THE BROOKINGS INSTITUTION

POWERING PROSPERITY:
INTRODUCING AMERICA'S ADVANCED INDUSTRIES

Washington, D.C.

Thursday, February 5, 2015

PARTICIPANTS:

Welcome:

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Framing Remarks: America's Advanced Industries and Why They Matter:

BRUCE KATZ
Vice President and Founding Director, Metropolitan Policy Program
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Panel 1 - Locating U.S. Advanced Industries: Off-, Re-, Next-Shoring and Beyond:

DOMINIC BARTON, Moderator
Global Managing Director
McKinsey & Co.

RON ARMSTRONG
Chief Executive Officer
PACCAR

JOHN LUNDGREN
Chief Executive Officer
Stanley Black and Decker

ERIC SPIEGEL
President and Chief Executive Officer
Siemens Corporation

Panel 2 -- Convergence and Disruption: Assessing the Advanced Industry Tech Scene:

SRIKANT INAMPUDI, Moderator
Partner
McKinsey & Co.

KATRINA BOSLEY
Chief Executive Officer
Editas Medicine

JAMES HEPPELMANN
President and Chief Executive Director
PTC

KLAUS KLEINFELD
Chairman and Chief Executive Officer
Alcoa

Perspectives:

THE HONORABLE TERRY McAULIFFE
Governor
Commonwealth of Virginia

MARK MURO, Moderator
Senior Fellow, Metropolitan Policy Program
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P R O C E E D I N G S

MR. VAN AGTMAEL: Good morning, ladies and gentlemen. My name is Antoine van Agtmael. I am one of the Brookings Trustees, and I might add a great admirer of Bruce's Metropolitan Program.

I am pleased to welcome you here to what I think promises to be a topic that is both very important and exciting. Important because I believe that advanced industries are the key to our competitiveness as a nation, and exciting because frankly there is a good story to tell here, as Bruce will do.

Let me illustrate that by something that I personally experienced. I have been going to Asia basically all my professional life, 40 years, couple of times a year. Three years ago, I went. I was talking to companies as I always do. What did they tell me?

They complained about American competition. Let me repeat that. They complained about American competition. I was blown away. I had not expected that. Then other companies started telling me that they were building their next plant not in China, no, in the United States.

Something was happening. Now, here I am, I coined the word "emerging markets." I have been doing this professionally all my life. Wrote a book called "The Emerging Markets Century." I'm committed to the idea the emerging markets are important. I even talked about the fact that the competitive edge was shifting in that direction.

Well, I think things are changing. As Pat Moynihan once quipped, "You are entitled to your opinion, but you are not entitled to your own facts." The facts on the ground are changing and are changing quite considerably?

Why? I think if you put it in a nutshell, what mattered over the past 25

years was who could make things the cheapest, but the paradigm is shifting. What is going to matter over the coming 25 years is who can make things the smartest, and that is where advanced industries come in, and where the United States and Europe, the old economies, have a new competitive edge.

They have a clear advantage, at least if we don't screw it up. We could. Global competition is a little bit like war. You don't fight it with your enemies' weapons, you fight it with your own new weapons that are surprising to them.

Advanced industries cater to the crucial strengths that knowledge economies, and the United States and Europe are knowledge economies, have. That is what makes this topic important. Not focusing on this is well, just plain stupid.

It is time, I think, to start changing our mind, to stop being down in the dumps, and looking at the glass half empty, and recognize that the old economies cannot be counted out so easily. There is a lot of life left in them. Instead of being prize takers, we are becoming trend setters again.

We know from high tech services like Google, Apple, Amazon, Uber, Facebook, all these names, but you also see it happening not just in services but also in manufacturing, and again, Mark will talk about that.

Sophisticated pacemakers, did you know the United States has a monopoly on sophisticated pacemakers? Wearable devices are being researched here, also in Northern Europe, that monitor our health. Self driving cars, smart tires that send sensors to adapt to both weather and road conditions, new generation of robots, drugs that use genomics to target diseases. These are just a few examples.

Now, we can be grateful, I think, to Silicon Valley and MIT who taught us again how to innovate, but in a completely new, more open, and more collegial way, essentially, and this is the key, by sharing brain power in open innovation, rather than

operating within academic or corporate silos. They already knew this, but had kind of forgotten it, and that really had a high cost, a disastrous impact on innovation.

All over the country, and Bruce, Mark, and me, because I'm a co-author of writing a book on this, in visiting all these places, from Akron and Albany, places that you would not expect it, we are not talking MIT and Silicon Valley, Akron, Ohio, Albany, Seattle, where I met Uda, Portland, and in Europe, places like Eindhoven in Holland, Zurich, Stuttgart. These are places where a hell of a lot is happening.

In those places, and basically this is the key, and this is what actually makes innovation much more efficient, and we have learned a trick, it's just simply universities, big companies, small companies, start-ups are all working together, government officials, no longer waiting for Washington, but cooperating in new ecosystems that very efficiently translate inventions into new products.

Let me give you an illustration of that. I was told by a venture capitalist that it used to cost $10 million to create a prototype. Now, with 3D printing and this sharing by all these little start-ups, these young whippersnappers, for whom this is second nature, it can be done for $50,000.

Even long lost industries are coming back and becoming advanced industries. We heard from Phil Knight here of Nike who when I asked him can you make a shoe by robots said well, we're already making the Olympic shoes with robots.

These industries, to everyone's surprise, are going to come back. Things are going to be produced where they are consumed more and more. The result is a whole new spread of innovation based on integrating what we are best at, on integrating IT, sensors, wireless communications, new materials, medical discoveries, into what I call "brain factoring" and what Bruce calls "advanced manufacturing," and this is so advanced, especially now that Chinese labor is becoming more expensive and our

energy is becoming cheaper.

I believe it will really upset the apple cart of competition, and that's important. Bruce will discuss all of this later. I think the news is surprisingly good even for jobs, as he will talk about. Let me just say I believe we will soon have to worry more about job training than job losses.

Bruce Katz, Mark Muro, and their whole team at Metro are what I would call true out of the box thinkers, and as usual, have been onto this new reality earlier than most. At this conference, they will tell you about it.

Let me introduce Bruce, who is a long experienced practical policy maker and an innovative researcher, and is someone who does not take conventional wisdom for granted. Thank you, Bruce. He will be your guide to the concept of "advanced industries" and define it for you. Knowing him, I'm sure you are in for a real treat. Thank you. (Applause)

MR. KATZ: Thank you, Antoine. Thanks to everyone who have come here today and for the folks who are in the extra room and the folks listening by Webcast.

This has been a long time coming. You don't do these reports overnight because the methodology and the data is so difficult to pull together.

I'm Bruce Katz. I'm Co-Director of the Metropolitan Policy Program with Amy Liu. First of all, just a thank you to Mark Muro and his team, because there is a lot of brain damage that went into this effort. Jonathan Rothwell, Scott Andes, Kenan Fikri, Sid Kulkarni, thank you.

They took on this small task of basically defining the driving industries in the United States that we call "advanced industries." In doing so, if public policy makers and private decision makers listen, I think we have a path for a stronger, more productive, more inclusive economy.

"Advanced industries" are the prerequisite for broadly shared prosperity, something that we desperately need in this country.

Another thank you goes to Dom Barton. You will hear from Dom, he will moderate the first panel, and his colleagues at McKinsey. They have been intellectual partners with Brookings and have helped us on the ground in places like Tennessee and Colorado, to basically market test this definition of "advanced industries." Dom, a Trustee of Brookings, thank you.

To the CEOs who have come here today, thank you for participating. There is a group of corporations and individuals who have helped us get this report done with their financial support, so I just want to call out Alcoa, Antwan, Lear, Microsoft, the Royal Bank of Canada, RBC, Rob Roy with Switch Communications, and Siemens. Thank you very, very much for that support.

Finally, you will all hear from Governor McAuliffe later, and I will show you some of the statistics from Virginia, that I think will be really interesting to help us rethink what that state is all about from a competitiveness posture.

Antoine quoted Daniel Patrick Moynihan. I will quote George Bernard Shaw at the beginning of this, should be almost a motto for The Brookings Institution, "The sign of an educated person is to be deeply moved by statistics." (Laughter.)

Please forgive me, right, as I provide some context for this report. First, it's clear that the recovery is well underway. We have had 58 months of consistent job growth in this country. The unemployment rate has dropped from a high of 10 percent to below six percent.

As the cyclical stresses of the recession recede, they are revealing the lingering structural issues that we need to deal with in the economy, wages that have stagnated for decades, as this slide shows, and that remain too low for many workers.

An economy that has relied too long on consumption and less on production and the innovation that production provides.

As we look abroad, rising competition, not really just from low skilled labor, but from countries that are catching up and exceeding the United States in productivity and innovation.

In response, we think and we have said for a long time at Brookings Metro that the United States needs a new growth model, and one critical component of that model is advanced industries.

In the next few minutes I am going to cover what "advanced industries" are, where they are located, and why they matter, particularly today.

Let's talk about the "what." It's clear that the nature of our economy is changing, the relentless pace of innovation, the blurring distinction that we will hear a lot about of many different types of enterprise, such as manufacturing and services, the digitization of everything.

It really demands a change in how we talk about the economy, so we think what is emerging is a super sector of advanced industries manufacturing energy and services that are R&D intensive and concentrate our STEM workforce, so these advanced industries obviously create technology, they deploy it across the economy, they drive regional and national prosperity.

What are these industries? When we looked at this R&D intensity and STEM intensity, what we come up with are 35 advanced manufacturing industries - aerospace, auto, medical equipment, as well as three energy industries and 12 high value services industries, software, computer systems and design, data processing and hosting.

These industries punch way above their weight. They have 12.3 million

jobs. That is nine percent of our employment in the U.S., 17 percent of private sector GDP, 60 percent of our exports, 80 percent of our engineers and patents, and they invest more than 90 percent of private sector R&D.

As Antoine has said, in the last several years, these are the industries that have driven the American economy forward. These industries matter because they are not just providing jobs, they are providing good jobs, they are providing quality jobs.

Over the past 30-40 years, advanced industries, unlike the rest of the economy, have provided steady wage growth, and partly thanks to this continued growth, advanced industries provide a significant wage premium to their workers at every single level of education.

This matters because these workers in advanced industries are not all scientists and engineers educated with Ph.D.'s at MIT or Stanford or Carnegie-Mellon. Half of advanced industry jobs receive less than a four year degree, or the workers receive less than a four year degree. These are good accessible jobs that provide wage premiums of 40-50-60 percent over comparable jobs outside of advanced industries.

Now, their impact on the broader economy radiates further. They develop technologies that transform lives. They drive productivity in other sectors. They support long supply chains critical to state and national economy, and of course, they stimulate the local economies and they drive job growth in the communities where their workers reside.

If you add it all up, we have 12 million direct jobs in advanced industries. We have another 27 million positions supported by this. Together, that is over one quarter of the U.S. workforce.

Let's talk about the "where." We are the Metro Program, so we care about where all this comes to ground. As to the geography of this super sector, it is

widely distributed across the United States, but it is differentiated. It's not an even distribution.

Overall, 70 percent of advanced industries' activity occurs in the nation's largest 100 metropolitan areas. Those are the metro's over about half a million, they are about two-thirds of our population, about three-quarters of our GDP.

Given that every single large metropolitan area contains at least a few thousand advanced industry jobs, the depth of the metro specialization varies widely, and the nature of it varies widely as well. Thirty-eight of the largest 100 metro's are basically manufacturing oriented advanced industry sectors, and you see Wichita Aerospace, Palm Bay, Boise City.

A few metro's are heavily involved with energy, not surprising to anyone in this room, Houston, but also Salt Lake City, Birmingham, Alabama. Another 17 metro's are tilted to services, Boston, our home metro, Washington, D.C., and Denver.

Finally, and this is really interesting to focus on, there are about 13 metro's in the United States that host deep balanced advanced industry bases, and there are some surprises here - San Jose is not just a software mecca, it is not just the Facebook economy. It is also a center of production and manufacturing tied to those tech services, particularly in places like Fremont, California, where Tesla is located.

On the other hand, Detroit, which is the iconic American manufacturing metropolis, is also a leader in data processing and engineering services, so at a time when cars are basically computers on wheels, many metro economies sit at the intersection of manufacturing and services, production and innovation, digital and material.

It's clear that every metro and state has their distinct advanced industry profile, and understanding your starting point is really critical to supporting those

industries, right? It's not ubiquitous in the United States. It is highly differentiated.

Let's take a random state, Virginia, the Governor is coming, 442,000 advanced manufacturing jobs. That is 11 percent of the state's employment. It puts Virginia above the national average.

Look where they tilt, they tilt toward services. Evidence of the strong influence of the D.C. metropolis, specializations in computer data systems, consulting, engineering services. A huge wage premium for advanced industries in Virginia and frankly in Maryland and the entire metropolis, right, seven of the 10 counties are among the wealthiest counties in the country.

Virginia is the fifth most advanced industry intensive state in the country, and that is why we invited Governor McAuliffe to talk today.

Let's talk about the "why" and what to do about this, because at Brookings, we obviously want to focus on where we head. There is the data. Why does this matter? Because the U.S. leadership is eroding in the three main factors in our view, subnational level, that drive the competitiveness of these sectors.

A strong innovation system that commercializes research and ideas for the market, a robust skills pipeline that gives workers the skills they need to compete, and dynamic regional ecosystems of large corporations, small and medium sized enterprises, universities, investors and workers who collaborate to compete on the global stage; right? It takes an ecosystem of advanced industry to compete.

As we begin to assess ourselves against these measures, we have some work to do in this country, and frankly, we are going to have to do a lot of it without the national government participating.

While the U.S. maintains a formidable technology development base, R&D investments are slipping, and as you see here, our R&D share of GDP has slipped

behind the competitors like Korea, Japan, and Germany.

Second, we need to acknowledge that the nation has developed serious skills deficits by comparison to our competitors. Antoine mentioned this. We could go through chapter and verse on a whole bunch of depressing metrics on U.S. education, but for now, I think it is just important to focus on the U.S. students and young workers' low participation in STEM, science, technology, engineering, and math, which really comes as no surprise to anyone considering that we basically dismantled our vocational education system in the United States over the past 30 years.

With Eric Spiegel from Siemens, we took a group of about 30 mayors and business leaders over to Munich to look at the Siemens plant in Nuremburg and understand the apprenticeship model in Germany and how it can be adapted and tailored to the United States.

Finally, Americans need to realize that the nation has allowed the advanced industries platform of our metropolitan innovation ecosystems to atrophy. Advanced industries cluster in specific places where they secure those inputs they need to compete globally.

