AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

S. HRG. 108–822

ADVANCED MANUFACTURING AND BIOTECHNOLOGY

FIELD HEARING

BEFORE THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

APRIL 14, 2003

Printed for the use of the Committee on Commerce, Science, and Transportation

U.S. GOVERNMENT PRINTING OFFICE

98–524 WASHINGTON : 2005

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2250 Mail: Stop SSOP, Washington, DC 20402–0001

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED EIGHTH CONGRESS

FIRST SESSION

JOHN McCAIN, Arizona, *Chairman*

TED STEVENS, Alaska	ERNEST F. HOLLINGS, South Carolina
CONRAD BURNS, Montana	DANIEL K. INOUYE, Hawaii
TRENT LOTT, Mississippi	JOHN D. ROCKEFELLER IV, West Virginia
KAY BAILEY HUTCHISON, Texas	JOHN F. KERRY, Massachusetts
OLYMPIA J. SNOWE, Maine	JOHN B. BREAUX, Louisiana
SAM BROWNBACK, Kansas	BYRON L. DORGAN, North Dakota
GORDON SMITH, Oregon	RON WYDEN, Oregon
PETER G. FITZGERALD, Illinois	BARBARA BOXER, California
JOHN ENSIGN, Nevada	BILL NELSON, Florida
GEORGE ALLEN, Virginia	MARIA CANTWELL, Washington
JOHN E. SUNUNU, New Hampshire	FRANK LAUTENBERG, New Jersey

JEANNE BUMPUS, *Republican Staff Director and General Counsel*
ROBERT W. CHAMBERLIN, *Republican Chief Counsel*
KEVIN D. KAYES, *Democratic Staff Director and Chief Counsel*
GREGG ELIAS, *Democratic General Counsel*

CONTENTS

	Page
Hearing held on April 14, 2003	1
Statement of Senator Cantwell	1
Prepared statement	4
Statement of Senator Wyden	5

WITNESSES

Carter, Dr. Bruce, President and CEO, ZymoGenetics	17
Prepared statement	18
Denton, Dr. Denice D., Dean, College of Engineering, University of Washington	34
Prepared statement	37
Hartwell, Dr. Lee, Fred Hutchison Cancer Research Center	12
Hood, Dr. Lee, Institute for Systems Biology	7
Janicki, Peter, Janicki Industries	40
Larson, Nona, Senior Materials Engineer, PACCAR Technical Center	42
Prepared statement	44
Overell, Robert W., Ph.D., General Partner, Frazier Healthcare Ventures	23
Prepared statement	25
Rottsolk, James E., Chairman, President and CEO, Cray, Inc.	19
Prepared statement	20
Rutkowski, Rick, President and CEO, Microvision Inc.	45
Prepared statement	48
Statkus, Frank D., Vice President for Technology, The Boeing Company	39
Prepared statement	40
Wray, Susan D., DDS, JD, Director for Industry Relations, University of Washington School of Medicine	14
Prepared statement	16

ADVANCED MANUFACTURING AND BIOTECHNOLOGY

MONDAY, APRIL 14, 2003

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SEATTLE, WA.

The Committee met, pursuant to notice, at 8:30 a.m. in conference room 3–B, Washington State Convention Center, Hon. Maria Cantwell, presiding.

OPENING STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. Good morning. We are here for a U.S. Senate Committee on Commerce, Science, and Transportation field hearing on Advanced Manufacturing and Biotechnology.

I am going to be joined in a minute by my colleague from Oregon, Senator Ron Wyden, but before he comes into the room, I wanted to make sure that since we had such a good turnout of Northwest interest here, obviously concerned about a variety of issues that may be impacted by the work of the Senate Commerce Committee, I wanted to make sure that people also saw some of the staffers that are here.

So if Floyd Des Champs and Chan Lieu and Gael Sullivan could stand up here in the front. Where did——

Mr. LIEU. I am right here.

Senator CANTWELL. Oh, right here.

Any of you who have other issues, materials or testimony that you would like to make part of the official record for the hearing, please see one of those gentlemen. I want to express my thanks and gratitude for their help in organizing this field hearing today and coming to the Northwest, and I hope that you will fill Senators McCain and Hollings in on the hard work that the Northwest is doing to continue to invigorate what has been a very stellar economy.

I also want to thank our panelists for being here this morning. We obviously have a very distinguished group of people who have given up their time to come and try to focus our attention on what some of the opportunities are moving forward.

We apologize in advance for asking you to be brief. I know that that is not necessarily a hard challenge, but there is so much to convey. If there are other things that we do not get through here this morning, please know that all of this material does become part of the official record of the field hearing and is shared with the rest of the Members of the Committee.

Obviously the Commerce Committee, from the first panel's perspective having really the oversight of the majority of authorization for science and technology funding for the Congress, it is very important that we get those remarks to them, and obviously for the second panel, the aviation focus and the Aviation Subcommittee that both Senator Wyden and I serve on will benefit from any additional materials that individuals can give us today.

Well, I think what I will do is as Senator Wyden is coming into the room, I will go ahead and start my comments and then turn it over to him so that we can get on with the panel.

The hearing this morning is going to examine two industries whose innovations, I believe, can continue to serve as an economic catalyst for the Northwest, biotechnology and advanced manufacturing. Biotechnology is often touted as the next step in the technology revolution, but we already know here in the Northwest that it is transforming healthcare, agriculture, and is poised to protect us from attacks on American soil, chemical and biological weapons.

Washington State has over 190 biotechnology companies employing more than 11,000 people, and in 2001, the annual revenue of these companies exceeded $1.2 billion, so Washington State has been well on the way.

Nearly one half of these companies were based on technologies developed at research and development institutions, and over 40 percent of these companies have been established in the past six years.

And I think that this is a very important note that our State's Academic Research Institutions attract a very large percentage of the NIH budget at $650 million in 2002, so the relationship that we have been able to garner and the good work that these individuals have done in securing Federal funds has played a critical role. I am sure we are going to hear more about that this morning.

I want to stress how important the collaboration between higher education research institutions, private researchers and the capacity for the work force to work together in this region makes our future economic growth and opportunity viable.

One of the bills that I have recently introduced with Senator Pete Domenici of Arizona, and something that I know that Senator Wyden is also interested in as well, is the Genomes-to-Life bill, a model of the kind of collaboration between the Federal Government and private industry that we need to promote the biotech industry.

This bill capitalizes on the enormous success that the Human Genome Product has done and promises to take this important research to the next level. While mapping the human genome is an unparalleled accomplishment on its own, this new initiative will allow researchers to go beyond the science and descriptions and begin to explore the complex interactions of the elements within cells.

