking the money because, you know, they're operating in a gray area whereas the banks that facilitate this fraud are, you know, out there in the sunlight. So, you know, there's a set of ways that you can appropriately monitor credit and debit transactions. You know, for example, under Reg. E there are certain, you know, rights that consumers have to dispute or claw back authorizations of credit card transactions, but these are you know, really poorly offered by banks. You know, it's sort of like you say oh, you know, my mom got signed up for recurring billing for this charity. If the person on the phone actually is aware that they have this obligation, they will charge you something like $35 to stop future billing by this predatory charity, as an example. But, there's similar things for wires, for checks, gift cards, where really small changes would actually enable a great deal of positive impact. If you guys did all of this stuff you would put me out of business but that would be a good thing.

You know, second, in terms of consumer protection, I focus on labeling requirements just because it's low hanging fruit that you imagine, you know, for example, there's the fiduciary standard that is a subject of much debate right now about whether you should require investment advisors to act consistently in their client's best interests. I would love to see that go through, but I think that there are financial advisors that have some connections in Washington that may help them get out of that. If you just put into place a labeling requirement, you know, much the same as it says, you know, we can't guarantee future results, this is not FDIC insured, if there was a sentence on that brochure that said unlike some other financial institutions, our wealth advisors are permitted to make money trading on your account in ways that are not intended to be in your best interests. You know, that would be like a remarkable sentence to put on your advertising materials, and I think that that—you know, it would also be an accurate label that accurately explains this product and how it's different from some others, and so, you know, that kind of thing. Similarly around telemarketing, the do not call list, charities and political parties are exempt from that under first amendment grounds, but if you just had to disclose whether you call people on the do not call list, a lot of the reason people are on the do not call list is because of a form of vulnerability, and so to say, you know, I can name two major political parties that make, you know, a decent amount of money exploiting people with Alzheimer's and dementia with repeat contributions. If there was just a, you know, a discloser whether you call people on the do not call to solicit them for donations, I think you could do a lot there. And then, finally, permissive rules for responsible caregivers. So, stuff like, you know, in the case of a will there's a default chain of executorship. In the case of cognitive impairment, especially mild cognitive impairment, that doesn't come with conservatorship, there's no chain of, you know, by default you can call the son, by default you can call the daughter. And in a case where, you know, for example, a financial institution but, you know, also a retirement home or adult protective services or an in home caregiver, feels that something might be going wrong, having that sort of default permissive attitude that you can assume that the kids are probably have their mom's best interest at heart unless proven otherwise. And, I guess I'll leave it at that.

>>Eric Lander: Okay. Thank you very much to both of you. I'm going to turn to Chris Cassel to lead our discussion.

>>Chris Cassel: Well, this was really not only interesting but inspiring. I think I would just say to hear about this and to know that I imagine that the two of you are not the only people who are looking at that dramatic growth in the older population and seeing not only a social problem, but also a huge market and a market that needs solutions and where, you know, the kind of solutions that you're creating are very relevant. I just want to, Eric, if I might say a couple of things about the context in which we're hearing this is the White House conference on aging

yesterday where these messages were heard and now following on that a much larger focus on technology solutions with the work that PCAST is undergoing now, and so, I think it's fair to say that one of the things that both of your companies have in common is that you start not with the notion of being—I mean, protection is an important part in safety, but we've heard from notable people such as Otule Aguandein this setting that sometimes policy goes overboard in the name of protecting people and ends up undermining what little independence or autonomy or dignity somebody might have in later years, and so, both of you are starting in a place how do we maintain as much dignity and the individual human autonomy as possible, at the same time, that there is protections against inherent vulnerabilities. So, I really appreciate that approach. I think that it would be interesting to see kind of a whole market grow up out of those kind of concepts. I was especially interested in the Honor approach to the payment of personal caregivers. The President actually mentioned this at the White House yesterday, more in terms of sort of the national drive for minimum wage and other kinds of legislation, but your point, Seth, is one that I've often made in my work as geriatrician, that there's this huge need for personal caregivers, highly unregulated. People don't really get much education. I mean, you mentioned finding somebody with dementia training. It's very unusual, and yet, that's a particularly demanding kind of personal care that not everyone is, you know, equipped to deliver. So, you know, you could imagine your company creating a market where there would be stable, lifelong work for people who don't have much education in our society, but who really have a natural gift for helping people, and would actually find a career in being able to do that and be able, as you say, to have their own families as well. So, I think that's really, that's an additional aspect of what you're doing that I think is really important. The issue that Kai raised, and you didn't talk to us a lot about your company, and for both of you I'm sure people have questions about how's it going and kind of what are your plans, but we had specifically asked you for advice for us in our working group which we've got that list and we are having a day-long meeting tomorrow. So, this is very timely. One of my questions is about whether you could use a kind of a big data monitoring for the big banks. You expressed the banks are reluctant to take on this responsibility that the credit card companies do readily because they're at risk when those transactions happen. So, have you thought about something like an opt out policy for someone who's over a certain age or something like we do on a driver's license or something where just to make it more kind of overt that the person has to think, well, you know, I might actually need some help occasionally and they would just sign something and the bank would be authorized and maybe even required to then call the daughter or call someone. The last thing I want to say is I don't think that would put you out of business because as I understand what you're doing is very nuanced approaches to specific kinds of limits that still allow the person to have their card and do other kinds of purchases, and I don't know that anything banks would do at a level that would really allow that. So, I wouldn't worry too much