Over the past three decades basically we have seen a hollowing out. In 1980 on the left, 50 of the countries largest metropolitan areas had at least 10 percent of their workforce in advanced industries. By 2013, on the right, only 23 major metro's contained such sizable concentrations.

The bottom line is less than half as many large metropolitan areas in our country now have the kind of deep supplier bases, the talent pools, necessary to support advanced industry growth. That is something that we really need to focus on, again, not just at the national level, at the state level, at the metropolitan level, at the regional level.

Here's the bottom line. Advanced industries -- this is a super sector. It's

pivotal but its viability in this country is threatened. To restore our competitiveness will require cross sector collaboration, so-called "triple helix" in the European term, from public, private and civil leaders at all levels of our federalist system.

Obviously, we are going to require -- this is where the Feds really matter -- some change in the macro rules governing tax and trade.

This is critically important. We think this report is really the beginning of an effort to change the narrative around the economy we want to build in this country and then change the actions of state and local governments in alliance with their corporate, civic and university leaders.

With that, I'm going to turn it over to some of those private sector leaders to talk about the opportunities and challenges for advanced industries.

There is no one better to moderate this panel than Dom Barton. He is the Managing Director of McKinsey & Co. He's a Trustee here at Brookings, and he is a very close friend and partner of the Metropolitan Program. Thank you so much. (Applause.)

MR. BARTON: Welcome, everyone. Thanks very much, Bruce, for the great overview and all the work that you and Brookings have done.

I think you have just in a very short period of time posed kind of the challenge and the great opportunity and what has actually happened, and to help with that great overview of the facts, we thought it would be terrific to actually hear from the real practitioners and leaders who are driving business in this area, and it is an honor for me to introduce these three colleagues.

We have Ron Armstrong from PACCAR. When I think about it, we have trucks, drills, and power systems. I'm not doing them justice. These are complex, big trucks, drills, and power systems. Ron has the trucks, primarily on the West Coast, but

other parts of the U.S. now.

One of the many interesting things about PACCAR is they have been effectively always based in the U.S. They didn't go overseas. A lot of their competitors have been in Mexico or are in Mexico. They stayed here, why? What is it that is going on there. Extraordinarily profitable and successful.

Everyone here is modest, but I will tell you, these are very successful companies and over time as we go through it. So, on the truck side, Ron Armstrong.

John Lundgren from Stanley, Black and Decker. Again, a very successful organization, 170 years old as an institution. It has gone through many different transformations. Over the last few years, has actually re-shored some of the businesses, maybe to Antoine's point, this is where the emerging market players are anxious and a bit jealous of the competitiveness, what is actually going on. We are going to hear that vantage point.

Eric Spiegel, who is the CEO of Siemens USA. Siemens, as you know, is a global player, multinational, very well regarded in this whole area of the advanced industries, but has made a real push in the U.S. They are a very significant player and I think has a lot of interesting insights in terms of global comparisons as to what is happening, where are some of the shifts as it relates particularly to software.

That is the group. I am going to talk as little as possible because we want to hear from the practitioners. Maybe we will start, Ron, with just a bit about PACCAR for the group to understand a little more about them, kind of your philosophy and how you operate and so forth.

MR. ARMSTRONG: Sure. PACCAR is beginning its 110th year, and we started truck manufacturing 70 years ago when we bought the Kenworth business. I think Bruce's comment about a computer on wheels is very pertinent to the truck of

today. It is much more than just a lot of aluminum and iron and components to get products.

The truck of today has evolved from two control units to 40 control units on any given truck. We build 140,000 trucks each year, about half of those in the U.S., the other half around the world.

The requirements for our people to be able to design and make all those pieces work together, to communicate, is a very critical part of what our vehicles do for our customers. By the time we get to the end of next year, essentially every one of our trucks is going to be connected back to the fleet, back to the dealer, back to us to get real time information on how that truck is performing.

As we have looked at our business, we have a lot of investment in skills and knowledge. In our U.S. operation, our primary U.S. locations are in Ohio and Texas. We have been there for many years, and are very productive. We have over 3,000 engineers and technicians in our company who really drive the development of our products and develop those over time.

We obviously support our trucks through after-market parts distribution, and that, too, is becoming much more technologically advanced, a lot of e-commerce initiatives, a lot of connectivity between us, the suppliers, and our dealers.

We also have a captive finance operation that is again being characterized by more and more technology being used in that business.

Last year we have $19 billion in revenues, achieved about $1.4 billion in after tax net income. We have earned a profit in a very volatile industry for 76 consecutive years, so we are very proud of that. We are looking forward to continuing to build our business, not just in North America but around the world.

MR. BARTON: Thank you. John, Stanley, Black and Decker, and again,

it is much more than drills, maybe a little overview of the company.

MR. LUNDGREN: Sure, Dom. Stanley, Black and Decker sounds more like a Washington, D.C. law firm. (Laughter.) That was a negotiated corporate entity as part of what in all seriousness was a very successful merger of two well established companies.

Our brands, Stanley, Black and Decker, and DeWalt, are ubiquitous, about 50 percent of our revenues are comprised outside the U.S., and the company itself is the result of the merger of Stanley Works and Black and Decker over four years ago now.

As I said, 50 percent of our revenues are outside the U.S. We have production around the world but major production facilities on four continents. In general we try to design in the market for the market, and I'm sure we will come back to it later, but that was part of the drive in a significant reshoring activity that we have undertaken in the last couple of years.

Beyond construction, do it yourself, professional products, and as everyone probably has a Stanley or a Black and Decker product in their house or I hope you do, two-thirds of what we sell are actually to people that do it for a living. It is fairly typical in terms of the 80/20 rule where 20 percent of our end users would actually account for about 80 percent of our consumption.

The overwhelming majority of the company is tools, as I said, for construction and industrial use, including supplying factories, OEM, and things of that nature, in addition to building.

The only other point is what a lot of folks don't realize is about 25 percent of our revenue is derived from security. I don't mean trading stocks but commercial security, so installation systems, integration and monitoring primarily for commercial

facilities. We are the second largest systems integrator in North America, in that business, and that represents about 25 percent of our revenue. Thanks.

MR. BARTON: Thanks, John. Siemens, Eric.

MR. SPIEGEL: Thanks. Siemens has been around for a long time. It was founded in 1847. I like to say it's the oldest biggest company in the world. There are a few older companies, not many. There are a few bigger companies, but they are not as old as Siemens.

I think a lot of that is driven by the company's ability to innovate in many different areas and also change itself over time. If I think about the business, we are in about 40 different businesses that cut across energy, both power generation, oil and gas sector, industrial automation, building technologies, health care, and also things like mobility and rail. We are the world's leader in high speed rail, we are the world's leader in offshore wind, we are the world's leader in MRs, and a whole variety of other technologies.

I think if you look back at the history of the company, it is really driven by this innovation and invention. In fact, I think Antoine mentioned that the U.S. has a monopoly on the pacemaker. I think Siemens invented the pacemaker or one of the first versions of the pacemaker, and sold it later, maybe unfortunately.

The company is now really refocusing itself. Globally, we are at about 350,000 employees in over 200 countries, over $100 billion in revenue. The U.S. is the largest market with over 50,000 employees and about 100 manufacturing facilities in the U.S., 25 of them which are large. We have acquired quite a few sites in the last years and also built from scratch many different manufacturing sites.

The company is now refocusing its portfolio around electrification, automation, and digitization, so hopefully today we can talk a little bit about where we

think some of those things are going in the industries, particularly in these advanced industries.

MR. BARTON: Excellent. Thanks. I hope that gives a good overview. These, I think, are truly representative of advanced industries and what is going on.

One little other factoid I would put out there, it was interesting and it wasn't by plan, all these companies over 100 years old, one thing that goes through my mind, we looked at the average lifetime of companies, and if you were an S&P 500 company in 1935, your average life would be 90 years. In 2012, it is 18. Most companied don't last. McKinsey is coming up to 90, so I worry about that. (Laughter.)

To be able to thrive and survive in an environment like this, I think, says something. I think that is something else we should look at. I'm sure these companies have changed a lot over time.

I'd like to focus first on since 2010 or so, there seems to have been a shift, if you think of the work that Bruce, Mark and Brookings has done, and you heard Antoine, there now seems to be more manufacturing that is coming back here, there is more investment and so forth. There are lots of challenges.

I just want to focus a little bit on that at the start. When you think about site decisions, where you decide to manufacture, what has changed if anything. Maybe we will start with you, Ron.

MR. ARMSTRONG: As we look at our business, a lot of key factors that drive us, but obviously labor cost is a key part. Freight costs. More importantly, the technology and the capability of the area to be able to support the engineering aspects of our products.

Peterbilt, Kenworth and DAF all have large engineering groups that are focused on making sure that our products are the best products in the marketplace.

Peterbilt, Kenworth and DAF enjoy a premium positioning.

As we made the decision to build a new engine factory in 2007, we evaluated a lot of different options around the world, and ultimately concluded to build the factory in Columbus, Mississippi. We could have built it in Mexico, anywhere.

We really felt like that gave us the right proximity to suppliers, to talent, to a state that was very receptive to supporting business growth, as well as a right to work state that provides workplace flexibility. That is very key to our business because of the fact that we are in a very cyclical business and having that flexibility with the workforce is key to our strategic planning and our decisions.

A lot of factors. Mississippi State is just down the road from us and they have a very well developed automotive engineering capability. Finding all those ingredients and finding the mix of those that make sense for our company.

MR. BARTON: The flexibility, the ecosystem, the support.

MR. ARMSTRONG: Yes, a very strong community college system that really was there to help train and develop the factory workers, and also the university to be able to support the engineering higher level requirements.

MR. BARTON: Excellent. John, you have also just opened up some more plant sites.

MR. LUNDGREN: Yes. Bruce showed a slide, I think, that said it all, it was very simple. It said innovation, skills, and ecosystems. That is what it is all about, and public/private partnerships are very important.

Ron just touched on it in terms of the local community colleges, many of whom will actually design a curriculum to train your people if in return you say, hey, we will interview at least 20 of your graduates and hire 5 to 10 every year. Those kinds of things all make sense.

Notice no one said “subsidies,” interestingly. While they help and obviously cooperation from local governments is terrific, I spent 14 years of my very long professional career living and working abroad, and if nothing else I realized subsidies exist for a reason, without them, you wouldn’t locate there. It’s what a government has to do. I see my friend from Siemens nodding. It’s that simple.

In terms of the innovation, it’s our life blood. In terms of the skills, we have talked about the need for collaboration with local institutions, STEM education. I won’t steal Eric’s thunder. He does wonderful work with a taskforce that he’s the vice chair of for the Business Roundtable, and there is a lot of work going on.

The ecosystems, and that leads to just very quickly why we re-shored a major production effort. Stanley, like so many others in the late 1980s/early 1990s where labor was a factor offshore, much production. The more labor intensive, the quicker we moved to China with great success. That included in the case of Black and Decker both consumer or retail and professional power tools.

There hasn’t been a power tool, cordless power tool, made in the U.S. probably in 25 years. A lot of electrical components, overwhelmingly made in China, usually in wholly owned factories that you control the IP and things of that nature.

About two and a half years ago for a variety of reasons, rising labor costs that we have talked about in “low cost countries,” currency, length of supply chain, we did a study and the end result of that is we moved production for DeWalt Power Tools, a professional brand, not all of it but a significant portion from Chizhou, China and Mexico to Fort Mill, South Carolina/North Carolina. The plant is literally right on the border of North and South Carolina, so we get great collaboration and cooperation both from Governor McCrory and Governor Haley, which was helpful.

It was simply about the fact that local component suppliers were there, a

skilled workforce was already there. It was the site of a large North American distribution center. Dramatically shortened the supply chain on average six plus weeks, 6 to 12 weeks of product on the water if it's coming from China, something like a West Coast port strike tends to slow getting those Father's Day presents or construction materials to the home centers for their customers and end users.

A whole lot of factors went into it. In terms of costs, we have been public with this, so I'm quite comfortable saying it, within the first year of operation, we had the cost of that power tool within five percent, delivered to the customer, of what we were able to do in China.

We think over time, as we ramp up production, get a little more scale, we will have it at parity. That doesn't count the benefit of 10 working capital turns versus four or five, which I don't need to explain to anybody in this room is incredibly valuable, and just a much more simplified and shortened supply chain.

It's been a great success. Lastly, I won't wave the stars and stripes. We knew this was a good thing. What we didn't realize is the strength and incredible support from our customers and end users when we introduced the first U.S. made professional power tool in 25 years in the U.S.

It has been a phenomenal success from a marketing or customer perception point of view. We knew it was a good thing to do. We quite frankly under estimated the positive impact that would have. It makes sense for us to continue to look at more opportunities like that.

MR. BARTON: Very interesting. It's quite encouraging, too, when you think about it as well. You don't just move a plant every other year. These are big decisions obviously.

MR. LUNDGREN: Eric is involved in much more I'll say sophisticated

processes, but these ecosystems, right now we talk about weak foreign currencies, to your point, Dom, we can't move it overnight. You can increase production 10 or 15 percent in a low cost country.

When you are selling professional products or really sophisticated products with lifetime warranties or life and death, if the product fails to qualify, a component supplier being a good example, it could take 18 to 36 months. These are not decisions that you decide on Friday you are going to move production on Monday. You can ramp up a little bit, ramp down a little bit, but these are decisions that you are going to live with for a while.

MR. BARTON: Yes, having that flexibility and agility is key. Eric?

MR. SPIEGEL: Yes. I think a lot of the good points have been made. I would maybe just add a couple of things. One is I think obviously what has happened over the last few years with the access to relatively inexpensive energy here and shifting labor rates, the U.S. workforce in general is very productive, and what has happened with labor rates in the emerging economies, has really improved the table stakes for the U.S. in terms of being a place to invest.

I think those aren't the most important things we look at, certainly they are things we look at. You have to be competitive. I would say the bigger things that we mention here, one is around innovation, and I think what a lot of companies found in the U.S. and around the globe is that if the manufacturing goes offshore, the innovation goes with it.

We co-locate, almost all of our manufacturing facilities have research and development and innovation ongoing, engineering design ongoing at the plants. The second thing with that is also to be in close proximity to customers because that is where you really get a feel for what needs to change in order to be competitive.

The more you separate those things, if you are separating R&D from manufacturing, from the customers, now you have to connect all those dots and also be fast to market. Just being low cost for a lot of the technologies we make is not enough. You have to be low cost, but you also have to be innovative, you have to be understanding the customers' challenges, and you have to be driving that in a real way.

I would say the second thing is the U.S. has the best university system in the world, so you have access to world class talent at the university level doing research, also the national, as we do quite a bit with the national labs here. You have access to some of the best talent in the world.

