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REGIONAL MANUFACTURING HUBS: A PATH TO INNOVATION
THE JOHN WHITE, JR. FORUM ON PUBLIC POLICY

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PARTICIPANTS:

Introduction:

DARRELL WEST
Vice President and Director, Governance Studies
Director, Center for Technology Innovation
The Brookings Institution

Keynote Address: The Future of U.S. Manufacturing:

JOHN WHITE, JR., Moderator
President and Chief Executive Officer
Taco, Inc.

JASON S. MILLER
Special Assistant to the President for Manufacturing Policy
The White House

Next Generation Manufacturing - Where Innovation is Headed Next:

DARRELL WEST, Moderator
Vice President and Director, Governance Studies
Director, Center for Technology Innovation
The Brookings Institution

MIKE GARVEY
President
M-7 Technologies

ED MORRIS
Director, America Makes -- National Additive
Manufacturing Innovation Institute
Vice President, National Center for Defense
Manufacturing and Machining (NCDMM)

Digital Manufacturing and Design Innovation:

DARRELL WEST
Vice President and Director, Governance Studies
Director, Center for Technology Innovation
The Brookings Institution

MIKE RUSSO
Director, Government Relations
GlobalFoundries

CARALYNN NOWINSKI
Chief Operating Officer
UI Labs

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P R O C E E D I N G S

MR. WEST: (in progress) –{*Brookings.*} edu. And we've also set up a Twitter feed at #USMFG, that's USMFG. So if you wish to post comments or ask questions during the forum we'd be happy to give you the opportunity to do that.

We do have several distinguished guests with us this morning who I would like to introduce. Our benefactor, John Hazen White is here along with his wife, Liz, and sons, John and Ben. And we really appreciate all of their support. So please join me in expressing our appreciation to them. Thank you very much. Thank you. Thank you. (Applause)

And I'm also very pleased to have Congressman David Cicilline here. Congressman Cicilline is the member of Congress from the First District in Rhode Island which is also the home District of John Hazen White. And Congressman Cicilline has been a real leader on manufacturing policy. He's done tremendous work in this area so we really appreciate the work that you're doing as well.

So today we have a great program that is going to look at several different aspects of manufacturing. As you know manufacturing is a vital part of innovation and economic development. The industry comprises around 12 percent of U.S. GDP and is crucial for job creation and the overall economy. And as you have probably seen in the last few months President Obama has placed special importance on manufacturing. He's invested over a billion dollars in the creation of a national network for manufacturing innovation; he has launched the development of several regional manufacturing hubs in sites across the country. The pilot hub is headquartered in Youngstown, Ohio and it focuses on additive manufacturing and 3D printing among other types of innovations. And there also have been hubs created in Chicago, Detroit, and Raleigh. So the questions that we're going to be posing this morning is how are the hubs

doing, how are they changing manufacturing, what new ideas are they promoting and new innovations, and what are the lessons that other communities and even other parts of the world can learn from this? We have a number of people from various foreign embassies here today so there's been a lot of international interest in this topic.

So to launch our discussion with the President's Special Assistant for Manufacturing Policy, it is my great honor to introduce my friend and the person who has made this forum possible, John Hazen White. Johnny is the President and CEO of Taco Incorporated. He's a distinguished leader in the private sector, he's a native Rhode Islander, and he's been employed at Taco since 1980. And Taco is one of our country's leading producers and designers of heating, ventilation, and air condition equipment. He's given numerous lectures around the country on business management, and Taco has an amazing learning center that has done some very interesting things in terms of work force development for his employees. He's a member of the Department of Energy's Advisory Committee. He's also a member of the Brookings Board of Trustees. So please join me in welcoming Johnny to the podium. (Applause)

MR. WHITE: Welcome everybody. It's just great to see so many people taking part in what I think is such an important, vital part of our economy and in fact our lives. So I appreciate you taking the time to be here and friends and new acquaintances alike. I'm very, very proud of this activity by the way. Manufacturing is kind of in my blood. It's a great love of mine and to see it grow and prosper and beginning to get traction again here in this country and to be able to host and sponsor a program like this is just a terrific honor.

And today to lead off we have a very special guest, Jason Miller, to share some thoughts with us. Jason is a Special Assistant to the President and Deputy Director of National Economic Council in the White House. Mr. Miller leads economic

policy coordination on manufacturing innovation, energy, small business, international investment, and economic development for the White House. He also serves as the Director of the White House Office of Manufacturing Policy at the NEC and in that role he serves as the White House point person on the President's manufacturing agenda, coordinating implementation efforts across Federal agencies. I don't know how you do all of this actually to be honest.

Mr. Miller has led the effort in developing the President's comprehensive manufacturing agenda, played a key role in initiatives including the launch of the National Network of Manufacturing Innovation, the President's Advanced Manufacturing Partnership Select USA. This was the first ever Federal effort to bring job creating investment to the U.S. and the successful and industry-supported light duty vehicle fuel efficiency standards through 2025. Prior to joining the administration Mr. Miller was a management consultant with a Boston consulting group in San Francisco with focus on energy and technology manufacturing firms.

So without further ado I welcome Jason Miller. (Applause)

MR. MILLER: Thank you. It's great to be here this morning, great to see so many people here interested in this topic, an important one for this country, an area that we've been making a lot of progress. A big thank you to John White for putting this together, to Darrell, to the team here at Brookings who have been focused on manufacturing and innovation for several years and have been ahead of the curve in a lot of ways in driving this discussion, the dialogue. There's been a huge team across the administration and in partnership with industry, universities, and others. So there's more names than I can possibly list to thank, but a whole team of folks at the Department of Commerce, the Department of Defense, Department of Energy, some of which are in the room today. Looking over there I see Roger, I see Steve. Um, Dr. David Hart who's a

former administration official, members of our Advanced Manufacturing Partnership. It's been a huge team effort. I also want to thank two former administration officials who were central to all the things that we've been doing on manufacturing, the recently departed Dr. Pat Gallagher who's left the administration to join as the President of the University of Pittsburgh, an incredible leader in general but has been an incredible leader in manufacturing, and my former boss, Gene Sperling, former Director of the Economic Council who's an enormous champion for decades for American manufacturing. I also want to thank JJ Raynor. JJ works with me at the National Economic Council and is truly central to everything that we do in this space, a true rising star for American economic policy.

Now to begin any discussion on manufacturing I think it's helpful to put in context the current state of the economy over all and the policy objectives that we're trying to achieve in that context. Last Thursday, monthly jobs day, big news. The economy added 288,000 new jobs. That's the 52nd consecutive month of job growth. To put that in context the first six months of this year were the fastest period of job growth in a six month period beginning of the year since 1999. Fifty-two months is the longest stretch of consecutive job growth in American history, or at least since we've been recording the data on it. So there's no doubt that we're making progress. In the manufacturing sector we added 16,000 direct manufacturing jobs, bringing the total since the beginning of 2010 to 668,000, the first period of sustained manufacturing job growth since the 1990s. Now we're making progress, we're making steady progress. That progress isn't as fast as we'd like. Unemployment is still elevated, particularly long-term unemployment. And obviously wages for middle class families have been stagnant for a long time.

Now in this context sound economic policy should focus on three

elements, continuing to spur growth and job creation to help the economy reach its overall potential, putting in place the policies that increase our potential economic growth going forward, and doing everything that we can to ensure that economic growth is broadly shared, that opportunities exist for everyone who works hard, who plays by the rules. Now one of the challenges in the debate on manufacturing policy that we've seen over the last several years, particularly in this context where we've had what will hopefully be for all of us a once in a lifetime economic crisis is a disagreement over what the purpose of supporting manufacturing is. Is it about spurring job growth as part of our recovery, is it about building a more innovative, prosperous economy for our future growth trajectory, it is about providing high quality jobs and growing the middle class? The reality is that manufacturing supports all three of these objectives in different ways. And some of the different policies that we've tried to put in place touch different elements of them. But that's been one of the challenges. Manufacturing supports all of these. Even if we weren't in a period of heightened unemployment we should be focused on our manufacturing sector.

So first manufacturing generates high quality jobs across the economy. Some have argued -- including some in this building several weeks ago -- have argued that the focus on manufacturing is misguided just because it's not going to create that many jobs. I think first it's a mistake to look at manufacturing job gains simply through the lens of the direct number of manufacturing jobs. I have to admit I'm a culprit, having already cited the 668,000 direct new manufacturing jobs, but if you look at what happens within the four walls of a factory you're ignoring the broader employment role that manufacturing plays in the economy. Not only does it support millions of jobs through integrated supply chains but millions more in communities through the wealth that it creates. And while the view of what I'll call silent factories undercounts the jobs

manufacturing supports it also fails to envision the future jobs for which we'll need manufacturing capabilities here to innovate and to compete.

Second, a core reason we should care about manufacturing even if the economy were at full employment as I said is that manufacturing is inextricably linked to our country's ability to innovate and therefore linked to our future economic growth potential. The claim that any support for manufacturing is misguided industrial policy, a claim that I would note has faded but not completely is still out there. However the evidence shows that manufacturing can be soundly justified by the degree it creates innovation benefits for the broader economy. As Darrell noted manufacturing represents 12 percent of GDP, but it also accounts for roughly three-quarters of private sector research and development, roughly 60 percent of all private sector R & D employees, the majority of our exports, the vast majority of our patents issued. We like to say manufacturing punches above its weight. Now others have covered this ground thoroughly including Gary Pisano and Willy Shih from Harvard Business School, including the entire endeavor at MIT, the Production in the Innovation Economy project, showing that the capabilities gained in production, capabilities gained in production, are intertwined with new learning and the knowledge activities of research, development, and design. You should think about it as a two way street, a manufacturing and innovation feedback loop. And I think some of our panelists later today can talk very granularly about what that means and about how some of these institutes influence that. The risk to the U.S. of course is that if we're willing to allow our industrial base to erode we lose our capability to produce as we create a vicious cycle that makes the U.S. less attractive for new manufacturing and ultimately puts at risk our continuing capability to innovate and compete for future jobs.

Now there's been a lot of chatter over the last several years about the

recovery of the manufacturing sector and what it actually means. There's no doubt that manufacturing took it on the chin prior to and during the recession, but since early 2010 the sector has grown at roughly twice the pace of the economy overall. Productivity has been growing at faster than four percent per year. It's the longest period of manufacturing outpacing overall economic growth in the United States since the mid-1960s. So we're in a period where something's happening, something is different. But before digging into this I think it's worth for a moment laying out the different types of manufacturing skeptics. First, those who argue that manufacturing has always been strong, pointing to continued gains in manufacturing GDP, gains in productivity despite all the employment losses and trade deficits that we saw in the last decade. They say there's no problem, there's nothing to see here. I think the work of Susan Houseman who's an economist who's looked at this thoroughly destroys this underlying argument to show that the value added in productivity measures that are being used to justify these claims don't hold together due to a whole set of issues with the actual data. Second, those who argue that manufacturing has been on a long secular decline for decades. This group would say this doesn't really matter. Manufacturing is just not that important and all of us here -- this is going to be an interesting discussion but it might not be that useful. They tend to look at manufacturing as share of GDP or a share of employment and argue that the sector's been on a relatively steady decline on a linear trajectory for decades. Now this group got a lot of air time last decade in particular arguing that in some ways the decline of manufacturing that we saw last decade was a good thing, it was some transition to a new information and services based economy. Third, there are those who argue that to the extent we've seen a rebound in manufacturing over the last four years it's been just a trickle of jobs and these new jobs are largely driven by low wages and benefits.

So let me take on these skeptics a little bit. But to do that I think we need a common understanding of what has happened and where we're headed. Now the manufacturing sector has faced challenges for decades and it's been different types of challenges over that period of time. In the 1980s for example the rise of Japan and the ongoing geographic shift of manufacturing within the United States, particularly in places like the Northeast. Shifting away from the Northeast caused significant challenges for a number of communities. And while manufacturing employment technically peaked in 1979 for the most part absolute employment in manufacturing has been steady and production growth has grown steadily. In 1965 there were about 17 to 17 1/2 million Americans employed in the manufacturing sector. In 1999 there were about 17 to 17 1/2 million Americans employed in the manufacturing sector. Over that 35 year period of time production growth grew on a relatively steady basis at over 3 percent per year, roughly 3.4-3.5 percent. And in the '90s, the decade after that, you know, we faced a new challenge from the rise of Japan we saw the fastest pace of manufacturing production growth, the fastest pace of capacity expansion, and over 700,000 new manufacturing jobs in the U.S. So we faced a challenge, we expanded over this period. But then the last decade happened and I think the last decade was profoundly different.

From 2000 to 2009 our manufacturing sector lost roughly a third of its work force, 5.7 million jobs. There was no 12 month period where we added manufacturing jobs on a net basis. Sixty thousand factories closed; forty percent of our largest factories, those employing over 1,000 people, forty percent closed last decade. Now many have debated the actual drivers of this decline, how much of a failure of trade enforcement or a lack of focus of policies related to manufacturing competitiveness. But I think we can firmly state that it's just plain wrong to argue that the changes last decade were due to a boon in manufacturing productivity here like agriculture we can make more

and more with less and less. Last decade was not a story of surging productivity, it was a story of stagnating production, period. From 2000 to 2010 our manufacturing production declined by roughly 5 percent. Meanwhile demand for manufactured goods continued to steadily increase and grow with the economy. If U.S. manufacturing had grown at its historical rate of production at 3.5 percent over the last decade U.S. manufacturing in 2010 would have been 40 percent larger than it was in 2000. That's what caused our job losses, that's what led to a large surge in our trade deficit. We are no longer growing the amount of stuff we made. Since the end of the recession manufacturing has been growing again and compared to the last decade that growth has been robust.

Now this has led to a debate about whether these gains have simply been a cyclical rebound, part of what you would expect as part of an economic recovery coming out of a deep, deep economic crisis, or whether there's a broader structural shift. You know, we believe that the data cannot be explained by cyclical factors alone. Two things to point to, one if you look at the U.S. global share of exports it's grown much faster than other advanced economies, in fact faster than all major countries except for China. In 2012 for example U.S. exports grew five times as fast as those of other advanced economies and three times as fast as exports from emerging Asia. So the U.S. was gaining share globally. Now the President's Council of Economic Advisers member Jim Stock looked at this problem and found that if you look at the current recovery compared to previous recoveries, if you adjust for a number of trends brought about by increased globalization and other factors last decade, that the recent performance strongly suggests that employment in production in the manufacturing sector cannot be explained by cyclical recovery. In fact their analysis finds that less than one quarter of the employment growth since 2010 was due to a cyclical recovery alone. Now whether or not you call this a renaissance it is clear that manufacturing's prospects

are very different than they were only a short few years ago.

