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PARTICIPANTS:

The Role of Higher Education:

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Issues in Innovation:

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P R O C E E D I N G S

MR. WEST: Our last panel focused on public policy, and our White House advisors talked about the new initiatives that are being undertaken, but we know that much of the innovation actually takes place outside of government. And so our next panel is going to look at the role of higher education and innovation, and as part of this I am very delighted to welcome my old friend and former president from Brown University, Ruth Simmons.

Ruth is one of the most visionary leaders in higher education. Before coming to Brown she was president of Smith College, the largest women's college in America. She is a rare leader who can look around the corner and see where things are headed 5 and 10 years down the road. She is smart, thoughtful, and well respected all around the country.

She is the recipient of many honors, including a Fulbright Fellowship, the President's Award from the United Negro College Fund, the Fulbright Lifetime Achievement Medal, and the Eleanor Roosevelt Val-Kill Medal. And I should also point out over the last week she came down with laryngitis. Brown has its commencement last weekend, and you have to talk like for about three days in a row, and as a part of that she is now recovering I am pleased to report. But we're delighted that Ruth is here with us today. (Applause)

DR. SIMMONS: Thank you. Thank you, Darrell.

Good morning, everybody. Is it still morning? Yes. Good morning, everybody. Well, I have to say that I am really pleased to be here. I'm especially pleased to be here at the invitation of Darrell West because I can officially in this forum forgive him for leaving us at Brown. He was one of our most important faculty members at Brown and had a tremendous -- made a tremendous difference on campus. So I'm glad to see you in your milieu and to know that this is working so well for you.

I am delighted to see the Taubmans. Al and Judy, you have made such a difference in so many areas across the country. To be here at the inauguration of this effort is a great pleasure for me, understanding our friendship and the ways in which you have made such a tremendous difference.

I do want to say that when we think about the role of education in improving science and technology innovation in the United States, I have to comment that the last panel is, I think, an enormously important evidence of why the United States even today, lagging as we do in the education of the number of scientists and technologists, why we continue to do well. And that is because the difference really is governance. That's why this program is so important.

I have an opportunity to talk with policymakers in many different countries around the world about this issue, and I have to say they don't have the forums that we have for this kind of discussion. I especially like the way that the panel, the last panel tried to explain to us the strategy that they employ and the way that they go about engaging the communities, the various communities in debating the issues, and I especially liked the fact that they're debating the issues.

You know, it used to be -- forgive me, those of you who are scientists and the enrollment used to be very hard to actually understand what scientists and computer sciences were actually saying and the fact that they were so articulate and doing so well impressed me. I have to say that I was really stunned. I was going to the University of Washington to give a commencement speech a few years ago, and I noticed that there was a young man at the carousel when I was picking up my bags staring at me, and he finally got up the nerve to come up to me and say, President Simmons, I'm so glad to meet you.

And I said, oh, are you a Brown student?

He said, yes, I am. I'm on my way to the University of Washington to see my sister who's graduating, and I understand you're going to be giving the commencement address there. And I'm very excited to hear you because this is the first time I will have heard you. I'm sure he didn't use the pluperfect tense, but he said something like, it'll be the first time I will have a chance to hear you.

So I said, very puzzled, well, how could that be? You're a student at Brown. I'm talking to students all the time. How could you not have heard me before?

And he said, very succinctly and very seriously, well, I'm a computer science major.

So, John, how do you like that? So they talk to each other, and it's wonderful to see them talking to us.

Now, I'm going to aim a little bit wider than higher education in my comment this morning because I think the signs that the United States may be losing its innovative edge in the coming decades are apparent. But before we ask what to do, we should also look at the same time at why we are slipping and why we have slipped. And what is it that we in education can do to address the apparently waning interests among Americans in studying science and technology fields?

First of all, as we work with young people it's pretty clear that we have to find ways of capturing the interest and support of young scientists who are the most promising of their generation. Mentoring those identified as the best potential scientists is absolutely essential, and while this is something that depends on the quality of science education, of course, in middle school and high school, I'm focusing on the university part of this, and what should universities be doing to address the issue of attracting these young people to stem fields.

First of all, I think that universities can do an enormous amount by addressing lacuna of that come from inadequate education in the K through 12 sequence. We can do that more by offering programs to the most promising students. Federal and foundation grants, of course, often support outreach to K through 12, but it's really on, I think, too limited a basis. Should a larger concerted program by universities acting together to educate many, many tens of thousands of high school students each year be developed and coordinated? And how would we go about doing that, given the independence of all of our institutions, how would be build such a concerted program?

Of course, many of you probably benefited from a program like this in high school; I know I did. I had the opportunity to go to a math-intensive summer program, and coming from the inner city in Houston and being able to go to a university campus in the summer to do that was a pivotal experience of my young life. It encouraged me to think about going on to college and, certainly, studying more science and mathematics.

But we need a more consistent model than is afforded, I believe, by individual institutions deciding unilaterally to engage in this kind of program. And you'll see from some of the other suggestions that I have that I believe that, in fact, this is probably a very systemic program in higher education with regard to addressing this problem.

Brown faculty participate in a variety of K through 12 programs to enrich science teaching in our K through 12 schools in Providence. For example, graduate students in geology work with elementary school children on science projects and teachers have training opportunities in the faculty labs. And this goes on in many, many different areas of the campus.

Secondly, I think that we need to address the curriculum. University science curricula too often serves as a deterrent to students who desire to focus on the sciences. Now, I know this is a very sticky issue for university presidents to address because there is nothing more sacred to scientists and mathematicians and engineers than their curricula. After all, they were trained a certain way, they were educated a certain way, and what was good for them must surely be good for their students. But the fact is, I think, we are at a very different moment in education, and we need to look very directly at whether or not the curricula that exists today are really the right curricula for the kind of future that we're facing.

There's one issue that I've long advocated is a particular problem for us. It's strange: I was advocating this 30 years ago; it hasn't changed much in the last 30 years, so it shows you my effectiveness -- I'm not having much luck at all -- the weeding out process that takes place often in math, science, and engineering. Is that really the way to capture the interest of all of the students out there who might want to major in these fields? I have long doubted that it is, and I still doubt today whether or not this is good strategy.

To what extent do students develop scientific interests in college without the needed high school preparation? If we rely on the foundation having been built by the time students reach grade 9, we again weed out a lot of potential scientists by cutting off the avenue for students to study science and to excel and innovate in these fields.

What of students whose high school don't even offer the requisite math level or physics, or other courses needed for advanced science and technology? Many, many schools do not.

I had a student who came to me at Brown who had been -- and he's such an extraordinary student, he had been admitted, and he was very embarrassed to say, you know, I really don't think that I can major in engineering because I really haven't had the right courses. Our faculty took him and worked with him, individually, to get him to the point where he could major in the field that he wanted. But how often can we actually do that on a one-on-one basis? It's very hard to do.

With respect to engineering, Dominico Grasso and David Bartinelli have said that American higher education is in an unusual position to create a new kind of engineer, one for the 21st century. They argue that the new engineer has a kind of integrative background. They are able to indulge in holistic thinking. Their point is that this kind of integrated and a holistic thinking does not rest with increasing the number of the global engineering workforce, but rather, with engineers who go beyond solving problems through the application of math and science, which is the classic definition of engineering, solving math and science problems.