Also, just the innovation culture in this country is something that we at Siemens are trying to adapt. We are actually opening a new corporate technology center. We do over $1 billion of R&D in the U.S. today.

Our main facility is in Princeton, but we have it located in a lot of the plants. We are going to be opening one in Silicon Valley very soon, just because we want to sop up some of what's going on out there in a much bigger way.

Those things are all important to the process, but I would say being faster to market, being closer to customers, having access to world class talent.

I should say on the other side of that where we have had some issues here is one around what I would call "skilled labor" and the middle skills, which we can talk about more, has been an issue. Some stories about opening some large plants where you need hundreds of new employees and the struggles to find the skilled labor to work in plants now that are largely run by lasers, robots, computers, et cetera. We just don't have the people that are trained for that.

The other thing is infrastructure in this country. The infrastructure problem is real. We have built four large plants in the last few years, and in every one of

those, we either had to upgrade roads or rails in order to be able to move supply chain in and out, and also to be able to export.

Those are things that a lot of companies who are thinking about locating assets here maybe wouldn't be able to afford or maybe they are not moving into a big enough market.

We had very little support from anyone for those upgrades, some support from some states and things like that, but in many cases, we had to do a lot of the upgrades on our own.

This issue about infrastructure is a real issue. A lot of those transportation assets in this country and other assets are really run down. It used to be 20 or 30 years ago people thought of the U.S. as having maybe the best and sophisticated infrastructure. That is just not true any more.

MR. BARTON: Very interesting. I'd like to sort of continue on that theme, improvement opportunities. If you could wave a magic wand in a sense, what you would like to see more of, what would make it easier in order to be able to do it.

We will open it up for questions for 10 to 15 minutes, so please be prepared to ask questions or send them in, and we will make sure we cover them.

Eric mentioned infrastructure and the need to ensure that is upgraded, and skills. John?

MR. LUNDGREN: Infrastructure for obvious reasons for all of us, not just the country. I was talking with some of the Brookings staff earlier, where you see Tom Donohue, the CEO of the U.S. Chamber, and then the head of the AFL-CIO in violent agreement on the need to upgrade infrastructure. That doesn't happen very often.

As a consequence, it looks like a duck, it walks a duck, it quacks like a duck, and it probably needs to be addressed.

For us, and Eric touched on it, it's the skills. As I mentioned, Eric is doing yeoman's work. I'm not his P.R. agent, by the way. (Laughter.) We're good friends. We're not competitors. He gives a lot of his time and his company's time and resources to a workforce readiness program on behalf of the Business Roundtable. That is why I mentioned it. I do the same at the NAM, National Association of Manufacturers. It is the skills gap.

As recently as a year/year and a half ago, there were 600,000 unfilled manufacturing jobs in the U.S. We can call it "advanced manufacturing" because as Eric pointed out, the image of manufacturing, dirty overalls and a missing finger and grease under your fingernails and your name on your shirt, that is not a modern manufacturing plant any more. It's an engineer and a laptop and basic skills.

These are high paying jobs. These are $80,000 to $100,000 a year jobs, as Bruce's data pointed out. There are a lot of sources and sources for this labor, but local collaboration, I think, in our case, some of the greatest institutions in the world where the Nobel Laureates and folks are coming from, that's great, but demand exceeds supply for these brilliant minds.

What we have found in terms of an opportunity, as I touched on earlier, is by partnering with the local -- I'll say lesser known community colleges, where most of these kids, often ethnically diverse, which is terrific, are often the first young man or young woman in their family who has gone past high school.

The local community college, in our case, we have a large population base in Connecticut, in Indianapolis, in and around Baltimore. They will truly design a curriculum that trains your people, at least to give them the basic skills where when they show up on the job, you custom trained them for that, so 80 percent of the work is done. The reward is, of course, their graduates have gainful employment. It's win/win. You can

classify that as public/private or just leveraging the system. I think clearly that is the biggest opportunity.

MR. BARTON: Build skills, get community colleges more integrated with the needs of what employers want.

MR. LUNDGREN: Yes, sir. I have to say, just to put my NAM hat on for a minute, the manufacturing industry, advanced manufacturing in particular, needs a face lift. It needs an image consultant. Many women are in these jobs and they are doing phenomenally well. It's a noticeable change.

You get hey, that's great for my neighbor's kid, but my kid is not going to go to a vo-tech school and work in a factory. A lot of folks sitting in the C suite, that's where they started their careers.

The point is these are not dangerous jobs any more and these are not physically stressful jobs any more. These are jobs that require some fundamental technical skills that not enough of our high school or two year or four year graduates have.

MR. BARTON: We heard, just building on that, the software needs and services, and you said technology, in every single one of these organizations. Ron, any views of where the gaps are or areas?

MR. ARMSTRONG: I think in our industry one of the challenges is the transportation system, the highway system. We can make our vehicles as efficient as we can, but as you enter into metropolitan areas, there is a high degree of congestion, and the quality of the highway system and the road system, I think, is in need of repair.

I think it's critical that we make the investment in the highway infrastructure and the road infrastructure to really get the efficiency out of the whole freight movement process. I share the thoughts about employment, but in terms of our

industry, the investment in the highway system is critical.

MR. BARTON: It's very much local, the way you guys have described it, whether it is in the Carolina's, you are talking about cities. Is it mayors and governors? Has that changed over time or has it always been that way.

MR. ARMSTRONG: When we made the decision to locate our factory in Columbus, Mississippi, the Governor at the time was Haley Barbour. He was a very strong proponent of engaging business development for the state. I think it is critical. We had Governor Barbour. We had all the local officials anxious for the jobs, anxious for the opportunity to get that higher level job in the community. It meant a lot to them and they worked really well in concert to put the package together.

MR. LUNDGREN: I would agree wholeheartedly with what Ron said. To me it's far more of a state and local issue. The CEO of the state, and that is the Governor in every case. I talked about Governor McCrory and Governor Haley. The folks that understand it's a great opportunity for their state to create jobs, to create revenue.

Again, it is not about subsidies. It is about what do you need us to do, what barriers do we need to remove, recognizing that we have responsibilities to the community, to the environment, et cetera. How can we work with you?

That is just really important and that is why I think you see particularly advanced manufacturing jobs locating in four or five areas. The need is there and the collaboration is there. That to me is the most important driver.

MR. BARTON: Eric, just to begin with a global overview, and Bruce showed some slides, what do we think about in a sense our competition on that side? Which countries around the world seem to be moving well in this area? What is your sense of it?

MR. SPIEGEL: You mean just in terms of innovation and in terms of advanced industries?

MR. BARTON: In terms of where advanced industries are also growing.

MR. SPIEGEL: I think obviously a lot of the emerging economies, China certainly, and some of the Asian countries, but also some of the European countries, Germany. I think we were chatting before. Germany coming out with this new phrase, "Industry 4.0," which is really going to be moving -- it's really talking about moving companies to the digital enterprise with digital design and digital manufacturing and bringing those two things together to really drive efficiency, time to market, and flexibility.

It's sort of the fourth phase in the industrial evolution, and not many companies are there right now. There are some industries that are moving that way pretty quickly. We would say the auto industry is probably the fastest moving toward that.

The idea, for example, with the Ford F-150, you can literally make millions of versions of the same F-150 coming off the same line, and it's the software that really allows you to do that.

You are going to see that now more and more. In the old days, they would say with mass production, I can make it cheap but I can only make one or two or three kinds. Now you are moving toward mass customization where I'm going to be able to make thousands of variations, have incredible flexibility to meet market demands at pretty much the same cost.

There is no longer going to be the big tradeoff between cost and flexibility, and that is really this Industry 4.0. Germany is pushing that in a big way. I think a lot of our customers here are looking very hard at that. We are working with a lot of companies.

That is really software driven. Everything we make, everything you see

in the factories now, software is playing a much bigger role. Everything is being censored. It is not just about the product design and manufacturing, but also the design of the plants themselves, and integrating those things to improve productivity.

That is going to drive that change along all those dimensions I talked about. This is the next big wave that we think is going to change advanced industries over the next few years.

MR. BARTON: We will hear more in the next panel from James Heppelmann.

MR. LUNDGREN: At the risk of doing Dom's job, real quickly, Bruce mentioned it. I think there may not be the understanding of spend a second on the German apprentice system for technical skills.

Quite frankly, I learned about it sitting on your taskforce at the BRT. To me it is an incredible system that I think is too often overlooked.

MR. SPIEGEL: Germany has had a dual education system for many years and an apprentice program. At Siemens, for example, in Germany alone, we have 10,000 apprentices. The idea basically is out of high school you get hired into an apprentice program. In Germany, there are over 300 different apprentice programs, not all of them related to manufacturing, a lot of other skills, in the medical field and culinary arts, all kinds of other things.

Those apprenticeships change over time. They add new ones and they get rid of ones that are no longer viable. You basically work part-time for a company in a facility, so you actually develop the skills, and you go to school part-time.

In the U.S., we started one at Charlotte, at our gas turbine facility, with a community college there. They go to school part-time. They work part-time. We pay them. They start out slightly above minimum wage and they end up when they are ready

to start full-time after three years making $55,000-$60,000. It's a great source.

The deal is you develop a real skill. You get a certificate, in that case, from the State of North Carolina. You have a job guaranteed if you pass the courses. It's a high paying job and you have no debt.

As we know in a lot of our education system, you graduate, you have a degree, but maybe you can't find a job in the area that you have a degree. You maybe don't have a real skill that someone can hire you into. You have to be an apprentice wherever you get hired, and you don't have any debt.

A lot of this is in the middle skills, so we have started these things and are actually working with the President's Council on Advanced Manufacturing, Klaus Kleinfeld, and I don't know if Klaus is here yet, with Alcoa, Dow, and some other companies who are involved.

We are starting some more apprentice programs around the country, seeding that in different areas, and hoping that once you build these programs, they will come.

For example, in Charlotte, there are now seven or eight other companies who are part of the apprentice program, in the same program called Mechatronics. There are many different areas you can apprentice people in.

It is also a good avenue for building the next middle class, right. Again, you have a job. In Germany, they don't see it as the end of your career, they see it as the beginning of your career. You can continue going to school. A lot of the senior executives at Siemens were apprentices when they started their careers.

MR. BARTON: Back to your P.R. point, I think as John said, they are very well respected jobs. It is not as you said you don't want your child to go there because it is seen as somewhat a lesser thing. It is actually a very good thing. Some of

the executives at BMW and others were apprentices. I think that is a mindset shift.

I would love to actually open it up to get any questions for the group, and if we could try not to have speeches, but get to the question. Otherwise, I will jump in. Over here.

MR. WU: Hi, David Wu, former member of Congress, and since we are in Washington, I'm going to ask a policy question rather than a business question.

I was taking a vacation in Costa Rica. There were four Swiss in the class, one was an investment banker, one worked on jet engines, two repaired bicycles. The two bicycle repair people were so focused, I mean it was really, really impressive.

The comparison is Europe versus the United States. In Europe, if you graduate from secondary school, the education beyond that is very low cost if not free, so if you don't know exactly what you are going to do, you can wander around for a few years in that training education system before you decide or find something.

In the U.S., it is not publicly paid for, and it is very expensive, and a lot of people drop out or never go.

How important is it, if important at all, for this country to better publicly fund beyond secondary education, would there be a positive return on investment?

MR. SPIEGEL: I can give maybe one part of the answer because I was on the BRT Work Taskforce as well as the President's Advanced Manufacturing Council.

I think one of the most important issues is there are a lot of programs which provide aid in the U.S. There are some Federal programs and some state programs, et cetera. I think the biggest issue is making them more business driven.

For example, the apprentice program I talked about in Charlotte, there are real jobs at the end. You are basically putting people in a training program and if they go through the process, they are going to get a job. You know there are jobs there.

One of the things I would say is not just to have people continuing to get education but to get it more focused and more in line with where are the jobs. I think there is a big disconnect in this country, not only in coming out of high school, and the high school systems, I think, needs to get more aligned with where the jobs are and start educating young people about where the opportunities are really going to be.

I think the community colleges need to get more aligned. We found the community colleges very receptive, and the university system needs to get more aligned with where the jobs are. In some areas, they do, but in other areas, they are not very receptive.

I talked about Charlotte and this gas turbine plant. We went to work with the University of North Carolina at Charlotte to develop an engineering program around gas turbines and energy because one didn't exist in the area.

It is at all levels. I think if the Federal Government and the states were going to direct money to things, I would direct them at things where businesses are saying there are jobs there. To me, that is the key part, not just it could all be free, but can you direct to those jobs.

MR. LUNDGREN: Just very little to add, respectfully disagree there is nothing there. I think the mistake and the image is that young man or woman that goes to four years of whatever, private, liberal arts, whatever school, has $200,000 in debt or they have spent that and can't get a job, I referenced the community colleges as Eric did.

In our particular case, Central Connecticut State College, Towson State University, near our facilities where we hire a lot of people, little to no cost to the student. The overwhelming majority live at home and commute. A custom designed curriculum that would allow them to at least be interviewed if not hired at one of our facilities.

They exist but nowhere near enough. To suggest there is nothing there,

I think is an overstatement, to suggest there is not a problem would also be naïve. Point taken.

MR. ARMSTRONG: Just one other thought, and I think "free" is probably too cheap. I think the students having skin in the game makes them more focused.

MR. LUNDGREN: Absolutely, Ron.

MR. ARMSTRONG: A more dedicated student. When they have skin in the game, they will focus and work harder.

MR. BARTON: I am going to take a couple of questions. Over here.

QUESTIONER: Really very interesting to hear the case studies you are describing, particularly the use of the German model. Two quick points. One, with a smile. It is sometimes a little interesting to hear businessmen talk about the importance of investing in R&D, the importance of investing in ecosystems, the importance of investing in infrastructure. I assume NAM is going to push hard for higher taxes to fund these things. Just a question. (Laughter.)

The second question, I mean this, I was pleasantly surprised to hear how much you are already doing with the community colleges. I think the idea that the Federal Government is going to fix that may be misplaced.

The question I would ask you, Eric, is can you extend the good things that you are doing across, and I think you mentioned 25 manufacturing facilities? This country has often been built from the bottom up, and I think your individual initiatives to do that training in collaboration with community colleges.

The MIT study argued that actually you can fill these jobs. There is some question about how much the gap is. There is clearly a gap in the type of specialized training you are talking about, but that's not going to come from a Federal program, I would argue, but what do you do?

MR. BARTON: We will take two more and I think we will wrap it up. Down here.

QUESTIONER: I'm a retired CEO in Virginia and I'm working with senior business people to diversify the economy in Virginia. On the 600,000 jobs, it's not intuitive to me why that isn't being addressed in a different way.

