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A National Perspective toward Innovation

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SPEAKER

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Thank you, Jim. First, thanks for the invitation to be here. It is a real privilege for Battelle to be represented at this forum. I had a brief conversation with Jim as we were planning some comments for this, and he said "I want you to know you are going to be kind of an odd duck here today in light of the typical kind of conversation we have in this CUSLI forum." As I was driving up to Cleveland from Columbus in the rain this morning, I didn't realize how prophetic the "duck" comment was going to be, but it is true. Listening to the previous panel, most of my comments are going to dovetail nicely with some of the comments that took place before lunch.

I want to cover five things. First, in terms of what to listen for, there is a lot of discussion about what role the government should play, what role should the private sector play, and what role venture and investment capital should play in innovation.

At Battelle, we believe innovation is driven by the interfaces of those roles, and the goal is to facilitate ways to make those interfaces as fluid, transparent, and frequent as possible. Those are the things that I think are important.

And when we talk about roles and specifically to Mr. McIlroy's points on the HR bill,[10] part of the role of government is to facilitate an environment that allows for natural connections to occur, not necessarily to force them to occur.

In essence, government can provide an "oxygen" supply to do that. Some of that happens through funding. Some of that occurs by legislation.

Let me now talk about Battelle in the context of some history about us, not as an advertisement, but to provide a snapshot of a uniquely formed organization that is specifically focused on innovation as a business.

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[10] H.R. 4654.

Battelle has been around for quite a while and we have had a chance almost by charter to do many of these things. If you explore innovation as a topic, you would find there are eleven and-a-half thousand different citations for innovation at various scales.[11]

These are mostly addressing enterprise innovation, and a lot of the work that is done about innovation is about enterprise innovation. For example, how does the next mouse and iPod emerge? How does the next Microsoft emerge from software engineering entrepreneurs?

I am not going to talk about that aspect and there are some wonderful works on this topic. Clay Christensen's work in innovation,[12] if you haven't seen it, it is probably one of the best works on the dilemma and the challenges of innovation and why it tends to come from such odd places.

At Battelle, we believe the majority of innovation happens at the interfaces of disparate events and technologies. Nanotechnology, which is one that is clearly a very hot topic, happens through physicists and chemists and others getting together.

Battelle was founded in 1925[13] by a philanthropic family, the Battelle family[14] in Columbus, Ohio.[15]

The core purposes of Battelle – founded as a charitable trust in the 1920's – was a belief on the part of our founder that research was the bedrock of making industry more competitive, but the challenge was that research was not widely available and affordable by industry.[16] Industry at the time didn't necessarily have an R & D department. They didn't do a lot of product development. They did a lot of testing and iterative development, but they didn't have much research going on.[17]

The vision that becomes the foundation of our organization is that Gordon Battelle stated in his will and testament that his estate would create an organization whose primary purpose would be the conduct of independent research and development for the benefit of mankind as measured by societal

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[11] Amazon, http://www.amazon.com (search "books" for "innovation") (last visited Oct. 5, 2006).

[12] CLAYTON M. CHRISTENSEN, SEEING WHAT'S NEXT: USING THEORIES OF INNOVATION TO PREDICT INDUSTRY CHANGE (Harvard Business Press 2004).

[13] Battelle History Timeline, http://www.battelle.org/careers/battelle/timeline.htm (last visited Oct. 2, 2006).

[14] *Id.*

[15] *Id.*

[16] Roy Church, *New perspectives on the history of products, firms, marketing, and consumers in Britain and the United States since the mid-nineteenth century,* 3 ECON. HIST. REV. 405, 421 (1999).

[17] *Id.*

and economic benefit, and the organization's proceeds would be a significant benefactor to the education of men and women for employment.[18]

That was the context in 1925, and the specifics of it are basically shown here, but the key is all the residue – at that time, the residue was three and-a-half million dollars and is what formed the corpus of Battelle.[19]

The essential elements of the will are: conduct creative work, reduce that work into patents, licenses, dispose of such items in industry and take the proceeds from that and use it to benefit education for men and women for employment. In 1925 that was relevant.

Eighty years later it is equally as important, but in different dimensions. But Battelle is guided today still by this will as our primary directive, the notion of translating discovery into practical application as measured by economic and societal benefit.[20]

Here is how Battelle is organized to carry out these purposes.