Now going back, some have argued that that expansion has largely been driven by the degradation of manufacturing wages. Steve Rattner made this point in a New York Time op-ed and on a stage somewhere in this building relatively recently. But I think this view that the manufacturing expansion is driven by low wage jobs mistakes anecdotes for evidence and ignores the data about longer term trends and manufacturing wages. The Department of Commerce last year released a report that shows that new hires in manufacturing enjoy an earnings premium of 38 percent relative to new hires in other sectors. And this premium was higher, slightly higher in recent years than it was through the middle of the last decade. Moreover the report found that the earnings of new hires in manufacturing relative to incumbent workers has hovered at a relatively steady rate of about 70 percent over the entire last decade including through the period of job growth after 2010. So new hires in manufacturing make more than other sectors, new hires in manufacturing make relatively the same ratio that they've made to incumbent workers, and there has long been understood an earnings premium in the manufacturing sector. So I think this argument that this is all due to low wage workers points to a handful of anecdotes but mistakes it for evidence.

So what are U.S. manufacturing's prospects? Now one area that's garnered little attention is the average number of hours worked per week in manufacturing. This has been talked about a lot for the overall economy, that there's too many people with too few hours. But when you look at manufacturing the story is the opposite. Manufacturing hours per week are at their highest level since World War II. And more than one hour per week higher than what one would consider a normal historical average. Now one hour may not sound like a lot but when you look across an entire sector that employs 12 million people it's an enormous amount. And I think you

can think about that one hour as pent up hiring in manufacturing. There's an amount of pent up hiring because that isn't sustainable over a long period of time. So if we were to reduce that overall hour by hiring people to fill the need for labor in manufacturing, that's equivalent to roughly 300,000 more manufacturing jobs. And that assumes consistent productivity with existing workers and new workers. So think, one, there's a lot of pent up hiring in manufacturing that those hours numbers point to. And there are more reasons that we should be optimistic. When you look at surveys of business executives, both in the U.S. and around the world, it suggests that the U.S. is a more competitive location for manufacturing than it has been in decades. A BCG survey late last year found that 54 percent of manufacturing executives were actively considering bringing production back to the U.S. from China. That is up from 37 percent of manufacturing executives saying the same thing 18 months prior. That's an astounding statistic. An A.T. Kearney survey of global executives found that the U.S. is the top destination in the world for job creating foreign direct investment for the second year in a row. Prior to that we hadn't been number one since 2001, surging ahead of China, Brazil, India, Germany, et cetera. And in this year's survey I think there was some interesting data. We extended our lead scoring the highest confidence levels of any country since the survey was launched 20 years ago.

Our low cost energy provides us with a new source of advantage, particularly low cost natural gas which is so important to manufacturing. Natural gas prices here are roughly half that of Europe, one third that of Asia. That's why there's tens of billions of dollars in energy intensive sectors, of announced capital projects in the years ahead. But more than that analysts estimate that the supply chain impacts on non energy intensive sectors could lower production costs in the U.S. by one to two percent. And for all of the manufacturing executives in the room a one to two percent cost

decrease just from energy alone is substantial.

Another item that I think bodes well for our future; manufacturing entrepreneurship is on the rise. Last year manufacturing entrepreneurship grew at its fastest pace in 20 years. Advances in new technologies that can democratize production, create what I think we should see as a new source of competitive advance for U.S. manufacturing. Technologies like 3D printing, digital manufacturing, both of which we're going to be talking about today, are lowering the cost and reducing the time to make prototypes, change processes, commercialize new products. Now our historical strength in software development actually positions us in many ways to lead in these technologies. Today in fact 80 percent of the world's software is still produced in the United States and we have more than half of the most powerful high performance computing systems in the world. Last month we hosted the first ever White House Maker Fair, highlighting the excitement across the country in making things. This wave of technologies has introduced a new wave of hobbyists that perhaps like the home-brewed computer club that spurred new young companies like Apple, the Maker movement might create new companies and even new industries. Now one of the exhibits at the Fair was from two young girls called Beatty Robotics, a team from North Carolina where the 12 and 14 year old sisters were making robots. And their company motto was who needs a paper route when you can start a robotics company. (Laughter) That's a pretty awesome company motto. But these are -- I think the Maker Fair -- I mean the interest was overwhelming and those are the kinds of stories that I think should give us hope and make us optimistic about the future for American manufacturing.

Of course change in sector, the size, and complexity, that manufacturing takes time and is not going to happen on its own. Manufacturing operates as an integrated system, producers, suppliers, customers. And while the economics of locating

production in the U.S. are better than they've been in years it is apparent, it has been apparent that rebuilding our capabilities and our infrastructure broadly defined, our supply chains, is hard work. The know-how on those supply chains develops over time and those capabilities cannot just be recreated overnight. And given the profound challenges we face in manufacturing I think it's safe to say that there's been underinvestment in a lot of those capabilities for too long and that investment will take time for us to see the returns and rebuild them. To put a finer point on it, one, the Commerce Department did an analysis of the age of equipment and software, the age of capital equipment in the U.S. manufacturing sector, and over time it's risen to its highest level since 1940. So we have our capital equipment in U.S. manufacturing is older than it's been in over 70 years. Second, data from the Department of Labor shows that the median age of the U.S. manufacturing worker is over 45 years old. And others have estimated if you just look at high skill production workers that average may be as high as 56 years old. That's a substantial challenge and a substantial challenge for when we think about how do you train young people for high skill production jobs including skills that are advancing over time. These facts should demonstrate a clear, clear need for reinvestment in our manufacturing sector to take advantage of some of these broader underlying economic trends, take advantage of the benefits that manufacturing generates for the broader economy.

So as we think about how do we achieve these objectives, how do we move forward, how do we address the challenges that the sector has faced, the administration's agenda broadly defined has taken on four pillars. One, continuing to take steps to increase the competitiveness of the U.S. as a location for production by doing things like reforming our Tax Code, expanding our energy advantage and investing in our infrastructure. Two, expanding our innovative edge by investing and cross cutting

R & D and new manufacturing technologies, including creating a national network of manufacturing innovation institutes. Three, ensuring that we have the human capital at all levels that we need to excel by investing in our work force, our businesses, and our communities which of course needs to include fixing our broken immigration system. And, fourth, leveling the playing field by opening access to markets while ensuring that our trading partners are playing by the rules.

So let me say a little bit more about the President's proposal to create a national network for manufacturing innovation institutes. We put together this proposal several years back working with a group of outside advisors including the Advanced Manufacturing Partnership, examining a range of models around the world that have aspects of the policy proposal we put forward. And the concept was to establish consortia of firms and universities that collaboratively help to bridge the gap between R & D and product development, but done in a way that helps to rebuild some of our core manufacturing capabilities, or what some have referred to as the industrial commons. Now this is truly an effort to spur both public and private reinvestment in American manufacturing. And one unique aspect I believe is that if you look at how this has rolled out, the Federal government in many ways has acted as a catalyst providing seed funding which if you look at the four competitions we've run to date over 40 teams have competed for those four institutes. And the teams that did win include more than 100 companies, more than 40 research universities, not to mention community colleges, local partners, local leaders. This is truly helping to recreate around a set of important technologies the networks that make it more attractive over time to locate and produce in the United States. We've seen an overwhelming amount of support. We've seen support around the country. We've seen bipartisan support in Congress and enormous demand from industry. This work is still in the early stages but we're proud of what's been

accomplished, but we recognize that this will be a big team effort and a big effort to make it last, make it successful going forward.

I also think that that outpouring of demand has another signal. It's a sign that we should be optimistic about our ability to tackle this challenge. I think the turnout here today and the number of dialogues like this show that we are more focused on the problem, we being the United States, are more focused on the problem of U.S. manufacturing than we've been in a long time. And while the institutes are just one piece of the broader puzzle I think it's an important element in rebuilding our capabilities and I thank everyone for participating in this discussion today. Thank you. (Applause)

MR. WHITE: Jason, that was great.

MR. MILLER: Thanks.

MR. WHITE: It's really interesting stuff. I had a list of questions to ask you and I think you've answered them all in your talk so I'm a little beside myself. But I do want to just -- if I can just recap a couple of things. Then I think I'd really like to go to open it up to the audience. But it occurs to me, it's very interesting because there's so much investment and in your paper that you released so much referral to high tech -- what you call 3D, that kind of stuff, the digital high tech manufacturing, there still is such a -- and what's driving that is the continued perpetuation of what I call metal bashing, you know, real manufacturing, like we do. And so it's a bit cyclical. The investment in this stuff that you're talking about is driving the ability to reinvest in traditional manufacturing. So it's quite interesting.

You know, as I was thinking about the 670,000 jobs or whatever that have been created since 2010. I would ask you this question, is -- and you may have answered it in your talk but I want to rehash this a little bit -- do you consider this to be sustainable moving forward, this rapid growth? And possibly what policies might need

tweaking or changing or adapting in total to allow that to continue? And perhaps are there policies that could inhibit that growth?

MR. MILLER: So let me make a comment about your first statement. I don't think there's a divide between -- I actually don't like the term "traditional manufacturing" because I think, you know, we often talk about advanced manufacturing and I think one should generally think of advanced manufacturing as all of the manufacturing we do in the United States. You know, all of this work operates as part of a broader integrated system and the process improvements that have taken place across the manufacturing sector are profound, whether or not you are making product X or product Y. So I think it is a bit of a misnomer.

To your broader question on whether this is sustainable and what can we do, I think there's a lot of reasons that we should be optimistic about the growth potential definitely over the near term for the U.S. manufacturing sector. The U.S. is more competitive for production, the economics -- if you will the economic winds are at our back whereas they were not last decade. Some of these underlying factors I think will make it more attractive to make things here, whether it be speed to market, the ability produce smaller volumes at lower costs, whether it be, you know, rapid customization, et cetera. I think there's a lot of reasons to believe that there's a lot of upside for the manufacturing sector in the near term. And I don't think we should think that where we are today is a success. I think it's progress but we have a long way to go. And what you're starting to see is that while things are shifting in this direction as I was trying to note, you know companies that are trying to bring production back to the U.S. face a set of challenges that they never expected, whether it be finding people to do specific kinds of things or finding a supplier that's going to produce a specific component, that we've lost that capability. So rebuilding those integrated supply chains I think will be a

challenge.

From a policy standpoint there's a broad number of things that we need to do. One I think overall ensuring that we don't do anything to get in the way of near term economic growth is going to be central. And we've seen some of that over the last several years, creating broader risks to the economy both in the United States and abroad. I think there's a set of things that we can do, broad things. When we talk about investing in infrastructure or we talk about immigration reform we tend not to think about manufacturing but they're central. Manufacturing in an outsized way benefits from those broader competitiveness policies. And these are a number of things that are on the table. I'm optimistic about them moving forward, things like business tax reform. We don't talk about the manufacturing aspect of it but for a sector that is globally mobile it is even more important than other parts of the economy that we get these things done.

MR. WHITE: Yeah, you know, and in your talk, you know, you pointed out something that I find particularly significant. I can relate it this way, in terms of growth but not necessarily job growth. You would call this a jobless recovery I think in the economic recovery. In our company for instance in 1991 or '92 we were about a \$30 million company in sales, we had 500 people. Now we're about \$200 million and we have 500 people. You know, so productivity investment is definitely a threat to job creation. So I think what that means is we need to find ways to grow the total market.

MR. MILLER: Yeah.

MR. WHITE: The capacity. Could we open it up to some questions from the audience? Yes, sir.

MR. HERSHEY: Hi, I'm Bob Hershey; I'm a consultant. How has the internet helped in getting together this integrated supply chain you talked about and putting together kinds of things where various companies might put up money and get an

integrated effort?

MR. MILLER: So how has the internet helped? Well, I mean it's definitely changed how we think about supply chains. I think one of the things that we looked at when we think about manufacturing entrepreneurship is the ability of the internet to connect those entrepreneurs to networks of people that can help get their businesses started, find the financing in ways that they couldn't before. And I think that's an exciting prospect. We've talked broadly about the decline in entrepreneurship in the United States for a long time which while true in the data we're still by far the world's most entrepreneurial place in aggregate, so we have a large lead. But manufacturing has almost been cutting against the grain and I feel like in a lot of ways the internet can help enable and support that.

MR. WHITE: Other questions?

SPEAKER: An Italian economist at Berkeley whose name I forgot but who wrote a book called, The Geography of J Jobs, has made the argument that jobs are not coming back to the old rust belts but new brain hubs are being created. First I want to ask your perspective on that number one. And then number two, history showed as you have talked about that each high tech job creates six other jobs, half of them well paying, half of them not so well paying. And I want to see what the research that you have seen shows on that point.

MR. MILLER: So I believe that is Enrico Moretti.

SPEAKER: Yeah.

MR. MILLER: And a couple of things to say about. I mean one, when you look at manufacturing overall, sectorally overall it does add more jobs than other sectors. Roughly the estimated aggregate is something like 1.6 additional jobs are created. Two, the argument that higher tech jobs create more is in part due to a broader

amount of value added across the supply chain that's created from that job. So if I have a -- Mike Russo from GlobalFoundries who will be up here later -- if I have an enormous semiconductor foundry I spend literally billions of dollars on capital equipment just to produce the things. So I have significantly more capital equipment per person that supports those jobs. Three, I do think these networks of capabilities are really important. But to suggest that we're going to end up with like four cities in the United States, which one could believe if you read that book, is just not right. And when you look at where the job growth has occurred over the last several years in manufacturing the Midwest has added a pretty significant amount of production. And I think you're starting to see the ability of those capabilities coming together. I think those knowledge capabilities are critical for a future. That's part of the reason that these innovation institutes are important policy in terms of tying together companies, research universities, in places where we're developing technology, we're developing work force, we're developing networks all in one. But I think it's a bit of a misnomer and I think this goes back to the point I made at the very beginning responding to John's comment about this sort of disaggregation between there's high tech over here and there's everything else over here. And I think that separation is a bit of a false one.

MS. MCINTYRE: Cynthia McIntyre with the Council on Competitiveness. Could you talk a little bit more about the connection between the NNMI institutes and the manufacturing communities that the Department of Commerce just announced, I guess it was end of May? Is there a connectivity there?