Further, the traditional engineering education model may continue to lose students unless we formulate a new engineering approach that is not based on manufacturing needs. If there's ever any evidence of there to hear the technologists talk in the previous panel about what the future is going to look like and try to relate that to the traditional engineering fields, and particularly curricula that we're familiar with, and you begin to see where that gap is.

The overhaul of engineering education is long overdue in my view, and universities that move to address this problem will be unleashing new possibilities for tomorrow's engineers as problem-definers as well as problem-solvers.

Now, one of the things that I did as president of Smith was to create an engineering program at a women's college. And part of the reason I did that was not simply to offer engineering to my students at Smith at the time but also to take advantage of the opportunity to innovate in the curriculum and to try to build an engineering program that really did something very different. Because what I posited from my own experience at Princeton and at Smith was that engineering loses a lot of students because there is a widening gap between what students today want, how they think, how they wish to innovate, and what the curricula actually offer them.

So to try to narrow that gap and to design an effective curriculum that will also retain and attract students, particularly nontraditional students -- I'll come back to that later -- was very important to do. And I had the help of the accrediting agency, ABAT, to try to do that, because ABAT has been saying for years that the engineering curriculum today is not needed for the kind of engineering that we require in the future. And yet, it's very difficult to get universities to focus on something else.

Should we just focus on more financial aid directed to areas of national need? This is very controversial, but if the problem that we're having is dire enough, should we not contemplate at least breaking the paradigm that we currently employ? And what is that? Well, students in this country have virtually unlimited choice for the most part. They can go in their financial aid, is distinct from their area of focus.

We cannot compete with countries where they demand that students study in certain fields, and so if you're in most countries in the rest of the world and you're a student, you apply to a certain discipline, entry into a university in a certain discipline. If you are in this country, you apply to a university; then you have a choice. You can major in engineering or you can major in my favorite subject which is French. You have a choice, and you can move back and forth between -- but is that going to be realistic in the future? Should we organize financial aid around specific subjects and provide incentives for students to study these fields?

And, by the way, one fantastic thing that I see is that the most able students are capable of majoring in any field. They can do computer science, they can do engineering, they can do mathematics, and they can do many science fields. It is their choice. It's not that they can't do it, they choose not to. We have to look at the reasons they're choosing not to.

We have to provide more information to the public about the discoveries in science and technology. I was speaking to the group of women in engineering, and they asked: What could we do to encourage more women to study engineering?

And my simple answer to that is, well, you can be more excited about engineering yourselves. You do have to communicate to young people the excitement of a field. That's what enables them to visualize their own lives, their own careers, by understanding the excitement that you have for your profession. And so we don't see many examples of physicists who are really hip, really glamorous, really able to command the attention of young people today. Not many -- or any. So we have to get those images before young people.

Now, somebody mentioned in the last session this very important question and that is minority students and women in these fields. We need more aggressive efforts to engage minority students in science and engineering. The demography of the United States today demands a different approach if we're ever going to continue to excel in innovative research. The overall enrollment of high school graduates and college has grown significantly since the '80s. Thank goodness for that. The major change in the makeup of college enrollment since then is the proportion of women and minorities in high education.

I don't understand why people don't get that. That is a major change in the last 40 years. In 2007, according to the National Center on Education Statistics there were 10,432,000 women in degree-granting colleges compared with 7,816,00 men.

Since 1984, the number of women in graduate schools has also exceeded the number of males. The proportion of students who are minorities has increased to 32 percent from 15 percent in 1976. So we identified decades ago the disparate interest in performance of women and minorities in science and technology, and while the profile of women's participation has changed somewhat in that period and is steadily improving, minorities still lag behind women. The holistic and inclusive approach may be the key to attracting an even greater diversity of students to science and engineering.

A significant number of minority students -- significant number of minority scientists and engineers are nurtured in smaller, more inclusive environments. Take the example of Xavier College in New Orleans, the number of African-American scientists produced by the sole college at the advanced level is telling, I think. And so again, programs that weed students out versus programs that nurture their continuation.

I think that the U.S. must remain open to attracting the best and brightest inventors, scientists, and innovators from around the world. This has been a problem for us recently, as all of you know. This means access in all categories of visa applicants: undergraduate students, graduate and professional students, faculty, researchers. We have to keep the flow of innovators and scientists coming into the country.

As you know, many of the most renowned scientists from our past have been immigrants to this country. We recently had a von Neumann seminar on campus, and Marina von

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We recently had a von Neumann seminar on campus, and Marina von Neumann, the only child of von Neumann, was on campus, and we were discussing this issue. And her father was an extraordinary person in terms of the innovation that he led in this country, coming here as an immigrant and being welcomed as an immigrant and being able to create what he did as one of the founding members of the Institute for Advanced Study in Princeton is a remarkable thing.

We should never forget that we have to continue to do that if we're going to remain competitive. But attracting such scholars may become increasingly more difficult as political stability, research culture and academic freedom in their home countries improve. More recently, the outflow to other countries by leading nationalized U.S. scientists is a sign that our innovators are willing to consider returning to their homelands for less monetary gain, where there's a significant amount of support for their research. So a clear national strategy and commitment to funding is paramount to retaining these individuals.

Just to be controversial, my Vice President for Public Affairs is here, and she warned me right before I started not to be controversial, but here it is. Okay.

(Laughter.)

DR. SIMMONS: It's very difficult to break the current paradigm, but I think somehow with a large number of institutions, not all of the highest quality, being provided funding through the federal research process is ultimately perhaps going to be a problem for us as. As more universities expand their mission to research university status, resources could become even more diluted. Should this be addressed at the policy level?

I've been advocating more systematic sharing of resources across universities for at least 30 years, but I found this again to be very difficult as it rarely works to the financial advantage of institutions. Some funders insist on joint proposals. The shared institutional efforts tend, however, not to extend significantly beyond the narrow bounds of this kind of effort.

Incentivizing cooperation on a much broader scale could allow for more rapid development of new ideas. The Science Coalition Report linked 100 companies to federally funded university-based research, including Genentech, Google, Cisco, SAS, TomoTherapy and so on. On our campus, such research funding has led to breakthroughs in brain science, and the development of a range of medical devices and therapies.

Policy should enable these developments rather than choke off their development. The calls for limiting the bureaucracy that discourages scientists from seeking funding are enormous. These calls are enormously important and should be heeded. Scientists complain of the bureaucratic burden associated with research today. Some wonder why are they bothering, actually. And some going to other countries recognize that by going, repatriating, they can dispense with the bureaucratic burden on their research.

Universities are under increasing pressure from agencies and Congress to comply with burdensome changes in policies and guidelines. This is something that we are trying to mitigate, but it's very, very difficult to do.

The competitive global environment is something we should pay a lot of attention to. Universities in the developing world are rapidly developing policies that allow for increased competition with U.S. universities. They are restructuring compensation, increasing required output for faculty and researchers, and building state-of-the-art facilities to support advances in research.