We manage large science assets for ourselves, and we manage them specifically for the federal government.[21] We have another line of business whose principal work is about applying technology.[22] Out of this branch of our business is typically several hundred new product innovations that you see in products every year, whether they are Battelle branded or branded by a healthcare company or other organization.

And the third piece of our business is our own venture capital fund.[23] It is a capital fund, independent of Battelle with Battelle as the sole limited partner.[24] It's exclusively to help fuel young technology companies and help those companies reach the next stage.[25]

We started with 30 people in the late '20s.[26] Today we are at about three and-a-half billion dollars of activity worldwide,[27] and by most measures, we

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[18] Battelle 75 Years of Innovation, http://www.battelle.org/solutions/fall04/SpecialReport.stm (last visited Oct. 3, 2006).

[19] Battelle History Timeline: 1925, http://www.battelle.org/careers/battelle/business.stm (last visited Sept. 28, 2006).

[20] *See* Battelle Company Vision, http://www.battelle.org/careers/battelle/vision.stm (last visited Sept. 28, 2006).

[21] *See* Battelle National Security Dept., http://nationalsecurity.battelle.org/clients/related.aspx (last visited Sept. 28, 2006).

[22] Battelle: Commercial Products, http://www.battelle.org/value/default.stm#3 (last visited Sept. 28, 2006).

[23] Battelle Ventures, http://www.battelleventures.com (last visited Sept. 28, 2006).

[24] Battelle Ventures Background, http://www.battelleventures.com/more_background.html (last visited Sept. 28, 2006).

[25] *See* Battelle Ventures, http://www.battelleventures.com (last visited Sept. 28, 2006).

[26] Battelle History Timeline: 1929, http://www.battelle.org/careers/battelle/business.stm (last visited Sept. 28, 2006).

[27] Battelle Business, http://www.battelle.org/careers/battelle/business.stm (last visited Sept. 28 2006).

are the largest independent and research organization in the world,[28] managing a variety of different enterprises, public and private.

That's the context through which I am talking to you about today. So what are some of the innovations that we have had a chance to be involved with? A few things that I would highlight:

First of all, the notion of contract R & D really was born out of the creation of Battelle. Contract R & D is far more prevalent in the United States than it is anywhere else around the world; in terms of industry-funded contract R & D. It is a natural element of our economy.

We have also pioneered university private sector partnerships. Early in Battelle history, we were also involved in the rebuilding of Germany[29] and the rebuilding of a science infrastructure for Germany[30] and involved in the building or the rebuilding of Korea's science infrastructure.[31]

We have been asked to help advance the science infrastructure of other countries around the globe, and to help establish science policy.[32] It's ironic that if you fast-forward to today, many of the places that the United States and Canada are competing with are some of these same countries, but that's the nature of a 21st century world economy. Laboratory excellence is a core strength of Battelle, it is managing large discovery science assets with performance accountability in mind.

One of Battelle's earliest commercial innovations was our support to the creation of the Xerox machine.[33] Battelle originated xerographic copying but it was not in a commercially viable form. Large companies at the time saw no promise for the technology. Market studies at the time said the North American market for the Xerox machine would be 200 machines,[34] and that would saturate the North American marketplace.

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[28] *See* About Battelle, http://www.seattle.battelle.org/about.htm (last visited Sept. 28, 2006).

[29] *See generally* Battelle: The Business of Innovation, http://nationalsecurity.battelle.org/news/briefing_files/Backgrounder%20-%20Battelle%20National%20Security.pdf (last visited, Sept. 28, 2006).

[30] *See generally* Battelle: The Business of Innovation, http://nationalsecurity.battelle.org/news/briefing_files/Backgrounder%20-%20Battelle%20National%20Security.pdf (last visited, Sept. 28, 2006).

[31] *See* Battelle Adds International Operations, http://www.battelle.org/solutions/summer06/page21.stm (last visited, Sept. 28, 2006).

[32] Carl Kohrt, *Model for R&D Cooperation: Science into Solutions*, KOREA R&D REVIEW, Nov. 2005, http://www.kicos.or.kr/data/letterfiles/KOREA%20R&D%20Review_final.PDF.

[33] Battelle Innovations: The Classics: Office Copier Machine: Xerography, http://www.battelle.org/innovations/default.stm (last visited Sept. 28, 2006). *See also* Chester F. Carlson: Inventor of Xerography: A Biography: University of Rochester: Carlson Science & Engineering Library, http://www.lib.rochester.edu/index.cfm?PAGE=467 (last visited, Sept. 28, 2006).