MR. MILLER: Yeah, so at the end of May we announced 12 manufacturing communities as part of the investing in manufacturing communities' partnership. There is a relationship but not a direct connectivity. The notion behind the investing in manufacturing community partnership is twofold. One was to the Federal

level run a competition that would spur local communities to bring together their economic development officials, their businesses, their work force entities, in ways that create a holistic plan that is thoughtful about how they're going to leverage all those different pieces of investment in a coherent and collaborative way. From the Federal perspective that helps us think about how we should organize what are a set of different programs that are targeting work force or targeting a transportation project or providing economic development planning which too often are done in silos. And if you can build places where these teams have their act together on the ground and the Federal government is organized and talking amongst itself about how you're going to fund these communities, you're going to get much better performance. I think Mike probably has a very interesting story to tell about Youngstown in terms of how some of those pieces fit together. So in some ways there are complimentary outcomes that we're seeking to achieve. But the investment in an institute similarly is catalytic in that it's bringing together a number of forces in a community than from across the country. But it's different in that it is a specific asset and set of capabilities as opposed more of what I would say is a holistic economic development strategy.

MS. RODHAM: Hi, I'm Penny Rodham with the Association for Manufacturing Technology and we produce the International Manufacturing Technology Show. So this fall we'll actually be featuring an exhibit on the NNMI. Do you have any indication as to maybe what future technologies will be featured in those, or maybe future locations for more of those institutes?

MR. MILLER: So we'll be announcing our fifth institute on advanced composites this fall. The competition for that is out being led by the Department of Energy. In the State of the Union the President promised that we would be launching four more institutes which means we'll have at least three additional competitions that

have been launched. We'll be announcing those technologies either later this summer or fall. Those are being led by the Department of Energy and the Department of Defense. I'm not going to break any news in terms of what those technologies are but that's being driven by the Departments. I think this -- the second part of your question is an important one which is how do you actually from the Federal perspective identify a winning location. We didn't say at the front end, you know, or the Department of Defense more specifically, with DOE, didn't say we really want to do something in Youngstown. They said we are going to be making an investment in additive manufacturing and we're going to run a competition. Twelve teams competed. Those teams were spread across the country. Some of the businesses, especially some of the large businesses were on multiple teams. But ultimately it came down to who had the strongest team, who had the strongest plan. And a combination of technical and business experts were reviewing those plans just like they will be for the advanced composites. So once those competitions launch later this year I think we'll see something similar. As I noted we had over 40 teams, 40 teams that competed for the 4 institutes. And I actually think what you'll see is -- even for the teams that didn't win, there will hopefully be some benefit in that they're actually creating some networks of companies and universities and be able to find new ways to partner with one another irrespective of whether they received the Federal funding to launch an institute.

MR. SANG: James Sang. In talking about manufacturing as you mentioned you talk about a very diverse sector ranging from materials, making steel, and to pharmaceuticals, to making automobiles, to making ships. How common are the variables you use? Do they actually fit together, really fit together that well in a single package or does one need actually separate policies, separate sectors? How coherent are the pieces at your level?

MR. MILLER: Yeah, so I think it's a good question. When you think about the economics of production in the United States there's no doubt that it's different if you're producing say a ton of steel versus if you're producing chips, like GlobalFoundries. The elements of the economics are different but it's what the percentage difference amongst them. The word that was common in everything there was "making". You're going to be making something across all of these different sectors and the economics of production while different across sectors still rely on a number of cross cutting things. When you look at the institutes one of the interesting things is that you see a number of very different types of companies that are participating because a lot of these technologies have broad application. So you're seeing broad application whether it be in materials, aerospace, transportation, defense technologies, energy technologies, et cetera, where a lot of them rely on overlapping capabilities and overlapping technologies. So when we think about it we're not saying, you know, what is the strategy to drive growth in the steel industry, we're thinking about what's the strategy to drive growth broadly and how do you make manufacturing broadly more competitive. There's no doubt that there's slight differences between them but I think a lot of the things that we're trying to put in place are relatively cross cutting.

MS. PACK: Good morning. I'm an intern; my name is Lauren Pack. How will the decision on the OCTG case on oil country tubular goods affect and reflect the future of American manufacturing?

MR. MILLER: For all the interns in the room I strongly suggest you use the word "fellow" on your resume. (Laughter) Just -- I don't know. You were a summer fellow. So look I think trade enforcement is an important aspect of U.S. manufacturing. We're a trading nation, we benefit in many ways from trade. We have to be able to enforce trade laws and we face a number of challenges in enforcing those trade laws

over time. You know, there's no doubt that the steel industry has faced significant challenges from unfair practices abroad and, you know, I think to be competitive going forward it's got to be a part of our agenda and it's got to be an important part of our agenda.

MR. WHITE: Very good.

SPEAKER: I am also an intern at the Senate Finance --

MR. MILLER: Summer fellow. (Laughter)

SPEAKER: Senate Finance Committee, not here. but on the same terms as she's speaking of, do you think the solution for that would be to like postpone TPA or to pass TPA in order to -- because I've heard many -- at many hearings I've heard people talk about how why should we go into these new agreements such as TTIP and TPP if they're not being enforced. So I'd like to hear your opinion it's better to go into new agreements or try to make sure that our old ones are enforced first.

MR. MILLER: I don't think it's one or the other. Look, I think, one, you know, there are a set of ongoing cases that happened in a quasi judicial process. Those cases need to move forward. On the broader question of open markets I think it's important for the United States to be a leader in defining the rules of the road for trade that doesn't include enforcing them. But to define the rules of the road for trade things like TPP and TTIP are incredibly important. Moving forward on those the U.S. is in the front not playing catch-up I think will be critical both for our ability to ensure that the U.S. is an attractive location for production but also our ability to define what the rules of the road are going to be.

MR. TULLO: Thank you. Tom Tullo from Compass Advisers. I have a question. You have done an excellent job of explaining the current administration's policies in favor of manufacturing. This is also an administration which has a number of

other important agenda items. And I was wondering if you could share with us how do those different agendas which may be in conflict at times, how those get thought through, debated within the administration to develop an overall policy?

MR. MILLER: So I'm not sure if you're referring to a specific thing but I mean generally --

MR. TULLO: Well, for example healthcare.

MR. MILLER: Yeah, I think that, you know, the challenge in public policy, particularly the challenge in public policy in the United States is that we -- you know, I came from the private sector and I like to say that if you're in a company you tend to -- most of the time you agree on what the objectives on and you're disagreement tends to be over how you get there. When you're in public policy you're disagreeing on both the objectives and the means which makes the job a lot harder. Look, I think it's an important question and it's always about, you know, balance, right. So we are pursuing steps to ensure that the economy is growing in a robust way, we're pursuing steps to ensure that that growth has a different shape than the growth in the past. For example exports now are about 14 percent of GDP, they used to be 11 percent of GDP. That's an important change. Manufacturing is a big part of that. We're pursuing healthcare in a very loud and vocal way. It's a critical part in a number of different areas including entrepreneurship which doesn't get covered enough, people being able to take risks, start companies because they have confidence in their ability to have healthcare. We're facing challenges in addressing changes in our climate, the health risks associated with that. And so when you think about how you balance all of those different things, one, you need a deep understanding of the direct and secondary effects to the policies that you're putting in place, and you need to understand when there are trade-offs. And we debate very vigorously within the administration when there's trade-offs and how do you move

forward.

MR. WHITE: Time for one more. Oh, two more. We'll do two more. But do the Reader's Digest version.

SPEAKER: Thank you. You spoke about benefits like customizability and time to market with new emerging technologies. How do you see the blend between local versus centralized manufacturing in the future?

MR. MILLER: There's a great professor from MIT who has a fantastic presentation on this exact point. Look, I think some of these -- it's not knowable right now but I think that what you see with some of these technologies is the potential to produce either in different volumes or more customizable products which allows much more local activity rather than, you know, massive plants. One of the I think geographic realities of manufacturing has been that in many cases manufacturing activity has moved out of city centers. And so you see a lot of places, particularly a lot of industrial cities where manufacturing used to happen in the city and it happens either outside or in other parts of the country. And we've been interacting with a number of mayors on this exact thing, how do you put in place local rules that allow smaller production shops to reintegrate into urban cores. And some of that can be driven by the growth in some of these technologies which I think will, you know, especially when you look at the amount of volume for some products that we continue to import from abroad, the economics of production combined with the ability to make it in smaller volumes in a both comprehensive and competitive way is one of the factors that I think should lead us to be optimistic about the potential for manufacturing expansion in the United States.

SPEAKER: To that point about reintegrating into the urban -- the need to learn these new manufacturing skills, do you think that will motivate a change in American education and if so what might those changes be?

MR. MILLER: I hope so. So, one, there's existing manufacturing skills that we need to do a lot of training on. It's not just that there are a set of new technologies that people don't know quite how to operate with, there's a lot of existing skills. And one of the challenges is that over the next five to ten years we're going to face a potential significant retirement of a number of very high skill individuals and those individuals haven't necessarily been backfilled in a lot of companies. I think we're starting to see that change happening within our work force training and our educational system. When you look at the community college funding, we've been giving out these blocks of \$500 million per year. The first year you had 19 percent went to the manufacturing sector, the second year you had almost 38 percent of that funding went to the manufacturing sector. And I think part of that has been a coherent effort by industry in partnership with for example the manufacturing institute and others that has really started to motivate that change, building those capabilities particularly within community colleges to help drive certification and training for high skill production workers.

Within the education system broadly I think you're starting to see a number of questions being asked about how do we do primary education, high school education where after decades we've lost for example shop. Are we teaching technical and vocational skills in a way that is potentially beneficial for young people who learn in a different way to gain some of the STEM skills? And that's actually one of the things that we talked about a couple of weeks ago at the White House Maker Fair. These are exciting technologies; they're exciting for young people. There are ways to get them excited about the prospect of manufacturing careers, about engineering, about STEM more broadly. And we've been pushing a lot on high school redesign. There's been a ton of discussion more broadly in the country about that. And I think we will start to see that shift, particularly with the economics as companies become more directly integrated

into the work force system and education system and demand specific things in specific competencies not just degrees, but competencies. I think you're going to start to see that shift in a meaningful way and in many ways it's begun, and the community colleges have been at the front of that.

MR. WHITE: Jason, thank you very much. It's been a great, great hour.

MR. MILLER: Thank you. Thank you for doing this. It was fun. Thank you. (Applause)

MR. WEST: So we have heard from Jason about the President's vision and the role of the regional hubs that have been set up, so there have been several different hubs set up. Today in our next two panels we're going to focus on the ones that have been set up in Youngstown, which is focusing on additive manufacturing and Chicago which is doing innovation in terms of digital design.

And so, Youngstown is an interesting area. As a native Buckeye, I remember the ups and downs of that city and that part of the world over the last several decades; the decades of the 1970s and '80s were tough times. We heard a lot about de-industrialization, the rust belt, the loss of manufacturing jobs, and Youngstown was one of the epicenters of that decline, but in recent decades there has been a resurgence there and manufacturing has started to come back.

So, we have two individuals who have been very actively involved in Youngstown and in the hub devoted to additive manufacturing and 3-D printing.

We have Mike Garvey with us. He is the President and CEO of M-7 Technologies, and he actually worked on Wall Street before returning to Ohio in 1985 to help his father rebuild the family's manufacturing business, and he helped transform what then was a struggling business into a high-tech precision-measurement and manufacturing company, and the company is now collaborating with Youngstown State

University to develop digitally-based multi-sensored components for the Department of Defense.

And then we also have Ed Morris here with us. He is the Director of the National Additive Manufacturing Innovation Institute which now is known as America Makes. He also serves as Vice President of the National Center for Defense Manufacturing and Machining. Previously he was the Director of Mechanical Engineering and Manufacturing on the Lockheed Martin Corporate Engineering and Technology Team. He also has served as a Chairman of the National Defense Industrial Association's manufacturing division, and he has more than 40 years of defense, commercial, and international aerospace experience with an emphasis on program management, engineering, procurement, and manufacturing.

So, what we want to do in this session is kind of dive more into the details, get a little more granular about these hubs, how they're operating, what works, what doesn't work, what are the lessons for other communities.

So, Mike, I want to start with you, so you helped to transform a struggling manufacturing business into a profitable one. What did you do, and how has the Youngstown hub been helpful in your particular area?

MR. GARVEY: Sure. Thank you, Darrell. And thank you to the entire John White Family for sponsoring this forum. It's very nice of you to bring such attention and focus to these pressing issues.

Getting back to M-7 Technologies, I returned to Ohio in 1985 with a struggling business. My father and my grandfather's business was a bronze foundry, so if you're familiar with that, that was probably one of the original types of 3-D manufacturing going back to the Egyptian Age. (Laughter) And matter of fact, that was my grandfather saying that things haven't changed much in the last 2,000 years, and he

didn't think things were going to change much in his lifespan, while lo and behold his namesake was left to clean up some of those post-industrial things.

So, growing up in Ohio we were raised at a dinner table, myself and my brother and my sisters, on appreciation for quality and customer satisfaction, so we set out to rebuild the company to leverage both advanced hardware and software and creating a world-class workforce to get best-in-class customer satisfaction, and the technology we decided to base our business model on was advanced digital measurement, and as a result of that decision we have significantly changed our business model, improved our profitability, increased our staff education levels significantly, and along with that the wage at M-7. So, in the last 30-ish years we have grown our family business from when I arrived at an average annual rate of 18 percent consecutively for the last 30 years.

MR. WEST: So, Ed, you run America Makes. Maybe you could start just by telling us about that organization, what it does, and how it's trying to contribute to the innovation culture of a rust-belt city.

MR. MORRIS: Good. Thanks, Darryl. The National Additive Manufacturing Innovation Institute is also named America Makes. We did a little bit of re-branding. There's some individuals and organizations that are a little fearful when they hear about an institute, so we wanted to be a little bit user friendly particularly to the maker community, so we are America Makes, and sort of a byword in that, when America makes we believe America works.

But we are still very much the National Additive Manufacturing Innovation Institute focused on accelerating the use of additive manufacturing, or 3-D printing as it's popularly known in the press and the media, for the specific purpose of fostering new innovative products. Those new innovative products result in new jobs and boosted the

fundamental economic activity in the United States specifically in manufacturing.

In that process of being an accelerator for additive manufacturing, the technology itself has been growing quite rapidly over the past 25 years. The compound annual growth rate has been on the order of 27 percent. Over the last three years it's almost 35 percent (inaudible). We want to accelerate it even faster, specifically for the benefit of the United States.

Now, turning to innovation, the technology itself of 3-D printing allows you to do designs and manufacturing of products that by definition are innovative because they can't be done any other way, but I also want to violently agree with Jason. This is a complimentary technology, not a replacement technology. They all fit very nicely together, and when you grow 3-D printing you grow the overall manufacturing economy.

Regarding Youngstown, the National Center for Business Manufacturing Machining, which is the organization that operates America Makes, is based in Blairsville, Pennsylvania. How did we get in Youngstown? The community just has an incredible energy. Manufacturing is in their DNA. When we were looking for the right place to be there was, as President Obama's announced in the past State of the Union Address, an abandoned furniture warehouse downtown was refurbished with the help of the local community, I believe, in 37 days from the time the site was selected until we were putting industrial 3-D printing equipment in the building to get us underway. So, that's a quick synopsis of who we are trying to accelerate the use of this technology for the U.S. economy.