This legislation ensures that the research within the origins of the Department of Energy, provides the science and technology basis for new industries and biotechnology, and ensures that DOE continues to play an important role in the commercial applications of these technologies.

This bill would provide funds for the national research laboratories such as PNNL, and potentially a major investment in Wash-

ington State. I look forward to hearing from our panels and witnesses on these issues.

I also want to bring up the fact that the second panel, the focus of advanced materials manufacturing, I think is an important opportunity for the Northwest to play a leadership role. Advanced manufacturing attempts to modernize materials with more sophisticated polymers, composites or light aluminum alloys. These materials are essential to national defense and to the aerospace industry.

Manufacturing remains a leading sector in our State's economy employing over 10 percent of our work force. And as we all know, this sector is under some serious challenges, but it is by the planning for the future investment in innovation and technology here in the Northwest that I believe that we can be at the forefront of the composites area, and local companies can play an important role in using composites and advance materials in future commercial planes and other manufacturing applications.

And while this investment is no guarantee that future planes like the 7E7 will be built in Seattle, it is clear in my mind that without this kind of investment in the 21st century technologies and the investment in the work force, we will not remain competitive unless we make this investment.

In addition to the aerospace sector, Northwest companies from Bellingham to Bend are applying a wide range of advanced materials, including composites and other cutting-edge materials like aluminum alloys to manufacturing from everything from boats to recreational vehicles to lightweight trucks and I think in the future even bridge supports.

So how do we have the best shot at this? Well, it is about transforming our manufacturing base to compete in the 21st century. It is about making an investment in the research and development of this kind of technology. That is why I have introduced Federal legislation for an aviation administration center of excellence that could be located at the University of Washington. This center would specifically focus on the research and encourage the broader use of advanced structural materials, including composites and the new aluminum alloys in future aircraft.

This center for excellence would focus on the applied research and training and durability and maintenance of advanced materials in air frame structures, including the use of polymeric composites in large transport planes.

We are looking to promote and facilitate collaboration among academic researchers, the Federal Aviation Administration's Transportation Division and the commercial aircraft industry including all the suppliers and carriers.

So I believe that both of these opportunities, advanced manufacturing and biotechnology, could help play a very significant role in the region's future job growth. But we have to make the investments now, and that is why we are here today to hear from these panelists on both biotechnology and advanced materials.

I want to welcome my colleague from Oregon, Senator Wyden, here. The Northwest has been blessed to have both Oregon senators on the Commerce Committee. I have been very happy to join them on that Committee. Senator Wyden has played a leadership

role in biotechnology and in technology and is considered one of the most technology-savvy senators in the United States Senate, and we are pleased to have him here with us this morning to conduct this field hearing.

[The prepared statement of Senator Cantwell follows:]

PREPARED STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

The United States of America has led the world in scientific research and in technological innovations in the 20th Century, and the 21st century will undoubtedly provide new challenges and opportunities. The true engine of the American economy has been to turn our scientific discoveries into practical applications and advancements in technology have allowed us to improve our economy, our national security, and to live richer lives. Today's science and technology innovations are uniquely characterized by the speed and information processing capabilities of our new machines. Traditional biology, traditional chemistry, and traditional physics have been literally transformed by technology. We are presently on the verge of new sciences, which will undoubtedly produce exciting new technologies.

The new fields of nanotechnology, genomics, bio-informatics, and micro-engineering, among others, grow out of a synergy of physics, biology, chemistry, engineering, and advanced computational modeling. Recent advances in proteomics and genomics promise to allow us to understand the complex interactions of proteins within living cells and provide important clues to the mystery of living organisms. This basic research in biotechnology will certainly have unique applications and the integrative and predictive understanding of biological systems will improve our ability to respond to the energy and environmental challenges of the 21st century. Nanotechnology is the other half of this complementary pair of new sciences. Like genomics, nanotechnology combines traditional sciences into a new 21st century science. Nanotechnology offers immense possibilities for scientific advancements, achievements, and applications, with immense potential to transform our lives. It has equally wide applications—from energy, to medicine, to electronics. Like genomics, nanotechnology is what scientists and technologists label as an "enabling" technology—a tool that opens the door to new possibilities constrained only by basic science principles and our imaginations.

I have introduced legislation in the Energy Committee to spur development and research in the field of genomics and bio-informatics, and look forward to considering the complimentary roles nanotechnology legislation can play. Along with Senator Wyden, I convened a Commerce Committee field hearing earlier this April on the Northwest economy that focused on the innovative science and industries that will drive that region's economy in the future. The hearing highlighted the exciting arid unique opportunities that advanced manufacturing, including nano-scale fabrication, can have in spurring technological and economic development. At that hearing we heard about challenges facing these developing industries, and the role federal research and investment could play in growing those industries. In response to these findings, I have proposed legislation in partnership with the University of Washington to establish a Federal Aviation Administration Center for Excellence in Materials Science. Such a center would produce research that would develop techniques in maintaining and ensuring the durability of advanced material structures in transport aircraft, including at the molecular level.

Another part of that same productive hearing on the Northwest economy revealed that biotechnology, including the nano-scale research into biological systems, can play a role in diversifying and driving economic development. I learned about many exciting advances fueled by biotechnology, and spoke with many bright innovators about challenges their research and their industries have faced. I am excited to say that many of these roadblocks will be removed, and a good deal of basic research provided, through the Genomes to Life bill, S. 682, I have introduced in this session. That bill capitalizes on the enormous success of the Human Genome Project, and promises to take this important research to the next level. While the mapping of the human genome was an unparalleled accomplishment on its own, this new initiative would allow researchers to go beyond the science of description, and begin to explore the complex interactions of the elements within cells—truly exciting and micro, if not nano-scale, research that promises great rewards in response to grand challenges.

Other nations have already recognized the need to be at the forefront in these fields, and many have already provided support for genomic and nanotechnology research. In the U.S., both genomics and nanotechnology have been recognized by the

Department of Energy, The National Research Council, and the National Science Foundation as high priorities for new research. American research institutions, companies, and universities have recently joined in these investigations. The State of Washington is already a national center for genomic research and the University of Washington is the first in the United States to offer Ph.D.s in nanotechnology. Washington is home to many world-class research facilities. We have over 190 biotechnology companies employing more than 11,000 people. In 2001, the annual revenue of these companies exceeded $1.2 billion. Nearly one half of these companies were based on technologies developed at research and development institutions and over 40 percent of the companies have been established in the past six years. I believe that federally funded research in genomics and technology will provide more economic benefits, not only for Washington, but also for the nation.