[34] Peter Zanan & Wong Yong Kim, *Market Research for Innovative Products: the Delphi*

Today there are probably 200 machines within 50 feet of where we are standing right now. Part of the reason we could help transform the invention is that at the very same time some of our scientists and engineers were working on nuclear materials and fuels for the federal government.[35]

As a part of that work, they understood things about materials problems that the inventor, Chester Carlson,[36] was having. At the interface of two different disciplines, the innovation of xerography was born.

Cancer diagnostics and therapeutics is an example of a more recent innovation at Battelle for inhaled chemotherapy for treatment of lung cancer.[37] The idea comes from an agricultural spraying machine that was used to spray acres of farm fields using a low residue pesticide delivery method[38] is the same technology that has now been migrated to something that fits in the shirt pocket of patients.

Essentially, an ingredient of innovation is getting the right people in the right place at the right time, which is not necessarily a crystal ball, but just a contact sport that continues to keep people involved with marketplace ideas.

I also want to highlight the Battelle "dividend".[39] The Battelle dividend is basically this:

Part of our founding is that we deliver back to the communities that we operate in by contributing twenty percent of our proceeds every year to charitable causes, especially education.

So the larger that we can make innovative successes, the more opportunity that we have to be able to put dollars back to work. So we are quite interested not in growth for the sake of growth, but we are very interested in impact because it will allow us to fulfill the mission for which we were formed.

Let's talk a little bit about regional strategies. I think this may have been mentioned this morning. A part of what we get involved with is helping re-

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Method, in FEDERAL LAB TECHNOLOGY TRANSFER: ISSUES AND POLICIES 128, 128 (Gordon R. Bopp ed., 1998).

[35] *See* Battelle Innovation: Market Driven: Trends through the Years, http://www.battelle.org/solutions/fall04/SpecialReport.stm (last visited Sept. 28, 2006).

[36] *See* Battelle Innovation: And Then, There is Xerography, http://www.battelle.org/solutions/fall04/SpecialReport.stm (last visited Sept. 28, 2006).

[37] Press Release, Battelle, Battelle Announces New Pulmonary Drug Delivery Spinoff to Begin Operations (Apr. 20, 2000), *available at* http://www.battelle.org/news/00/04-20-00BPTspinoff.stm.

[38] *See generally* Stephen W. Stein & James S. Stefely, *Metered Dose Inhalers*, DRUG DELIVERY TECHNOLOGY, http://www.drugdeliverytech.com/cgi-bin/articles.cgi?idArticle=112 (explaining the technology behind metered dose inhalers and its applications).

[39] *See* Battelle - In Our Community, http://www.battelle.org/careers/battelle/community.stm (last accessed Oct. 4, 2006) (describing Battelle's relationship with the local and national communities). *See also* BATTELLE, ANNUAL REPORT 2005 (2006), *available at* http://www.battelle.org/annualreports/ar2005/ar2005.pdf.

gions, specifically in the United States, looking at leveraging their regional strengths. One of the organizations in Battelle is focused on helping assess and formulate strategies that best leverage the assets and the research strengths that appear in a particular region. Battelle has assisted with many of the states across the country that have science strategies and technology-based economic development strategies, including Ohio.[40]

Let's move to the environments for success: I would suggest four things that we can think about as important pieces of an environment for innovative success when we talk at the scale of nations. The first one is: Does the national system have sufficient basic research; and is this fundamental science fueled at a level that is relevant?

Basic science needs to be supported at the federal level because it is the highest risk piece of the innovation equation. It is the place industry will never invest in at a sustainable level. But it is an element that industry needs to rely on in order for it to be competitive later. So are there mechanisms for industry to collaborate for pre-competitive topics? We talked a bit about that in the previous session.

Part of the role of high risk research is: Can you bring more of the industry close in to it, to help shape it in a direction which, if successful, will enable the next innovation to occur. So part of the first interface is industry involvement, not necessarily for a specific piece of intellectual property, although that's a key piece of it, but rather to influence the direction of R & D at its most basic levels by informing it about the most important problems to solve.