It's chilling every time I go to China and India to hear what they are doing contrasted with what we are now doing. The liberalization of education in China and India are examples of the aggressive efforts to bring American-style creativity to large rote-based systems. And if you think we're having difficulties with innovation today, just wait until they've reformed their systems. Just wait.

So what are they doing? I was recently in India, meeting in Delhi with their equivalent of a Better Business Council, and the questions they had really had to do with: We've got a rote system. How do we deconstruct the system and rebuild it on the American model? We want innovation. We want scientific advances. How can we do this?

China is doing exactly the same thing -- building. There's a new initiative in China that's coming -- I think it's not announced yet, I'm not sure -- where the Chinese government is sponsoring a certain number of institutions that are innovation directed, and they are being built on the American style. I met with one of the university presidents a couple of weeks ago, who is in charge of doing one of these institutions, and his whole approach is to bring the liberal arts tradition to this university, so that they can build more innovative work.

These are some ideas that I think will make a difference if we can consolidate our efforts. I do believe that we have the capacity in this country if we take radically different measures, to increase significantly the number of students in STEM fields. It would take the mandate from the government to have universities redesign how we are admitting students, redesign how we are designing our curricula, in order to facilitate retaining more students, bringing more students into STEM fields and retaining more students in STEM fields. And I think short of that, we will continue to go along at very modest levels, and we will be overwhelmed by that tsunami out there which is truly a tsunami.

Recently, I was visiting IIT Bombay, and they were on a very aggressive building program, new buildings everywhere. When I inquired what was going on, they said the government had mandated that every IIT must double its enrollment within a very short period of time. That's how massive the effort is in India. It is massive similarly in China, and there will be other countries, like Brazil that is certainly growing in economic strength and beginning to consider what they need to do. So this is coming to us, as I say, like a tsunami.

I just want to give you an example of one person, and then I'll finish, on the Brown campus that is indicative of what can happen to encourage students to remain in science and technology. We have a minority faculty member at Brown who has received a presidential early career award, and he has an enormous number of honors as a young scientist. I'm not going to give his name because I don't want him to be poached, like Darrell was.

(Laughter.)

DR. SIMMONS: This young man was educated in a small college -- educated, mentored and nurtured in a small college before going on to graduate school. In discussing his success, he mentions the mentors he has had as crucial factors in his career. He has been working at the edge of a number of fields, and he leads one of our research initiatives. In a recent interview, he said, we need as many great minds as possible.

Fundamentally, this issue of innovation is about that. We need as many great minds as possible. As the lady said earlier, with all the women and minorities entering college today, who knows if that number will grow? If we don't begin to focus on a curriculum that appeals to this new demography, if we don't begin to focus on structuring our financial aid in order to draw them into these fields, if we don't begin to think about across universities, linking arms and committing ourselves to doubling the number of STEM majors in a finite, reasonable period of time, we are not going to have a chance of competing. And so that would be my thoughts.

Echoing this young man's thoughts, I would say we need to focus on developing more of these great minds, with focused and concerted efforts across institutions.

I'll stop there, and thank you.

(Applause.)

MR. ANTHOLIS: Thank you, Ruth. We really appreciate your honesty in tackling a number of tough issues.

But I'm not sure what is going to be more controversial out of her remarks. She called for the need to break current paradigms and redesign curricula, but then she also proclaimed that physicists are not hip.

(Laughter.)

MR. ANTHOLIS: Now I know some of those Brown University physicists. It's going to be hard for them not to take that comment personally. But we do appreciate your thoughtfulness in addressing all of these issues.

We're also please to welcome Eva Feldman with us. Eva is one of the most distinguished scientists in America. She is the Russell DeJong Professor of Neurology at the University of Michigan. At Michigan, she also directs the A. Alfred Taubman Medical Research Institute. So you're starting to see the theme of this forum here.

I talked with her yesterday. She is doing amazing work on stem cells and Lou Gehrig's Disease in particular. So please join me in welcoming Dr. Feldman.

DR. FELDMAN: Thank you very much. I really have the pleasure today of discussing with you a building block of medical innovation, and that's the A. Alfred Taubman Medical Research Institute.

So I'd like to begin by showing you what the mission of our institute is. It's to provide the University of Michigan's finest medical scientists -- so the minds, as Dr. Simmons just said -- the freedom, resources and collaborative environment they need to push the boundaries of medical discovery, to produce breakthroughs and cures and treatment of disease, and ultimately to alleviate human suffering. Truly, as you will see, I think a building block of medical innovation.

This institute was launched in the Fall of 2007 at the University of Michigan Medical School and was funded by a very generous endowment from A. Alfred Taubman, the sponsor of today's forum -- a true entrepreneurial spirit of science, a true philanthropist who understands that what scientists require for medical innovation is to have funds that are unrestricted, that will allow them to begin to broach the major questions in medicine. And he's here today with his absolutely wonderful wife, Judy and his daughter, Gayle Kalisman who chairs the Taubman Foundation.

As I indicated, the monies that the Taubman Institute has used is funding minds, again as President Simmons said, minds with ideas for medical innovation, with the idea that we will drive medical research and drive medicine towards cures.

The institute supports physician scientists with active clinical practices. I'm an example of a physician scientist. I spend three half-days a week seeing patients and the other seven half-days a week, which is how we divide our world; I am actively in the laboratory, doing science. So we are the foundation of this institute, and we are driven to be innovators really by our patients. Our patients give to us the passion to understand disease and to develop new treatments in our laboratory then to carry forward.

We fund, again in the institute, a wide variety of diseases, and we invest in the person and the idea, and we do concentrate on very innovative translational research. We provide funding; also I think it's important, for the very difficult last steps that innovators encompass when they want to take an idea from the bench to the patient.

So let me tell you a little bit about the success of this approach since in the last three years this institute, the scholars in this institute, have produced 122 publications in leading scientific journals. But more importantly than the publication record is that the risk, the challenge has been met, and we now have five clinical trials due to the unrestricted funding of the institute.

Three clinical trials are targeting human cancer stem cells. Indeed, the first clinical trial targeting cancer stem cells in breast cancer is being done via the institute by Dr. Max Wicha, the director of our cancer center. And if Max was here, he would tell you it was that investment allowing him to innovate, take that risk and challenge as a clinician scientist. It wasn't a sure bet at all, but that investment, that risk, that led to these clinical trials.

Dr. Valerie Castle, who is Chair of Pediatrics, is also in the Taubman Institute. She is a Taubman Scholar. She took the high risk of trying to treat resistant childhood cancer neuroblastoma with a new therapy, and the risk won, and she now has the first clinical trial looking at chemotherapy-resistant neuroblastoma.

And I would like to tell you today about my own clinical trial, and that is the first human clinical trial of direct intraspinal injection of stem cells in Lou Gehrig's Disease. I'd like to tell you before I begin that every piece of this story was funded by A. Alfred Taubman and that without, again, the entrepreneurial spirit of wanting to seek out innovative high-risk, high-reward medical research what I'm going to show you today would not have been possible.