While our past leadership in science and technology may provide us a head start, it must not lull us into a false sense of accomplishment. We cannot afford to become complacent, but must take proactive steps to ensure our economic and scientific future is a real possibility, and that barriers to these new technologies are removed through targeted federal involvement. While these new fields involve experiments at the microscopic level, they often require sizable instrumentation and investments of federal support. This support is an example of the targeted role the government can play, not in competing with businesses, but in training America's workforce and providing fundamental theoretical research into new fields of knowledge.

We must provide the federal support for a coordinated national program of research and development in emerging sciences. Federal investment in these new sciences will produce important scientific breakthroughs and result in long term benefits to our health, our economy, and our national security. I look forward to hearing today how we can do just that.

Senator Wyden?

STATEMENT OF HON. RON WYDEN, U.S. SENATOR FROM OREGON

Senator WYDEN. Well, thank you, Senator Cantwell, and I am really pleased to be with you. Let me say to the people of Washington, having chaired the Science, Technology, and Space Subcommittee in the last session of Congress, one of the very first people that I look to for input and counsel on these issues is Senator Cantwell who has a long record in these concerns both in the private sector and in Government.

So, Senator Cantwell, it is great to have a chance to be with you. And suffice it to say, it is our judgment that Oregon and Washington can be a magnet for entrepreneurs and scientists with cutting-edge ideas and technologies. And the reason that we are here is that we want to advance public policies that are going to unleash those kinds of private sector talents.

And I think it is worth just noting a bit what the Government's role is in all of this and we are going to hear from our panelists in just a second, but Maria and I do not have machines on our desks where we thrash them around a couple of times and then out spit the jobs.

I mean, we do not create jobs in the United States Senate. The jobs come from good people like those who are on the panel and all of you in the audience, people in the private sector.

But what Senator Cantwell and I are in the business of is setting the climate. Our job is to help set the climate. So if the proper decisions are made in the education area, for example, with respect to incentives research and development and the access to essentials like water, which are so important to the technology sector.

If we can get that right, if we can set the climate properly, then all of you in the private sector can go do your thing, and we are going to create family-wage jobs in the private sector.

So we are really here today to get information in those areas to help set the climate. And just by way of wrapping up, there are two special interests I have: One with Senator Allen, and his staff, I think, is represented here today, we note the presence of our Republican colleague staff. Senator Allen and I have introduced the first major nanotechnology initiative.

Our Committee will be considering that legislation very quickly when we return from the recess. I think we can have it on the President's desk within a matter of months.

Suffice it to say, the small sciences, as nanotechnology is known, is an area of extraordinary potential.

I see, for example, with the interest there is in Washington and Oregon in the healthcare area, a special interest of mine, that with nanotechnology appliances, we are going to have small bulldozers, in effect, eliminating cancers and a variety of exciting therapies and applications will stem from that.

Finally, a special interest of mine and I know Senator Cantwell's as well, is the importance that we get more women into the hard sciences and the fields that we are going to be discussing today.

We cannot accomplish what we need to do in this country both from the standpoint of the private sector and from the national security standpoint unless women get a fair shake in these fields.

There has actually been a reduction of the number of women in some areas, particularly computer sciences, in recent years, and I have called on the Federal Government to make an especially aggressive effort to get more women in these sciences.

So this is going to be an exciting morning, and, Senator Cantwell, I thank you for doing this and the chance to be with your constituents. The Northwest is going to have a full court press, so to speak, between Oregon and Washington for jobs and economic opportunities in this area under your leadership, and I look forward to being your partner.

Senator CANTWELL. Well, thank you, Senator Wyden. And I do consider it a partnership with our neighbors to the south. We had an opportunity to, Senator Murray and I, address the Portland Chamber of Commerce last week, about 60 individuals who were there, and these same issues came up, and so we will look forward to working with you on them.

We have a very distinguished panel here this morning. I would like to introduce them all at once, if I could, and then I will turn it over to them to start their presentations.

But first we are going to hear from Dr. Lee Hood, the president of the Institute for Systems Biology. ISB is internationally renowned as a nonprofit research institute dedicated to the study and application of systems biology. Many of you know that ISB is having its second annual symposium on systems biology and human disease, and so I know that you will actually have to leave to go to that, so we feel very honored that you have taken the time to be with us this morning.

I know that immediately following your testimony, Senator Wyden and I will have a few questions, and then we are going to

let you rush back. But I am going to go ahead and introduce the rest of the panelists now.

Dr. Lee Hartwell will be next on the list and no stranger to most of us in this room. Dr. Hartwell is the President and Director of the Fred Hutchison Cancer Research Center. Dr. Hartwell spent most of his research career at the Department of Genetics at the University of Washington where he used yeast cells to study the fundamental problems of cell biology related to cancer and in 1997 joined as the Director of the Fred Hutchison, and working with a variety of friends he co-founded the company Rosetta Infomedics.

I think next on the list we are going to have Dr. Susan Wray. Dr. Wray is the Director of Industrial relations for the University of Washington School of Medicine. She has worked for a variety of biomedical and high-tech firms and has served on the board of the U.S. Patent and Trademark Office's Biotechnology Institute, a very important area of this whole field, and we obviously need to make sure that the Patent Office continues at the same funding to make sure that this process works smoothly for us in the Northwest.

She and Dr. Paul Ramsey, Dean of the University School of Medicine, are key leaders in the university's research expansion efforts, and she is going to talk about that this morning.

Next to her, Dr. Bruce Carter, President and CEO of ZymoGenetics, a local private biotechnology company is going to speak about the real products that are emerging from collaborations between higher education and research and private industry.

Next to him, James Rottsolk who is Chairman and President and CEO of Cray, Incorporated, a company which he also helped cofound will be speaking about the shared computational capacity and that information technology and hardware advancements are going to be key in the leap forward in genomics, and we are very proud of the work that that company has achieved and that they are here in Washington State and look forward to his comments.

In closing, Dr. Bob Overell, general partner at Frazier Healthcare and Technology Ventures is going to talk to us about the early stage investments and where we are in the Puget Sound area and in the Northwest in encouraging the access to capital at a time when the capital crunch seems to be quite severe, but how the role of capital formation will be critical for us moving forward.

So with that, Dr. Hood, if you could start us off this morning. And again, we appreciate your time.

Dr. LEE HOOD. Sure.

STATEMENT OF DR. LEE HOOD, INSTITUTE FOR SYSTEMS BIOLOGY

Dr. HOOD. We stand at a fascinating convergence for biotechnology. With the completion of the human genome imminent, we have new opportunities for thinking about biotechnology. So in addition to healthcare, in addition to animal husbandry, agriculture, protection against bio-terrorism, even mining, there are two areas that I find particularly fascinating that the Northwest may be uniquely qualified to participate in.