And if we go to a national laboratory, as an example of this, we will find that the places where they probably have the most meaningful engagements with industry is where they know a particular set of grand challenge problems, which, if solved, would be highly valuable. Left to their own direction, they will solve some other problems that may be important, but that industry interface is critical.

The second, national element is policy and legislation that create the right atmosphere that will allow for transparent and frequent dialogue between the research, academic community, and the private sector.

That's everything law, like Bayh-Dole[41] and other types of legislation that will permit technology transfer arrangements. It's also about companies and research organizations speaking a common language,[42] which they typically don't do, but the ones who do it well tend to be able to bridge that gap between science and the marketplace.

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[40] Battelle-Technology Partnership Practice, http://www.tpp-online.org/fr_states.htm (last accessed Oct. 9, 2006) (describing Battelle's economic development work in Ohio).

[41] 35 U.S.C. §§ 200-212.

[42] *Id.* § 202.

When I referred to constructive competition here in this slide, I am not talking about capitalistic competition. I am really talking about shaping competition that brings out the best research. Are there national systems in place that create constructive competition so that universities, federal laboratories, and so on are doing work that is meaningful and impactful because they have to continue to account for their results?

And then the final part in the food chain for innovation is a national economy that allows for small companies to be acquired by larger and larger companies through mergers, acquisitions, and license.

Now, let's take a look at fueling it from the funding perspective. I picked a couple of items to highlight. First, in 2006, we will see the first year where total R & D spending in the world will top a trillion dollars.[43]

It continues to grow at a reasonably healthy rate. America and Asia [are] roughly equivalent by all measures. In about fifteen years, the prediction is that Asia will be more than half of the total, of R & D spending,[44] so that's growing at a rapid rate.

Another interesting statistic is to look at R & D as a percentage of GDP. I look at that as where does any country put its priority on whatever resources it has? You see countries that are in the three, four, five percent range that's an enormous bet on technology. Look at some of these countries: Israel has been high in these percentages for a while,[45] and they are tending to see some very good results from that.

Japan has always been up there.[46] The United States sits in that same category. You see Canada right below two percent.[47] Notice China[48] and, India,[49] despite all the other things that you hear, not particularly high in percent at this stage. That's certainly shifting, and they need to have the mechanism to shift that.

Again, looking by country, the vast majority of the world's R & D is still spent in the United States.[50] Again, that is shifting over the course of time. Just by comparison, because we are a Canada-United States forum here, since Canada is near the bottom of these lists, due to limited resources,

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[43] JULES DUGA & TIM STUDT, GLOBAL R&D REPORT: CHANGES IN THE R&D COMMUNITY G1 (2005), *available at* http://www.rdmag.com/pdf/R&D%209_05%20Global2.pdf.

[44] *See* John P. Mello Jr., *Global R&D to Reach $1 Trillion in 2006*, E-COMMERCE TIMES, Sept. 27, 2005, http://www.ecommercetimes.com/story/46364.html (reporting on the high level of R&D growth in Asia).

[45] DUGA ET AL., *supra* note 43, at G3.

[46] *Id.*

[47] *Id.*

[48] *Id.*

[49] *Id.*

[50] DUGA ET AL., *supra* note 43, at G3.

spreading resources as opposed to focused bets. Canada certainly has a challenge in terms of how best to utilize the resources that it has.

The second piece that is: –

MR. ELMER: Excuse me. Are those the top countries expenditure- wise?

MR. ROSEN: They are the top countries in the top four or five, and then I selected some others, so the – I can't comment below India as to whether or not the rest of those are – if there are any countries in between there.

MR. CRANE: On the outside, R & D is a share of GDP.

MR. ROSEN: Yes.

MR. CRANE: You have Sweden is higher than Israel, isn't it?

MR. ROSEN: No, it is not,[51] at least in this referenced here.

MR. CRANE: Something around 4 percent.

This comes out of the R & D magazine forecast. Sweden certainly still spends a fair amount.[52] I think the interesting thing is, again, if you look at the rate of change of some of these countries another interesting indicator.

This is another interesting perspective. Industry is still, across the world, a predominant piece of that trillion dollars, and you get a sense again by looking at some selected countries. You have everything from South Korea and Japan, which has three quarters R & D coming from the private sector[53] to the 50-50 models, to India where the vast majority is coming from the government.[54]

Notice in Canada – and I can't comment on the policy for this, but it is just an interesting thing to note – that academia is 21 percent,[55] and as opposed to in, say, the United States or other fairly strong academic research communities, seven or eight percent[56] – and again, someone here may be able to comment on the policy for this.