MR. WEST: So, Mike, it seems like one of the virtues of these hubs, not just in Youngstown but the other ones that have been created, has been their collaborative nature bringing together universities, business firms, innovators of various

sorts, so can you tell us a little bit about how this played out in your particular firm, what kind of resources were made available, and how that helped you build your business?

MR. GARVEY: Sure. So, in creating the business model to transition from foundry technology to advanced digital manufacturing technology that was based on sustainability and the collaborative nature of this Institute brings together over 100 -- what do we have? Over a hundred?

MR. MORRIS: One hundred and two as of last week.

MR. GARVEY: Yeah, 102 members of the Institute, all paying somewhere between \$15,000 to \$200,000 of annual dues and being able to participate in research calls to move technology from the technology readiness levels of one to three, which is basically lab environment, proof of concept, through technology levels four to seven, which are levels of taking it from a working model in the lab to a working model in the operating environment.

So, we have been able to participate with different project calls at America Makes with companies such as Lockheed Martin and Northrup Grumman and Ingersoll Machine Tool to apply our manufacturing technology that we recently developed and have patents pending on, and so it's an early-stage technology that we're able to combine to help mature our technology while maturing the additive manufacturing technology. We have over 25 projects active right now at America Makes and totaling over \$100 million total of committed resources to these development projects.

MR. WEST: Okay, so Ed, you were mentioning the additive manufacturing component and 3-D printing, and we see lots of hype kind of surrounding this in terms of the potential. What do you see as the real contributions in terms of advanced manufacturing and how that's going to contribute to rebuilding economic prosperity?

MR. MORRIS: Well, the amazing things about 3-D printing is the ability to do configurations, again, you can't do with classical manufacturing. You can make very lightweight structures that are artistic in appearance and a lot of our classical design because of the constraints of physical machining there's limits on the shape -- the investment you want to put in time to machine away unneeded material particularly for mechanical parts. When you're depositing material you can be very efficient with that material, particularly important if it's very high-cost materials such as titanium. You can hit the same or in many cases improve performance and incredible reductions in cycle time.

One of the activities that we're funding through our research and development is based in the Youngstown area working with the local casting foundries. The lead for this research and development is Youngstown Business Incubator working very close relationship with Youngstown State University as a community activity in our region with the objective of taking the time it takes to make the forms for doing classical casting foundry work from months to a week. That's an incredible reduction in cycle time. With the ability to improve the casting performance with the ability to do the 3-D printing of the forms, when you talk about those sorts of cycle-time reductions and improved performance you're also taking out costs.

In classical manufacturing communities we talk about cost-performance and schedule, and the general sense the United States is pick any two. And with 3-D printing you can get all three, and that changes the game. One of the reasons I'm comfortable with saying that 3-D printing, even with all the hype, is really a game changer in advance manufacturing just because it has a whole new set of rules, and when you change the rules you change the game.

MR. WEST: So, Mike, you have moved into advanced digital

measurement, and Ed was just talking about 3-D printing, so in our earlier Q&A with Jason, Antoine asked a very interesting question. He's also a Brookings trustee, about the development of brain hubs, so it sounds like each of you, because you're moving into more advanced manufacturing, this certainly has ramifications in terms of workforce development, education needs, and kind of the role of the community colleges in those particular areas. So, could each of you talk a little bit about the education component, the workforce implications, and what you're looking for now that maybe you wouldn't have been looking for 20 years ago?

MR. GARVEY: Okay, first of all I would like to address Antoine's question earlier about the lack of development in these rust-belt cities because I don't think that there's another city in the nation more so than Youngstown, Ohio that has that designation, and we have to remember is the prosperity of Youngstown was based on world-class engineering, and with the de-industrialization of that area of the country, that world-class engineering remained present in our DNA. Even though the heavy industrial manufacturing declined, we still had thousands of children that were raised at dinner tables talking about complex engineering, having complex engineering discussions, whether it's materials engineering, it's former shaping engineering, it's application engineering.

And so, when the decline happened in Youngstown there was a mass emigration, but there was still a state university that was there that had departments that were built as a result of the companies that had been located there, so there was still a resident knowledge there in these -- and I believe they're still there in other rust-belt cities such as Allentown and Pittsburgh and Cleveland and things like that that are considered to be part of the rust belt.

Now, transitioning those skill sets and talents and criteria, curriculum

from whether it's chemical engineering for steel manufacturing or mechanical engineering for forming steel or things like that, they're still math based, they're still science based, they're engineering-based talents, and it is a natural progression of those skill sets. So, I think that it is an evolution of the skill sets, and that's the great thing about these institutes that I've seen in Youngstown is we have the opportunity to evolve the skill sets that at one time a hundred years ago were considered world class and had gone kind of dormant.

Now there's a re-awakening of those skill sets in the community and in the college, and the curriculum is being developed around those skill sets. So, advanced digital measurement is based on advanced statistical modeling, which has a lot of application in some of these advanced technologies such as 3-D printing and lightweight materials, gap band electronics, and digital manufacturing.

MR. WEST: Ed, your view on the new skill sets that are needed in advanced manufacturing?

MR. MORRIS: I like very much the way Mike began with his response, and let me go from there and set a foundation in terms of definition of manufacturing that is very germane to the National Additive Manufacturing Innovation Institute. Most folks in the United States when they hear the word manufacturing think of production, and incidentally "dirty, dumb, and dangerous" which is incorrect. When we think of manufacturing and particularly in the context of advanced manufacturing, it's everything you do to conceive, design, produce, test, field, support, and ultimately dispose a product. That's what manufacturing companies do, and we use the phrase big and manufacturing to get the right perspective, the right context.

In the area of additive manufacturing and 3-D printing workforce and educational development, one would think that there's a growing, fast demand for

technicians to run the equipment. There is a growing demand there, but the real -- but the blockage that we have to get to the tipping point for ubiquitous use of 3-D printing particularly in the United States is not a shortage of technicians. It's re-training the design engineers to design to this new capability, and a new capability that you can use polymers or plastics. You can use metals. You can make electronic parts. You can make mechanical parts. You can make electronic parts. You can also print with organic tissue for food, and you can print with human tissue, with body parts, so that the trade space is enormous, and the initial workforce education has to begin up front with the engineering community that goes all the way through the transition. At the feeder stock to the re-establishing the historic strength of engineering in the United States is obviously with STEM; science, technology, engineering, and mathematics. And by the way, I like to add art to that, STEAM, because if you're going to start to use 3-D printing technology you need to think a little bit artist and little less orthogonal X-Y-Z.

And a piece that excited us as we were wrestling with our charter to do workforce and educational outreach, specifically in additive manufacturing, 3-D printing was the "aha" moment that you can use 3-D printing to teach. You can make STEAM. You can make mathematics fun. After all, when you do 3-D printing, you're using mathematics in 3-D, so if you're having trouble perhaps as an algebra student in eighth grade, print an algorithm and see what it looks like, and suddenly mathematics becomes real, something you can relate to. One of the things I find exciting with the technology and the youth of America, to reinvigorate the interest and the career path since that this is a valuable and very rewarding field.

Brett Lambert, one of my friends was in leading manufacturing industrial-based policy in the Department of Defense bought a 3-D printer for his girls, two twin girls, and they started shifting away in their activities on Saturday morning to doing

design and manufacturing of jewelry, which they would then sell in their school on Monday. Think about it.

MR. WEST: That's entrepreneurial talent. I like that.

MR. GARVEY: Who needs paper to write when you have 3-D printing?

MR. MORRIS: So, that's real STEM education where they're learning to do the design, then manufacturing, the marketing, the selling, the holistic approach re-establishing the fundamentals of manufacturing as a driver, a positive strong driver of the economy of the United States, through this technology. That excites us.

At the university level we've had some conversation with universities talking about I want to start a degree program, bachelors or masters in additive manufacturing. And I appreciate their intent, but I very pleasantly as a kid, please don't do that. Please embed additive manufacturing, 3-D printing in all of your curriculum. It's important for mechanical engineers, it's important for electronic engineers, it's important for manufacturing engineers, it's important for the business school, it's important for the medical community. Put it throughout what you're doing. That's the power of what we're doing with 3-D printing in the United States.

MR. WEST: So, Mike, sticking with this education theme, so you've worked closely with Youngstown State University, so could you describe that relationship, what they do for you, how you collaborate with them? Have you seen them make changes in their curriculum in response to your needs?

MR. GARVEY: Oh, absolutely. Our relationship with Youngstown State goes back about 10 years when we established M-7 in Youngstown in 2004. And the resources that Youngstown State is able to bring to the table are the lab resources, which are the X-ray photometers and high-resolution electron microscopes, to look at the materials that are produced and to qualify truth in our measurements.

They have also begun to customize some of their graduate programs to more address some of the identified challenges moving forward, and one of those challenges that we see moving forward -- we were talking earlier about localized manufacturing, and I couldn't agree with that concept more. My vision of manufacturing in the next 50 to 100 years, it will become localized. It will become massively customized. It will address the cultural desires of that particular geographic region, rather if it's south Florida, Chicago, the Northeast. There's some -- this particular cultural desires whether it's weather driven or ethnicity driven or whatever, so to help address those opportunities in the future, there has to be a curriculum developed so that you understand how to manufacturing into those cultural desires. We're getting back to heavy math and statistical processing, so that's exactly where Youngstown State has answered the bell.

MR. WEST: So, Ed, are we going to see like a southern version of additive manufacturing that's different from the Midwestern version which is different from the California brand?

MR. MORRIS: Excellent question. We are the National Additive Manufacturing Innovation Institute. We're located in the Ohio tech belt region and proud to be there. As we do things in our region we want to populate across the United States with our members. With 102 members we've got a pretty large foot print. On the other hand where we see activities in 3-D printing and manufacturing in other areas of the nation, we want to cross pollinate and bring them back in the Youngstown area.

I want to expand a little bit in terms of the concept of hubs and geography in the regions. Jason touched on this, but I think it would be just a little bit more of a foot stomper if you will. Geography matters. That's why regional hubs make sense, and why it matters is when you disconnect the design engineer from the shop

floor, you're starving that engineer from the fertilizer of innovation. That feedback from the shop floor drives new products, innovative products, evolving products, so it's crucial that we reconnect the design engineer to the shop floor. As we've gone through this off-shoring, outsourcing, and so forth with some distance background and reasons to do that, but the unintended consequences have disconnected the engineer from the manufacturing floor. And in a lot of cases, they don't even know where it's made, and it's crucial to reconnect that so that you can design it, get the feedback. You can evolve design. That leads to more innovation, so that this geography thing does make a difference; the relationship of the colleges and rapid response to the needs of the local industry.

We talk about integrated supply chains, and certainly you can have long-distance integrated supply chains, but it's harder because geography makes a difference. And as I was thinking about that last night, I was thinking about the word -- in some cases what I'm seeing, and particularly with this disconnect for the fertilizer for innovation with the feedback from the shop floor, it's almost like it's dis-integrated, disintegrated supply chains.

So, the hub region drawing it to local communities and then proliferating that across the United States with a strong foot print on manufacturing throughout the United States, I think makes a lot of sense.

MR. WEST: Okay, I want to close with one last question, then we'll open the floor to any questions from you. And the question for each of you is I know we're early in this concept of regional manufacturing hubs, but just based on your experience so far, what are the lessons for the other hubs, for other communities that might want to develop a hub? What's worked? What hasn't worked? Are there things you would do differently based on what you've seen so far?

MR. MORRIS: Be prepared to move fast. It's a new company start-up as a practical matter. We are in the business of collaborating and connecting the dots, and it's certainly a very difficult challenge to support, to sort out with all of the pent up demand that's coming at us. Who and when to spend time with? Those are the curious versus those that are serious and being able to understand which is which, and properly invest our public and private funds to accelerate with those that really want to make a change in how they do business using this technology.

MR. GARVEY: Yes, and I think that one of the biggest successes of Youngstown hub -- and when I say Youngstown hub I mean to say the tech belt hub which encompasses from Cleveland to Pittsburgh. Youngstown just happens to be geographically right in the center of that corridor -- is the attracting private investment, so we are in the process right now of architecting and building a 21st Century business park that will co-locate the value chain suppliers of 3-D printing, and so that we can compress the technology intersection between the different contributing technologies that result in a final product of 3-D printing. So, whether it's the design, the equipment manufacturers, the material manufacturers, the application engineers, the commercialization, the distribution, we will be building this park in Youngstown with about 15 innovation centers populated primarily by Fortune 500 companies that each center will have approximately 100 employees, and when you do the math and think about just the payroll taxes that will result in this development, there's about a six to one payback in one year of the federal investment that went into establishing the center that is now attracting private investment that realize that they need to become involved in an industry that is growing at the rate of 25 to 35 percent a year for the next foreseeable 10 years.

So, that's substantial growth, and it is going to allow the United States to retain what Ed was talking about, the fertilizer to innovation where we'll have the design,

the manufacturing, and the commercialization and innovation centers all co-located, so location does matter. Geography does matter, and this is a natural evolution to Michael Porter's technology cluster theory, and this is just the natural growth. So, we're very excited to be the test kitchen in this arrangement for the federal government, and we take that responsibility seriously. We're going to make these things happen.

MR. WEST: That's good because all eyes are on Ohio. (Laughter)
Let's open the floor to questions. If you can give us your name and your organization. Yes, we have a question over here. And I'd also like to remind our webcast audience that we have a Twitter hashtag, USMFG, so if you have a question you can submit a question through that Twitter hashtag, and we'll integrate your question.

MR. SANG: James Sang. I have retired. About five weeks ago in this room AICGS said -- I think you guys or maybe it was one of the other people -- had a program on German models, and mainly the emphasis was on apprenticeships, but including -- it also discussed other things like the Fraunhofer Institutes.

MR. WEST: This is German models of manufacturing.

MR. SANG: Manufacturing, yes. And so I was wondering if you would like to contrast the manufacturing hub approaches as we've developed them with the Fraunhofer's which had somewhat more broad, general starting point from origin and spreading out through the country and how you would compare -- but also in general what your comments on German manufacturing models for support of SMEs?

MR. GARVEY: So, being an SME, we have a very small company. We're 35 employees. Being familiar with the Fraunhofer model, the Fraunhofer model really takes technology development from very early stage which would be TRL levels one all the way through TRL levels 10, okay.