So here is Lou Gehrig. He, of course, was a very famous baseball player in the 1930s and actually probably considered to be one of the best baseball players ever. But he noticed in the thirties, in the mid-thirties he had a spectacular year, and then the next year, as you can see, his frustration; his batting average began to decline. Indeed, he was getting a lot of bad press, and this is the last time he ever swung a bat, and he took himself out of the game at this point. He went to the Mayo Clinic where he was diagnosed by a University of Michigan trained physician with a disease that now carries his name, Lou Gehrig's Disease.

As a sideline, I will tell you that the transfer of information, medical information between University of Michigan and Mayo Clinic, which happens frequently, has not really changed except for the fax machine, since the 1930s -- so, a point that we discussed earlier.

Here, I thought you would find of interest. Here's the analysis of Mr. Gehrig's batting averages on a week-by-week basis. So you can see how well he did in 1936 and 1937, and here is his average in 1938 when he pulled himself out of the game.

And I'd like you to notice and look at his arms. You can see the profound wasting that he had in his arms due to the disease that carries his name.

So what is this disease? Well, what happens in this disease is the large nerve cells in the brain and spinal cord degenerate. What I'd like you to do is pretend that I have just cut myself in half here, and you're looking down on my spinal cord which is shown there in the upper right-hand panel, and you can see the large purple cells there with the arrows. Those are the large motor neurons in the spinal cord and the brain.

What happens in this disorder is that they slowly degenerate. Because those large nerve cells then have the nerves that connect to your muscles, the muscles then lose their ability to move. Eventually, people lose their ability to speak, to swallow, to breathe, and they eventually die.

Currently, the longevity of an individual diagnosed with Lou Gehrig's Disease today is no different than it was the day Lou Gehrig was diagnosed.

So our approach was to begin to try to use the new idea of stem cells for cell replacement therapy in Lou Gehrig's disease, and we developed this with a colleague, a surgeon, Dr. Martin Marsala. Here, I'd like to show you our idea.

So here now is the normal spinal cord here, and then in the middle you see a spinal cord, a depiction of a spinal cord with Lou Gehrig's Disease, with all the diseased cells.

Our idea was then to use cell grafting of stem cells, a new technology to directly place stem cells into the spinal cord of a diseased patient. But of course we could not begin with a patient. So we began with an animal model of Lou Gehrig's Disease, which we helped developed, and that is the Lou Gehrig's rat. We took the human gene for ALS. Ten percent of people who have this disease have an inherited form. It was placed into a rat, and the rat actually duplicates the human disease.

What I'd like to show you here then is the approach where we remove the bones from the spinal cord, so we have a clear vision of the spinal cord, the rat's spinal cord. Here, you can see the depiction where we would then inject stem cells directly into the spinal cord.

What we found -- and here's an example where we label the stem cells green -- an innovative idea to see how they would grow in the spinal cord. Here, you see the beautiful growth of these green stem cells in a spinal cord of a diseased animal, and indeed what you can see is that these green stem cells become nerve cells. They begin to put out the beautiful projections of the nerves. And what they do is they attach to the diseased -- those diseased nerve cells in the spinal cord, and allow them to remain healthy.

So, we're extremely excited about these results because we were able to show that direct stem cell injection in an animal model, allowed for preservation of function in the animal model. But, of course, we can't go from a rat to man, so we needed to use science and technology to develop a way to approach a larger mammal and we did that using the mini pig. And what we did is we developed a device as a group using, really, engineering to develop a device to stabilize the spinal cord. And in 3A what we're seeing here -- what you're seeing here is the device we developed that stabilized the spinal cord of a larger mammal, in this case a pig. And then we injected stem cells labeled with ferritin, again using technology and engineering, so that we could visualize the stem cells using imaging, MRI. And so what you see here in B is an MRI image, which you can also see in A, of the ferritin-labeled stem cells. So they survived in the spinal cord of a large mammal. And what was also very important is that not only do these stem cells survive, and they actually look quite similar to those stem cells I showed you from the rat, but that the pig actually did very well with the surgery. And here's an example of one of the 40 pigs that we needed to do in order to take this technology into man. And this is 6 hours after surgery and the thing the pig is most interested in is eating because this pig had to be what we call NBO, nothing by mouth, before his surgery.

This then led to -- from an idea to a rat to a pig to man. And the A. Alfred Taubman Medical Research Institute in collaboration with a small biotech company, Neural Stem, and our colleagues at Emery University, have begun the first FDA Phase I clinical trial using stem cells in the treatment of Lou Gehrig's disease. Initially, the patients we are entering had very severe weakness and they continue to be relatively severely weak. Progressively, as we enter patients in this trial, they are going to be less affected. Initially, we did unilateral injections of stem cells on one side of the spinal cord. We are going to proceed to do bilateral injections.

And as you can see then, on the diagram to your left, you see really a depiction of our idea of direct injection of stem cells into the spinal cord. So, what we had done in the animal model, and we had shown safety in the large mammal, it was now time to take it to man.

So in my mind, this is really the medical innovation. This is taking an idea, as a clinician scientist, from what I did in my laboratory to a patient.

In order to know where to exactly inject the stem cells, we needed to call upon our radiology colleagues and our engineering colleagues, and we've used MRI to locate the exact area. I apologize that I don't have a functioning pointer so I'm going to step away for a minute because I want to show you something. And I can project, I have three teenagers.

So, I want you to see that, again, this would be if I was standing like this -- excuse me, like this, towards you, okay, so this is your vertebral column and the white here is your cerebrospinal fluid. That's the fluid that bathes the spinal cord, but the black that you see there, that is actually your spinal cord. This is exactly how you or I would look. So what we need to do then is actually get the dimensions of the spinal cord in man so that we can properly inject.

And here you see now a cross-section of that where, again, we've now measured the dimensions of the cord and, again, the dark area -- the dark area here, then, is where we will inject the spinal stem cells. But again, this was an innovation in order to use MRI to measure for injection.

Here is a picture taken in the operating room of a patient, and I'm going to actually show you a video of the patient. The surgeon here is Dr. Nicholas Boulas. He is the one wearing the M, for Michigan, cap. He is a neurosurgeon trained at the University of Michigan, who then worked in my laboratory as a fellow. He is an active clinician scientist, also, so -- and he's been very involved in working with the engineers to develop the correct stabilizing device needed for this surgery.

And here is a picture of Dr. Nick Boulas, and our other colleague at Emery

University is Dr. John Glass. Why Emery and not Michigan? Because Dr. Boulas currently is practicing at Emery and he was the surgeon that trained with me, that helped me develop these technologies, and I wanted his surgical hands to be the hands that did the first patients. And he also is the person who for the Taubman Institute we did the pig work with.

So, here I'd like to actually show you what the surgery looks like. So, this is the patient's spinal cord -- and again, I'm going to step away from the microphone -- so this is actually the spinal cord now. We've removed the bones. This is like a large blood vessel in front of the spinal cord. The silver on the side is the device we've developed to stabilize the spinal cord because as we're injecting, you know, the patient is breathing so we need to stabilize the spinal cord. Here is also a device we developed, and that was a -- we developed a rigid injector with a very thing stylus tube inside so we could find the correct -- again, using MRI -- the correct place to place our stem cells, and then we put the very thin stylus into the spinal cord.