Does it mean that you are foregoing revenue that exists because those jobs do not exist, and in which event, there would be an ROI if you did certain things to address that, so it's not 100 percent intuitive to me that those jobs are real. Can you explain that a little bit more?

Secondly, we have tried on two or three occasions to create apprentice programs and go to employers in the region and say okay, we'll fund a lot of this, they need skin in the game, too, of course, or it's not real.

We said will you commit to an outtake. Of course, you go through economic cycles, you know, you can't do but so much. Can you address that with a little more particularity? It's not intuitive to us as we deal with it.

In other words, if there really was a return on investment for you, you would hire those people. You would develop your own programs and you wouldn't forego revenue.

MR. BARTON: Okay. One last one here.

MS. LEE: Hi, Ester Lee. I created and led the Office of Innovation and Entrepreneurship in the Obama Administration. I worked at Siemens as well.

Expedia was an idea started by a Microsoft employee who was funded by Microsoft, which later spun off. What are the kinds of things your companies are doing to encourage entrepreneurship within your companies? If not, maybe outside your companies as well.

MR. BARTON: Antoine, do you want us to make a comment? We will stop, we won't answer the questions. (Laughter.)

QUESTIONER: You briefly touched on the tax, tax incentives, subsidy issue. My question is really how often is that the clincher in your experience?

MR. LUNDGREN: Let me start with the 600,000. Those aren't jobs at Stanley, Black and Decker. I run Stanley, Black and Decker. I don't run the United States of America, just to be clear. (Laughter.) We are a really small piece.

Your point is well taken. First of all, I was trying to be politically correct. Half the people that apply for those jobs don't pass a background test, criminal record or substance abuse. Half the applicants are ruled out even if they were to have the technical skills. That is sad, but that is the state of the world that we live in today.

In terms of the jobs themselves, you are absolutely right, but the view is if you are indebted to or answer to your shareholders, you have to be met halfway. Yes, we could hire. We could completely train at great expense.

Or you can do the kind of programs I know we at least as a company are doing, working with the local schools, community colleges, bring me somebody with the basic skills, either coming out of the military or a basic STEM education, so we are not starting completely from scratch, and then we can train them to do these $60,000 to $90,000 a year jobs with specific skills that are required to make power tools or make components in the automotive industry.

I suspect the same thing would apply to PACCAR and Siemens, but I won't speak for them.

The whole idea of just someone walking in off the street, there is a very long, if you will, training period before you are going to get a return on investment, your words, on that employee. Bring me someone with the basic skills. I can get them there

in six months instead of three years. That is the person I'm looking for.

Those jobs remain open. As I say, half of it is simply those applicants can't pass the background check for the companies that require them, and half of it is clearly still lack of STEM skills.

MR. SPIEGEL: Actually, that is why we developed our apprentice program with the community college because we couldn't find people. We put a training program together to train hundreds of people for over a year to be able to fill the jobs because frankly we couldn't find them in the marketplace.

We worked with the community college, we put a curriculum together, we flew people to Berlin to train. It was very expensive, but there was an ROI.

The second thing I would say is what we are finding is these STEM jobs and these kind of middle skilled jobs, I don't mean Ph.D.'s. The time to fill those jobs is much longer than other jobs. Instead of 30 or 40 days, it might be 60 or 70 days, whatever.

Eventually, you might find some, or you put them into a training program. Some of these things can be a three month training program and you can do that.

MR. BARTON: There were a couple of questions around the community colleges extending that, is that done more locally?

MR. SPIEGEL: Yes, we do have a relationship with about 30 or 40 community colleges, and they are mostly around the 25 large facilities we have. We have now started formal apprentice programs at several of those, in Sacramento, Atlanta, Alabama, and also in Charlotte.

One of the issues, and I'll just be blunt, is it is quite expensive here relative to the cost of doing it in a place like Germany. One of the issues is as I said, we pay them while they are going to school and while they work, and also to develop the

training and whatever equipment is needed for the training.

In Germany, the federal government picks up part of that and the state government picks up part of that. That doesn't exist here. The Federal Government has come out with a $100 million program, which is an interesting start. (Laughter.) There really isn't money dedicated, where in Germany, it is a whole process with the apprentice thing.

Yes, we are trying to find a way to scale that, and there are many other companies who are looking for ways to participate and scale it. I think support from things like the national Governors or state Governors would be nice, but I think again this is going to be mostly business driven.

MR. LUNDGREN: The one on tax, very quickly, without opening a political can of worms, an important point. I think BRT, NAM, and a lot of other folks, we talk about comprehensive tax reform, territorial tax systems, everybody understands it. You can't address corporate tax without addressing individual tax. I think there would be consensus there.

I think most important from the manufacturing perspective, 70 percent of manufacturers in the U.S. file taxes as individuals or Subchapter S.

They are not Siemens. They are not Stanley, Black and Decker. They are not PACCAR. These are the folks that create the jobs, the 10, 12, 15, 20, 40 person start up that ultimately becomes Siemens or PACCAR or whatever. Seventy percent of the manufacturers in the U.S. file as individuals or Subchapter S, and I think that is a fact that is kind of often lost on legislators or when the tax question is raised.

It doesn't solve it, but I think it is just an awareness that the folks in the room should have.

MR. BARTON: On the entrepreneurship question that was asked, any

comments on that?

MR. LUNDGREN: We have devoted actual innovation space in each of our locations to help people come together with some interesting designs, some places that are out of the box, people really focus on human centered design of how people use our products, and allow them the chance to just be creative and put together paper prototypes.

We really encourage that because to keep that competitive advantage, you have to create that kind of an opportunity for the technologies, the engineers, factory workers, they all use those spaces to keep moving our company forward.

MR. BARTON: It's not just big R&D money.

I think we are running out of time here. I would love it if you all would join me in thanking the panelists, Ron, John, and Eric, for a terrific session. Really appreciate it. (Applause.)

Without a break, we are going to do a switch over here to my colleague, Srikant, who will come up and lead the next panel and introduce people. Thanks.

(Recess)

MR. INAMPUDI: As Antoine mentioned I was telling him during his introduction before the first panel, the majority of his talk was all around the technologies that go into the advanced technologies that go into the advanced industries portion. So he made it a lot easier for us in the second panel to start the introduction. So when we at McKinsey look at what are the technologies that will fundamentally reshape the global comparativeness and there are a dozen technologies. And we are quite fortunate, we have three leaders who basically Klaus will hopefully join quite soon, three companies who are leaders in their field and leaders not just in United States but globally, and they just happen to be in (inaudible). And we are basically having an opportunity to talk to

them. We have Jim Heppelmann. Jim is the CEO of PTC which is a company which is reinventing itself and being a leader in the internet of things. And his recent HBR article in fact has laid the foundation on what internet of things can be in advanced industries. He has fundamentally reshaped in terms of through this article what it could be. And we have Katrina Bosley who is the CEO of Editas. Basically they are trying to reinvent using genetics to cure almost any disease. Like so basically we'll have an interesting perspective. And Klaus Kleinfeld who will join us quite soon due to travel schedule. He's the CEO of Alcoa and he's looking at how do you actually reinvent from fundamental building blocks through material. So these three folks we are quite fortunate who are leaders in their space join us for the panel.

Jim, if you could quickly just give us a brief intro.

MR. HEPPELMANN: So PTC is a software company based in Boston. In sort of t-shirt sizes we'd be a large, not quite an extra large but not a medium. We were founded 30 years ago. We're celebrating our 30th anniversary. So 30 years ago there was a Russian-born mathematician who had an idea to do three dimensional modeling of things. And that's the 3D in 3D printers. So somebody has to come up with the 3D shape and then the printer produces it. So he pioneered that idea with a fairly famous product in the industrial world called pro engineer 30 years ago. And for the next 10 years I mean the company had explosive growth because this allowed mechanical engineers to design in three dimensions a component on the computer screen and then design all the other components and make sure they fit together and then simulate how they would work. And maybe you would find some problems and you would change the design a little bit. And then finally you'd turn the factory loose, but by the time you started up the factory you had a design that you were pretty confident in. So it was a huge savings in prototyping and time to market and quality and so forth.

What happened is over the next 10 years the world changed and products changed and we began to see -- you know, what Marc Andreessen was talking about when he said software is eating the world; that software is showing up everywhere. It's in refrigerators, it's in trucks, it's in drills, it's in planes, trains, and automobiles, it's wind turbines, you name it. And that the actual engineering of these things was kind of rebalancing around a mix of hardware and software. So we at PTC reacted to this phenomenon and we expanded into software tools that would help software engineers build the digital half of that product next to the mechanical engineers that were building the physical half of that product, and then it would all come together and be a great product.

The next thing that happened is we also realized that business models were changing, and that people weren't thinking about just selling things, a transaction, one and done, they wanted to sell something and then hang around and provide value added services, accessories, spare parts, technician services, maybe bundle some of that up into a contract like a warranty or a performance based contract. And then taken to the fullest extent they might say I don't even want to sell the thing, I just want to charge for use of it. And that led us into a new kind of software for optimizing the servicing of things. So at that point we were helping companies create things, engineering and manufacturing, and we were helping companies service things. And so along comes this idea of the Internet of Things and if you think that all these products are becoming computers as we heard in the previous panel, that leads you to what Scott McNealy, the founder of Sun, had said some time ago which is the network is the computer. And by that he meant when computers work together they can accomplish far more than when they work independently. So now you get the idea that these computer products are coming on line, these refrigerators and trucks and so forth, and that gives you all kinds of

new capabilities to control them and optimize them and give them autonomy, and then let them work together in systems, share a common data base. If you think about how Apple's iPad, iPod, iPhone, iMac all share a common data base called iTunes and a common app store, and to the point where if you buy one of them you actually want to buy all of them because they work together so well. So that idea is spreading over to John Deere who wants harvesting equipment to inform a database in the sky that then informs tillage equipment which informs planting and fertilizing equipment which informs irrigation equipment and so forth. So we really realize that this Internet of Things would radically transform the way that products are created, operated, and serviced. And so then we expanded into that business and that's really what let to the HBR article, was Professor Michael Porter and I spending some time thinking about what does this mean. Is it just a new feature set or is it a deeper, more fundamental, competitive transformation? And in that research and in the article that we published we concluded that this will definitely affect value chains and the motions that companies go through as they create, operate, and service products. It will change the dynamics in an industry, the so-called Porter's Five Forces, actually change pretty radically. It will actually redefine the boundaries of industries. The Apple example where suddenly a decision for a music device is also a decision for a phone and a computer and a laptop and tablet and so forth. So we think it's a pretty big thing and that's become really a transformative moment for our company to think about a new type of product and product system out there and how to enable our customers to do that.

MR. INAMPUDI: Great. That's, Jim. Katrina, do you want to?

MS. BOSLEY: Sure. So Editas Medicine may well represent the opposite end of every spectrum of everybody who is on all these panels. Just to give you a little context we are 15 months old. We have 29 employees, but somebody else is

starting next week so we're almost up to 30 (laughter). And we do genome editing which is fixing broken genes that drive genetic disease. It is out there. When I first heard about it, it sounded like science fiction to me and the more I dug in the more amazing it seemed because it's not science fiction, it's actually the beginning toehold of something that's been envisioned for a very long time, probably since -- you know, with Watson and Crick we understood the structure of DNA, we began to understand that the wrong sequence of DNA could cause disease. Gee, wouldn't it be nice to fix it there instead of just treating the symptoms down the road. So that idea has been around for a very, very long time.

You might imagine being able to actually do that is a little bit tricky. Now there are certain technologies that have been around for a few years that have made some progress on this, but in around 2012 there were a number of scientific publications on a technology -- CRISPR/Cas9 -- it's scientific jargon I realize that, but that's the terminology that scientists named things in crazy ways sometimes. And this technology has exploded onto the scene scientifically because it's actually been able to achieve this thing that was in people's vision for so long.

Just to put in a plug for funding basic research really matters, the original work that kind of led to all these observations was about 15-20 years ago, people who were studying the genes of bacteria. They were sequencing them, they were looking at patterns. Clearly a very basic inquiry and as that was chased through -- people were really interested in the genes of bacteria and how they're structured and how they worked -- they noticed these patterns, they chased it, what does it mean, how does it work. They discovered this tool that a bacteria uses to modify its own DNA and they said, you know what, actually we could sort of co-opt that, repurpose it, and use it to modify human DNA where you have a broken gene that's causing a disease. And it sounds kind of crazy. Most things in my world when you first hear about them, if it doesn't sound crazy it's

probably not ambitious enough. (Laughter) This definitely fits that category. The thing is it actually works. And some of you may have seen that -- I think it was a year or so ago Andy Pollack and the *New York Times* did a wonderful overview article on this technology because even though it was so young and really just being pursued in academic laboratories you could see the potential of where this would go, realizing this promise of treating genetic diseases at their root instead of just after they've taken hold.

So as I said we're a very young company. We're translating this technology from academic science into the kind of science you can apply in patients and to ask a patient to be an experimental subject in a clinical trial because that's how you develop drugs. People have to volunteer to be experimented upon. And to try to then take that forward and really turn it into an approvable medicine. And that's why we exist. We're in the beginning of that journey.

MR. INAMPUDI: Thank you. So I think just to bring Klaus -- since he was able to get here just in time for his introduction (laughter), so we have gone through the digital portion of it from Jim, we have gone through the genes portion of it, and now we are trying to the items of the basic materials portion of it from Klaus.

MR. KLEINFELD: And what was the question? (Laughter)

MR. INAMPUDI: If you could just introduce yourself and talk about some new cool technologies that you guys are working on at Alcoa.