So, typically in this country, TRL levels one to three which is lab type to

proof of concept are executed in the universities -- in the research universities. There was a big gap between four to seven which is the valley of death, which takes that technology to operating environments, and that's the space that the manufacturing institutes occupy. That's the real estate that manufacturing institutes -- and then the technology levels eight through 10, that will be the space that this private investment will occupy. So, Ed, would you like --

MR. MORRIS: So, I don't pretend to be an expert on Fraunhofer Institute. I know it was well studied as the vectors were put in place to establish these manufacturing innovation institutes.

I've become a champion of public/private partnerships. I think they make sense. Obviously, if we're going to cross the valley of death between research and true product deployment applications, you've got to begin with a public/private partnership that's going to embrace universities, embrace industries. We do a lot of activity in our National Additive Manufacturing Innovation Institute on road mapping. What direction does industry need to go for their future products -- involve academia on what research they are doing that feeds the roadmap and causes it all to come together all with the purpose of accelerating the process or getting across that valley of death? I believe that the public/private partnership is the best way to do that.

I've been asked some planning questions. Why public money? Surely industry will put enough funds to invest in this to get us where we need to go in the United States? And each time I've been asked that, I look back at the person and say, "Well, you're right. Industry will ultimately invest and get us where we need to be. However, other nation states are investing substantively in this technology and other advanced manufacturing technologies, and if we want to finish last then we can do it just industry. But if we want to finish first, we're going to have to do a public/private

partnership with investments in this specific technology on par with other nations across the globe. We are in a global competitive economy, and we need to remember that.”

MR. GARVEY: And we're also subject to the larger companies who are subject to shareholder requirements, and a lot of decisions become very short-term-based decisions, as far as the development goes. And as a result, a lot of these great technologies that have been developed in universities are kind of the baby that's been left at the door, so with this public/private partnership and the seed funding that goes along with these institutes, we're able to take that to the commercialization level, and that's the whale in this whole model is creating the jobs from the commercialization of this, so they become spawning pools for jobs.

MR. WEST: Other questions? Antoine has another question. We have a microphone coming up from back.

QUESTIONER: Hi, (inaudible). Just about a year ago when you were just starting at NAMII, and at that point you talked about some issues that you needed to resolve in additive manufacturing; things like the kinds of material you could use, the infusion of materials, the post-process inspection, the size, et cetera. So, a year later, tell us about how you view those issues now and what you feel NAMII has been able to do to get over some of the issues?

MR. GARVEY: Sure. So, first I'll comment very politely that we killed the acronym, and we're America Makes; not an acronym just to be friendly with our community.

MR. MORRIS: The problems, the challenges to use 3-D printing are not inconsequential, which is one of the reasons we exist: to identify those technical barriers, how do we understand and are confident that the product that is delivered at the end of the manufacturing process is that which we designed for, so that it's engineering analysis

capabilities that we're working on materials characterization so that the engineers doing the design have the right material properties as they do their analysis and configuration, rigorous process control because when you're doing 3-D printing and you're creating internal structure you can't look at after you're finished is something that we're focusing on, foregone destructive evaluation and non-destructive inspection and so forth. So there's, as you pointed out, there's lots of things to be dealt with to achieve the full capabilities of 3-D printing. We're not there yet. Nobody on the planet is.

To that end we are investing research and development projects. The first seven contract awards are coming closer to finish, and we're starting to see some good results out of that and sharing that within our members. And when we do these research and development projects, it's a combination of the public money with at least a dollar per dollar cost share of private funds, so it is truly a public/private partnership to accelerate the solutions to these issues that we're dealing with. That seems to be working well.

We've done our second project call. We're in the process of updating road maps and strategic investment plans for the next project call. Right now we have a portfolio of about 25 different project and growing, and we're also starting to take on what we're calling agency-driven projects where they have very specific things they want to address in addition to the public/private investments that we're making. It seems to be working well. We've got a lot to do, but we're picking up steam.

MR. WEST: Other questions? In the back in the corner?

MR. BAGLEA: Hi, I'm Jack Baglea, consultant and have a small role in the strategy that led to your success on behalf of Case Western. But my question is how do you deal with IP issues when you have public money, private money, and you're trying to create technology that you can't figure out who did -- where the money came from?

MR. MORRIS: Very carefully. (Laughter) It begins with our membership agreement and the construct we have in place for intellectual property as it's developed. A fundamental with regard to National Center for Defense Manufacturing Machining and our business model for operation, we're in the business of solving technical problems for clients. We do not retain intellectual property. The intellectual property resides appropriately with the companies that are using the technology for new products and any ongoing products.

To that end, when we begin a new research and development project we require the project team to be very deliberate in declaring any pre-existing intellectual property that is required for that research and development. If there's no pre-existing intellectual property required, then they stay silent and hold it appropriately.

As a project team moves on through their activities and they develop intellectual property that intellectual property is owned by the team, and the team manages the exact ownership within that. Then the balance of our approach to intellectual property within our consortium of America Makes is the requirement that they share the intellectual property with the balance of the members at a fee, and that, so far, is working well.

The classic observation I make regarding intellectual property, everybody's an expert, and almost nobody's an expert, and we've found that it's important to have some really strong rigor in the management of intellectual property, so we're in the process of finalizing a very detailed document with as many details as we can put into it. Good question. It's always a sensitive topic.

MR. WEST: Christine has a question from one of our webcast viewers, so if you can get a microphone up here. Thank you.

QUESTIONER: Thank you. Bob Potter from Washington State asks

what role do you see workforce investment boards, local public employment and training programs playing in manufacturing communities and also the hubs?

MR. GARVEY: Well, I can answer that since I'm on the local workforce -- formerly on the Local Workforce Investment Board and the Governor's Workforce Policy Board. It's a very critical role, and helping working with the secondary schools, the high schools, the trade schools, the career centers in developing the skill sets that can then be leveraged into these more advanced technologies, so it's just a matter of creating a continuum in the curriculum that's starting in the grade schools and then continuing in the high schools and continued into the community colleges and continuing into the undergraduate degrees, the graduate degrees to the post-graduate degrees.

MR. WEST: This gentleman here has a question, with his hand up. There's a microphone coming over to you.

MR. BENTON: James Benton.

MR. WEST: I know this is an emotional subject for you, so (Laughter). I get choked up too.

MR. BENTON: James Benton. I'm from Georgetown University, and my question relates somewhat to the question that the person just submitted online. I'm concerned about how retraining programs are working, not just from people who are coming through the educational system but displaced manufacturing workers and other populations that have been shut out or locked out of industries. And to that extent my question is what are some of the challenges that these workforce development programs face in getting the displaced manufacturing worker and other target populations who are out there who might have the education but not necessarily the experience to get into industries like these?

MR. WEST: That's a great question for Youngstown. I assume you

have lots of those people there?

MR. GARVEY: Yes, we do. So, one of the greatest challenges are both on the employer's side and on the employee's side, understanding the requirements and the responsibilities of the positions that are currently open, and actually having an adult moment and realizing, hey, I need to get some training on understanding fundamental math, understanding how fundamental math builds into algebra builds into geometry builds into engineering. So, that would be one of the most typical, hey, I'm a crane operator and I've worked in the steel mills for the last 30 years, and I have 15 years left of my career path, and the steel mill's no longer working, and I left a job that was paying \$35 an hour, and I expect to be re-employed at \$35 an hour doing software development, but I have no experience or no training in software development.

So, it's basically having the adult moment and realizing I need to get trained. I need to take this seriously, and if I expect to provide for my family in the fashion that I've provided for them in the past, then I have to take responsibility for this. And equally the employer needs to create the opportunities for these people in training coming in and have a graduated level as they begin to show experience and competency in levels and giving them additional responsibilities with additional pay and just building them back up. So, it's a slow, gradual pace but it's all -- it's a mutual responsibility (inaudible).

MR. MORRIS: A real delight for me is to get a deeper exposure to the rich resource called community colleges across the United States; horribly undervalued, tremendous asset. Everything we can do to support their mission to address your point, I think, is the right thing for us to be doing in the United States. They're doing great work, and we need to support them.

MR. WEST: And what is it that community colleges are offering that

four-year colleges and universities are not doing? What's their unique role?

MR. MORRIS: They'll take the students back to the fundamentals so that they're ready for the post-doc mathematics, but if you don't have those fundamentals you're building on a foundation of sand instead of rock or concrete.

MR. GARVEY: At a third to a quarter of the cost pursuing the same types of training in a four-year degree organization, university.

MR. WEST: Okay, great. Other questions? Yes, up here up front there's a question.

MR. SARDA: Anil Sarda from NDP Analytics. I was wondering what some of the regulatory or red tape that SMEs are facing specifically as they pertain to advanced manufacturing firms? Are they energy in focus? Are they environmentally focused?

MR. GARVEY: Well, like all manufacturing, just depending on the flavor or manufacturing you're involved in, we have quality standards and requirements to meet in the marketplace, whether it's ISO certification or military spec certification or several certifying bodies.

We're very, very interested in creating organizations that are zero-landfill organizations, that are energy-efficient organizations. We understand that energy is one of the prime components to operating costs, and to remain competitive we have to reduce our operating costs as best as possible employing all available technologies for that.

We are compliant with the Armed Services Act where we provide paid leave absence for people in our Armed Services whether it's on weekend endeavors or two-week training courses that they -- to remain active and keep a readiness level in our country should we have -- be posed with threat.

MR. MORRIS: Just expand -- there's a flavoring in what Mike was sharing. From my sense with small companies is keeping up with all the rules and regulations, and being able to efficiently do them without being an undue administrative burden. It takes cost. It takes people to respond to some of these policies and procedures, and they can be an inhibitor to growth. They drain cash.

MR. GARVEY: They can be an inhibitor to growth, but they also can be looked at as an investment to growth, yes. So, we look at them as investments to growth, and the reason some of these policies are established, and we embrace the philosophical reasons for them and try to execute within those parameters.

MR. WEST: Over here there's a question.

MS. MC INTYRE: Cynthia McIntyre with the Council on Competitiveness. Perhaps Mr. Morris could address the issue of the software industry and how it plays into America Makes activities? Are they gravitating to new modeling, physical modeling for manufacture?

MR. MORRIS: Well, Cynthia, to you I am Ed, okay? We've had a nice long-term relationship in the community.

Software, of course, is a very important tool to do the engineering and manufacturing modeling and simulation and analysis, and we're stressing the capabilities of these tools, so we're in conversations and looking for opportunities to advance the capabilities of the tools to support what we're able to do with 3-D printing.

If you do a lattice structure with microfluidics in it, and you're challenging a finite element analysis in the computational fluid dynamic software tool to analyze all of that, it's a whole new world and we're stressing them which is a good thing. So, we want to continue to encourage the software developers for engineering and manufacturing modeling analysis tools to address the specifics of 3-D printing, and to that end we're

eager to deeply partner with our sister institute on Digital Design and Manufacturing Innovation Institute and --

MR. WEST: That's a preview of coming attractions in five minutes.

MR. MORRIS: -- because there's no doubt that there are things that we have mutual interests, and we want to sort out so that we collaborate and partner on the things that make sense. There will be some items that they will address and there will be some subset that we'll address, and we're eager to partner with them and the (inaudible) that they've been established. I think it was a very wise choice on the part of the nation.

MR. GARVEY: Just to follow up on Ed's comments, I think one thing that software addresses that needs to continually be addressed is the size of the files in manufacturing. Okay, so, it is not uncommon to have terabytes of information, the size of the file. And getting back to the SMEs, some of the challenges the SMEs have in advanced manufacturing and these types of technologies is we need to have a policy for web neutrality, so meaning that it doesn't matter if you're a small guy or a big guy, you're paying the same rate going across that highway with the same amount of data as the big guy. So, if we can get to a nation with web neutrality, that will be a significant improvement in the obstacles to innovation improvement because a lot of these innovations do come from the small companies like at M-7 where we believe that the work shop is the cradle of innovation, so we develop our innovations in the work shop and then reduce them to digital files that we need to compress and get across the network.

MR. WEST: With those large files, I assume you are now a big believer in cloud computing?

MR. GARVEY: Oh, yes.

MR. MORRIS: So, there's another aspect of software that merits

attention. Fifty-plus years ago blueprints, and of course, there was espionage in stealing blueprints. Kind of hard to do. With software, Internet, cyberwar, it ain't that hard, and it's something we have to pay attention, and we are paying attention to so that the incredible technology, even the CAD files of proprietary designs are intellectual property that must be protected, and in a cyber-warfare that's something you have to pay attention to.

MR. WEST: All right, the very back. There's someone standing who has a question.

MS. BRIDGES: Hi, Jasmine Bridges. I'm an industry fellow at the Department of Energy, and Ed, you said something that is awesome. As a manufacturing person I know how critical it is to connect the designer back to the shop floor.

MR. MORRIS: Yes.

MS. BRIDGES: Can you speak a little bit more about that in terms of this advanced manufacturing landscape? What is your vision? How do you think we continue to make sure the designer is connected to the shop floor, and how that affects current manufacturing in the future?

MR. MORRIS: Again, proximity makes a difference only because of the travel time and travel costs. You can have a really great, integrated supplier that's a thousand miles away, and you just have to endure the business expense of doing the face-to-face. After all, technology development, it is a contact sport. It just gets more complex when you're 10,000 miles away versus 1,000 miles away, and certainly is very convenient when they're 10 miles away.

But the face-to-face, then once you've got the rapport and you do the occasional face-to-face, then you can do a lot of, obviously, electronic webinars, so on

and so forth, but without even the initial contacts -- I certainly had the opportunity in my past of working with some key suppliers and walk the shop floor and go over to a machinist, and, hey, I understand you're from such and such a company. Let me show you how stupid this is. And I'll pick that up and we'll go back and deal with it with the engineering community, but the engineers that did it didn't learn. And it's important that we have that feedback so that we can continue to improve our engineering capabilities, and it's, again, a contact sport and requires some investment. The electronic medium and teleconferences, even the video, it helps, but it doesn't completely solve the issues of a good learning experience to again feed the next product evolutions and so forth and have better design engineers.

With the culture that we're pursuing like Red Lambert's children where they're in this environment where they do the design, they do the manufacturing, they do the inspection, they do the selling. If we get that culture re-established, if you think it you can build it, it will help I believe with the engineers coming up through the ranks to recognize the importance of staying in contact with the manufacturing shop floor.

MR. WEST: I'd like to close with one last question for each of you before we move on to our next panel, and that is kind of taking advantage of the fact that we are sitting in Washington, D.C. If each of you could talk to members of Congress and/or people in the administration and just offer them advice on how we should be doing this based on the experience you've had in Youngstown, what would each of you tell them?

MR. GARVEY: I would recommend that they do more of these manufacturing hubs. Absolutely, they pass legislation, get these hubs funded. I think that as Jason described very appropriately that the erosion of the manufacturing base has led to tremendous amounts of social ills, and I've lived through it. I've seen it in Youngstown, and if we can re-establish our prominence in manufacturing, design,

engineering, distribution, then we have a greater chance of enjoying prosperity in our country. So, I don't understand how anybody could possibly argue with these things.