about it. But, let me just stop there and I can see that there's a line here, I'm going to turn first to my co-chair Ed Penhoet for first question.

>>Ed Penhoet: Thank you both for your care for your elders and for your interest in this space generally. A question for Seth about critical mass, I mean, San Francisco is a unique place almost in terms of the penetration of technology in that community, but as you think about scaling across the country, or across the world, what are the numbers you need in order to make your model work in terms of participants both on the caregiver side so you have a big enough population to draw from and then on the recipient side? How does that actually work out when you think through the problem of how you put all these things together in a community?

>>Seth Sternberg: Yeah, that's a good question. So, one is local density and I think there are two parts to that. So, one is San Francisco actually, in a lot of ways, is a bad testing ground for a new product because it is too kind of tech oriented. It's actually the reason why we started testing in Contra Costa County. It's still right next to San Francisco, but it's kind of not in the extreme bubble that is San Francisco and the peninsula. We actually specifically designed it to feel like a service not like technology, because we want it to be really simple for everyone. In terms of the actual mass, so I don't know yet, because we need to see, it's actually a question of density per square mile, right, it's not even a question of density like within 1800 square mile zone which is roughly what San Francisco Bay Area is. I would say that, you know, at about a thousand homes spread across the SF Bay Area you're probably at a point now where you have enough density that you start to get, you know, pretty dramatic impacts of scale, right, in terms of efficiency that will drive. And actually, what people miss is that there's one part where scale and density help you with just kind of the business of it to make the business model work but there's another part which is the product will get fundamentally better with increased scale as well. You can do—just like as one random example, if you have a lot of scale, all of a sudden you have a bunch of seniors who live near each other and you can start focusing on social issues as well as physical issues, right? We're too focused on just the physical needs of seniors and we're not focused enough on kind of the psychosocial needs and especially isolation, and so, actually the thing I'm most excited about around density is actually working on the social angle and improving the product.

>>Unidentified Speaker: Thank you.

>> Chris Cassel: Bill press.

>>Bill Press: Thanks. Thanks for very interesting presentations. It seems to me that an enabler of a lot of the financial frauds is the way the financial system has pressed towards more and more rapid final confirmation of transactions, because the buyer with the credit card by phone or on the Web wants to know immediately that they've bought the goods, the merchant wants immediate confirmation, but I wonder here if there's a niche to insert delays, or if there could be a niche to insert delays to encourage, for example, banks to issue credit cards which don't clear immediately which clear only an hour later or maybe even four hours later. Merchants would have to decide whether they wanted to accept that kind of credit card, but it seems to me, anything that expanded the time which would have to be done within the financial system would then open up a whole bunch of entrepreneurial niches for how that time could be used, you know, checking transactions or informing people or something like that. Is there any chance that the financial system could be movable in this way, or are we just stuck with the way it's evolved into this instantaneous final confirmation?

>>Kai Stinchcombe. It's an interesting question. One of the things we would love to be able to do, for example, is, you know, sort of get in touch with the daughter and sort of, you know, in gray area situations, you know, the practical challenge is if you're at the cash register and maybe the daughter's out of cell service, you know, you're not going to be standing there for 45 minutes or whatever while the, you know, but

>>Unidentified Speaker: Is that the most common scenario, or is the most common scenario someone ordering by telephone or by the Web?

>>Kai Stinchcombe: The charges—basically the only in person charges we block are sometimes ATM's where there's sort of a suspicious cash transaction or there's, you know, a couple in person scams with door to door delivery or, you know, fake doctors selling custom hearing aids. Eight thousand dollars. So, you know, I mean, actually, I think the financial system for what it's worth is actually pretty good at those delays. For example, you know, Visa actually only clears overnight for 30, sometimes 90 days you have the right to dispute transactions. ACH is very reversible, actually, and it's more that those protections are tailored today in the interest of the financial system rather than in the interest of the consumer. And so, for example, you know, there's obviously sort of, you know, more hazard problems in allowing people to say oh, I don't want to pay for that thing that I had the credit card transaction on, but you actually sort of do have that right in the financial system today. So, you know, it's an interesting set of questions, but I don't know that that's where I would mostly focus.