MR. KLEINFFELD: How much time do we have? (Laughter) Klaus Kleinfeld; I run Alcoa. And obviously in terms of digitization I mean it affects everybody. I guess you've talked a little bit about that and probably have a little time on that, but also on the material side I mean there's so much happening, you know, on the materials side, on the process side. I mean on the materials side for instance if you just look at we announced last year, I mean on the aerospace side we announced a new generation of

aluminum lithium, and aluminum lithium is a metal that allows for structural solutions on airplanes that are 10 percent lighter than composite materials. You know, we would have said oh is that possible, how is that doable. And we see this requires a very different type of manufacturing process. One example, end of last year we announced the micromill technology and abled new materials for automotive. And I mean everybody has a car so you all kind of know the deal. Usually you want if you looked into cars and what the car designer, what the option the car designer had is that if they wanted less weight they got less strength, right, and less formability. So this was really the -- and usually also worse surface qualities, right. So this was basically the formula that was around all the time and everybody knew it. So we announced end of last year that we now have new materials out there that we are bringing out there that are already getting tested by some automotive firms that basically bring the weight substantially down 30-40 percent, increase the formability 30-40 percent, and increase the strength at the same time also 30-40 percent, plus have surface quality that is even in line with the highest standards that the automotive industry has for auto surfaces. You say holy cow. I mean how is that possible, right. And it's only possible because we -- to make this we had to invent a new process of making this material which we named micromill. And the micromill is a process where you go from hot metal to a rolled coil in 20 minutes. Something that today all around the world, even for the best ones, takes 20 days. And it takes about -- the reduction of the footprint brings it down to 25 percent of the footprint of what you usually have, and we believe the energy consumption will go down by 50 percent. So you have an unbelievable crazy thing there. And what enables this, the question why was nobody able to invent that before, this is where all the sensing 13:50 comes in, right, because when you got from hot metal to rolled coil you have to really know at any point in the process exactly what is going on and respond to this. And that's also where materials on

how you make rolls come into the game, when your surface qualities come into the game where you basically use certain lubricants to make sure that the material doesn't stick. That's another one.

Another cool thing, we acquired a company called Firth Rixon last year. And one of the reasons why we acquired it is because they have a technology that's called isothermal forging. I mean isothermal forging as the word says, I mean it's iso, which having the same temperature, and it forges, and in this case it forges nickel superalloys. And the reason why it does that is because it's mostly for application in jet engines or industrial gas turbines. It's all about the temperature in the combustion chamber.

We are number one when it comes to blades in this, but we didn't have -- the bottleneck was what the blade sits on which is called the disc, because the disc couldn't stand the temperature. So the great, great engineers invented a technology where the dye gets heated up to almost the same temperature than the material and then gets forged. But to do that at the temperature, you want to go to the maximum temperature, you do that in vacuum. So now imagine a forging press of let's say 25,000 tons operating in a vacuum where the temperature of the dye and the temperature of the material is almost at a melting point and it doesn't stick together. So that alone as an engineering monster you have to basically build an all robotic -- you could not have done that before because it needs total robotization. It's really amazing piece and it allows for a 70 degree -- Celsius that is -- that's the temperature that the world thinks in (laughter) -- Celsius 70 degrees increase of temperature inside of the combustion chamber, and that alone allows the total efficiency of the jet engine to go up by 4 percent, and that's big -- 4 percent -- gigantic.

So those are the stuff -- and you want me to? (Laughter) Have you had

enough? We had enough, okay.

Very good.

MR. INAMPUDI: The good about the panel I basically get to moderate is all of you are so incredibly passionate about the technologies that you are talking about.

So, Jim, one of the big things having read your article is the whole Internet of Things, right, like where are we? Are we like in the first inning of a nine inning game? Where are we in terms of the Internet of Things?

MR. HEPPELMANN: I mean it's kind of funny because I live in Boston and we have a lot of international clients come visit us and occasionally I take an international group down to Fenway and we watch a baseball game together and, you know, it's pretty hard to understand baseball the first time around. So I always say I think we're at like the midpoint of the second inning where, you know, you've seen an inning and a half and you're kind of starting to understand how it's played, but you still have some questions, but you have no clue how it will end. So I think that we're starting to see patterns here. And I mean probably most people in the room or somebody in your family has a Fitbit or a fuel band or some kind of quantified self device, or a wearable of some sort. Certainly you all have smart phones if we want to count that. Maybe you live in a smart home or you've been in a smart home. You probably either have an automobile that's connected to the internet or maybe you watched the Super Bowl and noticed that Chevy led off that ad about the new truck talking about its 4GE LTE connectivity capabilities which was sort of interesting. So I think we're starting to see what's possible, but people can't yet comprehend what we could do with it, you know, the kinds of efficiencies we could create, the way that we would evolve products so much quicker if we actually understood how they were used, the way that we would actually change the way they operate if we had feedback loops; that we would run algorithms in the sky and

in the product and we'd use big data and we'd have the product continually adjusting itself and its usage motions to create a lot more productivity.

We can begin to comprehend the business model changes we'll see, although we've seen what Uber has done really by understanding and unlocking latent capacity in the transportation system through sensors. In this case the sensor is simply an iPhone or a smart phone reporting whether the driver is on line or not and available or not and where they are, and then hooking that driver up with a passenger. So we're starting to see disruptive business models, we're starting to see breakthrough products, but it's very difficult to comprehend where this will all go in the next 10 years. But I'm obviously pretty excited about it because having studied it a lot I see some just incredible things happening.

MR. INAMPUDI: Yeah, it sounds like a great opportunity.

Katrina, in terms of genomics, right, like in the biotech stuff, you've been talking about this for a long time in terms of human genomics. Like where do we think we are and your perspective and what do you think the next five years would look like?

MS. BOSLEY: So I sometimes talk about genomic medicine as the fourth frontier of medicine. If the first two, which came around the same time, around the turn of the 20th century were vaccines and using small molecules or little chemistry drugs. The third frontier came in the sort of late 70s with biologics, you know, proteins and the great biotech companies that were built off of that, Genentech and Biogen and Amgen being in that first generation. The genomics medicine wave, there have been pieces of it coming along but you're seeing it explode now in a number of different ways. If you look at gene therapy companies, the number of companies that have shown truly transformational results. At this big hematology and oncology conference in December showing that you could essentially cure patients with beta thalassemia, which is a terrible

blood disorder, by giving them a gene that repairs what was their broken gene. This has been an idea that has been around for a long time and to use a -- I love nerdy science analogies -- it's either a super satistrated solution or you've hit critical mass, or whatever you want, but there's a confluence of a number of different understanding of data, technologies, et cetera. Just as you were talking about sensors being critical to what you're doing, what I'll call the genomics infrastructure, the investment in sequencing the human genome was worth it. Maybe it took longer for that value to be realized that we had anticipated, but what we're doing now is because that investment was made and it's been an infrastructure just like building roads in an infrastructure. Some of the folks on the earlier panel were talking a lot about physical infrastructure In my world what matters more is knowledge infrastructure and data infrastructure, the human genome being one example of man. And I think that the President's point about precision medicine and the initiative he's proposing there is a further investment in that that will further potentiate being able to know how to fix genetic diseases or genetic drivers of disease. But I think that all of those come together now; we're able to start to make these medicines, not because of any one thing but because of a lot of things coming together. The knowledge, the data infrastructure, the technologies. And then frankly in my world investment -- for all of you who are people with businesses that have revenue and profits, biotech is going to seem completely weird because -- in my company I' am expecting to raise and spend about $2 billion before I make any money. That's what it takes to make a new medicine. Now there are a lot of people who are willing to invest and there's tremendous risk. I can give you all kinds of statistics about the probability of failure. That's fine, but that's also what it takes to make a new medicine and I have no problem with that risk. And my goal is to go find the people who are willing to take that risk along with me.

Last year, just to give you a sense of -- particularly in the United States,

the willingness to take that risk is unique in the world. It just is. The capital availability here is profound. There is wonderful science in Europe and Japan and many other places, and they do not have the capital availability to take these risks. Last year $40 billion was raised in the U.S. for investment in young biotech; $8 billion of that in venture, $8 billion in IPOs, the rest in secondaries and such. That's one year's worth of capital, and that's funding all kinds of spectacular research, not just genetic based medicines, immuno-oncology and a lot of other stuff. That's why we can do it here; it's not only the science but also the capital availability.

MR. INAMPUDI: So, Klaus, just talking about your technologies in aerospace -- and I live in Detroit, I have to say everyone talks about Alcoa in a different way after the F150 launch. So if you basically look at it and you say what are some of the new developments that you see two years out, right, like that's -- you already talked about a lot in aerospace, but also in other fields because you fundamentally could transform many industries.

MR. KLEINFELD: Those examples that I gave are not just for aerospace. I mean the jet engine side and all of the other is automotive. I think new materials basically go into pretty much everything. And if you look around I mean many of you have devices -- I'm just looking at this one device there, you know, and then it's all encased in aluminum. Who would have though, you know. If you could hold it up. See, beautiful aluminum shining (laughter), see that. I mean that's so nice and the wonderful surface. You touch it every day and so -- isn't that true? I mean it has a nice tactile feel, you know. Who would have though honestly? And it has penetrated so many areas of our life. I mean everybody has it at home and so I'm not concerned about that. I mean we predict for this year that we're going to have another seven percent increase of demand growth for aluminum worldwide. And I said a while ago that in this century the

demand for aluminum is going to doubt worldwide, and that requires a six and a half percent growth per year. So far in this century the growth number has been well above it. And again we are not just aluminum, we are now also other materials and a lot of light-weighting.

I think that let's also talk about the (inaudible) which I'm particularly happy about, at the same time I'm concerned about it because there is so much. I mean you were talking about the Internet of Things, you were talking about some of the data analysis, and all of these things come together. In a way the big challenge I see is how do I make my team aware of all the opportunities, right, because I had this experience. I love travelling also to our plants and then go around and talk to folks, and recently I was in one of the rolling mills and they introduced me -- we have this internship program through which we hire -- introduced me to a young group of folks and they had taken basically out of their cell phones, they've taken the cameras out and put an array of optical sensors together on a big piece of aluminum and then wrote a little bit of software behind it, right, and installed it over a slitter. A slitter is basically a line with slits off the sides of a coil. And typically there was a person standing left and right of it inspecting whether the slitter was working in basically three shifts, you know. And they put it in there, looked at this. The device probably cost $500 if it cost a lot, the software they did themselves -- most of it they downloaded, right. A little pat on recognition, right. And they could immediately eliminate the two people because obviously I mean those optical sensors, the resolution is much, much higher than the resolution of an eye and it never gets tired. So then the next debate was oh wow, I mean because those two people standing there and the capabilities of the human eye and the tiredness was a limiting factor that we couldn't run the machine faster. So we could immediately start to run the machine faster and this was a machine that was a bottleneck in the shop. So these

young kids not knowing what they did, just were playing around with stuff that is totally natural to them, and what they have found is something that is literally worth a couple of hundreds of millions, you know. My struggle is how do I get more of this into the organization and goes through from sensing -- I mean sensing is revolutionizing, really revolutionary to communication devices, you know, to the question of assembling the data and then analyzing data, doing it real time. The importance of automation that you can put into this. So the list is long. How do I get this as a natural thing injected in the whole organization? So that's my biggest challenge today.

MR. INAMPUDI: So I know we'll get to the questions from the audience, but just a couple of questions just to get the conversation started. You're all distinct in what you to, right, like from atoms to genes to digital stuff, but truly innovative like in your own fields. But all of you are -- well, really unless you're trying to get the 30 person start-up, but how do you stay ahead of the global competition? Like how do you make sure that you have your talent issues, we get the fact on capital, Katrina, that you raised, but how do you truly stay ahead of the global competition? Maybe, Jim, we'll start off with you.

MR. HEPPELMANN: I think that the United States in the area of bids -- I mean we invented the whole concept and we've had an incredible, incredible lead. I mean I think it's getting more distributed around the world, but you know as bids become more important to every company and every product and every manufacturing process and so forth, I think that we in the U.S. have a great opportunity to leverage what's a core fundamental advantage we've had since the beginning. I think we have to invest more in it, but this idea of clusters and ecosystems is very important. I think in our business I'm fortunate to be in Boston. In Boston I'm on the Board of one of the biggest automotive and industrial sensor companies in the world. We have let's say an EMC in pivotal and

VM wear, you know, and RSA. We have some of the best data and cloud and security infrastructure. We have a number of software companies, and the engineering and service and Internet of Things world. Yu know, sharing talent pools and building off of each other. We have a great venture capital community. So I think that we've got to leverage all of those assets and then keep thinking outside the box. I mean I know how things are done today but how can we imagine them being done tomorrow in a way that's very different and more powerful and transformative. And then let's figure out how to go do that and create the right kind of partnerships and the right kind of companies, and the right kind of alignments that would allow us as a U.S. headquartered company to lead.

Now we're U.S. headquartered. Sixty percent of our revenue comes from outside the U.S., so we're a big exporter of technology. But we have to do the core innovation back at home in order to sustain that position because we certainly have global competitors on almost every front. But I think it's this quest for always to think about a different tomorrow and then try to be the one that makes it happen.

MR. INAMPUDI: Katrina?

MS. BOSLEY: I guess I have a bit of an odd view towards competition. One is that I like it because I think that great rivals can make each other better. Think about two great sports rivals. Do you want to watch the world great playing the local club, no, you want to watch the world greats playing one another. They raise the level of each other's game. Plus in my world where the goal is to try to make therapeutics if we didn't quite get there maybe it's because it didn't work scientifically, but maybe it's because somebody else made a better produce, and therefore a patient is going to suffer less. It's kind of hard to feel bad about that. So the competition to create a better therapeutic, that is something that there's rarely going to be one solution for patients. Patients are diverse, you need a variety of solutions. So partly it's really understanding

what problem are you solving and making sure that you're really relentlessly focused on that.

There can be new technologies that make us obsolete; that in the world of biotech, you know, you hope that you're kind of continually making yourself obsolete. And whether that's within a company or a program -- I don't think so much about the competitiveness of my company as are we going to create great therapies. Maybe we'll do it on our own, maybe we'll do it with partners, whatever gets there the fastest and creates the most value, I'm happy to take that solution. I have responsibilities to my employees, to my shareholders, to the patients, to the physicians that we work with. As long as all of those are getting served then there's a lot of ways that we can be a successful company.

I've been in the industry about 25 years and I've been part of two companies that were acquired, another one that's now a $90 billion company, part of another start up that failed, part of another start up that's now sort of $5 billion company. So I've seen a lot of different ways that these things can evolve. At the end of the day I think the metric is how many drugs came out of that and so far the answer is three approved and about ten in development. I will say being based in Boston for biotech, it's the probably most important place in the world to be right now. And if you ask anybody in the industry, you see all the pharma companies essentially relocating their R&D to Boston. I looked up some statistics to prepare for this and it turns out Massachusetts, little Massachusetts has the most bioscience R&D employees in the county, about 28,000. That's more than California at 24,000. Of those 23,000 are in the Boston-Cambridge area. Right now there snowbound (laughter), but they are all right there and the density of interactions is I think where you get this absolutely unprecedented competitiveness of that cluster. And so being able to always have another opportunity to

create the next technology is in part because of where we are.

MR. INAMPUDI: That's actually quite interesting. Even in the previous panel everyone spoke about the clusters for the stem workforce in a different way, but now we are hearing on technology which is the cutting edge technology and both of you just almost reiterated it.