MR. WEST: I don't know. In this town I believe that's possible.

(Laughter) Ed?

MR. MORRIS: Certainly, we are very pleased to see the leadership of the nation on both sides of the aisle recognize that manufacturing is critical to the future economy of the United States, and the appropriate investments on the public side partnering with industry is something that we must continue. We need to judiciously expand it in the right areas, and we again are delighted to participate in the discourse.

In terms of innovation, one thing I want to further observe. What we're doing at the innovation institutes and certainly with the one that I'm privileged to be associated with with America Makes, it's more than innovation on the technology. It's innovation on how you do business. The public partnerships, I've participated in some in the past, and we're trying to push the edge on how deeply can we partner. To the extent when we're doing research and development projects led by industry or led by a university, but certainly a holistic team of academia, universities, and industries participating, we are embedding some of the agency department employees that are experts in the specifics of a research and development project in the project. That's getting to the true essence of a public/private partnership, and we think we need to continue to do that as a nation.

MR. WEST: Terrific. That's a great finale there, so I want to thank Ed and Mike for sharing their views with us. Good luck in your future ventures, and we'll look forward to seeing how things develop over the next year or two. Thank you very much.

(Applause)

MR. WEST: Okay. So our closing panel is going to deal with the subject

of digital manufacturing and digital innovation, and the focus is going to be on the regional manufacturing hub that the Administration has set up in Chicago. And there are innovative companies there that have developed great capacity, and so we're going to delve into some similar terrain that we covered in regard to Youngstown but also try and draw some broader lessons for other areas as well.

So, to help us with this topic, we have two distinguished guests.

To my immediate right is Caralynn Nowinski. She is the Chief Operating Officer and Interim Executive Director of UI Labs, standing for University Industry Labs.

She also serves as the Associate Vice President for Innovation and Economic Development at the Labs. In that role, she promotes the strategic relationships between the university community and external stakeholders that are designed to foster technology, commercialization, talent development and overall economic impact.

She was one of the founders of the Labs, and she has been named by the *Crain's Chicago Business* as one of the Top 40 Under-Forty List.

Mike Russo is the Director of Government Relations for GlobalFoundries. He is responsible for the strategic plan development and execution to support the business needs, policy development and lobbying work on behalf of that firm.

He works closely with the Administration here in D.C. in an advisory capacity, and he's also leading several initiatives designed to develop nationally scalable platforms in areas that are important to the U.S. economy. And this includes areas such as education and workforce development, the supply chain and developing a 21st Century smart grid.

So I'm going to jump in with a question for Caralynn.

So tell us about the university role in working with industry to advance manufacturing innovation. What is UI Labs, and what is doing to improve manufacturing?

MS. NOWINSKI: Well, first of all, it's a pleasure to be here and great to talk about what we're doing in Chicago at the DMDI Institute and thanks so much to John White and the family for their support of this event.

So the University of Illinois was one of the drivers in creating UI Labs, which is now an independent nonprofit organization. And it really goes back, I think, nicely to what Jason said in introducing the concept of NNMI. It was trying to figure out a way to harness the great work being done in our research universities in the U.S. with the industrial needs of next generation technologies, in this case, specifically in manufacturing.

There's been a number of surveys over the last several years that industry generally predicts that they are going to be increasing their investment in R&D. At the same time, there's a recognition that for the majority of those companies they don't believe they have the internal capacity at their organizations to be able to do that type of applied research and development.

Looking at another kind of macro trend, we've got -- largely speaking, R&D is invested in primarily by industry over other sources. However, less than 6 percent of that R&D is actually invested in at universities to do industrial research and development.

So we've got these disconnects here. Industry says they need these external partners to be able to innovate better, and at the same time such a minority of investment actually happens within our great research universities.

And so in Illinois and in Chicago, specifically, there's a recognition that we need to do better at bringing these groups together. Hence, UI Labs was founded to bring together the university talent and technology with industry and be able to create a neutral platform for that type of collaboration.

UI Labs is actually designed to be a portfolio program, sector-agnostic, but very early on in the development, we had realized that advanced manufacturing was indeed going to be our initial area of focus and for a variety of reasons, which we might go into in today's conversation -- digital manufacturing, specifically.

So, when we learned of the Administration's intent to establish a digital manufacturing institute, we were already off to the races and bringing university and industry together, and so we were fortunate to be able to pull together our application and fortunate enough to win.

MR. WEST: And what is digital manufacturing?

MS. NOWINSKI: That's a great question, probably the question we get asked the most. And there are all sorts of answers, but I'll tell you --

MR. WEST: Wait a minute. I thought this was a unique question from me.

MS. NOWINSKI: I'll tell you how we are learning to describe it better is really it's about the application of both data and the tools to process it to be able to make better decisions.

So one of the reasons that we believe that the Chicagoland area was prime to be able to do this is to be able to harness some of the high performance computing power that's resident at the University of Illinois, at the National Center for Supercomputing Applications as well as at Argonne National Labs and a number of other supercomputers in the region, where we can now have the tools to be able to process that data because that was missing.

It's not that manufacturing and data -- or that data is new to manufacturing. It's that now we actually have the tools to be able to use that data, turn it into information and then use that information to make better decisions that therefore

improve the productivity of our manufacturing companies, and that application of that data is what digital manufacturing.

MR. WEST: Okay. So, Mike, GlobalFoundries is not located in Chicago. It actually is based outside Albany, New York.

But your company is one of the leaders in terms of the semiconductor field. You do a lot of in terms of digital manufacturing and digital design.

What is your company doing and how can that be a guide to how we can do a better job in manufacturing?

MR. RUSSO: Yeah, well, we're actually the nation's largest semiconductor foundry. So we're basically a contract chip maker. We're number two in the world.

We have a global footprint, but our asset in the U.S. is based in upstate New York. And we're in the process of constructing and ramping the most advanced semiconductor foundry fab in the world there, and that is our advanced fab. In other words, the technologies that we produce there are our most advanced.

That represents about a \$10 billion investment. It could be many more times that.

So, first of all, I want to thank the Administration for their keen focus in this area, and Jason Miller basically covered the basis from our perspective. They're doing a great job within the realms of what they can do within the Administration.

The focus that they have on manufacturing -- and when you say manufacturing, it's not just GlobalFoundries, arguably, like the most advanced of advanced manufacturers, but the entire supply chain really is very, very important.

From our perspective, to your question, Darrell, how is that relevant?

You know, when you lose manufacturing to the degree that Jason

referred to earlier, some could argue change policy; get manufacturing back. It's not that simple because you lose supply chain.

And GlobalFoundries, when we talk about a 5:6:1 spinoff as far as jobs, they are higher value jobs we're pumping about. When we're not even fully ramped, it's about \$350 million in annual payroll within that region.

But it's really about all the other connected supply chains that affect not only the processes in GlobalFoundries and what we do and what we produce, but it's also those connected to all the economic activities related to employees. So the supply chain is really much bigger.

What we're doing in leading and learning and contributing really has a lot to do with supply chain development. How do you use digital capabilities to truly integrate the supply chain?

And, when I say the supply chain, let's call it the manufacturing community, and basically, it's the entire spectrum of those involved, from one end to the other.

And, supply chain -- that's including workforce development. That's including early on in design processes, manufacturing, operations, facilities.

You know, when we talk about a clean room, for example, you talk to government relations. I'm a political scientist, right, from the Lincoln Logs era. So it's kind of funny to be in this position.

But when you talk about that, when you just talk about the people that are responsible for air and water into a factory, they think, geez, it's a factory.

Well, just can you imagine a clean room bigger than six football fields, with the air that's in the main part of the room 10,000 times cleaner than the cleanest operating suite and 100,000 times cleaner than in a tool space, and moving that air in

and out every 3 minutes? That facility has to talk to manufacturing.

And think about the supply chain not only related to what we produce but the supply chain to do with parts to keep the clean room operating, right.

So that continuum and connectivity and using real-time data to be not just where you need to be but ahead of the curve is so, so important.

When we say ahead of the curve and when I say supply chain, we're a large manufacturer. Some people look at us as like the -- we're not the end user of the supply chain. It's the customer.

So being ahead of markets, understanding how you enable what the customers need you to enable and have a continuous feedback loop, so there's continuous improvement in real time -- that is really at the heart of what we do in our fab, and that is what will make the U.S., at least in my view, globally competitive and a leader in innovation for decades and decades to come.

I would also argue that if we lose that capability, if we don't focus, at jeopardy is not only our economic security but our national security. You know, you have to lead in innovation.

So to your point, Darrell, really some people say, why would you invest \$10 million in the U.S. to do this type of activity?

There are certain things that we offer here and have in the U.S.: rule of law, the ability to protect IP and supply chain security, our university collaborations, our ability to congregate in hubs, for example, the NNMI. We really have some great tools to work with.

So the question would be: How can we all collaborate, including the GlobalFoundries of the world, to really completely leverage those assets?

MR. WEST: And I know in New York you've worked closely with a

community college that is close to your factory. Could you describe that relationship and what it adds to you and also how you being there has affected it?

MR. RUSSO: Yeah, it's really much deeper than even that one community college you're referring to. We have a close collaboration with 6 regional community colleges but more so the entire state university of New York system, which is 30 community colleges and 64 including universities and community colleges.

And we're actually leading the nation's largest education initiative of its type, which encompasses 13 counties, 111 school districts and 345 schools, to really scale best practices but also innovative practices in education today and develop a scalable platform that can be used nationally.

So we're doing a lot of work, but related to the one I think you're probably referring to Hudson Valley Community College, but there are several others that we're partnering very closely.

It's how can we -- Jason mentioned earlier how we're losing hands-on skills. Shop classes are disappearing. Kids don't work with their hands at a young age. And that's very true.

So leveraging community colleges, trade schools, helping them develop programs that bring project-based learning, experiential learning into the education environments, to ensure that it's demand-driven is very, very important. It's not only important to a GlobalFoundries, but it's important to our country.

So what can we do to innovate in that space and then scale those practices?

And we're doing a lot of work with the education system and that community college in particular there in Upstate New York.

MR. WEST: And, Caralynn, how are you working with the local colleges

and universities in the Chicago area?

MS. NOWINSKI: It's actually much bigger than even just Chicago. I mean, as the nature of these institutes, we're the national hub for digital manufacturing.

While there is definitely a regional concentration in the Midwest, we really see this as a national resource. And so we have partners as far away as Oregon to the West and New York to the East and down to Texas and up to Michigan and Wisconsin.

We really do see this as collaboration broadly and bringing in all the different layers. Certainly, that's been the theme, I think, of all the discussions so far today.

And the community colleges, vocational schools, the high schools, the technical high schools in particular -- there's a great role, that they absolutely have to be at the table, because we need to be able to advance those skill sets.

So, for us, one of the -- probably the most -- the largest portion of our budget and any of the budgets for these manufacturing institutes is applied research and development. I mean, we're in the business of funding new translation of R&D.

And so in doing that, as we fund our projects -- and we actually just launched our first project call last week. Yesterday, in Chicago, we hosted our first proposers' day to talk about the first two sets of project types that we're going to be funding, deploying about \$10 million to those, across those projects.

And the way that we do some of the selection process actually is based upon: What is that plan for workforce development and training? How are you bringing in those types of partners?

I mean, there's all sorts of other criteria, but that is a very important one for us -- to make sure that those institutions are at the table and part of those project

teams so that there is a plan from the beginning about what those on-ramps are for the workers and for the skill sets that we need to make sure that we can actually use those technologies in the workplace.

MR. WEST: And what are the two projects that you are specifically focusing on now?

MS. NOWINSKI: So the first set of projects that we announced were transitioning some of the technologies coming out of a program that DARPA had been funding. There's about a \$200 million investment into a program called Adaptive Vehicle Make.

A number of the companies and universities that were a part of that initial DARPA funding, as Mike talked about earlier, the early TRL levels, 1 through 3 -- there are now technologies at the point where they have got to move from 4 through 7, and so we're going to be that transition partner to move them across that gap.

So we're fortunate that after the initial \$70 million that the government invested into our institute there was an additional \$10 million that was awarded to us last month to specifically focus on this technology transition. That was our first project call.

So we have two different types of projects we're going to be funding.

One is of those technologies coming out of this AVM program, they have that technology proof of concept in the lab. So they're mature enough to be able to be moved to the marketplace, to a commercial proof of concept. We'll be funding about \$6 million worth of projects in that area.

And then the balance will be funded in some of those technologies that are maybe still a little immature but have great potential and that there's industry around the table saying, these are important technologies and we want to advance them.

One of the keys to these projects that we fund will be making sure that all

these various collaborators are involved and that they're contributing a 1:1 match in funding these projects. So they're really putting skin in the game here, to say: This is important. We are your customers.

So industry is saying, we are your future customers for this.

The community colleges are saying, we are the future skills developers, skills trainers.

And the universities are gaining the benefit of being able to take their expertise and help drive these technologies out of the lab and into the marketplace.

MR. WEST: But when you have multiple partners involved in developing products, how do you handle the intellectual property component.

MS. NOWINSKI: That is --

MR. WEST: Sounds like this could be a nightmare.

MS. NOWINSKI: Yeah. So this is definitely the hot topic, and I think Ed framed it nicely in the last discussion about how America Makes is looking into intellectual property.

We, too, have tried to adopt best practices. One of the benefits of having a national network of these institutes is that we can share best practices. We can learn from some of the work being done, for example, in Germany and France and Italy and some of the other manufacturing investments that have been made there. But we can, most importantly, learn from each other in the U.S., and so we don't have to be recreating the wheel every time.

That's actually the model of UI Labs -- is that with each program we get better and we get smarter about how do we create these frameworks. And intellectual property is definitely the trickiest of them.

So the way that we look at it is that we've got three guiding principles that

we established during our proposal development process, and then each individual project proposal has to include its own IP management plan, similar to how America Makes does it, to really empower the project teams to be able to determine how that technology can be commercialized.

But the three guiding principles, I think, are really important, and this is what we heard from our prospective members during the partnership process. We've got companies, large companies like G.E. and Proctor & Gamble to small family-owned businesses just outside of Southern Illinois.

So we've got such a range of companies. How do we make sure that this is relative to them?

Briefly, the three guiding principles are:

We're going to have to be collaborative about bringing back our IP to the table. There are going to be projects that are going to require preexisting IP, and we want to bring it to the table and allow the projects to be able to build on top of them. But at the end of the day, we also assure you that we're going to figure out ways to protect that background intellectual property as well so that when you're bringing something to the table you know that there are processes and procedures in place to protect it.