One is the convergence between information technologies and biotechnology. Because they share the same kind of digital lan-

guage, there are many strategies that will obviously be shared between the two.

And the other is the convergence between nanotechnology material sciences and biotechnology. And I think it is in these latter two areas that there are really unique opportunities.

Now, the Human Genome Project has clearly said the key thing about biotechnology is understanding information. And on the one hand there is a genome with the 30,000 genes that make the 30,000 proteins that are the molecular machines of life, but what has really emerged clearly, and it is what our institute is about, is those proteins participate in parties called systems. The heart and the brain each are systems, and understanding how to study systems is really the key to the future.

And I might just illustrate some of the approaches that we have taken at the institute. The essence of systems biology it turns out fascinatingly enough, as cross-disciplinarian scientists, you have to put together mathematicians and computer scientists and engineers and chemists and biologists to be able to do this new kind of science.

What is critical is to drive new technologies. So, again, at the institute, we have recently formed a nanotech alliance with Caltech and UCLA, and we are designing machines such as a new way of sequencing DNA that will be 3,000 to 4,000 times as fast as what we have today. And in 10 to 15 years, each of us can have our genome done on a little chip, and it will be the beginning of what we call predictive medicine.

The institute is also a pioneer in this area called proteomics. Ruedi Aebersole is the world leader in this particular area.

It is key to be a world leader in bio-informatics and computation and the mathematical sciences, for this is the means whereby systems biology really gets not done, but understood, whereby the models are created and so forth.

And it is the understanding of human systems that will give us new insights into the IT world and how to do computing much better.

The final area is the idea of predictive medicine. In the future, we will be able to look into your genomes and make predictions about your health history. We will be able to give you a little nanotech device which will prick your finger and make 10,000 measurements and tell you you are in a good health state or has some particular disease, cardiovascular or cancer, started. You will be able to monitor real-time disease.

We will be able to use systems biology to place defective genes or pathologic environmental signals in the context of systems and understand how to circumvent their limitations. And medicine will be forced to treat us as individuals because we each differ from one another on average by 6 million letters of the DNA language, so we are predisposed to differing kinds of combinations of disease.

And together with the Fred Hutchison, we have recently initiated a partnership to really push forward the technology and implementation of this predictive, preventive and personalized medicine.

Finally, the institute is really committed to transferring knowledge to society, so we have spun off three new companies in the three years we have been in existence, and more recently we have

put together what is called an accelerator, a partnership with three outstanding venture capital groups that puts up the capital for instantaneously setting up small start-up companies that are testing out new kinds of ideas.

Indeed, we have had six companies that have already been reviewed in the last two or three months. So this new world is an enormous driver of technology and its realization in the economy.

So with all of this in mind, what should we really be thinking about? Well, I would argue that we really want to think very seriously about building on our unique strengths.

I would say in the Northwest, one unique strength is this creation: The Institute for Systems Biology is the first place in the world that is doing systems biology. And systems biology is important not only because it is a new approach to biology, because it enormously enables classic smaller biology. Big and small science can work together in a very cooperative fashion.

So how can we facilitate this interaction? How can we facilitate the pioneering of these new technologies that are going to transform biotechnology? How can we create an environment where not only we invent the future in bio-informatics and computation, but it is made available to all of those, industry and academia alike, who are involved in these kinds of things?

How are we going to be training scientists for the future? Again, the Northwest will have a really unique capacity for being able to do this.

So I think we have an enormous, enormous opportunity. And I will tell you one of the things I worry about most is, frankly, the tax structure that exists, at least in Washington, because when I look around the country and see the kind of support that new start-up companies get, I can say Washington is a long ways behind how most of them do. My own view is it all starts with having an income tax, frankly, rather than sales tax which makes people desperate to do things like the business and occupation tax, which is an enormous hindrance to, I think, small start-up companies.

So I think there has to be a review of this kind of infrastructure, too. But I would just say we are in a unique position to take advantage of this enormous inflection point and opportunity, and I hope we can all join and go forward and make the Northwest really a unique environment for this new kind of intellectual capital and intellectual opportunity that stretches out before us.

So in closing, I would just like to thank Senators Cantwell and Wyden for the interest they have shown in this area, in particular Senator Wyden for the new nanotechnology bill.

I think nanotechnology is going to transform, more than anything else, the field of biology, biotechnology, and medicine. So I applaud you for your efforts.

Senator CANTWELL. Senator Wyden?

Senator WYDEN. Thank you. Just one question on this tax structure issue, and I appreciate your kind words about nanotechnology. And by the way, Senator Cantwell has been a leader in this area as well, and we are going to be working together as we process this bill, and we may have some additions to the legislation as well.

I am very interested in this question of the tax structure and have been particularly exploring the idea of saying that essentially

start-ups, you know, innovative, creative start-ups that are not making any money, we just ought to say the taxman does not cometh. I mean, we just ought to say that as an incentive to get people to take those risks, that we ought to try something very different in the tax area.

Congressman Chris Cox, the Republican Conference chair, and I are saying that in the hydrogen area. I mean, nobody is expecting anything anytime soon, so we said that with respect to developing hydrogen, why do we not say if somebody is going to set up a hydrogen filling station or sell equipment for hydrogen or do something to take a risk, let us say the taxman does not cometh for the next 10 years.

I mean, we are not going to lose any revenue because nobody is expecting anything.

Dr. HOOD. Right.

Senator WYDEN. And I am just curious what your thought would be if Senator Cantwell and I with our colleagues, again, on a bipartisan basis were to explore the idea of basically being able to say to Northwest start-ups that when you are just starting out and you are trying to generate risk capital and risk funding, we just say this is going to be a tax-free zone for a while as a way to jump start this.

Dr. HOOD. You know, I think that would be a superb idea. I know Hawaii, I was over there recently, has actually set up enormous tax breaks for starting companies that extend years into the future. So it actually helps to support getting them started. And they are actually making available land and space.

I mean, we are in the process of exploring a new systems biology company, which I think is going to have an enormous future in the biotechnology industry, and they made an offer of space and land and all of these tax-free benefits.

So I think the more one can do to get started, and what you have suggested is really a good concrete possibility, the better off we will be.

What we do have is this wonderful infrastructure of the University of Washington and the Fred Hutchison Cancer Center and the strength in biotechnology we have here, so people will be enormously attracted.