So, this is the actual -- I took this movie in the operating room to share with you. What I'd like to do now is share with you the patient.

(Video played)

MS. FELDMAN: So, I want to thank you today for sharing with me what I think is really a building block of medical innovation. And as I was hearing today about President Obama's STEM Initiative. I think this is actually a very good example, stem, of course, for stem cell, but also, S for science, the science of stem cells, again funded by the entrepreneurial, high-risk, high-reward investment that is mandatory if we're going to have medical innovation. And again, I think the investment needs to be, in part, in clinician scientists who have the passion to take their discoveries into the clinic. For the T, in terms of technology, we had to develop the technology to do the intraspinal injections. E, for engineering, we had to engineer that platform that was pivotal in allowing us to do these injections in man. And M, for me, M, I think, is more mission, medicine, and I'll have to be honest, Michigan. Thank you so much. (Applause)

MR. WEST: Well, Eva, that was an amazing presentation, just kind of seeing the progress that that patient was able to make and the amazing way in which you were able to present that. I mean, that really is extraordinary, so our hats off to you for that. And it's interesting just watching that both from a science standpoint as well as from a policy standpoint. The science, obviously, is starting to progress in a very impressive manner, but then we have all these policy issues associated with that type of research as well, and so it'll be interesting to see how those things develop.

Our next panel, I'm going to introduce Michael Holston, who is the executive vice president and general counsel at Hewlett Packard. In that position, Michael Managers HP's global legal functions and the company's compliance, ethics, privacy, and government affairs offices. Before joining HP in 2007, he was a partner at Morgan Lewis focusing on complex civil litigation and white collar criminal defense litigation. He is a former Assistant U.S. Attorney for the Eastern District of Pennsylvania, and he also is a fellow in the American College of Trial Lawyers.

So, we'll hear a little bit from Michael on some legal issues in terms of technology innovation. He is on the front lines of those types of issues.

And then after we hear from Michael, we will hear from Rick Howard, who is here with us. Rick is the deputy chief technologist of the National Aeronautics and Space Administration. In that position he serves as an advisor on matters concerning agency wide technology policy and programs. He has served in the past as deputy of the astrophysics division, but when Ruth made her comment about physicists not being hip, I told him not to take that comment personally as an astrophysicist. We think you're hip which is the reason we invited you here. He also has served in NASA's Office of Space Science. He's worked in the NASA headquarters since 1991, and so he'll be telling us a little bit about the innovations that are taking place at NASA.

So, with that I will turn the panel over to Michael and then we will hear from Rick. Michael, thank you.

MR. HOLSTON: Good morning. It's great to be here with such a tremendous group of panelists and speakers today. I'm going to follow up on a theme from Ruth this morning. If physicists are not thought of as hip, lawyers probably aren't your first thought for innovators, and to come behind Eva Feldman's presentation, I think, will underscore that point all the more.

I would just like to -- that was just spectacular. What I just saw there was amazing and I'd like to thank you and congratulate you for that work. It's just wonderful. (Applause)

What I'd like to talk a little bit about this morning is privacy and, to a smaller degree, cyber security, and their relation to innovation. I think probably my guess is everybody in the room has one of these with them. And if I asked everybody in the room who had one to raise their hand, we'd probably get 100 percent. And if I asked you how many people in this room felt 100 percent confident that their information was secure on that device, I think probably all the hands in the room would go down.

It's an issue that we struggle with at HP, and I'd like to talk a little bit at the end and then maybe on the panel we can talk some more about how we're tackling some of these issues. But really what I'd like to talk about today is technology and trust and how they converge to create issues for -- and opportunities for innovation.

We're living in a time, frankly, where our dependency on technology is growing every day. We're also seeing continued blurring of the lines between our business and our personal lives. There's a trend towards moving IT outside of the organization and into the cloud, and expanding interconnectivity of devices and people and an increase in expectations of organizational accountability for the risks that are being created. The new applications, the business models and techniques that have emerged with the Internet provide tremendous benefits to consumers and are critical to economic growth and prosperity, yet these same innovations create new issues for privacy and cyber security.

Last month, the University of California-Berkeley released a study showing that while participation in social media continues to be strong, more than half of young adults are more concerned about privacy now than they were five years ago. This means that for the first time, there's little difference across the age groups about online privacy concerns. The so-called tell-all generation, or the live out loud generation, is starting to change their minds and catch up, maybe, with the rest of us.

The Berkeley study shows that more than 88 percent of 18- to 24-year-olds agree there should be a law requiring websites to delete information stored about them, and 62 percent said they wanted a law that gives people the right to know everything a website knows about them. These trends signal, frankly, an erosion of trust and create a compelling challenge as we work to balance innovation and the protection of data and individual rights. We have to get smarter and we have to ensure that we can provide meaningful protections.

As more and more processes and interactions shift to online transactions, there's a major trend toward devices and applications that are connected to each other and to the so-called smart grid. In a recent meeting with the privacy in cyber security community, Commerce Secretary Gary Lock sited research that global online transactions are currently estimated to total $10 trillion and by 2020 they will exceed $24 trillion. This is transformational not only in size, but in how we use technologies and the Internet. Cloud computing will become the central nervous system of this new, interconnected world. And as power as this interconnectivity is, it brings complex issues for innovators, for regulators, for users, and, frankly, for national security. The challenges in privacy as evidenced by recent studies show the need for new ground rules and frameworks that respect the legitimate rights of individuals.

Current laws and regulations struggle to keep pace with the new forms of data collection, use, and storage. This is one of the reasons we're seeing proposals for new privacy laws around the world today. In the United States a draft privacy bill was recently introduced and in Europe, EU Commissioner Viviane Reding has promised a redraft of the European Directive for privacy by the end of the year.

In both cases, they're trying to address the new challenges that come from Internet-based global economy with a focus on online tracking, data collection from sources other than the individual, consent processes, improved transparency, and permissions related to data use.

Given the length of time it takes to enact or revise such laws, legislative solutions invariably will continue to lag behind the next innovation or business model being adopted by consumers.

For instance, new data from the Pew Research Center shows that the share of Internet users that have reconnected with someone from their past using a social network now stands at 40 percent, doubling in less than 3 years. Individuals are placing more and more content about their personal lives, relationships, and interests, on the Internet. Many do not realize their data can often be accessed by just about anyone and everyone.

The June issue of *Consumer Reports* featured a story titled "Seven Things to Stop Doing on Facebook." They included using weak passwords, leaving your full birth date on your profile, overlooking privacy controls, posting your child's name in a caption of a photograph, mentioning that you'll be away from home, and letting search engines find you. The fact that these behaviors are prevalent highlights a lack of consumer understanding as well as the unanticipated effects that can result from new technologies.

But we've also seen a failure on the part of industry, frankly, to anticipate such issues. It's almost impossible to miss news articles about privacy or security concerns, and large and well-known companies frequently are in the spotlight. In two recent examples we find incredible innovation being delivered and adopted by consumers worldwide, but we also see illustrations of the unanticipated issues I've just mentioned.