MS. BOSLEY: It's interesting too for my industry; I assume it's the same for others. It's also the ancillary factors. People talk about incubators -- I hate the phrase incubator because it misses the point. It's just for me the hospitals, the academic laboratories, the big companies, the small companies, it's also the attorneys, the intellectual property attorneys, the corporate attorneys, the PR folks, the part-time human resources people who know how to do biotech a day, a week, the part-time lab manager for when you're 30 people and you don't need somebody full-time but who's been doing it for 30 years. The fact that Alexandria Real Estate which does lab buildings, they built -- basically they're building entire millions of square feet in the Cambridge area, and knowing that you have a landlord who knows how to build you a building -- lab buildings are hard to build, right. I can't even imagine building a vacuum that can house that. (Laughter)

MR. KLEINFELD: There is no people (inaudible) actually.

MS. BOSLEY: Right. These very, very technical facilities, you know, you really want somebody good at building that. So there are all of those aspects of the infrastructure that are very sophisticated. Education was mentioned. One of my favorite programs in Boston is Northeastern. I've used their co-op students; they're awesome. If you don't know the Northeastern Co-op Program you should. It's spectacular for all of our industries, right. I hire these students all the time and they are amazing. They built us a computer -- our summer intern built us a computer that was five times faster than

what we could get -- you know, it was great. Now it's analyzing all of our guide (inaudible) data.

MR. HEPPELMANN: I think if I could add to that, you know, the education environment in Boston is truly special. I mean the phrase Internet of Things was coined at MIT, you know, out of their auto ID lab that drove the RFID which is sort of a pretty important precursor to the bigger concept of Internet of Things. The research I did with Professor Porter suggested Harvard's involved, and everybody knows MIT and Harvard, but when you take Northeastern and you add the rest it's like a hundred more colleges and universities in the Boston area that are providing a talent pool that's just unparallel.

MS. BOSLEY: And the sports teams are good.

MR. HEPPELMANN: Yes, sports teams are good, too. (Laughter) Well, Ron's a little sore about that coming from --

MR. KLEINFELD: I think what that echoes is one thing that -- basically the enormous importance of talent. That's what it starts with and as long as I can think I've always said talent is the only sustainable competitive advantage in today's world. And if I look at -- I mean when ahs something succeeded and when has it failed, it's really only two components in the end. It's the people, you know, and that's where it starts. And then the second component I'd say is whether people can work in a high performance team. Because that's unfortunately what you sometimes see that you have a single performer who's excellent as a single performer, but when you put them together and create something bigger they can't get their act together. So it's really those two things.

So what we are aspiring is to find a way how to attract the best and brightest. The recent years with the crisis have actually helped there. I mean there was

a time when we were very frustrated going to the top universities and literally nobody would be interested in listening. And I still remember -- I'm not going to mention one -- it's an East coast Ivy League and they lured me in for a meeting with their business school folks and they said, hey, we really don't know -- kind of setting the bar very low, we don't know how many people are going to show up. Don't be surprised, it might only be ten. In the end they had to switch the room to go to the biggest room. And this is three years ago. And it's fascinating to see the positive change that's happened. I think the message particularly to the very good students has gotten through. There's a lot going on and this is an exciting thing. And there are a lot of people that say I want to create something, I want to leave something behind. And they want to also at the same time have an international career. So this is a positive thing. That's a really, really positive thing.

On the concept of the clusters, I am a big believer of clusters and I certainly remember when Michael Porter's book came out, where he very nicely put these things together. He had advantage of nations -- I think that's it.

SPEAKER: Competitive advantage of nations.

MR. KLEINFELD: Competitive advantage of nations, yes, exactly. That's what it was called. So I think it's fantastic. And for us the critical thing -- I mean if you can get it in a proximity the better off you are, right. For us you sometimes are not at the luxury that my locations, our places that were you even have a hard time to get there, right. And that historically has been for all kinds of reasons, whether it's energy, it's transportation, or whether it's defense reasons, you know, why there are places like Davenport, you are in Tennessee, or god knows where, or in upstate New York. So we have to bridge it, but I'm very aware that this bridging of a location that's remote has some complexity. But the other thing is also there with proximity with aerospace as well

as automotive. Modern technology can help but you have to bridge it, you have to make the cluster available to those folks with all the modern communication media.

And the other thing that we use cluster concepts for is on the education side because when you want to start something in the region to design the program, the educational program in such a way that it really benefits the region you have to have a deeper understanding of what is the industrial cluster in the region and what are the needs. And those things really work extremely well. And there you go rather micro than macro.

MR. INAMPUDI: Maybe we'll take some questions from the audience. Go ahead. If you could keep it to a question format more than a statement I think that would be very helpful.

MR. ALTMAN: Hi, I'm Fred Altman and I have a question for Katrina. In most areas as the technology progresses the prices go down. Medicine seems to be a notable exception to that. With genomic medicine is that likely to change the curve?

MS. BOSLEY: It's a great question. It's actually one of the challenges that we have as to how do we think about the ultimate economic model because if what we do is a one-time treatment that's a cure, I mean how are we going to make that work economically? I don't know the answer to your question. What I can say though is that the new medicines that get introduced do tend to get introduced at very high prices, particularly those that really extend life, et cetera. In addition when a drug comes off patent, within six months of coming off patent usually 90 percent of the branded sales are gone, so it just comes off a cliff and then the generic comes in at a much lower price. And frankly that's great, that's as it should be. Patent life has a defined time period and then when it's done it's done and it's in the public domain. So I do think that the high prices command attention for a lot of very good reasons. Not everybody can afford them.

If you have a high co-pay it can be very difficult. I think companies have a role in trying to find solutions. Most companies with high priced products do have programs to pay for that product where patients can't afford it. Obviously the economic model is different in a lot of countries. But in addition I think if you look at the overall arc of new medicines over time they earn their return and then they become generic is the general model. So I realize that's a complete answer to your question. I'm sure that maybe genomic medicines will not be cheap, but I think too they also -- they will deliver results that are unprecedented. And finding the balance and how we pay for it is something that companies have to be a part of solving as well.

MR. INAMPUDI: Helmuth, I think you had a question.

MR. LUDWIG: Helmuth Ludwig from Siemens. The study presented today on advanced industries talks a lot about the importance of small and medium enterprises for innovation, for growth, for employment. Klaus, Alcoa is not only a leader in materials, but also in its way to a digital enterprise. How do you make sure you take the supply chain, which very often are small and medium enterprises, with you on this journey?

MR. KLEINFELD: Well, it's a challenge, but at the same time I think it's also an opportunity because with the capabilities that the digital chain allows and the cost -- I mean to the audio question, our industry the costs have substantially come down on most of these things. They are relatively cheap. And also you find software models which are per use software models. I mean one of the big problems before was you always had to negotiate with a supplier that they first had to enable their whole software structure. Now more and more often you find pay per use models. So my view it has made it all much easier, right, and then on top of it the pressure because of the big advantage that it brings to the end customer on the whole supply chain has also

increased. So I think everybody understands that you want to be integrated.

For instance, I mean we didn't talk about 3D printing which we use today on a regular basis even for large and very complicated parts, metal parts and some hybrid structures. And it typically brings down the lead time by more than 50 percent and the cost by more than 50 percent. And that's a huge advantage in terms of not just speeding up the development process, but also allowing for a faster innovation process because before people wouldn't have the budget and wouldn't have the time to play with three-four concepts. Now they can play with three-four concepts in parallel. But for this you basically have a closed chain between a closed digital chain from the CD design to the making, to the pilot production, and then back for the test results, going back into the CAD one. So it's a seamless chain and I think it's much easier today, really much easier and much cheaper also.

SPEAKER: Question for Klaus. You've operated both in Germany and here. What would you say are the distinguishing characteristics that make Germany and the U.S. different in terms of their potential to innovate?

MR. KLEINFELD: I think some of the things -- let's start with some unique advantage that exists here in the U.S.

And some of it we already heard. I mean what you have been referring to as the availability of venture capital. So many people have tried it and there are some pockets, you know, like in Berlin, you know. You see this coming up but I recently had a discussion with a good friend of mine, Peter Artere over this who also has a good footing in Germany and he had some studies showing clearly that the returns on venture capital investments over in Europe are substantially lower. And you would say why is that. So there is something else there and I guess the something else could also be the excess to the market. I mean the U.S. market and most of the industries is substantially bigger as a

homogenous market, right, whereas in Europe very often you still have some boundaries of applications of traditions, you know. So I think there are a couple of things that make things in principle easier here. The other thing that I find easier here also is the attitude of failure as an honor not deadly, right, because I mean some of my venture capital friends are always telling me, and they are not joking actually that they say if we invest in a company we actually want to meet with senior management and we want to hear where senior management has failed. And we're not investing in a company where we are not having senior management that has failed somewhere before because we don't want to be the first ones paying for their failure. So whereas in Europe very often you have the counter position. People have failed once and therefore they have a burn mark on their forehead and people don't want them to be leading something. That's very, very different.

The thing now on the European side, I mean you have ingrained and that's different obviously in Europe but in Germany it's very, very strong, you have an engineering culture. And to be an engineer is a badge of honor, you know. Over hundreds of years I mean you have a tradition that when you are an engineer or when you work in an engineering environment even as an apprentice you have a certain honor code I would say, and you have an esteem in society. You don't have to have a 12 year education in high school and then have gone to college. I mean if you have gone through an apprenticeship program and worked in a shop, I mean the esteem that you would have in society would be very, very high because people would know even when they give something very complicated you would be able to manufacture and you would not deviate from the highest quality standards that would be expected from you. So this is sometimes something I'm sure that you struggle with when you want to get some glass made or something where it might not be exactly to the specs. But then the great thing

about America comes in, you know, we then basically say an 80 percent solution is great, it's rather go for the speed which sometimes hampers on the European side because they would rather want to go for 100 percent solution.

MR. INAMPUDI: I think we have a little -- sorry, go ahead, Jim.

MR. HEPPELMANN: Well, I was going to share an observation building on Klaus said which is this idea that it's an esteemed badge of honor to be an engineer in Germany and I see that all the time with our German customers.

You know, I think part of the problem in the U.S. isn't the output of the universities, it's the input into the universities; that kids don't grow up wanting to be an astronaut like I did anymore, they just don't. And that's a real problem. One of the things our company has been involved in and very supportive of are high school level programs that are trying to inspire kids to be engineers, or let's say STEM graduates of some sort. You know, things like first robotics, and a real world design challenge in star base, and there's a lot of programs that are supported by various federal agencies and so forth. But the real problem is that I think if you doubled the amount of STEM graduate programs I think you'd have a lot of empty chairs right now. So I think we need to change the cultural attitude of people that want to be those advanced people that make these kind of companies work or we're going to keep having as a percentage fewer and fewer of them. And we can't blame the universities, we should blame the moms and dads who if they had still --

MR. KLEINFELD: One of the advantages that we have here used to be the immigration side --

MS. BOSLEY: I was just thinking that.

MR. KLEINFELD: -- because there were long lines, you know, out there of the best and brightest that want to be an engineer and we have this great education

institutions, but I think the last year it's unfortunately through our own making we've fallen behind which is very, very sad. Very, very sad.

MR. HEPPELMANN: Yeah. We train them and send them home.

MR. KLEINFELD: Yeah, exactly.

MR. INAMPUDI: First of all I wanted to thank all three of you for your time. I know we are a little bit short of time and there are a lot of raised hands, but we first wanted to thank all three of you for taking the time out of your busy schedules. So if we could all thank them. (Applause)

(Recess)

MR. MURO: Welcome here at Brookings. Lead author of this work along with a great team, and it's my privilege to take this in a bit of a different direction now. I think we've -- the first Panel really talked about the new possibility of the American platform for this advanced activity industry. The second panel took us deep into the world of technology development. You know, I think incredible opportunities are evidence there, but I picked up a sense that it's going to be a tumultuous, exciting ride to stay ahead both for firms, but for states, regions, places, and individuals too. So what I thought we should do now though is to bring this home not only to our region in the State of Virginia, but the sense of what governments, what regions can do and how they fit in this incredible set of trends I think we've been talking about.

So to do that I'd like to introduce the irrepressible Governor of the Commonwealth of Virginia, the Honorable Terry McAuliffe. I think rounding out his first year in office, Virginia's 72nd governor. A lot of illustrious predecessors you've had. But to talk about the work of advancing advanced industries. Now not only is Virginia a true powerhouse in this sector given its 400,000 workers in the advanced industry sector, the Commonwealth is fifth amongst states for the density of those workers, which we think is

the right way to look at this. It's not how many but how big a share of your economic operation. Eleven percent of the economy directly employed in these industries. So this is significant, diverse presence in the state. I don't know if Terry calls them advanced industries, but I do know he's all over the sector, he's made it clear whether he's travelling to Bedford or Beijing he's all about these industries. He certainly sought to attract them, but he's spending an awful lot of time, and I think we're going to hear about, growing them organically within the state as well.

So what I thought we'd do is spend maybe about 30 minutes here, have a dialogue about what, why, and where in Virginia, and then we'll open this back up. But I thought maybe why don't we just start, you know, to what extent does this whole concept resonate to you? I mean we've had separate discussions. We had a discussion about manufacturing, separate discussion about energy. We seem to talk about software, services, it's all sort of fragmented. Trying to put it all together, do you see a continuity here? Are these the right things to be thinking about?

GOVERNOR MCAULIFFE: Well, clearly, Mark, it's the right things to be thinking about because if you're going to grow and diversify an economy it is your advanced manufacturing sector that's going to do it for you.

I'm here; I do want to introduce my Secretary of Commerce, Maurice Jones, who is here with us today. But he and I spent the last year -- we're in a very unique situation in Virginia. We are the number one recipient of Department of Defense dollars. Number one in America. We have a lot of military assets, we have the largest naval base in the world, the Pentagon is in Virginia, the CIA, Quantico. That's great when they're spending money, but when they're cutting back through defense cuts and sequestration we get hit harder than anyone else. So our whole emphasis is bringing in businesses and building businesses that are less reliant on the federal government. That

is my whole goal and this is what I think about every day. We've had tremendous success in our first year. We did about 270 economic development projects. We brought in about $5.6 billion of direct investment, many of those advanced manufacturing. Not that anyone is counting but I'm proud to say that is double what any governor has done in the history of Virginia in their first year in office, and we're just warming up. But we've brought businesses back from -- and exciting businesses, the largest greenfield, the largest Chinese investment in America. We just one that in Virginia, a $2 billion investment, 2,000 jobs, advanced manufacturing company, Appomattox, Virginia; we just made announcement the other day. I mean this is what I talk about, this is exciting. It brings technology, it brings it all together. We got a company from China to come back in and invest millions and millions of dollars to take over a shuttered furniture facility which we've now reopened and they are now manufacturing pollution control devices, which we take manufacturing, advanced manufacturing, and we take that finished product to our port and guess what, we sell the finished product back to China. I mean that's as good as it gets. We take their money to come back and reopen a plant, we build manufacturing, advanced manufacturing, use our port, the deepest port on the East Coast. And that's what you have to do and we've done dozens and dozens of these types of operations in Virginia. Less reliant on the federal government, new twenty first century technologies. I enjoy selling. I did seven trade missions last year, will continue to do it. But, listen, you've got to have the fundamentals. Innovation, creativity, a world class infrastructure. We have very low tax rates in Virginia, we're six percent corporate tax. It's been like that 45 years, it's not changing. Very pro-business environment. Infrastructure, Dulles Airport, deepest port on the East Coast, world class education system, and when we get all sort of this gelling together, working together, I mean we are very competitive. We can bring any business back we want. Building technology is so

critical. And the one thing I say, these jobs pay more than standard jobs. In Northern Virginia in advanced manufacturing the average pay is $100,000, compared to $65,000 for those non advanced manufacturing jobs.