I can tell you we do a fair amount of interactions and collaborations with the universities in Canada, and we see, you know, quite a fair amount of strong research going on in Canada, which may be a byproduct of that academic emphasis.

MR. ELMER: What is the top Canadian research institution?

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[51] *Id.* (Showing Israel's R&D as a percentage of GDP at 3.6% and Sweden's at 3.9%).

[52] *Id.*

[53] *Id.* at G12.

[54] *Id.*

[55] *See* U.S. and International Research and Development: Funds and Alliances—International R&D by Performer, Source, and Character of Work (2000), http://www.nsf.gov/statistics/seind00/append/c2/at02-65.xls (last visited Oct. 9, 2006) (quantifying academia's percent share of R&D spending in Canada).

[56] *See* Jules Duga & Tim Studt, *2005 R&D Funding Forecast: Government Spending Continues to Drive R&D Growth*, R&D MAGAZINE, Jan. 2005 at F11, *available at* http://www.rdmag.com/pdf/RDX0501Forecastfinal.pdf [hereinafter *R&D Funding Forecast*] (discussing academia's percent share of all R&D spending in the United States).

MR. ROSEN: University of Toronto.[57] If you look at it from the perspective of health and life sciences, which is the one I know the best, the University of Toronto has more than a half billion dollars of research going on in the GTA,[58] and, in fact, it is the number two worldwide cited medical center just below either Harvard or Johns Hopkins.[59] They are the second by publication.

The example I want to use in the United States is the National Laboratory Systems, and I want to talk about the National Research Council just briefly in Canada by highlighting the territory that they cover.

Battelle categorizes four ways that you can manage a laboratory, whether it be public or private. There is a model that is predominant called government-owned, government-operated. Think about NASA and similar organizations. They are federal employees working in federal laboratories on federal missions making federal wages.

There is a second model, government-owned, contract-operated, which is where the government sets the mission, owns the assets. The private sector is accountable for the management of that model and accountable for performance, and the continued results of being able to manage them come from their ability to deliver results.

Privately- owned, -privately- operated, that's Lucent, IBM laboratories, Watson. Privately-owned, contractor-operated, is a very small segment of the marketplace right now, which is where a private- sector organization will give a portion of their laboratory to a contractor to manage on their behalf.

Those are the four. The reason I want to bring these up is Laboratory Management, which is where the highest risk research in the world takes place, is in a state of transition. I would say that Battelle gets visited and, in fact, five times this year, by various branches of the Canadian Government, to benchmark what we do in managing U.S. laboratories, to see whether or not there are applicable pieces of that model that might be brought into Canada. These visits are a common occurrence.

Our international expansion is largely to look at managing laboratories around the world for countries that want to take on this model. There are a couple of reasons for that. Today there are more than two dozen national laboratories across the country.[60]

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[57] Canada's University Innovation Leaders: Canada's Top Research Universities 2005, http://www.researchinfosource.com/media/2005-top50-sup.pdf (last visited Oct. 4, 2006).

[58] Economic Impact of UofT VPPB, http://www.utoronto.ca/planning/Publications/economic_impact.htm (outlining total dollars spent and generated in the Greater Toronto Area).

[59] *See* REPORT NUMBER 145 OF THE BUSINESS BOARD 5-6 (2005), *available at* http://www.utoronto.ca/govcncl/bac/details/bb/2005-06/bbr20051128.pdf (stating that the University of Toronto ranked second in number of publications and sixth in the number of citations).

[60] *See* U.S. Department of Energy: Labs & Technology Centers, http://www.doe.gov/

The vast majority of them are operated around this government-owned, contractor-operated model, which means the mission is set by the federal government, but the performance is managed by private sector contractor.[61] Most of them are done in conjunction with a contractor and a university, so I will show you our portfolio of those in a second. We manage five of those,[62] so we have the largest fraction of the nation's science laboratories.[63]

In addition, our headquarters in Columbus is a laboratory we manage.[64] The way to think about these laboratories, is that each has a mission. For example, remediation might be the laboratory mission in the Pacific Northwest. Idaho National Laboratory in Idaho Falls is about nuclear energy, nuclear policy, and non-proliferation.