In one case last month, privacy regulators came together in a joint letter and press conference to denounce a company's practices. They acknowledged the company's innovations and many accomplishments, but communicated an increasing concern that too often the privacy rights of the world's citizens are not being adequately addressed. The regulators referenced a social networking application where holders of e-mails accounts had their contact information automatically populated into their social network. They went on to say it was not the first time the company had failed when launching new services. In the letter and the press conference they called on the company and other organizations to incorporate fundamental privacy privileges and stated a minimum set of expectations. The letter was jointly signed by 10 leading regulators across all regions of the world.

While in this example the concern primarily came from regulators and advocates and NGOs, if we shift to recent Facebook concerns, we see more backlash on the part, frankly, of consumers. Last Monday, everyone knows, was Memorial Day. But for those of us in MySpace, we also knew it as Quit Facebook Day. And judging by the numbers of people who participated in this national movement, it could be viewed as a failure. Less than 50,000 users out of more than 400 million quit, but the fact that 50,000 people quit and national and international press covered the topic is significant and something not to be ignored.

The controversy was stirred by recent Facebook changes that included driving users to share more content publicly and making certain profile information publicly available without, in the view of the consumers and some regulators, adequate privacy controls. The negative publicity that resulted forced Facebook to modify their privacy controls and hold a press conference to reassure users.

In both cases, and maybe we can talk more about this on the panel, but, frankly, the biggest issue that we see is the gap between consumer awareness of what's happening and the protections that are out there. Traditionally, these kinds of gaps have been filled through education and industry self-regulation. But regulation -- but education is, frankly, sorely lacking in this area on the part of most consumers, and most self-regulation attempts have been seen as failures by the public and by some regulators.

As consumers, advocates, and regulators become more aware and more concerned about these issues, organizations will need to do more to consider the privacy risks that they create through their innovations. New organizational accountability frameworks are emerging that set expectations for companies to design privacy enablers and risk mitigation into every stage of product development. It's often referred to as "privacy by design." At HP we've put a lot of energy into working with regulators, other companies, and consumer advocates in the development of these new frameworks, including working with the binding corporate rules in Europe and cross-border privacy rules in Asia. And it's, frankly, been a fascinating work at watching cross-functional development where my privacy team of experts and lawyers, working with software engineers, to develop tools that can be used by our engineers at the time they develop the product to ask the questions that force people to take into account privacy rules and privacy concerns at the time the product is being invented and developed.

So, to avoid the situation where a product is invented and developed without regard to what the implications may be to people's privacies and to try and think about those issues and take those things into account at the time of creation of the product, to hopefully not stifle innovation, but, at the same time, take into account the very legitimate and real concerns that people have for the privacy of their data.

The internal program in technology that HP has created integrates the privacy operating model into an end-to-end program to better guide our employees about privacy requirements, risks, and considerations. It's meant to hold every one of our employees accountable for privacy and data protection. By using technology to engage employees and provide them with guidance for their specific program, we're better positioned to ensure they think about privacy in the right context and at the right time.

Let me turn for a second, I said at the beginning privacy is not the only issue that arises from innovation, our ability to keep data secure is growing in complexity and cost while threats and risks are, frankly, increasing dramatically. There's significant pressure on companies around the world to cut their IT budget as is evidenced by the attractiveness of cloud computing to many organizations, especially small- and medium-sized businesses. It's making it harder to justify new expenditures in security and yet the expanding threats to information security cause us to need to do more. The answer is to spend our money, frankly, in a smarter way and technology is needed to help us do this.

In Symantec's recent 15th Annual Internet Security Threat Report, there are some disturbing trends that I think go to the cyber security issues. Malicious activity and cyber attacks are increasingly flowing out of countries where broadband and IT penetration is growing the fastest, so think Brazil, think India. Second, advanced, persistent threats focused on large enterprises are becoming more common as thieves seek customer data, financial information, and intellectual property assets.

I can tell you that a large, multinational corporation will face more than 10,000 attempts a week to penetrate its firewalls from hackers trying to gain access to the data. So when you think about the offense that's being played, there is a true concern, I think, that we continue to develop security and that we continue to push organizations to force them to use that technology and to spend the money to protect the data. It's not just great to use the money to develop new technologies to advance the business, but we need to develop the technologies that protect us. There is an entire industry that exists for the purpose of getting that data and profiting from it, and when you think about the dollars being spent on the Internet and you think about $10 trillion being spent today on the Internet, there's not an addressable market out there that looks more attractive to anyone. And so these issues are, frankly, something that need to be taken into account by organizations throughout the world of all sizes that are dealing with people's personal information.

The last one I'll mention is mass market attacks, like phishing and viruses, continue to evolve in their sophistication. This is an arms race with both sides escalating on a regular basis and, frankly, the attackers are just as sophisticated as the defenders. And with the ever-increasing power of IT and the sophistication and skills of cyber attackers, we need to apply more science, more innovation and technology to security challenges in the interconnected world.

The traditional view of security management has been very siloed. The assessment of risks, policy decisions, deployment of technologies and monitoring is not always done cohesively and can lead to significantly increased costs, but even more important significantly increased vulnerabilities. If we focus on an integrated life cycle view, we can better consider the risks, the tradeoffs, and strategies that will mitigate the security threats and vulnerabilities facing us. It also allows us to be more nimble, predictive, and responsive to the changing threat landscape.

Unlike privacy, we have much better guidance for security expectations from laws and industry standards, but we have to ensure that the principles and guidance transcend technologies. Accountability and security by design is just as important as privacy by design. The "what" that needs to be done is not changing, but the "how" is changing rapidly. The protection of data remains critical and we need to apply some innovative spirit and use new products and services to keep data secure in these environments and against these new threats. We need concepts that make our infrastructure smarter and give it the characteristics that we want, including the ability to react quickly and maintain business continuity.

What is common, frankly, between privacy and cyber security issues is that innovation is generating new risks as well as expectations for increased organizational accountability, but with all of these challenges and issues come huge opportunities to be smart about technology innovation and to strengthen trust. If industry does not focus on both, trust will erode and consumers will react negatively and regulators may have to step in. And frankly, this almost certainly will stifle innovation and growth.

So, I think there are tremendous challenges out there and I don't want to underestimate the work that needs to be done. But I do believe that if we can harness our collective capabilities and work across industry, governments, and consumer advocacy organizations, I think we can find solutions that will promote innovation at the same time as providing meaningful protections to everyone.

Thank you. (Applause)

MR. HOWARD: Okay. I guess we're not going to use the big screen up front, just the two side screens. Oh, it's coming down right now. All right.

While the screen is coming down, I did not take any offense at the comment about physicists, mainly because my background is astrophysics. And as Ruth pointed out to me, astrophysics are a little bit special. So, given that, I want to talk to you today about a new exciting direction that the administration has put into the FY '11 budget for NASA, for both human and robotic exploration. And I've got a package here that's available actually on the website -- our NASA website, if you want to look at it later on. It's got more charts in it than I'm going to actually talk to, but it's good background material. It's at nasa.gov/offices/oct, which is the Office of Chief Technologist.