The second thing is that this is about commercialization; this is about making American companies more competitive. And so there has to be a plan for licensing or for ownership that's really commercially driven.

There are certain benefits that our members get based on the tier of membership. We have a slightly broader set of tiers. The cheapest tier is about \$500 to get in, and the largest is \$400,000 a year. And depending on where you fall in line as a member there are certain rights and privileges that are available to you.

Most important is being able to use those technologies internally to be

able to improve your business processes, but we also want to make sure that there are the commercialization opportunities on an exclusive basis, too. So we have to understand that there's a plan to do that.

And then the third component of our guiding principles is that we're trying to create sustainable institutes here. One of the things that -- you know, and Jason mentioned this earlier.

This is seed money to catalyze a public-private partnership, but the government is going to transition from investor to customer over the five years of these initial institutes so that we need to be prepared. The institute and the members of it need to be prepared that after five years the customer funding in terms of seed investor goes away, and we need to maintain our sustainability.

And so part of our IP business model is also ensuring that there is a return to the institute to help sustain it, to be able to allow us to use that intellectual property to train workers, for example, and be able to show small and mid-sized enterprises how to use those technologies.

MR. WEST: So, Mike, one of the impressive things that GlobalFoundries has done is demonstrated that America can still build products and do innovative design.

And, when Jason was here, he talked about the challenge of rebuilding manufacturing, specifically looking at the supply chain thing, and he mentioned that sometimes you can do the manufacturing but it's hard to rebuild all the elements of the supply chain.

So you've been doing that. What's been the secret of your success? How have you managed the supply chain part of manufacturing?

MR. RUSSO: It's really you have to be proactive. You have to reach out early on. You have to understand where the assets are. Do due diligence early on so

you understand supply chain capabilities, where gaps are.

And you really are -- as a larger manufacturer, you really have to understand that you do have a role to play in developing the supply chain. You have to be proactive.

And, if there are gaps in the supply chain that need to be filled, if there are suppliers that need to be picked up, if you need to help ensure that SMEs, small and mid-sized manufacturers, have access to product and process innovation, you need to be very active and proactive in doing that.

One of the reasons why we're excited about the NNMI and are focused on creating regional hubs that are focused is that if you're a small or mid-sized manufacturer today you're just worried about keeping the lights on. You might have one product or process that you sell, and you don't have time to necessarily invest in being proactive and understanding which way the ball is moving.

You might be a longstanding manufacturing that has not had the money to reinvest, and your roof is leaking. You know?

So having a collaborative environment with the entire manufacturing community that helps to develop the necessary workforce, that helps provide a safe harbor for those SMEs to be able to really get some questions answered and be involved in that manufacturing ecosystem so they can fill the gaps that would otherwise exist is very, very important and really very exciting.

And I think to Caralynn's point; I think we all need to really fully leverage those.

I look at the NNMI's just in general. Are they the answer to the economic problems of the country? No.

Are they going to, in and of themselves, create hundreds of thousands of

jobs and turn around the economy? No.

So, for those that take shots at the NNMI's because that's not it, then that's not the purpose; that's never going to happen.

However, they're jewels, and they're seeds that are being planted by the Administration. And they're an enabling device, if you will, to really bring in the complete supply chain, and more than the supply chain but the entire manufacturing community, to leverage the collective strength, to be able to get somewhere that we would otherwise not be able to get.

And, when you talk about global competitiveness and a need to really anchor manufacturing as a key driver in national economic security, the NNMI concept is very, very important.

I think what you see moving forward are even more ways to broaden the tent, to encourage others that might not have been directly involved in like winning -- I hate the terms, winning and losing, but winning applications. But, broaden the tent so other regional collaborators and national collaborators can use that foundation to really fully leverage it. And that's going to be key as we transition.

Caralynn mentioned currently the NNMI's are funded solely -- seed funding is provided solely by the Administration, and that was not the original design. So some of the handcuffs that are felt there are that the focus has to fit within the budgets that are doing the funding.

So, for example, if DoD is funding something, it's got to fit a DoD mission. If DoE is funding something, it's got to fit within a DoE mission.

That's not the fault of the Administration. It's really a product of not having Congressional funding.

So as we move forward -- and it's exciting to hear both sides of the aisle.

I'm excited to hear whenever there's agreement on anything anymore, and both sides of the aisle get the importance of manufacturing. People now understand that the country will not survive on just a service economy.

So I'm hopeful that there will be funding for additional centers. And I think that once the toe is in the water there's going to be more excitement in Congress, more excitement by the private sector, and ultimately, we will be able to transition it to the model that Caralynn referred to and it will be really a great asset for the country in moving forward.

MR. WEST: So we're going to see other institutes, but what about the sustainability of yours and the other ones that already have been established?

MS. NOWINSKI: I think the sustainability is going to come in us showing that there's a return on investment to our members.

I mean, at the end of the day, even though we're technically a charitable organization, a 501(c)(3), this isn't charity. We've been very clear about that, and our members have been very clear to us back on that topic, which is we've got to demonstrate there's a return. When we do that, that allows the opportunity to continue to benefit from their investment into not only membership but into the projects, to be able to bring more investment dollars and be able to leverage each other's dollars. And I think that ultimately becomes a large component of the sustainability.

There's also a number of other factors that can lead to that. The entrepreneurial ecosystem was talked about a little bit earlier and also is, I think, a great opportunity for sustainability. When you start creating an increased cluster of likeminded companies and individuals who are about advancing a particular technology, I mean, there's great investment that can come from those types of ventures.

And also, in just delivering some of the services, the institutes

themselves will become best practice hubs in particular domains. So whether that means from a training perspective or from consulting perspectives, standards perspectives, I mean, there's a number of opportunities. And we'll see over the next five years how the institutes -- and we'll learn from each other and understand how the institutes are going to be able to benefit from providing those types of services.

When we provide value to the supply chain, to the manufacturing community, then I think sustainability becomes inevitable.

MR. WEST: So just one more question and then I'm going to open the floor to questions from the audience.

How much collaboration is there across the four institutes -- you, Youngstown, Detroit, Raleigh?

MS. NOWINSKI: So Youngstown is the longest in existence, and the other three have all been awarded this year.

MR. WEST: But what the hell have you been doing this year? That's my question.

MR. NOWINSKI: And, in fact, actually, Ed and I were just talking about this earlier today. The first convening of the four institutes just happened. There's a second one already planned. And so there is this growing network excitement and an opportunity about potentially working together and learning from one another, picking each other's brains on the kinds of requests.

I think management of our time and resources is something that I would say all of us face, and learning from each other is going to be key.

I think over time we're going to be able to understand also better how the members of each of those institutes can interact with one another, and I know that's an ongoing topic within the Administration and within the AMP 2.0, the Advanced

Manufacturing Partnership group, because there is great opportunity for collaboration across the institutes.

Just a quick anecdote on some of the -- you know, kind of echoing the points that Mike made earlier on the supply chain. Digitally connecting the supply chain is core to our mission. It's core to the key innovation that we're looking to build -- a Digital Manufacturing Commons that literally links this community in a virtual fashion and allows that interoperability and sharing of data and usage of data.

But we've got companies that are at the table. I mentioned earlier, just as an example, G.E. and P&G. Others -- you know, Siemens and Dow and Rolls Royce and others who are at the cutting edge of using digital technologies within their manufacturing floors.

So why do they -- why are they paying these membership fees to be a part of this? It's to be able to ensure that the capabilities and the skills get reached down into their supply chain. They're investors because of the supply chain opportunities and closing that gap and making sure that a more capable supply chain makes better business for them as well.

So I think as this network grows there are going to be increased opportunities for connecting the supply chains of the companies that are part of those networks.

MR. WEST: Okay, questions from the audience.

Over here. If you can pass the microphone down the row.

QUESTIONER: Jim Stein.

A question for Mike on scale of hubs. It's my impression that your hub is actually related to the investment that Pataki and IBM made in SUNY-Albany, which was a \$6 billion investment. Am I wrong, or are you part of actually that hub and so rather

different from the sort of stuff we're talking with NNMI and things like that?

MR. RUSSO: There are differences, and there are similarities.

Actually, the hub had its roots back during the first Cuomo administration, when then-governor Mario Cuomo and then-Speaker Sheldon Silver made the first investment in Albany in nanotechnology.

But what's interesting about that environment down there is there have been, I think, five governors. Sometimes they go and come quickly in New York, but there have been five governors, both sides of the aisle, that have stayed the course on investing on what they saw as a strategic industry. So that's really where it began.

But, in essence, what that hub consists of is academia, industry and government partnering, leveraging a collective asset to do the same thing that the NNMI's are doing.

So, no, it's not an NNMI, but there are a lot of similarities, and not the least of which is that common investment between -- in that case, it was the state government, not the federal government, but that investment -- initially, that seed investment was key.

Even when it comes to GlobalFoundries there was some investment by the state government early on to help level the playing field with the rest of the country. But, if you look at when they do that, you have certain performance metrics on return on investment. We've blown those out of the water. So it's proven to be a very wise investment.

So I think that some of the learnings from that are applicable, many of them applicable for the NNMI concepts, and we're doing a lot of sharing with the Administration and others so you can pull best practices and learn from them.

QUESTIONER: But do you have a number for the total investment New

York State has put in?

MR. RUSSO: Not a total investment because there's -- I mean, it's very wide and broad. It's public and private investments over time. I don't want to, you know, give an inaccurate number, but it's been sizeable.

They've invested a lot for a number of years. I mean, the first investment was in the early to mid-90s. So there's been a lot of investment.

I would like to know the total investment but also the ROI on that, right.

MR. WEST: Antoine. There's a microphone coming over on this side.

QUESTIONER: I have been intrigued by the GlobalFoundries project for some time, first of all, because you're owned by Abu Dhabi, but in the end a decision was made not to build a factory in the desert but to build it near Saratoga in Malta where you are now. And now it's supposed to be expanded.

So the question is, first of all, what drove that decision to build it there? How important was what you were just referring to, what Alain Kaloyeros is doing at the College of Nanotechnology in Albany? How critical was that for you to take the decision to go there?

And the second question is, what supply chain did you find left, or was there any supply chain left?

MR. RUSSO: It's interesting when you talk about supply chain. Many probably do not know that that area was the heart of the industrial revolution at one time, and so they were ahead of the curve.

I mean, you could trace it back to even, arguably, you know, what happened with the Civil War and the outcome of the Civil War because of innovation in horseshoes and horseshoe nails, right, which came from there and the foundries there.

So you're right; the supply chain was decimated. It's taken a lot of focus

over a number of years to rebuild the supply chain.

It's a different type of manufacturing that in some cases makes development of the supply chain easier in that you're bringing in minds and developing mindshare versus big, huge, old furnaces and that type. It's a different type of supply chain.

But you have to look at the partners you have regionally -- Rensselaer Polytechnic Institute, SUNY, the College of Nanoscale Science and Engineering. Our proximity to other universities there in the Northeast -- you know, there's a lot of good mindshare that takes place there.

And it is a snowball effect. As people begin to -- if you go back to the beginning of the 2000s and if you look at like the CNSC and the amount of activity that was going on there then versus what has happened there and in the region since someone said, look, we are going to invest and build a big -- that's where you commercialize.

R&D is one thing, but you could take that and go anywhere.

But now we're actually going to make things with it, right. Look at what's happened in that region.

So you asked the question, why did we decide to locate there?

I like to kid with some of the politicians as they stand up and take credit for it; take credit for this. Actually, the turf that we sit on with Luther Forest Technology Campus is an old glacial deposit ground. The sand is over three feet deep.

So let me see a politician take credit for the geographic stability. From a seismic standpoint, you can't have any vibration, especially when it's an advanced fab like this.

But, more importantly, it's the willingness for the community to

collaborate and to develop the necessary workforce, to work collaboratively and develop curriculum that makes sense. There's a university side and the work that we have on the manufacturing technology piece with RPI and data analytics, et cetera.

We look at the state and the county and the towns, reaching out then and saying, what can we do? We're not going to wait to develop the infrastructure. Big infrastructure -- power, water, gas.

They said, we're going to find out what something like you would build would need, and we're going to have it there ready for you. Then you can make the decision.

So they really went out on a limb to bring in big, big power, big water, big gas, to a region that did not exist before. That was very, very courageous and very, very important.

So, really, it's education; it's the regional economy and ability to support a fab and willingness to develop the infrastructure and then partnerships when it comes to university collaboration.

MR. WEST: Do you have a follow-up?

QUESTIONER: Sorry; I can't resist following up with one question.

How important is what you're doing and what they're doing in Albany to really bring back the leading edge in semiconductors -- from Korea, Taiwan, Japan to some extent, back to the U.S.?

MR. RUSSO: I think it's very important, but I don't want to say all-important because from a policy perspective and a continued collaboration perspective it is possible for the grapes to dry up on the vine.

I think that we're moving the ball in the right direction. I think that we've made a lot of really good decisions collaboratively from a nation, state and regional

economy. The focus is there, but we have to have continued focus and diligence when it comes to continuing to develop the necessary workforce and the necessary supply chain.

Let me take a second out when it comes to workforce.

So we're talking about -- we're bringing it right back around to the actual topic that we're on right now. If you can imagine the amount of technology, I mean, we can produce currently 60,000 wafers per month. Wafers are 300 millimeters, about the size of a record album, with hundreds, if not thousands, of chips on a wafer.

We're working with technologies now and developing technologies. The width of a future size is how much it takes a human fingernail to grow in five seconds.

Subatomic.

Think of the amount of data that we generate, just within our walls, to do with the production of a wafer. Design and production.

Then think about the facilities operation.

Then think about the integration of the supply chain.

Think about the role of IT and then securing it all.

It's mindboggling.

Again, maybe it's just mindboggling -- I might be the only one in the room that it's mindboggling, being a political scientist. I don't know.

MS. NOWINSKI: I'm with you.

MR. RUSSO: But it's pretty impressive.

But how about the workforce it's going to take to manage that, to develop that, to stay up on that? We have a huge gap there.

Most people focus on the talent that's needed to operate the fab -- the technicians, the maintenance capability. There's a gap there, too. We don't have enough people to hire.

We have all hands on deck. We're recruiting from all over the globe and all over the country.

Just think of the IT piece, which we don't talk a lot about.

How do you collect data, analyze data, use data in real time throughout an integrated supply chain?

How do you develop open architectures that are secure but allow for supply chain integration?

So, from a workforce development perspective, it's much more than building the talent and collaborating with.

CNSC is not only R&D, by the way, but CNSC also is part of -- we have very progressive internship programs that people start in the community college. They get basic fundamentals. Then they go through CNSC, and their experience is more from a research perspective and theory perspective. And then they go to the big factory and actually make it, right.