So what falls on Idaho is research around the next generation, safe reactors as well as policy around global use of nuclear energy in a responsible way and bringing the work force globally to be responsible managers of nuclear energy facilities.

One of the things that characterizes most of these laboratories is they have significant user facilities. A user facility is basically a national asset, that could not be replicated in any reasonable cost by a private sector organization, but they are open to access by U.S. citizens. At Brookhaven, that ring you see in the back there is a couple of miles in circumference, and there are other one of a kind instrumentation there, and private sector organizations can come in to do basic research.

They pay a small amount to get access to the space. They are trained to use it, but user facilities are one of the benefits of a National Laboratory System. It is not nearly the only thing they do but one of the things that they do well. In general, how do you think about managing these significant assets in a responsible way?

Here is the way we think about it. Managing laboratories is to benchmark performance by comparing to the best laboratories there have ever been in existence.

And when we think about innovation, we think about these six things: Can you sustain excellence? Can you be good for a long time? Can you consistently develop commercial value at some stage? Because they are danger-

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organization/labs-techcenters.htm (last visited Oct. 4, 2006) (listing all of the National Laboratories and Technology Centers in the United States).

[61] *See R&D Funding Forecast, supra* note 56, at F12 (defining Government-Owned/Contractor-Operated models).

[62] *See* News Release, Battelle, Battelle Energy Alliance Wins Idaho National Laboratory Contract (Nov. 9 2004), *available at* http://www.battelle.org/news/04/11-09-04IdahoLabWin.stm (discussing Battelle's management of National Laboratories).

[63] *Id.*

[64] Battelle – Background information about Battelle, http://www.battelle.org/more/default.stm (last visited Oct. 9, 2006).

ous operations, can you operate them as safely as possible because of the communities that are around them?

Are you working on the most important problems, some of the newest technologies? Are you working on moving from scientific discovery to see the light of day in industry, and are you working with the outside world?

And so you will see here that we look at those and say, well, one way to do that is to look at the best laboratories that have ever been in those categories and aspire to be like them in the portfolio that you manage. And we have our system of management to reach those benchmarks.

Let's get back to interfaces. The way that we think about the innovation spectrum is that it moves from a general environment, that environment that is associated with discovery for the sake of discovery, its universities, laboratories, etc.

There is a second universe that is associated with translating ideas into marketplace needs, not necessarily products, but looking for the conversion between those two, we call that maturation or development. That's the idea that those who work in discovery, one of the biggest critiques of universities is around their failure in some ways to have meaningful commercialization is that the things that they do aren't that meaningful or aren't that ready. Well, the reason is because they are not developed to be that ready. Their mission is not to do that.

But there are places and organizations and environments that are designed to move things from discovery into practical application, and there is a second universe for that. And then the third universe are those organizations fixated on products for the here and now, that they can build manufacturing products, distribution, and sales around.

In this particular case, those three universes, one of the keys to success is being able to manage innovation across those boundaries. You will see that we referred to what are the things that go on in there. Those who are really good at maturation and development, generally inside of companies, are doing things like trying to meet tomorrow's marketplace needs and looking to the universities and finding ways to source ideas, bring them in as early as possible and prototype those type of ideas.

So back to a Battelle design. Our lines of business are designed to basically follow through those three worlds. Our discovery business is federal laboratories, our product business is our middle piece, and our venture business is connecting to collaborate with the outside investment world.

Now I will show a different model. This is the Canadian National Research Council model. I won't spend a lot of time here other than just to highlight – you are going to see some similar intentions, different implementation but similar intentions, with the National Research Council model.

And here again, you will start to see support of incubation, support of innovation systems, etc., and in this model, the predominant implementation

around the institutes is the so-called Go-Go model, government-owned, government-operated.

These are all government employees. These are specific functional institutes with several hundred employees in each that are working on specific, I would say, marketplace informed ideas at the research stage, and they sprinkle across the Canadian landscape, and you will see them, everything from nano and bio to IT, to the manufacturing technologies in plutonics.

Again, in this world, the idea is this: We can't see the one on the left that says university research. There is what we call at Battelle a valley of death that goes between the world of university research and the world of industrial research, and the stuff coming out of one end is not necessarily ready for the other, so here is the issue: What can you do to fuel that?

The National Research Council's world is to try to bridge that gap through the institutes themselves and also through their assistance programs to help industry reach back on higher risk research. So that's one of their views.