So, with that, I'll talk a little bit about the budget that the administration has released, the FY '11 budget: top line increase of $6 billion over 5 years. That is a significant increase in NASA's budget and in an environment and era where a lot of agencies are struggling just to maintain. There's a reason for this and it has to do with the increased emphasis on science and technology and innovation and a change in direction, as I said, on expiration.

Increase in the science area is primarily in the Earth science arena to be able to do more global monitoring and get submissions that are high priority in the decadal that was just published a year or so ago, started and up and taking data. It reverses a direction that was not a good one on aeronautics, modest increase, but still an increase, and then this shift in exploration. The goals remain the same, but there's additional money for flying the shuttle flights out; extending the International Space Station through 2020, which we are looking at to maximize the utilization of this asset that we have, this national resource that we now have; rough 2020 for research in all areas, not just in NASA's interest, but in other areas -- National Institute of Health, for example --

access to commercial -- commercial access to lower Earth orbit is being worked; and a few other things there that I won't talk about right now.

The main thing I'm going to focus in on is the technology development that is refocusing activities both in exploration area as well as in a new program with a renewed emphasis on technology and innovation. Part of this, as I said, is the human exploration strategy, and then there's this new space technology program which is almost $5 billion over 5 years. That includes about a billion dollars of existing program content in the Innovative Partnership Program, which is where the small business of Innovative Research Program is, for example.

Okay. The path for human space exploration is, as I said, this renewed emphasis on technology. The approach here is not to just go to one place, go to numbers of places in the solar system for exploration, preceded by technology development and precursor missions -- robotic missions and human missions -- that try out new technologies, new approaches, new paths, to come up with more affordable ways to accomplish the objectives and goals of our human exploration initiative.

A lot of these things that you find in our technology area are not new. These are things that have been around for the last 20 years or so as critical areas of technology development that need to be invested in, in order to be able to afford and do the kinds of missions that NASA wants to do as far as space exploration, both robotic and human exploration. So this is just a mapping that sort of shows you that, you know, it's not that this was just invented last year, this has been around for a while and it's now finally being addressed with this new emphasis on technology.

Just as an example of how hard this is, and it's not easy to do, if you look at this chart, down here in this corner over here is what they call the Design Reference Mission V, which is one of the design architectures for getting man to Mars. Where we are today is if we had to do that today with current capabilities, we'd have to launch into low Earth orbit 12 times the mass of the International Space Station. That would take a little bit of time, a lot of money, and it's a huge effort to even think about trying to do anything near that in today's environment.

However, with significant advances in technology development and cryogenic boil off of cryogenic propellants that we need to take to orbit and then use that to get onto Mars, in air capture and ways that we enter the Mars atmosphere and find landing places, close loop life support systems for the astronauts that are up there, we are hoping that we advance these technologies and go into some new innovative approaches; that we can get down to where this is much more realistic, closer to something on the order of a couple of times the massive International Space Station as to what we would have to get into low Earth orbit in order to get a man to Mars, safely there, explore, and then come back.

So, it's sort of a three-phased approach. We're starting now with this building the foundation. This is commercial sector becoming more involved in access to space and providing capability to deliver payloads and experiments to the space station and to other places eventually. The precursors -- robotic precursors need to be done to find out what you need to do to learn before you can go send humans on to other places in the solar system, and game-changing technology development, I'll talk about that little bit more.

Phase 2, of course, as we get on to this is design and build those capabilities that we need to be able to do that. And then Phase 3 is actually send the human explorations off to other destinations and not just be in low Earth orbit around the Earth.

So, this is just another way of portraying it. The potential destinations, again, it's not just focused on low Earth orbit, it's not just focused on the moon. It's other places also where we want to try and reach out and explore, understand things, expand man's awareness and involvement with the rest of our solar system, and also, you know, start looking for in situ utilization, what we can do there to maintain sustainability on another surface than the Earth.

There are common capabilities we have to develop, there's technologies that have to be developed, building blocks that go a long way. I've talked about some of those. Breakthrough technologies is a different path, and I'll talk about that in a second, but things like hypersonic inflatable air shells; revolutionary Earth-to-orbit launch capabilities or rockets; things like using nano-propellants, which is something which we've just started looking at over the last five or so years.

So, the value of robotic precursors, I think everybody knows all the success from the Mars missions that we've had and the other missions to the other parts of the solar system. These robotic missions clearly are needed in order to be able to see what resources are there that we can utilize. This is an interesting picture taken high resolution from one of our orbiting satellites around Mars where what we have found is even at the mid-latitude regions on Mars; 43 degrees north latitude, for example, there is somewhere between a half-meter to a meter of ice, and it's pure water ice, beneath the surface. You look at recent, very fresh craters that we've seen, which we have evidence that there wasn't a crater and then all of the sudden there is a crater. So we see a crater and we can look at it. And you see this ice there popping up in the images and then it quickly, over a period of a couple of weeks, several weeks, sublimates back into the atmosphere, so it is there. And what this points to is the value of robotic missions to find this kind of information out and offer up the potential that these resources may be utilized, strongly can be utilized for in situ utilization by colonies and exploration missions to Mars.

As I said before, this is not -- a lot of this is not new and not surprising. It's been things that we've been trying to do for a number of years. More recently, there's been a number of reports coming out focusing very much on the fact that NASA has -- especially the second bullet there -- has gotten itself into a situation where it has done basically incremental gains and sort of what I would call enhancements in technology areas rather than leaping into new, innovative ideas, things that are completely game changing as far as how we would approach something, what we call disruptive technology development; and that NASA has gotten over the last 5, 10, 15 years into more of a mode of doing incremental capabilities and not putting the seed corn money into technology innovation, early ideas, and maturing them, and then having them infused into the mission lines.

So, within NASA there was established an Office of the Chief Technologist back in February. There are several main goals for this office. The chief technologist is the principal advisor to the NASA administrator on all things technology in the agency. The footnote at the bottom, the little bullet at the bottom, all things in the agency, yes, we are responsible for advising the administrator on that and knowing what's going on across the agency and establishing a portfolio and a roadmap. But also the mission directorate, the science mission directorate, the exploration mission directorate, aeronautics, and the operational space operations, which runs the shuttle in the space station program, they have what we call mission-focused technologies. They have specific goals, specific missions that they're going to be going after, that they have technology plans for as part of their missions. The Mars program is a good example. They're doing a number of things getting ready for the next Mars missions beyond the next couple we're going to launch in the next few years.

So, they continue to do those activities. This program, third bullet there, is the space technology programs, and this is really to look at things that are cross-agency or what we call cross -- multiple use. More than one mission directorate is interested in it. It doesn't have to be another mission directorate, it could be another agency. Another agency in the government could be partnering with us on an activity that is of interest to both NASA as well as another agency; could be industry, could be commercial space. So, it's just -- the real keyword is more than a single user.