So if we can even do minor perturbations like striking the business and occupation taxes for the first 10 years, in some ways that would be a terrific advancement.

Senator WYDEN. We will explore it, and I know Senator Cantwell wants to go on. Obviously when people make money, then we are saying clearly that is some——

Dr. HOOD. Absolutely.

Senator WYDEN.—you know, something where you have to, if you are going to fund services, generate some revenue. But as a way to reward the risk takers, this is an idea we would like to explore. I thank you.

Senator Cantwell?

Senator CANTWELL. Thank you. Dr. Hood, I know you are not an economist, but when you look at the Institute of Systems Biology and where you think this will go, I mentioned in my opening comments about 11,000 people employed in the biotechnology field,

where do you think that this leads us as far as, if not a number, a characterization about the opportunity for future employment in the Puget Sound area?

Dr. HOOD. Well, I can give you an example of the companies that I have been involved in starting in roughly the last 20 years. It has been 11 different companies, including Amgen and Applied Bio Systems. I guess I do not know how many people they employ, but my point would be with the new kinds of science that we are talking about now, and particularly with predictive, preventive and personalized medicine, I think there are going to be myriad opportunities to create very, very strong biotech companies.

These convergences that I have talked about, I think, really represent some unique kinds of opportunities. So I think we really could make Washington one of—not sixth in the country or seventh in the country in biotech, but right up there among the leaders.

But it will require dealing with the infrastructural tax issues as well as the technical kinds of issues.

Senator CANTWELL. Do you think that that is a potential doubling of that work force? I guess when I look at the last decade in the 1990s when we transitioned from having a one-company town to really having software be as predominant an employer as aerospace, we diversified our company. This is very positive.

So part of our going back and looking at investment and obviously, I think, the NIH investment made in our State continues to be a main driver of what this work force could be, but how——

Dr. HOOD. So my guess is——

Senator CANTWELL. Is that a small, medium or large opportunity in the Northwest?

Dr. HOOD. I would be shocked in 10 years if we could not quadruple at least the work force if we were even partially successful in what we have talked about here.

Senator CANTWELL. Quadruple the 11,000 people?

Dr. HOOD. That is correct.

Senator CANTWELL. I would say that is a big opportunity. Big opportunity.

Senator Wyden?

Senator WYDEN. Lots of jobs. We like that. I think the only other question I had is obviously there are some who are saying that the biotech sector has fallen on tough times in terms of access to capital and the like.

We do not share that view, but what are the couple of steps that you think at the Federal level would most likely pump some new confidence in the bio sciences area and make it as attractive as possible?

Dr. HOOD. Well, you know, I think there are a couple of things. This conflict between big and small science is really reflected at the national level in equivocation about how to fund the future opportunities.

The tendency in the funding agencies is always to do things as we have done them in the past, so that I think there has to be an acknowledgment of the enormous complementarity and power of big science in an integration together with small science.

We can talk about ways that that could be done, but I think that is really going to be important. So pumping in resources to the aca-

demic side of things that lead to the discovery is really going to be critical.

But I think the other thing that, again, NIH is only now coming up to par on is the realization of how much technology and computation and computer science are driving this new world. There has to be a focus on these new areas of nanotechnology and material science of the mathematical sciences and how we use those really effectively.

So, you know, I always argue new ideas require new structures. Well, we are stuck with funding the structures, so how you get them to change in major ways, I think, is a fascinating question and a fascinating challenge.

Senator WYDEN. Well, we thank you. I think it is fair to say that those of us who have looked at nanotechnology think this really has the potential of the computer revolution, whether it is healthcare, the environment, agriculture. This is not nano-hype. This is on the level. I think there is great potential, and we are going to be working with you

Senator CANTWELL. Thank you, Dr. Hood. We will let you get back to your international symposium so that quadrupling can begin and thank you very much.

We will go next to Dr. Hartwell. Thank you.

STATEMENT OF DR. LEE HARTWELL, FRED HUTCHISON CANCER RESEARCH CENTER

Dr. HARTWELL. Senator Cantwell and Senator Wyden, thank you very much for the opportunity to be here today.

Senator CANTWELL. You might need to pull that microphone a little bit closer.

Dr. HARTWELL. From the instructions that I received, the purpose of this hearing, as we have heard, is to think about how to translate academic research to improve innovations and job growth.

With this in mind, let me talk just briefly about how it currently works at the Fred Hutchison Cancer Center and the University of Washington and how it might be improved.

Both institutions have successfully founded many companies out of biomedical advances. The University of Washington Medical School faculty receives over $600 million in sponsored research and the Fred Hutchison faculty receives about $200 million. The vast majority of our research is funded by competitive grants, primarily from the National Institutes of Health with a small amount from other Government agencies, foundations and private donations.

So the important point is that Federal research funding is the source of essentially all innovation and job growth that comes out of academic research institutions.

An important point I will come back to, though, is that Federal research grant funds can only be used for the approved research, and, consequently, innovations that might impact the economy usually require additional funding.

Now, there are really five important components in the equation that create economic growth from research. The first is the creativity of the academic faculty, the second is the Federal research funding that supports their work, the third is the environment and the infrastructure provided by the culture of the institution, fourth

is additional funding to commercialize an invention, and fifth is the intellectual property laws that provide the rules of the game.

One can do little to increase faculty creativity. It probably comes inborn. Federal research funding has been augmented by recent doubling of the NIH budget and innovations are certain to grow proportionately. The NIH peer review system has been enormously successful in assuring that these public funds are effectively utilized to advance biomedical science.

Since most biomedical research is done by graduate and post-doctoral trainees, Federal research grants not only buy research, but also train the work force of biotechnology, achieving a two-for-one advantage.

Individual institutions probably differ greatly in providing the culture that can balance free inquiry with entrepreneurial spirit necessary to catalyze commercialization. It is a very delicate balancing act, and I suspect that biologists still have a lot to learn from engineers and computer scientists on how to do this.

Now, personally, and I am speaking only from my own opinions here and not necessarily those of the institutions that I represent, I think the strongest limitations to economic innovation and job growth as a result of federally funded supported research lies first in the lack of funding for commercializable research and second in the intellectual property laws as they are currently applied to academic and nonprofit research institutions.

Academic research institutions usually have no source of funding to supply the missing link between Federal research grants and funds to support the proof of principal research necessary for commercialization. Consequently, many good ideas are never commercialized and others are unnecessarily restricted in their potential by those providing venture capital.

Senator WYDEN. Can I just interrupt for a second? Are you talking about the Bayh-Dole law here in your concerns about commercialization?

Dr. HARTWELL. I am going to come to that.

Senator WYDEN. Oh, excuse me.