>>Chris Cassel: I just need to ask Eric, at the time we have, do we have public comment.

>>Eric Lander: We do. We are coming up on the time? How many questions? Given that there are no public comments, we may eat into the public comments session without concern. Carry on.

>>Chris Cassel: Okay. Then I'll turn over to Wanda.

>>Wanda Austin: Thank you. My question is maybe another business opportunity for you because, like you, I think there are a lot of early career people who are struggling with this problem of, you know, what can I do to help, and it's very frustrating. So, it would seem to me that maybe there's an app that could be developed that would be a dashboard that says, you know, how is Mom doing today, and what are the things that you might want to have visually transmitted, you know, on a regular basis, to just sort of be an indication that something's gone awry, sort of like a trending, because these things don't tend to happen on a dime, and as you say, if you're just mildly cognitively impaired you don't want to jump in and say, you know, you can't buy a dress today. Have you all thought about, you know, is there some way to use the technology to, in fact, create this group of trusted friends who are sort of creating a bubble around this impaired senior?

>>Seth Sternberg: Yeah. So, there are actually quite a number of apps that are designed to kind of be family organizing caregiver apps, I would say, and I think there have been, none of this has achieved scale. I think there are two reasons. One is by and large they have found it difficult to raise sufficient investment dollars. So, like I said, investors have tended to shy away from this space. I hope that starts to change. But that's kind of problem No. 1. Problem No. 2 is an app like that, believe it or not, does kind of fall into the straight consumer communications category, and those things can be very hard to nail the perfect user experience and so they tend to be kind of very binary. They either, like, crush it, or nothing happens with them, and so, I think that a lot of people are trying, and at some point we'll probably see someone crush it, but it's not as straightforward as you would imagine.

>>Kai Stinchcombe: You know, two things you sort of generally related to that. You know, one of the things, Chris, that you brought up is, you know, the sort of check box on the driver's license, you know, is there a way to sort of make it easy to opt in to certain levels of protection. You know, I think that that might be one of the sort of best things that government can do actually is not the policy role but the microphone, right, that, you know, even just telling people by the way, you will grow old. I mean that's actually like a revolutionary message, and if you're willing to add—

>>Chris Cassel: You think the government needs to be the one to deliver that message.

>>Kai Stinchcombe: Anyone. If you guys can persuade celebrities to do it, the Hollywood council on aging and technology, you know, we'll go there next, right? But, you know, I mean, and, you know, I mean saying actually you will die also, I mean, man, you know, and so thinking about putting into place, you know, whether it's technology or whether it's whatever, you think about how people plan to go to college, right? You're going to stay at college for four years and you see people in the cribs wearing college T shirts and then, you know, for technology around aging and place or retirement homes it's like oh my God, Mom's old, you know? But you're not looking for years at retirement homes or for years at caregivers and stuff like that, it's like you go home for Thanksgiving, oh my goodness when did this happen, and so, I think that a big part of the underpinning for adoption of any of these things is going to be around making it not an emergency but an expected thing and maybe even something that, you know, maybe you don't look forward to aging but you look forward to doing it better than what happened if you didn't plan around it. An observation about investment as long as I've got the mic in my hand, it has been remarkable to me also, you know, that people, you know, it's like you're meeting with an investor and they get this wide eyed look, you know, like they're Steve Jobs, right, this may be a lot bigger than you think, because you can use this for teenagers also. You're like, you know, teenagers don't spend any money and there's not that many of them actually, you know? Look at how much money is spent by teenagers versus people with dementia, I mean dementia, you know, it's around the block different and yet there is that perception.

>>Seth Sternberg: Yeah, I'll just add real quick we did quick math I think 2014 total VC funding that actually was directed at seniors was .7 percent of total VC funding in 2014. That's our quick math looking at studies and putting a bunch of stuff together.

>>Christine Cassel: Michael, you're next.

>>Michael McQuade: Seth, you made comments about sort of about two things, about improving the sort of effectiveness of the caregivers so one related to sort of the dating service, matching service, and then a big issue around pay, where else in the Honor model do you look at sort of actual qualifications and, you know, sort of bonded capability of the care giver process?