One thing I'm going to get back to and this has to do with the concerns of issues concerning innovation that we have that I'll talk about a little bit later on, and this is the fifth bullet on here, and this is the culture towards creativity and innovation. And this is not just in the NASA centers, it's across the entire board, and I'll talk a little bit more about that. But that is a major change in direction that we need to address in order to be able to take these leaps, take these chances, try new things, allow failure to happen, and accept the fact that failure is not a failure, failure is you've learned from all that information that you got to that point, it's time to terminate, stop it, and then move on with something else and that's perfectly fine. If you don't take those leaps and try to do those things, you're never going to get some of these new, innovative, game-changing technologies to the point where they have a huge change on the way we proceed with our missions and new capabilities.

So, within the division -- or within the Office of Chief Technologist there are 3 main divisions with 10 programs in them. They're broken -- I'm not going to go into the details of them here, but there's three main areas.

One is very early stage innovation. We at NASA have this thing called the Technology Readiness Level Scale that goes from zero to nine that defines the readiness of technologies to be infused into a mission. So this is the early level stuff -- concepts, ideas.

The next level is to take those things and prove out the feasibility, demonstration on a lab bench that the concept works, that it works at a system or a subsystem level, and then ultimately getting to cross-cutting capabilities, which are where we take those things, fly them in the relevant -- or do the demonstration in the relevant environment -- in this case mainly suborbital or orbital flights -- so that those technologies have been proven, so that a mission manager, project manager, can sign up and say, hey, I'm going to put that on my next mission. It's been completely demonstrated and is ready for infusion.

Infusion, again, doesn't have to be just into NASA. This could easily be into industry, into commercial space, into other government agency applications, also.

So, this is a cartoon that -- we talk a lot about push and pull. And, again, this has to do with the mission directorates. This is an example for the exploration system mission directorate, which has a technology pull. They have objectives: We want to get to Neo with humans by 2025. They have requirements as far as how long they want to stay, radiation effects, things like that. Those are the pull side. From the Space Technology Office of Chief Technologist area, this is the push: Let's come up with these great ideas, see if they mature, push them forward and make them available, and, in this case, sort of disruptive approaches.

Meanwhile, the mission directorates are still focused on the best they can do on what the current technology is, some new technologies that see nearer term payoffs, because they have objectives and mission goals that are coming up relatively soon. And as we play those two games against each other, looking at their requirements flow down and the development of new, sort of disruptive approaches, we modify where they're going. We modify what we're doing and end up trying to get to the bottom end of that curve from Mars where we cannot have to put 12 times the International Space Station in orbit to get there.

So, this is a chart I wanted to spend a little bit of time on, getting back to that earlier point that I had as far as culture change. So, this is just another way of looking at it. But the entire program, the Space Technology Initiative that's in the '11 budget that the administration has laid out, has been scaled and structured in such a way to motivate innovation and accept failure, and then take those -- but take those successes that do move on forward, that are game changing and completely revolutionary ideas, and infuse those into missions. So, if we don't do lots of great ideas early on, take those things and mature them as best we can, realizing that some are not going to work out at all, and them infuse them into missions, that's the whole purpose of this structure. So, lots of ideas early on, these would be solicited -- open competitions, hundreds of ideas, and also on ramps -- outside there's sort of a funnel there. Outside that funnel there's a couple arrows. There's also on ramps for the next stages so that there will be competitions for people who haven't gotten the early phase funding to come in with their ideas for something that could be completely game changing. They just need a little bit of money and a little bit of time to be able to develop those and mature those ideas, and also for the flight demos, who also have an opportunity to come in at size.

So, when I talk about size, the overall size of the effort has been sized correctly for, and structured correctly for, having a lot of ideas early on, taking those best and brightest ideas and new concepts that are out of the box. I mean, they're not what the mission directorates want, it's not necessarily the things that are focused on their next missions, but what the agency or national needs or other government agencies would like to see done to address some of these national -- these challenges that were on that earlier chart -- take those, mature those, but realize there's risk associated with that and that they're not going to all work out. The game-changing Technology Division program is modeled very much after the DARPA approach to things, which is pick a few ideas, go off and work them, and if they work, great, it's a completely different approach to doing things. If it doesn't work, monitor it and at the appropriate point decide enough is enough, we've learned some great stuff, but it's time to move on.

So, the sizing of these efforts are sized for a large number of activities. Failure is acceptable. And there's also limits to these activities, both dollar and schedule, so you're not continuing to say, well, okay, we got here, but it's going to take me five times more money, over five times as many years -- five or six years more to do it, and that's just not the right answer. That wasn't the problem you were trying to solve.

So, by monitoring those things and scaling those things, and sizing the overall picture, it's very important that you do this so that you can talk to and convince the stakeholders -- public and the Congress and actually the researchers doing this work, including the NASA folks -- that failure is acceptable, risk is okay to take, and it's okay to have things that don't mature on, and to reach limits, either physical limits or that can't be applied to space, whatever the stumbling blocks are, and move forward with it.

So, this change in culture within NASA is not just within NASA, it's within stakeholders as well as the entire industry. You've got to be willing to take those risks. One reason you want to have this large number and the sizing of the overall program is so that everybody can accept that, once in a while, things will not work and not pan out, and that you can still proceed forward with those other things that will have significant new ideas and new capabilities to allow us to move down that curve on the total payload weight that we have to put in orbit to get to Mars.

So, that's the cultural change. We have to do it within NASA; we have to do it within the industry, and certainly within all the stakeholders to understand that.

There's another element that's tied into that, also, and that's stability. It's very difficult to convince, even within NASA, the NASA centers, to invest in early fresh outs, get people coming out of the education program, and who have creative new ideas about doing things, unless they see a stability in the program. It's very difficult to get partners from other agencies to agree to work on a two- or three-year effort to mature a technology that's high risk, but is high payoff, unless they see stability in the program, too. So I think the two issues in terms of seeing this out are one of a culture change in terms of how you value risk and failure, and the other is stability in the program. I think those are two main elements.

I think I've talked about most of these bullets, at least hit a few of them, so I'll skip that.

Potential grand challenges. This is a list of things that are across the board for the entire program, the entire NASA program as to what we may want to go forward with. These are, again, not surprising; they shouldn't be surprising to anybody. These are things that have been there for a number of years as challenges that we want to try and achieve and attain, and that we can only achieve and attain through innovation, new technology, and completely different approaches to the way we do our missions.

These are some of the ideas that we're talking about that are being kicked around as far as technology demonstrations. The middle picture on the top, inflatable decelerators is something that we have; is at a very low level of maturity. We haven't used these before. If you want to try to land something on Mars that's bigger than what we've currently landed up there, you can't use the current techniques or, if you do, you need to require a huge amount of mass that you've got to get up into orbit in order to be able to decelerate and slow down when you get there. So, inflatable decelerators, which also have aeronautics applications, too, so there are other parts of that that may pan out.

And this is, I think, just my last chart. This is the -- as you would expect, this is part of a broader national strategy on innovation and technology to get the agencies and the country more involved with technology and innovation, stimulating the economy and building on our national goals. NASA's budget is aligned with that strategy and it is a critical element of both promoting new ideas, new concepts, and exciting the next generation of scientists and engineers. (Applause)

MR. WEST: Thank you, Rick. And thank you, Mike, for your comments.