Dr. HARTWELL. Okay. I am talking right now about the funding for taking something from an academic insight to a commercializable product.

The process could be vastly accelerated by providing nonprofit research in academic institutions with a fund amounting to about 5 percent of their total Federal research grant base to be used at their discretion to develop the commercial potential of research findings.

Second, I think that we are limiting innovation by the way that the Bayh-Dole Act and current patent law are being applied to research supported by taxpayer dollars. The current landscape for biotechnology looks a lot like a bunch of small farms each fenced off with patents to limit innovation and collaboration. Broad enabling technologies and reagents are sequestered in exclusively licensed arrangements and prohibitive cost structures.

I think we should change the rules so that the methods, tools and reagents developed with public dollars are more readily available as platforms for further innovation. Thank you.

Senator CANTWELL. Thank you very much. And we will hear from the rest of the panelists before we go to any questions.

Dr. Wray?

STATEMENT OF SUSAN D. WRAY, DDS, JD, DIRECTOR FOR INDUSTRY RELATIONS, UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE

Dr. WRAY. Thank you for the opportunity to appear in front of you today. The 2002 report by the Brookings Institution entitled "Signs of Life, the Growth of Biotechnology Companies in the U.S." describes the link between the formation of biotechnology companies and a well-recognized and well-funded medical research establishment.

I am pleased to report today that the State of Washington is ranked as one of the five biotech hubs in the Nation largely due to the UW School of Medicine and the Fred Hutchison Cancer Research Center. However, I will also testify that the future promise of that link is in jeopardy.

First, let me report the good news. Research faculty at the University of Washington brought in nearly $809 million in external research grants and contracts during the fiscal year ending June 2002. The School of Medicine faculty contributed more than half of that amount, with over $600 million from all the faculty at all the School of Medicine locations.

For the tenth consecutive year, the School of Medicine was ranked number one in the Nation in primary care training. Thus, we do have that well-recognized and well-funded medical research establishment that is called for in the Brookings Institution report.

This success is the direct result of the drive, intelligence and competitiveness of the faculty that we have, including, four Nobel Prize laureates, 26 members of the Institute of Medicine and 25 members of the National Academy of Sciences.

The School of Medicine, therefore, winds up being second in the Nation, just behind Harvard, in total NIH research dollars received. And it has only been able to attain this status because of the Federal dollars received as research grants and the support given by the Federal Government to build research buildings.

The State of Washington contributes only 4 percent of the UW Medicine's budget, 4 percent. In contrast, the steadfast support of Washington Senators and Congressmen has had much to do with the success over the decades.

But what is most important for the Federal taxpayer is that we can show real benefits from all of this sponsored research that has been going on. For an example, a basic research experiment in yeast by Professor Benjamin Hall resulted in the development of a Hepatitis B vaccine. There are more than 200,000 new cases of Hepatitis B each year in the United States, resulting in over 4,000 deaths. Again, this was a basic research finding. Professor Hall was not attempting to create a new vaccine. But the point is that successful technology transfer has occurred from hundreds of inventions from the University of Washington's basic science research programs.

We can also show real benefits to the taxpayer in the form of new businesses and new jobs that have been created out of UW re-

search efforts. Over 175 spin-off companies have resulted from UW research. For example, the origins of Immunex, which was acquired by Amgen, Icos and ZymoGenetics are in the School of Medicine's research enterprise. At least 20 medical device companies have been created.

The School of Medicine, together with the research efforts of the Fred Hutchison Cancer Research Center, the Institute for Systems Biology, Washington State University, and several other research institutions in the State, can continue to invent new technologies and form new businesses. However, this can only occur if the Federal research dollars are increased beyond current levels and if we obtain new money to build new buildings.

Prominent research faculty want to work where they can make the most exciting discoveries. We are fortunate that Dr. Robert Waterston, one of the leaders in the effort to sequence the human genome, has joined the School of Medicine as the Chair of the Department of Genome Sciences. We will soon break ground on the new building that will house this department, but no direct State dollars are available for this building.

Exciting breakthroughs in computational biology, human genetics and other areas will continue to occur if we can continue to attract and keep the best and the brightest.

The building complex that will house the new home for Genome Sciences will also have a new building for the Department of Bioengineering. This department has been a focus of entrepreneurial activity with over 362 invention disclosures, 120 issued patents, 75 license agreements and 24 spin-off companies. Again, that is just one department with 24 spin-off companies.

But the key to keeping these people working and on the job is to continue to have good facilities for them to do their jobs.

Here is the dilemma: Even with these two new buildings, the School of Medicine is out of space. The creation of new facilities and the maintenance of older buildings is even more of a problem for the rest of the UW campus.

Each year Washington State University and the University of Washington award degrees to more than 14,000 highly educated graduates, attract nearly a billion dollars in research funding from outside the state, and create scientific discoveries and technological advances that fuel the growth of the new economy. In the current economic climate, forward momentum at our two research universities is critical and important to our state. But the state's investment in higher education has been declining for years, putting our economic future in jeopardy.

Obviously, this hearing cannot address all of the state's economic woes, but for the benefit of all Federal taxpayers, we would ask that the Federal dollars to not-for-profit research institutions continue to flow. There are many new medical challenges that face us—bioterrorism, an aging population with health concerns, an epidemic of obesity and diabetes—we can only meet these challenges if we have our medical research faculty hard at work on these problems.

Thank you for this opportunity to provide this information.

[The prepared statement of Dr. Wray follows:]

PREPARED STATEMENT OF SUSAN D. WRAY, DDS, JD, DIRECTOR FOR INDUSTRY RELATIONS, UNIVERSITY OF WASHINGTON SCHOOL OF MEDICINE

Thank you for the opportunity to appear in front of you today. I am Dr. Susan Wray, the Director for Industry Relations at the University of Washington School of Medicine. I am representing Dr. Paul Ramsey, Vice President for Medical Affairs and Dean of the Medical School, who could not be here today.

The 2002 report by the Brookings Institution entitled, *Signs of Life, the Growth of Biotechnology Companies in the U.S.*, describes the link between the formation of biotechnology companies and a "well-recognized and well-funded medical research establishment." I am pleased to report today that the State of Washington is benefiting from the results of that type linkage. In the Brookings study, Seattle was ranked as one of the five biotech hubs in the nation, largely due to the UW School of Medicine and the Fred Hutchison Cancer Research Center. However, I will also testify that the future promise of that link is in jeopardy.