>>Seth Sternberg: Yeah, great question. So, the approach that we've taken is if you offer people the ability to earn substantially more and you can do that because of efficiencies in technology then you get a very wide funnel of people who want to be on your platform, which is great. Then we do very, very strict background checking. So, we have kind of two systems that kind of decide who gets let on. The punch line is only 5 percent make it through. One part is a kind of

security background check, right? So everything from drug screening to, you know, credential checks to felony, misdemeanor when we can do it, driving record, the whole 9 yards. You know, we are not a transactional business. You know, ne drive with someone who's bad is kind of like okay but us sending someone into your home who's not great is pretty terrible. So, we have to be very careful on screening, and then, we have a small office in Concord, California, right? We opened it up because we wanted to be closer to the care post we are on boarding in the East Bay. So, we see everyone face to face and we do a personality assessment. We do a skills assessment as interviews and then we also actually hand them a cell phone. So, we literally hand them a cell phone and say there's a quiz on the cell phone find the quiz and take it. Now, it's a CNA exam that's on the phone so it tests for do they have the skills of a CNA but also tests for can they find the quiz on the phone and take it on a phone and some people can't, and so, we end up with accepting 5 percent. If you do the math, we have a real supply problem, right, but I think we can overcome that because if you make this a profession, right, and you create a path for people, because there are a lot of people who want to care for people and if you make this a real path for people I think you can expand pretty dramatically the pool for people who want to be amazing care professionals for our parents.

>>Chis Cassel: Rosina.

>>Rosina Bierbaum: Michael started down the path I wanted to ask, so let me ask if I was going to ask about your training and certification of your care workers and everything that you said could go wrong I have personally experienced in the last few years with both my parents. But I thought maybe now to turn from what Michael asked to do you have suggestions for us on what recommendations for caregivers because, as you were saying, and as Chris said, many of these caregivers have pretty low levels of training, and yet, you're talking about increasingly sophisticated care helping with the social network and all that and so it seems like it's either, you know, you have a caregiver or you have to jump to an LPN or RN or doctor, and so, do you have thoughts about how there could be more graduated help or super caregivers or, you know, as we think about the system?

>>Seth Sternberg: Yeah. So, it's actually interesting. We have found that the No. 1 correlate with who does make it through our screening process is education and it's actually level of certification. So, it's very clear at least the way we screen for people that their training and their education really matters a lot. There are a fair number, you know, like The Domestic Workers Council, Caring Across Generations, there are a whole number of organizations that are rather focused on training for home care workers, and I think all of those organizations need more support. You know, we have this interesting challenge in this country. In 15 years, is my guess, if your profession currently is to drive an automobile, which is one of the top, if not the top

profession in the country, you won't have a job. That's a lot of people, and so, you know, we've historically gone through re-balancing of our workforce. We transitioned from, you know, Labor & Industry to more services economy. We're going to have another big transition, but we're going to need a lot of people who are able to care for other people with needs, partially because of sub replacement fertility, partially because urbanization, partially because of the growing senior population. So if we wanted to—It's not even getting ahead of it. There are 2 million paid care pros today, according to the BLS. That's massive. 2 million. That's almost 1 percent of the U.S. population in total, counting kids, alright, that are paid care pros. The guess is that we are going to need between one and two and a half million more over the next ten years. Wow, right? So, if the need is that great, I think at some level, you can measure a society by how well it cares for its elders, and so, we might want to really look at, you know, fixing two problems. It's kind of, you know, what's it called, two birds in the hand of whatever, you simultaneously fix a real kind of labor shortage/where will the labor go issue that at the same time you help our seniors by enabling more training for care professionals.

>>Eric Lander: Okay. I think we have—Wanda's flag is not—okay, that's residual. Excellent. Well, let me thank both Seth and Kai. I think, I think these are enormously stimulating presentations to think about, just all the opportunities to greatly increase the quality of care that we give. I think you've really gotten us thinking, and there are probably a wide number of areas where you could probably apply technology in this way. I'm very much looking forward to Chris and the group that she's assembled and the report that they are going to work on to look at just a huge range of potential wins for the American people there. So, let me thank the speakers. Let me thank Chris for organizing this. I'm going to turn back to John if he has any parting words to close this meeting.

>>John Holdren: Well, my initial parting words are to our last two speakers. I think you guys are fantastic. I think the work that you've been doing is just uplifting in its focus, in its commitment, and in its effect. So, I thank you for that on behalf of all of us. That does bring our meeting to an appropriate close on an extremely uplifting note. I again thank the members of PCAST, the OSTP Executive Office for PCAST led by Marjory Blumenthal and supported by Ashley Predith and Diana Pankevich and Jennifer Michael and I thank the audience, the wider audience, our folks from the wider science and technology community both in the room and on the Web. Another terrific PCAST meeting. We look forward to seeing you next time.