So as Governor we're creating a lot of jobs. I just announced the lowest unemployment rate in Virginia since 2008, so the lowest we've had in six years. Jobs are jobs, but we want to make sure they are good paying jobs. And these advanced manufacturing on average pay double.

MR. MURO: But what are some of the industries you're focusing on most too? It seems like you've by our accounting a really diverse array. I mean you've got the ship building, on the one sense classic manufacturing, but then you've got a whole bunch of digital and IT and even energy activities.

GOVERNOR MCAULLIFFE: Well, Virginia is a great state. I always say we're like five different states. If you look at Northern Virginia we have more data centers than any other state in America that we have up in Northern Virginia, we have more tech workers per capita; we have more tech workers than any state in the United States of America. So Northern Virginia, a lot of tech related data centers, tech businesses booming here, related to the federal government of course. But then you go down to the Hampton Roads region. I'm such a huge advocate of the Hampton Roads region. We have the largest naval base in the world. You've got Virginia Beach, you've got the tours of -- that is a dynamic economy down there and we're trying to bring in businesses that piggy back. I mean it's great that we have the largest naval base in the world. We have a lot of cyber security related industries down there because of the military assets. So we're really trying to grow cyber security. The President as you know just put about $270 million dollars in the budget. They're going to build what we call a new cyber campus. We want that in Virginia. I've told the President it needs to be in Virginia because when

Virginia grows America grows. Forget the other 49 states (laughter), they really don't matter. It's got to be done in Virginia.

When I talked about Appomattox with pollution control devices, but I'm really trying to help south side, southwest Virginia which really have been hurt. Textile, tobacco, furniture, you know, over the last 30-40 years have been disseminated. We just brought another company back that is doing manufacturing. We've got aerospace, huge aerospace business that we're building in Virginia. Alco just did a big announcement on their blades that they use in their advanced manufacturing. You know we've -- Continental just announced a huge deal in Newport News related -- that's 500 new jobs, auto supply manufacturing for parts, we beat Mexico out to get that which was a huge win for us.

So honestly, Mark, there's not a business we won't chase. If it's jobs we're after it and I want it in Virginia and we're going to go get it. It has to make economic sense; we don't chase every deal. But really trying to build the manufacturing. I am so excited, but then again who know me, I'm always excited, but I'm really excited. We just announced a new pipeline. It will be the biggest pipeline built, over 500 miles. We will now be bringing natural gas to Virginia from the Marcellus and the Utica shale. What this pipeline will allow us to do -- we already have very cheap energy costs, our mix, we're about 41 percent nuclear today and I've got about 30 percent gas, and a small percentage now of coal and some of the renewables, but with the nuclear we have today, with this new pipeline there is no reason because these pipeline folks are like highways, and you can do an exit and enter ramp anywhere you want to a manufacturing facility.

Why are we being successful bringing all these billions back from China? Because are now competitive. You can get into the United States market. Forty percent of America is one hour's drive from Virginia. You've got the deepest port on the East

Coast, but if you want to enter the U.S. market low energy costs really make up a difference on the differential on employment pay. I can now compete with any Asia country on manufacturing. And this pipeline will take us to the next level. So it's exciting.

MR. MURO: So it's another factor.

GOVERNOR MCAULIFFE: Yes. And it's manufacturing. I really focus on manufacturing. These are good paying jobs. We have to do a lot more work on fairness. I think every governor struggles with this. Workforce development, we all talk about it. We're really hitting in hard. I think we have 30 or 40 bills in the legislature right now on workforce development. I know a lot of folks talk about degrees. I tell my education department, Secretary Holton, don't talk to me about degrees, I don't want to hear it, I want to hear about skill sets. You get out of college or school with a degree with a lot of debt and without a skill set is immaterial to me as Governor. I want credentialing done. I've called for 50,000 credentials by the time I leave office. I've called for 500,000 credentials by 2030. We have 165,000 credential right now in Virginia. That will make us number one in America. There is not a job we cannot fill, but it is taking the jobs that exist today and matching them with our education system to build a skill set. I have 30,000 jobs open in Northern Virginia today in the high tech space. They're not going to wait for me. They'll go to another state. So changing our whole mode of operation, how we do it. Working together, acting regionally instead of everybody fighting each other, building those credentials. That's how you build a state economy.

MR. MURO: In our report we highlight sort of three priorities. On the one hand commit to innovation, you know, build that skills pipeline. And then we talk a lot about ecosystems, those regional economies. You know, I'm curious, you want to talk a little about -- pretty impressive set going back, you know, both prior to your administration, now you're continuing some very innovative efforts in the innovation

space. Do you want to talk a little about that?

GOVERNOR MCAULIFFE: Well, we have something very unique in Virginia that no other state really has. We have, you know, the Commonwealth's advanced manufacturing CCAM which has got a lot of great companies, Rolls Royce, and basically we have about 21 companies who've come together to fund this operation, and we have 5 universities. It is a very collaborative effort. So the universities who have all of this great research, they have a problem in commercializing and taking it out to market. So we match them with the companies who at times have problems on the research. So we brought them together and they now work collectively in one place so that you pooled your resources so all five universities who were coming up with these great new innovative ideas, all the 21 companies share in that research and development and that technology that's developed. They all are involved in it and it really has broken down barriers. It has incentivized our universities to commercialize and to g out into the market, and it's helped spread the cost of R&D which for many businesses is prohibitive, but they've all come together under CCAM in Virginia. So this is a great idea that we have going and more companies are constantly coming in with sort of new avenues of innovation that they want us to look at.

MR. MURO: Does that tie into the skill work? Talk about some of the things you're doing skills wise as well. I mean it seems like you're doing apprenticeship, you're doing STEM education at some scale.

GOVERNOR MCAULIFFE: We're doing a -- in fact all this legislation -- we're very creative, if we can get passed, we're in session right now so we sort of laugh here -- we're working hard -- if we can get passed all of these bills that I have -- I think we have 40 Governor's bills -- I would say half of them relate to workforce development to close this skills gap and to give the credentialing. Listen this is not a partisan issue and I

think we're going to have tremendous success. We've already seen a lot of our bills get through subcommittee. This is not a democratic or republican issue, this is about Virginia. This is about being competitive because we are in a unique position of the headwinds of sequestration that no other state has. Now Maryland has challenges because everybody here is sort of defense government related, but we're more vulnerable than anyone else, so I'm very optimistic we can get this done, but doing the credentialing, getting into our schools earlier. We need -- I agree with the gentleman here before, we've got to get down in fourth, fifth, sixth grade, start talking about these STEM courses. I tell my Secretary of Education and my Superintendant of Schools, when these kids come into kindergarten I want a Crayola book that says STEM on the front (laughter) because if you wait until high school or college -- I just saw a report the other day, women -- I mean they're declining going into the STEM courses. It makes no sense to me. We should be growing today. These jobs exist. And in Virginia here's the challenge I face, we in the next decade I'm going to have 955,000 Virginians retiring. We're going to have 500,000 new jobs being created. That's 1,400,000. These are going to be new jobs in new technologies. We better have an education system that is very nimble, that can work very quickly with the business sector to say what do you need.

We have Newport News shipyard. Obviously spectacular. Thousands and thousands of employees. Right now they're building nine nuclear submarines, Virginia Class submarines. They've had apprenticeship for years. They go away four, five years, they work with our two community colleges in the region, they get their degrees, they're working simultaneously, they're being paid. But they tell us that at education system here's what I need. They would hire every single welder that we can give them. And I think the average pay, Maurice, $60-70,000 starting out. These are good paying jobs. But we need to do that with every sector, to match -- and I really

encourage our business community to get -- we'll move our education system. I know sometimes it's like moving an aircraft carrier. As you probably can tell patience is not a virtue that will be chiseled into my tombstone; not going to happen. We will move very quickly on this. I get out of bed -- I'm being honest with you, I've got to compete against 49 governors and 200 nations around the globe. I want to beat them. I want us to win every single jobs development project in the globe. Now you don't get that, but that's how I think. It's education early on and then doing the credentialing that we're talking about and building an innovative system.

And for folks that are watching let me be very clear, we have very low taxes, six percent as I say, hasn't changed in 45 years, not changing. Very pro business environment. I mean if you're thinking of doing business I have the deepest port on the East Coast. When these post panamax ships come around next year, I'm talking 10-12-14,000 TEUs, there's only one port they can come to on the East Coast and that's Virginia, our deep channel. Now they'll come to Virginia now, these huge ships, and they'll offload their cargo and the ship will rise and then they'll go to those dinky ports in Baltimore and New York (laughter) where they can get in and then they'll load their ship up and then they'll come down to Virginia. And with my new pipeline with the new advanced manufacturing, take it all, train it right now and load the ship up and it will go back over to Asia selling produce.

MR. MURO: That's an exciting vision and you're selling it externally and internally. You know, I think we heard in the panel before some concern about not so much the outputs of the university system and the outputs of training systems, but the inputs, that we're simply not engaging as you're saying kids at the young enough level.

GOVERNOR MCAULIFFE: We're not.

MR. MURO: Are you thinking about that and how are you attacking that?

GOVERNOR MCAULIFFE: You're exactly right. We've got to -- listen, the jobs exist there today, but we've got -- the STEM-H courses, obviously we have to do a much better job and it goes down to your teachers. And listen, I'll be honest with you, I mean I have school districts in Virginia that are in real serious trouble. That's my first priority, to make sure we get every school district where they need to be. I'm tired of people complaining about schools, it's time to take action. So in my budget we have proposals for new training for teachers, for our principals, for our school board members. I mean to be honest with you, Mark, you've got to get into the weeds in your education system. And it's not about throwing more money at universities and our higher ed, it's not. It's starting earlier, K-12. I happen to be a huge advocate of pre-K. If 80 percent of the brain is developed between birth and four or five years old why is every child not entitled to that ability to go to a pre-K? So I'm really trying to work hard on this issue. I just received about $17.5 million. I want to thank Arne Duncan if you're watching TV. I'll have about 1,600 at risk children in Virginia that now will be able to go to pre-K because of a nice federal grant that we received on that. So I would make the argument, start early. But we need to do a better job of exciting children in that K-12 about the STEM-H courses. We need to do a better job, all of us, and it really comes down to -- and I agree -- it's parent, but it's also your teachers to get them excited. So maybe change how we think about STEM-H courses in higher ed, let's start thinking K-12, let's get some of the best teachers early to get them excited about it.

MR. MURO: And even this whole industry complex we're talking about, these advanced industries, many manufacturing that I think people associate with decline over 25 years, and yet we're now seeing a different trajectory. Do you feel there's a broad understanding of the kind of opportunities and what these industries look like now? I think our suggestion is that there isn't a broad feel and there's a great concern that a

sense of overhang of lost jobs in the past. Can you talk some about that?

GOVERNOR MCAULIFFE: Yes. I think that's a great point and I do think some of these industries for some young people may not be as sexy as some other areas that they want to go in and exciting. That's totally false because if you just look at the data in the report that you have these are very high paying jobs. So I agree with you, in the old days, you know, did I want to go on and be a welder and all that. Well, I'm telling you I can hire every welder you can give me in Virginia today to go down and work at our shipyard. So I agree with you, we need to do a better job of explaining. Listen, when kids come to college now, I always say in the first week of school we need to be telling them four years later when you graduate here are the jobs that are going to be available. We don't seem to be doing that in our higher ed system. When you come to freshman orientation, I think it's great, let them all have a good time and we do the orientation stuff, but you lay out statistics, here's the courses you need to take to fill -- here's how many jobs are available today in this sector, boom, boom, boom, boom. And if you want to work here, here's what you're going to get paid and here are the courses you need take. We don't do that, and we're really trying to shake up our education system to get us to do that.

I had fun in college like everybody else in this room, but telling them that in four years you're going to get out and you know that these jobs will exist I think is probably the most important thing we can do. And I've talked a lot -- we have a lot of folks in Virginia that are really serious about our higher education. I think that someone told me Dubby Wynne was going to be here today. I don't know if Dubby is actually -- Dubby Wynne who used to be the CEO of Landmark and was one of the founders of the Weather Channel. And Dubby and I have had many conversations about this. I mean this is what we have to do to build that. Listen, I feel very good there's not a job we can't

bring to Virginia. I love the challenge; I like to beat the other states. I mean I love it (laughter), but I've got to convince a CEO in fairness if you're going to spend millions like all of these millions that these companies are now spending in Virginia, that they're going to have a workforce, 10-20-30 years. That's a fair argument to have. And it's not talk, you've got to prove it to them. Our whole economic development team, they spend hours sitting with companies trying to explain to them that you invest this, we're going to have that workforce for you. So it's all tied together. It's a global economy.

MR. MURO: It absolutely is. Let's talk a little about -- you know, I think we've been talking most of the morning on the one hand about the relative competitive opportunities or deficits in the U.S., we've talked about technologies. I'm interested about politics and policy. Let's talk a little about the role of a state, the role of the governor at a time where we certainly -- it's no secret that the federal apparatus is not getting it done right now.

GOVERNOR MCAULIFFE: No.

MR. MURO: So let's talk. Does that change the governor's role? Do you feel a special sense of leadership on the economy? How are you thinking about that? I know you've been an actor at the federal level too and observed federal discussions. Where are we, what's the role of the state and the governor?