But first, let me report the good news. Research faculty at the University of Washington brought in nearly $809 Million dollars in external research grants and contracts during the fiscal year ending June 2002. The School of Medicine faculty contributed to more than half of that amount, with over $372 Million dollars flowing directly through the School of Medicine. When we include all of the research from all of the School of Medicine faculty at other locations, such as Children's Hospital, that number rises to over $500 Million. For the 10th consecutive year, the School of Medicine was ranked number 1 in the nation in primary care training. Thus, we have the "well-recognized and well-funded medical research establishment" called for in the Brookings Institution report.

This success is the direct result of the drive, intelligence, and competitiveness of the more than 5,600 full-time, part-time and volunteer faculty at the School of Medicine. These include: 4 Nobel Prize laureates, 26 members of the Institute of Medicine, and 25 members of the National Academy of Sciences.

The School of Medicine is second in the nation (behind the Harvard University System) in total NIH research grant awards. The steadfast support of Washington's Senators and Congressmen over several decades has had much to do with this success, and the School of Medicine appreciates that continued support. Research awards, primarily from NIH, provide almost 45 percent of the School's financial support. The State of Washington only contributes 7 percent of the School of Medicine's budget—only 4 percent! The steadfast support of Washington's Senators and Congressmen over several decades has land much to do with this success, and the School of Medicine appreciates that continued support.

But what is most important for the federal taxpayer, is that we can show real benefits resulting from that research. As an example, basic research in yeast by Professor Benjamin Hall resulted in the development of a vaccine against Hepatitis B. There are more than 200,000 new cases of Hepatitis B each year, resulting in over 4,000 deaths. Again, this was a basic research finding—Professor Hall was not attempting to create a vaccine. But this successful technology transfer is but one of 100's that have flowed from UW's basic science research into the biomedical industry for the development of new products that improve health and save lives.

We can also show real benefits to the taxpayer in the form of new businesses and new jobs that have been created out of the UW research efforts. Over 175 spin-off companies have resulted from UW research. For example, the origins of Immunex (which was acquired by Amgen), Icos, and ZymoGenetics are in the School of Medicine's research enterprise. At least 20 medical device companies have been created, including ATL (acquired by Philips). Philips Medical Systems has now moved its North American headquarters to Washington.

The School of Medicine, together with the research efforts of the Fred Hutchison Cancer Research Center, the Institute for Systems Biology, Washington State University, and several other research institutions in the state, can continue to invent new technologies and form new businesses. However, this can only occur if the federal research dollars continue to grow and if we obtain new money to build new research buildings.

Prominent research faculty want to work where they can make the most exciting discoveries. We are fortunate that Dr. Robert Waterston, one of the leaders in the effort to sequence the human genome, has joined the School of Medicine as the Chair of the Department of Genome Sciences. We will soon break ground on the new building that will house Dr. Waterston's department, but no direct state dollars are available for this building. Exciting breakthroughs in computational biology, human genetics, model organism genetics, and other areas will continue to occur in the Department of Genome Sciences, but only if we can continue to attract and keep the

best and the brightest with state of the art buildings, equipment, and research support.

The building complex that will house the new home for Genome Sciences will also include a wing for the Department of Bio-engineering. Bio-engineering is an unusual department, in that it is shared between the School of Medicine and the College of Engineering. The Department of Bio-engineering is number 1 in the nation in National Institutes of Health research awards to biomedical engineering, and it is number 1 in the nation in the number of graduate students. This department has been a focus of entrepreneurial activity, with over 362 invention disclosures, 120 patents, 75 license agreements, and 24 spin-off companies. Again, the key to keeping these excellent bio-engineering faculty is to provide them with good research facilities.

But that is the dilemma—even with these two new buildings, the School of Medicine is out of space. The creation of new facilities, and the maintenance of older buildings, is even more of a problem for the rest of the UW campus.

"Each year, Washington State University and the University of Washington award degrees to more than 14,000 highly educated graduates, attract nearly a billion dollars in research funding from outside the state, and create scientific discoveries and technological advances that fuel the growth of the new economy. In the current economic climate, forward momentum at our two research universities is critically important to our state as a whole. But the state's investment in higher education has been declining for years, putting our economic future in jeopardy."[1]

Of course we realize that this hearing cannot address the state's economic woes, but for the benefit of all federal taxpayers, we would ask that federal dollars to not-for-profit research institutions be increased. There are many new medical challenges facing us—bioterrorism, an aging population with health problems, an epidemic of obesity and diabetes—and we can only meet these challenges if we have our medical research faculty hard at work on these problems.

Thank you for this opportunity to provide these comments.

Senator CANTWELL. Thank you.

Dr. Carter?

STATEMENT OF DR. BRUCE CARTER, PRESIDENT AND CEO, ZYMOGENETICS

Dr. CARTER. Thank you and thank you for your interest in the health of our industry. I represent ZymoGenetics. We are focused on the discovery, development, and commercialization of protein drugs, that is to say, we look in the human body for proteins that might be useful as drugs and produce them by genetic engineering. And the most clear example of that is insulin as a protein. There are, in fact, five proteins on the market today that stem from discoveries made at ZymoGenetics.

As Susan pointed out, we actually came out of the University of Washington. We were founded in 1981. Now we employ 360 people. And in fact, history is not always the best predictor of the future, but in the last 10 years, employment in the biotechnology industry in the State has tripled.

We spend $100 million each year on research and development predominantly in the Northwest. I think it is fair to say that for many people, the world is a better place because of the collaboration we have had with the University of Washington.

The majority of the people who have diabetes and get insulin get that insulin from a process that was discovered at ZymoGenetics. I used to say that Mr. Gorbachev probably today got insulin from a process discovered by ZymoGenetics in the old Gasworks Park

[1] *Cougars and Huskies for Our Economic Future* (http://www.washington.edu/univrel/cougarsandhuskies/index.htm)

over there until somebody told me nobody knows who Gorbachev is anymore.

[Laughter.]

Dr. CARTER. And that came from a collaboration with Ben Hall at the University of Washington.

Another protein that has saved people's lives in every continent in the world and certainly somebody that I know up in Everett who would have died without it is a drug called NovoSeven, and that again came from a collaboration with the University of Washington, this time with Ben Hall.

Anybody in the room who is a diabetic knows that diabetic wounds heal very poorly. And another protein that is sold, Regranex by Johnson & Johnson, came from a collaboration between ZymoGenetics and the University of Washington through the late Russell Ross.

I think it is no coincidence that if you look around this country and say "Where do you see the foci of biotechnology companies? Where are most biotechnology companies located?" You see them in Boston, in San Francisco, in San Diego and the Raleigh-Durham area. And what do they all have in common? They all have in common strong academic institutes and strong biomedical research.