I want to rapidly wrap up here with this: Back to the U.S. Government. So when the U.S. Government thinks about managing what I just described, there are four things to think about.

Is it going to derive economic benefit? The way they view the mission, is that it is not done until the private sector puts it to use, but notice that the government tries to put itself in a place to never be in conflict with industry.

That's not always the case, but it tries to do that and also tries to be as transparent as possible. That has created several interesting pieces of legislation and related work like Bayh-Dole,[65] which was discussed a little bit earlier.

Battelle is a 501(c)(3),[66] so we can take title to intellectual property we manage, prohibitions with private sector competition, and a whole series of those. An interesting one is the U.S. manufacturing rights. What does it mean in a 21st century world if everything that ever comes out of a federal laboratory has to have a U.S. manufacturing component? If nobody in the U.S. manufactures it, it is being done somewhere else, how does that work?

So these things are constantly in tension. Here are the implications. This is in your package, but the key indication here is simply the world over the last 20 years has moved from heavy R & D, that is captive inside, to highly collaborative R & D, that is not owned by any particular place so collaboration is the key.

Once you start crossing borders, whether it is international or academia, to corporate, to intermediaries, it is everything about knowledge sharing and intellectual property and all those types of things and this whole variety of

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[65] 35 U.S.C. §§ 200-212.

[66] Battelle – Background Information about Battelle, *supra* note 64.

cultural awareness issues that start to appear that have not been there in the past, and so let me bring up one piece that is key to us.

When we think about innovation systems, we also think about our pipeline of talent. It is no secret that pipeline talent in the United States is dwindling. Just a couple of statistics that should scare anyone who lives in the United States about our desire to be economically competitive at any time in the future, and I would submit it this way: Every technical field that you can name – and I have just listed engineering as one of them – is declining by a third a decade in terms of people who are interested in going into that field.[67] Engineering is an example. Six out of a hundred graduates of high school will choose to go into engineering, as opposed to other fields.[68]

Two other interesting statistics: 2010, four years from now, 90 percent of the total living human beings that are practicing engineers or scientists will live in Asia,[69] and that's a numbers game no one can change because that's just numbers. At the very same time, 50 percent of our work force in the United States is entering the retirement window,[70] and what we like to say ironically that the only thing that may keep them from retiring is the pension programs are in chaos and they can't leave early.

Maybe that's our competitive advantage. High school rates are declining,[71] and we have fewer and fewer math teachers, [72] however, Battelle, as one of our key signature initiatives, is trying to reverse those trends in whatever way that we can help.

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[67] *See* STEPHANE BALDI ET AL., INTERNATIONAL EDUCATION INDICATORS: A TIME SERIES PERSPECTIVE, 1985-1995 113-117 (2000), *available at* http://nces.ed.gov/pubs2000/2000021.pdf (illustrating the declining percentage of first university degrees awarded in science).

[68] *See* National Science Foundation: Science and Engineering Indicators 2006, http://www.nsf.gov/statistics/seind06/c0/fig00-24.htm (quantifying the number of science degrees per one-hundred twenty-four-year-olds).

[69] WAYNE CLOUGH, HIGHER EDUCATION: DRIVING THE INNOVATION ECONOMY (2005), http://www.ed.gov/about/bdscomm/list/hiedfuture/3rd-meeting/clough.pdf.

[70] *See* KEN DYCHWALD ET AL., WORKFORCE CRISIS: HOW TO BEAT THE COMING SHORTAGE OF SKILLS AND TALENT 9-11 (2006) (describing the percentage of the United States workforce nearing retirement age).

[71] *Contra* NATIONAL CENTER FOR EDUCATION STATISTICS, U.S. DEP'T OF EDUCATION, THE CONDITION OF EDUCATION 2006: PUBLIC HIGH SCHOOL GRADUATION RATES BY STATE 65, 170 (2006), *available at* http://nces.ed.gov/programs/coe/2006/pdf/28_2006.pdf (stating that high school graduation rates have increased from 2000-2001 to 2002-2003).

[72] *See* RICHARD M. INGERSOLL, IS THERE REALLY A TEACHER SHORTAGE? 7 (2003), *available at* http://www.gse.upenn.edu/inpress/Is%20There%20Really%20a%20Teacher%20Shortage.pdf (illustrating the percentage of math teacher vacancies in secondary schools).