GOVERNOR MCAULIFFE: No offense to federal folks. I love them all dearly, but it's actually at the state level where you actually get things done. As Governor I don't have filibusters and things like that, I've got to make a decision every day. And if you're focused on job creation I do view that -- and listen, I ran for governor, this was my whole platform. And everything I've tried to do -- and I say to legislators who come to see me, does this help us create one job? If it doesn't then don't waste my time. Because listen, folks, I am under the gun because of sequestration. I mean we don't have the

luxury. We've got to get this done and I'm moving at warp to get it done. As I say we've had great success. So things happen at the state level. The reason is you can execute. You want to make a decision -- I do think governor is the best job in America, you want to make a decision or you make a decision, you can get it done through executive order. Now I have to work obviously on different issues with my legislature. They're in for 45 days this year, but I'm sitting at that desk 365 days a year, every single day. There's no let up. I'm on call seven days a week, twenty hours a day. And I do enjoy it. The different time zones, I mean there's nobody at anybody time of day I can't call.

MR. MURO: We're seeing some states -- we've worked a lot in Colorado with Governor Hickenlooper, the space industry, we've worked very closely on the other side of the aisle with Governor Haslam in Tennessee. And I think there a (inaudible) where some of these states are assuming new responsibilities in the absence of other action.

GOVERNOR MCAULIFFE: Or the absence of their ability to work together in a bipartisan way to get things done. We're in gridlock here. I mean this is not -- everybody in this room would agree with that. Things aren't happening. Which to a governor, just as an American citizen I'm dismayed over because it is a global economy. Do you think other nations around the globe, do you think China is waiting around or Germany or any of these other economies? No. And they are in gridlock today. The partisan bickering that goes on today is really impacting our ability to compete. That's why as I say at the state level I don't have time for it. We've got to get it done and I have a very good working relationship with members of the other side, especially on the money committees. We all sit down like adults. We may disagree on issues and party of the other side, doesn't mean they're bad, but you negotiate, you compromise. And I think what's happened, this loss of ability to sit in a room and compromise, it's really destroying

I think the American fabric and our ability to be competitive. I will sit down with anybody at any time and negotiate a deal. I don't get everything I want, nobody does. You've got to compromise. It's not a bad word, Mark. And that's sort of been lost. I know we're talking manufacturing, but I do think this political gerrymandering of districts has created this. I think it has done such damage to democracy, where candidates, elected officials do not have competitive races. Eighty percent of members of Congress are guaranteed to win elections. The only way they have any competition is challenges within their primaries. So it pushes people to the right and it pushes people to the left, and the middle is gone. I am a very fiscally conservative, pro business democrat. I'm very socially progressive. I believe government ought to be out of people's individual lives. I try to operate in the middle. And I think that's where most people are, but unfortunately with this they get pushed because of these partisan primaries, and we get rid of this partisan gerrymandering and non partisan drawing of lines I think America would be in much better stead.

MR. MURO: I mean when we talk about these thing you need in advanced industries, sort of what are the absolute minimum commitments you need from the nation, you know, the federal government as opposed to what you can do yourself in the state government?

GOVERNOR MCAULIFFE: Well, yeah, you can't have --

MR. MURO: There are limits, right? I mean, you know, things like R&D for instance are crucial.

GOVERNOR MCAULIFFE: Yes, but on the federal side, I mean listen I have to do -- I mean we are very competitive on our R&D tax credit, and our angel investor tax credit. Our R&D tax credit, it's refundable, refundable in cash which, you know, gives us a huge advantage. We do grant programs, we do loan programs. If you

want to invest in Virginia in the biotech space, if you come in as an investor as one of the founders we give you a long-term capital gains exclusion; you'll never pay any long-term taxes in Virginia. So we have to develop our own tax code which raises an important question, there is all of this money sitting offshore with American companies. Now I don't sit here and bash these CEOs of companies who have this money because at the end of the day they have a fiduciary duty to their shareholders to maximize profit. That's their job. So let's redo our tax laws here so that guess what, you can bring that money back and you are maximizing shareholder return. That's what they should focus on and if they could get that figured out the billions and billions of U.S. dollar company money that's sitting offshore that would like to come back to our great country and create jobs here, that should happen. If they didn't do anything but fix that, Mark, we'd be in a much better position.

MR. MURO: So that's your short list then? That would be --

GOVERNOR MCAULIFFE: No, that's my short and long list. There's capital sitting out, bring it back. But I'm not going to sit here and -- listen, CEO has to put the money in investment where he or she is going to get the best return on investment that is their job. So I'm not going to criticize that. What I will criticize is our inability to make our tax code to allow them to bring that money back and maximize shareholder dollars.

MR. MURO: Channel that opportunity.

GOVERNOR MCAULIFFE: Of course.

MR. MURRO: Well, why don't -- you know, this has been excellent. Why don't we open this out to some questions from the audience? We've got a few minutes. Great, yes.

SPEAKER: With the recent elections of Larry Hogan and Mayor Bowser

you're now the elder statesman.

GOVERNOR MCAULIFFE: Yeah, can you believe it already?

(Laughter)

SPEAKER: Share what you see is unrealized opportunities for collaboration among Maryland, DC, and Virginia that would realize your vision for a diversified economy.

GOVERNOR MCAULIFFE: Yes. And listen, I called Muriel the day she won, I called Larry Hogan the day he won. I'm actually convening a meeting of all three of us in Northern Virginia; I think it's February 16 we're all getting together to talk about this, how we act regionally, because you're right. Listen, we want jobs in Virginia, Governor Hogan wants them, and they Mayor -- we get that, but also -- and I just came up last week and had lunch with Mayor Bowser to talk about this, when we all work in concert together, boy, there's nobody that can beat us, honestly that can beat this region because we have it all in the education and, you know, we've got NIH which is funding all the biotech space and all that. So I agree with it, we're all working together. So as I say I'll be convening a meeting. We're all linked intrinsically through our metro system of course, so that is a natural because of the new silver line. And you look at what has happened with this new silver line, for Virginia, for Tysons Corner. I mean the new Wiehle Ave. station, I just read a report, $1.8 billion in new economic development just since this was announced. We'll then go on into Dulles and then into Loudon County. Huge opportunities for us. So you're right, all of us working together, we are competitive because, you know, we want as much in our own respective states, but I do think -- and we'll meet on the 16th, what will the common core plan of what need to do to bring businesses to the region. And then we'll scrap one out a little bit. But when you bring someone to a region as you know there are jobs for all three of us because they'll live

somewhere or so forth. But it's a good question. As I say I'm taking the lead and inviting everybody in northern Virginia on the 16th.

MR. MURO: We've got a good sized advanced industry agenda for you guys.

GOVERNOR MCAULIFFE: Yeah. Well, cyber security. Obviously, let's cut right to the case, there is the one area that the federal government is going to plus up and spend billions of dollars on. We have all the assets in the region as you know and this will be the Department of Homeland Security, FBI, Defense, all of them interrelated, so that should be -- respectfully this new campus that they're going to build needs to be in our region here and that's a perfect opportunity. And I tell you, I have five children and I tell them all the time, you know, cyber security sector, go into cyber security. (Laughter) My oldest daughter, I mean she loves philosophy and I think that's great. And she just graduated and I love her dearly. I have a son at the Naval Academy and he's going to the Marines next year; he's taking care of it. But the three youngest I am working this cyber piece every single (laughter) -- because they are the jobs of the future.

MR. MURO: You're own selling job at home, right?

GOVERNOR MCAULIFFE: Yeah.

MR. MURO: Let's see, anymore? Any other -- let's go to the back of the room though. Anything?

SPEAKER: What's wrong with me?

MR. MURO: Yeah, no, she is -- the woman right here, yeah.

SPEAKER: Thanks, Governor, and I appreciate your presentation, I appreciate you're optimistic, but I think one thing you should answer is what's the problem in the United States, what's a problem in Maryland or even in (inaudible). That while you pretend it's so optimistic, but I suppose you didn't really discuss the point

what's wrong now America is that the people don't like capitalism because they don't think it's working. They forget about fairness, they forget about justice, and they use misleading project.

MR. MURO: What's the question? All right. I think --

SPEAKER: Excuse me.

MR. MURO: I think questions about --

SPEAKER: My question is here, would you be able to really based on fairness and justice to see how you can improve our society including economics and job and housing and everything? What you are saying is if you can spend the federal money or say taxpayer's money --

MR. MURO: Okay, I think that's good.

SPEAKER: -- you can help some operation to send (inaudible).

MR. MURO: So I think it's a question about maintaining the competitiveness of the U.S. and U.S. directly.

SPEAKER: I didn't even raise it. And what I'm trying to say is if you based on the real basics, the simple of fairness and justice to promote the general welfare of the general public. Forget about tax rate if they are not helping the general public.

MR. MURO: Okay, let's let the governor respond. I think talking about the overall competitiveness of the United States and maybe that there is a lack of recognition of that right now

GOVERNOR MCAULIFFE: That we're not being competitive?

MR. MURO: Right, yeah. I think yes.

GOVERNOR MCAULIFFE: Well, I think we're being --

MR. MURO: You would take the other view, right?

GOVERNOR MCAULIFFE: Yeah. I would take the other view. I think we're being very competitive. Listen, our national economy is rebounding. As you saw unemployment -- they just came out for the nation as well, I think it was lowest level we've had since like 2000. The unemployment rate has gone down dramatically, stock market is at an all-time high. I think America is being very competitive. In fact, I won't mention names, I think I've hosted 22 ambassadors from around the globe to the mansion in the last year. I'm trying to make it like the UN, encouraging these ambassadors to do business. I just met with the finance minister up here the other day for breakfast of a major country who said they're going to put $35 billion into the United States in the next five years because of the strength of our economy. I think if you look at China, why have they decided -- I think for a lot of reasons -- I think historically they've gone over and done a lot of investment in Africa and for a lot of reasons they're not as comfortable there. They've made a strategic decision, they're going to invest more here in the United States of America. I think all based on the strength of our economy and the resilience of the U.S. economy. I mean I'm the ultimate optimist but I'm really optimistic. I think we're in very good shape. The key issue -- and I think this will be the key issue in the presidential campaign, is the middle class income take home pay for many Americans has dropped dramatically. And the challenge is going -- when I talk about jobs, folks, to me it is jobs that pay well with benefits. A job should automatically -- now I'm not talking about someone who has to go work two or three jobs to make ends meet, quality jobs. That's why this is so important because these are all high paying jobs and it gets the standard of living up for everybody. But our challenge in this country, and the people in the middle rightfully feel squeezed and have been squeezed economically. So making sure as we grow that there is a sense of fairness, that everybody has an opportunity to get that.

MR. MURO: Do you think people perceive this swath of industries as relevant to their household fortunes. I mean there's thoroughly the perception that some of these industries have high paying often PhD. level or advanced degree jobs. And I think -- it seems like you have spoken a bit about that (inaudible) area.

GOVERNOR MCAULIFFE: Well, do we do in Virginia and I hope for the next three years they don't quite figure it out until I'm out of office. I do realize and we realize that these are the future jobs, they're there. The metrics alone speak to it, just look at the data. And as I say in Northern Virginia, they average $100,000 versus $65,000. These are very high paying jobs. And I can sit with one CEO after another up here in Northern Virginia and, Governor, I need this number, I need this number, I need this number of employees, and they're all good paying jobs, so you get on that.

MR. MURO: Good. Any more questions? Antoine?

MR. VAN AGTMAEL: You said a few words earlier about this -- I think you called it the CCAM --

GOVERNOR MCAULIFFE: Yes, sir.

MR. VAN AGTMAEL: -- or the Commonwealth Campus, and you mentioned five universities and twenty one companies. Can you talk a little -- I've never heard of it frankly and I live in Washington -- can you tell a little bit more about who are these universities, what are they good at, what are the companies, why were they attracted, et cetera?

GOVERNOR MCAULIFFE: Yes, it's a good question. And it's a very creative idea that's been in Virginia for several years now. And the companies do it so that they are able to pool their resources and have access to university research and development. So we bring them together and there are different layers of -- there's the gold level and so forth of how much they pay a year. I think the tap -- what's the tap you

have to pay? Half a million a year is it? $400,000? And it goes down for different companies. At the $400,000 level everybody has access to all the research and data. Universities love it and they pay to actually join it because it incentivizes their professors that they have. I mean universities -- the one thing I'm trying to break down a little bit in Virginia, we've had too many silos. We need to do a better job of commercializing our great research and development at our universities, we need to incentivize our professors. I am all for if they come up with some great technology, they ought to be able to make money doing that, but we need more collaboration. And listen, I know it's hard. Every university has to worry about their own university and they, you know, want to have the best and the latest, but when you can bring them together and they work in one room together, it really turbo charges your research and development for a state. And we're in it, the state is in it, and our team works with them every single day, and we're constantly bringing in -- every month or two I go to a signing ceremony where a new private sector company has come in to become partners of it. They love it. Why do they do it? They pool their resources, unlimited access to the research and development. You know, it's UVA, Virginia Tech, you know, many of our top universities that we have and the universities get access to the private sector to work with the private sector so that they can take their whatever research they have and the private companies will take it out to the market and they will likewise make money. It's a very unique concept; it's call CCAM. It's the Commonwealth for Advanced Manufacturing, Center for Advanced Manufacturing. It's a beautiful state of the art building that we have. It's right outside Richmond and you ought to come down and take a visit. It really is state of the art and every time I go there it's really exciting with these scientists and professors and all the latest R&D they have going.

MR. MURO: And I think is a state innovation that's been influential on

say the federal manufacturing hubs.

GOVERNOR MCAULIFFE: Right.

MR. MURO: In some ways I think the idea came from that.

Well, you know, I think it's time to bring this to a close. And to that I just want to thank the full line up of outstanding leaders we've had today, Antoine, Dom and our friends from McKinsey, all six of the industry leaders, and as well as yourself. I don't know about you, but I'm feeling we've got some strong leadership on deck at a time obviously of great opportunity and challenge given the speed of things that -- I hope you all in the audience have a new appreciation for the importance of some of these industries and a sense in which really they're quite different than maybe one imagined in particular areas. So we have a lot to do to ensure they flourish. And I'm pretty certain that their growth is a prerequisite to getting a handle on our broader economic challenges. Without a vibrant advanced industry sector we're not going to have --

GOVERNOR MCAULIFFE: It won't happen.

MR. MURO: -- broadly shared opportunity in this country. So I think that's critical.

So I'd just like to say Brookings and McKinsey I know are committed staying with the story, to continue working on this. We hope many of you will remain interested. And with that I'd like to say good day. Thank you, have a great afternoon and we will talk to you soon.

GOVERNOR MCAULIFFE: Thank you, Mark.

(Applause)

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I, Carleton J. Anderson, III do hereby certify that the forgoing electronic file when originally transmitted was reduced to text at my direction; that said transcript is a true record of the proceedings therein referenced; that I am neither counsel for, related to, nor employed by any of the parties to the action in which these proceedings were taken; and, furthermore, that I am neither a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

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Expires: November 30, 2016