So there are very collaborative partners.

Back to when we were talking about geographic early on, having close access both from an e-access/technology access, but really geographic access is very, very important.

What we're working on right now is how do you bring -- some of the supply chain right now is spread out too far when it comes in our industry to packaging. You know, testing our wafers and packing. How can we actually bring that closer as well?

So, if we're able to do the things we'd like to do in partnership with our regional partners and other national partners, that, in my view, will definitely give us a leg up on some of our global competitors in the rest of the world. It's very hard to replicate

what we're doing in Upstate New York now in some areas of the world that would like to compete.

And I would argue it probably doesn't make sense to compete when it comes to developing countries. Don't try to reinvent the wheel and lead in innovation. Partner with the countries that lead in innovation and go after manufacturing and creating large numbers of jobs in segments of manufacturing versus super advanced manufacturing, where you can put people to work.

So that's a bigger policy discussion between countries, and maybe I'll live long enough to see some of that. I don't know. I don't think we're going to fix it today, though.

MR. WEST: Right.

Over there, Rick has a question.

Behind you, there's a microphone coming up, yeah.

QUESTIONER: Rick Lampert.

Every speaker, if there's a theme, it's the importance of the public-private partnership.

And one of you said something quite encouraging, that both sides of the aisle get the importance of manufacturing. But the both sides of the aisle today get the importance of lots of things, and nothing happens.

In particular, in this area, you hear from both the left and the right, condemnation of corporate welfare, as they call it. You see the troubles of the Export-Import Bank. You see, again, the notion that the government should not pick winners and losers, which these competitions seem to do.

So could you discuss a bit more about the political situation today and the political challenges that we face if we're going to keep up the kind of innovation

public-private partnerships with the federal government playing an important role?

MR. RUSSO: I think that's probably directed to me.

Maybe it's you, Caralynn. What do you think?

MS. NOWINSKI: Feel free to take it. I'll jump in.

MR. RUSSO: A political question. You'll bail me out if I get too -- there are definitely challenges, and I don't think it pays to go to a deep dive on what's happening here in our democracy and why there is the gridlock there is.

And some are quick to say that it took a couple thousand years for Rome to show some cracks, and we're only a couple hundred years down the road.

So what are we going to do about it?

I have faith in our democracy. I think over time things will level out.

Sometimes it's hard to believe that common sense will prevail.

The thing that I think is encouraging is under, arguably -- I mean, I'm close to 60 years old, and in my lifetime I can honestly say that I haven't seen the degree of gridlock that we have today, and it bears itself out on the numbers of bills that actually get passed in our total Congress.

But what I think is encouraging is that the Administration and I think administrations to come that are faced with that have to get really -- they have to use a little ingenuity on how to move the ball forward.

And what I've seen with this Administration is a willingness to reach out to the private sector and not just say, will you advise, but this is the answer I want you to come up with, which is not unusual in Washington, but rather, say, we're not going to give you the answer; we're going to facilitate; we're going to give you what you need to meet, to convene, but we really want to hear from the private sector on what needs to happen and what the priorities should be.

When you take our economy the way it works and you engage the private sector -- small manufacturers, start-ups, mid-sized manufacturers, longstanding manufacturers, education, all the folks involved -- and when I say manufacturing community, it's the people that sells hoes.

People don't understand what manufacturing community is. It's everybody along the continuum.

And you reach out, and you say, what do we need to do?

And then all those people in their communities, they vote, and they talk to others that vote.

It's actually like the start of a movement where people at the -- when you're at your kitchen table, you don't say am I a Republican or am I a Democrat? You think about, what does it take to get a job and put food on the table and to have safety for your children?

And I think that engaging the private sector in constructive dialogue is the beginning of a way of doing business that will ultimately translate to a more proactive -- a more -- not a proactive but a more active community when it comes to engaging through the elective process -- the electorate.

So I think that it's not going to happen overnight. I think it's a change in how we operate. I think, ultimately, with people's focus on things that are important to them, it's going to come around and it's going to eventually get Congress back to the middle.

So I know coming from a political science -- like if you're good at what you do, how could you be saying that?

It's like I'm saying, there's hope. It's not going to happen overnight.

MR. WEST: So, Caralynn, aside from the political aspects, Mike has

given us some indication of the lessons he's drawn about how to drive success in this area.

And even though you've only been in operation a few months, do you have any preliminary lessons you think other communities or other projects could benefit from?

MR. NOWINSKI: Well, I would say awareness engagement is key. I think that's what allowed us to be able to form the type of consortium we did.

And I think touching even on just the question that was just asked and kind of pulling the policy away from it, these companies have a lot of choices about how to invest their dollars, and there's a lot -- I mean, particularly the larger companies that have global footprints. And when there are foreign governments making huge investments in leveraging R&D from the private sector, there's a choice to be made.

We, frankly, faced discussions with our partners early on in forming the consortium of: Why should I choose to make this type of investment here? Why with you guys versus another country, another institute?

And I think that keeping that dialogue going in that awareness and engaging piece was absolutely critical, and it was across so many different ranges of stakeholders.

So, as other communities are thinking about how to put this together -- you know, I will say we absolutely had missteps along the way in terms of communicating. You can always communicate better. But I think we -- that's one of the things I think I'm very proud of about our team -- is how we got the message out there and how we engaged folks.

Shortly after we received the award, we did a series of road shows, and we're continuing them, with communities across Illinois, across Chicagoland and even the

broader Midwest, to talk to small and mid-sized companies, to talk to the workers, the community colleges and say, how can we better tell you what we're trying to do, and how can we engage you in that process? And I think that's going to continue over time.

But I think the fact the Administration has pushed this forward, the fact that there is bipartisan support of this, goes to show this is a conversation that needs to happen because just getting the awareness that if we lose manufacturing innovation our competitiveness as a nation is deeply threatened.

I think the conversation is happening now, and it's happening on both sides of the aisle, and awareness and engagement will be key.

MR. WEST: Okay, right there on the aisle. There's a -- if we can -- yeah.

QUESTIONER: Hi. Zoe Lipman from BlueGreen Alliance.

I wanted to ask a question about a different divide, not the partisan one.

I absolutely support what was said earlier about when we talk about advanced manufacturing today we're really talking about the state of manufacturing today. We're not in a traditional or what is an historic view of manufacturing.

But I think the areas that both of you are in touch on is a divide that's conceptual and, I think, also pragmatic in the manufacturing sector between, say, Silicon Valley and the Allegheny or Cuyahoga Valley.

Can you talk a little bit about -- we've talked a lot today about manufacturing and really engaging in the digital sphere and thinking creatively.

How has the traditional tech industry reached out to the manufacturing sector, and how is that communication, that cultural conversation, going?

MS. NOWINSKI: I'll take a start at that.

So I've spent really the majority of my career in Chicago, where 10 years

ago it was how can we be more like Silicon Valley because we've got great research universities, great companies, no venture capital; what's going on?

I think it's been very interesting to me to be able to watch that evolution of that conversation, where we're no longer trying to be like another place but, rather, create our own ecosystem.

And I think that's what some of the traditional tech hubs really have had - - is a robust ecosystem that brings together the broader community.

There's not just one solution to the challenge of innovation and entrepreneurship and local investment. So, more venture capital, more entrepreneurs, better universities, more research dollars and a more proactive government.

I mean, there's always like, oh, that's the silver bullet question, and there just isn't one. It's about bringing the ecosystem together.

So, as we think about how do we create that ecosystem in and around Chicago as the Midwest hub, but again, the Midwest economic hub, looking at the great communities and local economies within the region, we're trying to pull it together virtually but also create a sense of place-making. That's a big part of our mission in developing that ecosystem where there's a place for the community to go.

It starts with the hub we're building in Chicago, which will be open early next year. But we also, as part of our practice, will be leveraging local hubs across the Midwest and ultimately, hopefully, even beyond that.

And each of those, I think, goes to that ecosystem approach so that when there's a great technology coming out of one of our research universities that is looking for an entrepreneur to take it to the next level or looking for an industrial customer, whether that's a big company or a small company, they don't have to go to the Valley to find that. You can find that in your backyard. And that's what those regional

clusters start enabling.

MR. RUSSO: I'd take a little bit different approach on that. One of the big growth markets today is in manufacturing technology and automation and bringing technology that we produce to the manufacturers.

You know, PLCs are pretty much in everything, even in your home today as we get into the internet and things.

I used to think I didn't want to live too old. You know, I want to be physically there and mentally there and then go out.

I'd like to be kind of frozen in time right now and come back 1,000 years from now and see what it looks like because it's really crazy.

But we are really contributing to manufacturing when it comes to bringing technology into those more -- you know, some of the more standard forms of manufacturing. If you look at those factories now as compared to 50 years ago, there's been a big change. It's not only safety. It's efficiency. It's process and product innovation.

I'm just talking about GlobalFoundries now. We see that as a growth market, and we're really contributing heavily to bringing technology to manufacturing.

MR. WEST: Right here.

QUESTIONER: I'm Brian Paul from Advanced Manufacturing National Program Office.

Caralynn, this question is for you.

I'm interesting in the development of UI Labs, kind of how that all got started. Where did the leadership for that come from? Was it state? Was it university? Was it the industry? You know, how did that come about?

MS. NOWINSKI: Thanks for the question.

The conversation around UI Labs, before it even had a name, actually started in late 2011, and there was really a confluence of multiple things happening at the same time.

There was a recognition by the University of Illinois, which is where I was at, at the time, that it's a top five engineering/computer science program there and graduating more engineers and computer sciences than several of the other top programs combined, and yet, we have this complaint in the region that there's not enough engineers or not enough computer scientists.

And we said, well, part of our economic development land-grant mission is we've got an obligation to make sure that our graduates are staying here and we're having an opportunity to really embrace that talent.

At the same time that was going on, the mayor in the City of Chicago, Rahm Emanuel, was newly in office and really challenged the research universities locally, to say: We've got to keep our engineering talent here, and we've got great technologies coming out of our universities. And they can't keep going off to the coast to get commercialized. We've got to keep them.

There was also a national debate. The National Academies published a report in mid-2012 that talked about the fact that we've lost great institutions like Bell Labs, where you broke down the silos between different stakeholders.

So UI Labs was founded on this principle that we needed a platform, a neutral platform, to bring all of these different groups.

The University of Illinois Chairman, Chris Kennedy, has a saying that universities are the greatest renewable asset or the renewable source of economic development in our region. So that means they produce such great resources and technology and talent. How do we embrace that, and how do we use it for economic

development?

So we actually set up UI Labs prior to this, and it started exploring digital manufacturing based on a pilot that had been done by the Council on Competitiveness -- I know that we had some folks here earlier -- that had supported, along with our university partners as well as four major industrial manufacturing companies, to say that there is a problem in translating digital technologies to the supply chain -- to the small and mid-sized companies.

And so we had been building that as an independent, nongovernment-funded program, and the timing was just perfect.

So thanks to the leadership of the AMNPO because this has been a great opportunity to take that to the next level and be able to take kind of what we had done and had started working on as a pilot program, and be able to bring in not just 4 companies and 2 or 3 universities but bring in 40 major technology and manufacturing companies, along with 24 universities, including 6 of the top 20 engineering schools in the U.S. These groups are now having that dialogue on a regular basis and using the platform that UI Labs provides to do so.

MR. WEST: So, in other words, it was her idea.

Right there.

QUESTIONER: I'm Malte Ahrens with the World Bank.

I was wondering if you could comment on the reasoning behind the access, size, scale and focus of some of these Manufacturing Commons, and perhaps your vision for the future of them.

Thank you.

MS. NOWINSKI: Well, maybe I can touch a little bit on what we're trying to do as it relates to the Manufacturing Commons and, specifically for us, the Digital

Manufacturing Commons, which is really a project that we intend to evolve over the five years or more of our institute.

This was an idea that there needed to be a platform for the dialogue to happen among the different members of the community.

I'm going to start using that, Mike, by the way, the manufacturing community, because really it's not just -- you can't just think about it as the supply chain.

And, a place where there can be exchanges of ideas -- so crowd-sourcing design, for example -- to also sharing data about designs and sharing data about existing machines and existing facility capabilities, for example.

And I think the idea of a commons is this type of platform that brings together the range of skills that are necessary to be able to be competitive in a given industry.

In this particular case, for digital manufacturing, that means being able to collect and store data, to do it securely and to be able to put protections around it, and to be able to segregate it when necessary and integrate it when necessary.

It means bringing in the range of companies involved across the supply chain, including distribution and logistics and quality assurance and of lifecycle management, all the way then to the early designers and early makers.

And so we're creating an online platform that's leveraging a technology that has been utilized at G.E. internally with its supply chain and making it open-source as part of our institute's goals so that there is, over time, an increasing number of process technologies and software capabilities that are really delivered virtually to our members and at the same time that our members are virtually connected.

So we'll be online before the end of the year, and the primary goal will be getting as many of the manufacturing technology companies in the U.S. to be on this

common platform and working together.

MR. RUSSO: To just expand on that a little bit, I think that as far as the future, what does the future hold?

One of the exciting things about the NNMI concept is that while early on we have the pioneer in the front row and there are three more to join him on the bench here -- America Makes here -- but we don't have a true network up and running yet.

But, if you can fast-forward to a few years from now, when there is substantially more of these national hubs within a network, tied together within a network, where they have enough autonomy where they can go about their missions, serving the customers that they have within their respective regions and in the greater manufacturing community, while being integrated within a network, having a true national network asset that has pulled from best practices around the world, that learn from each other -- but if it's able to stay together and if we are truly able to fully leverage that national network, that's really powerful and it should be longstanding.

The key will be to make sure that we institutionalize the necessary diversity.

So what happens is -- and those who are involved in organizational development would know this -- even with the best intentions up front, sometimes you get the same people around the table, and diversity sounds good, but ultimately it's not there. You end up serving the people that are around the table. So, institutionalizing diversity.

When I say diversity, it's diversity within the supply chain. It's diversity within size. It's diversity, really big-D diversity. So make sure, whether it's ethnicity and culturally, et cetera -- I'm talking all types of diversity. Education, all levels.

If you are truly able to institutionalize diversity so the focus remains broad enough so you see everything and so you can do what makes sense to drive the

economy the way you should, that's really, really powerful.

So I would say the jury is still out, but I think the focus is there, the intent is there, and the capabilities are there.

And if we're able to deliver on its intent, I think they're going to be, again, around for quite a while.

And I think that with an ability to continuously learn it's going to be -- really, the U.S. will be a force to reckon with, and that's with one big building block in the foundation of manufacturing potentially being these national hubs.

MR. WEST: All right. Caralynn, Mike, thank you very much for sharing your views. We wish you well, and we'll keep track of how things are going. Thank you very much.

(Applause)

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