And if you look at those places, I think you also see something else, that is to say, when you have strong academic institutions and a vibrant biotechnology industry, there tends to be clustering, there tend to be more brought in. So that is where you get your tripling, I think, to your quadrupling.

If you think about Boston, Boston had strong academic institutes, it had strong biotechnology, and now you see major pharmaceutical companies, the Merck and Pfizer putting in research there, you see British companies like AstraZeneca, you see Japanese companies like Eisai all bringing research facilities into that area.

And most remarkably of all, the conservative Swiss pharmaceutical giant Novartis has moved its research and development headquarters from Basel, Switzerland to Boston.

I think that we could see some similar clustering here with the strong academic institutions and a strong, vibrant biotechnology industry. I think that the companies that you see here like ZymoGenetics, they were founded really on ideas that were generated by academic institutions, and they actually thrive and will be developed by the people who are trained in those academic institutions. So I think it is very important that we maintain the strength of the academic institutions in this area, in the Northwest.

Thank you very much.

[The prepared statement of Dr. Carter follows:]

PREPARED STATEMENT OF DR. BRUCE CARTER, PRESIDENT AND CEO, ZYMOGENETICS

My name is Bruce Carter and the company I represent is ZymoGenetics. We are focused on the discovery, development and commercialization of therapeutic proteins for the treatment of human diseases. Five protein products on the market today stem from discoveries made at ZymoGenetics.

The company was founded in 1981 by three university professors, two of whom came from the University of Washington. We now employ 360 people and spend almost $100 million/annum on research and development, mainly in the Northwest.

For many people the world is a better place because of the collaboration between the University of Washington and ZymoGenetics.

A protein drug called Novoseven was born out of collaboration between ZymoGenetics and Earl Davie at the University of Washington. It has saved many people's lives who would have otherwise bled to death; people in Japan, Israel and many other countries including people in Washington State.

Diabetics in every continent are being treated with insulin that is made by a process that was discovered at ZymoGenetics through collaboration with Ben Hall of the University of Washington.

Diabetics who have wounds that won't heal have been helped by Regranex, a protein drug that came from collaboration between ZymoGenetics and the late Russell Ross of the University of Washington.

It is, I think, no coincidence that the cities with the largest number of biotechnology companies are Boston, Raleigh-Durham, San Francisco and San Diego, all cities with strong academic institutions and strong biomedical research.

I believe that strong Universities associated with vibrant biotechnology companies bring in other companies as we have seen in the Boston area, where Merck, Pfizer, AstraZeneca and many other companies have initiated biomedical research activities. Novartis has even moved its headquarters of R&D into the Boston area from Basel, Switzerland.

Biotechnology like many other high tech industries has a tendency to clustering. The more companies located in a particular area, the more other companies join them. These companies depend on ideas generated in Universities and people trained in Universities.

Senator CANTWELL. Thank you, Dr. Carter.

Mr. Rottsolk?

STATEMENT OF JAMES E. ROTTSOLK, CHAIRMAN, PRESIDENT AND CEO, CRAY, INC.

Mr. ROTTSOLK. Thank you for the opportunity to speak to you today. I would like to applaud your efforts and your leadership both in the genomics to life initiative as well as the nanotechnology initiative. I think these are the types of things that we should be pursuing, and the fact that you are taking the time to consider these important areas today I think is very useful.

I did have a written statement, but I will just summarize a few comments that I have. It is clear that the life sciences themselves present tremendous challenges as well as opportunities.

From our perspective, the challenges both in the area of computational biology itself as well as in computational science is what we find most interesting. It is—we have talked about a number of things involved with biotechnology here. From our perspective, what we are seeing is a burgeoning in the amount of data that is being generated in this field in this post-genomic era. And what is not so important is this vast amount of data itself, but what we can do to take advantage of it, how we use this data.

And in that sense, what we at Cray are involved in, supercomputing, presents a tool with which to leverage the data that is being created.

Market researchers in the computer arena are convinced that the leading segment, the highest future growth area in the computer marketplace over the next few years is likely to be biotechnology. This is caused to a large extent—I mean, just to put things in perspective when I talk about this burgeoning amount of data, we are all familiar with at least megabytes, millions of bytes of data, some of us even think about gigabytes or billions of bytes of data, but in fact what we are talking about and having to deal with increasingly are thousands of trillions of bytes of data.

At Cray, we are involved in building systems, computer systems then, supercomputers, that can process vast amounts of data. Just as an example, we have set a target for ourselves to have systems available to researchers in biotechnology and nanotechnology and homeland security areas by the end of the decade that can process a thousand trillion instructions per second. It is almost an unfathomable amount of computational power, but it relates to what Dr. Hood was talking about. If you think about what a whole system can do, then you can think about what a single chip is able to do.

We are already involved in a number of collaborative efforts in this area. We have a very important partnership with the Department of Energy and its research laboratories. We are in the process at the moment of designing and building a computer system to be installed in Sandia National Labs, but accessible to researchers within the community that should regain the leadership for the United States in high performance computing from the Japanese.

I should point out that we take for granted that the U.S. has the lead here. In terms of a computational tool today, the most impressive tool available, in other words, the fastest supercomputer is the earth simulator system installed in Japan, and, in fact, it is already being used for breakthroughs in nanotechnology.

We are also beginning to install a fairly large system at Oak Ridge National Labs. Both Oak Ridge and Sandia, as well as Pacific Northwest Laboratories here have been involved in early life sciences work, and these systems are expected to be utilized in the area of—you know, in the area of life sciences with the hope that new breakthroughs can be made.

More locally we will actually install this quarter at the Arctic Region Supercomputing Center in Alaska two of our new systems, two of our new X1 systems, and we are working in conjunction with the Institute for Systems Biology to do early, early work developing algorithms and techniques necessary for science and research in the life sciences.

Not surprisingly, all of these efforts require a fair amount of funding. I think a number of the areas have been touched upon, but most importantly we need to fund academia. In building life sciences expertise, this is computational biology, it is mathematical sciences as well as computer sciences. Beyond that, we need to make certain that funding is available for research utilizing advanced tools as they become available.

Again, I applaud your efforts in this area and look forward to having Cray become a player in the Northwest in this area. I think we, the Northwest, could represent a major hotbed of activity and could be a real center of excellence in the life sciences arena. Thank you.

[The prepared statement of Mr. Rottsolk follows:]

PREPARED STATEMENT OF JAMES E. ROTTSOLK, CHAIRMAN, PRESIDENT AND CEO, CRAY INC.

Introduction

Cray Inc. is the premier provider of supercomputing solutions for the world's most challenging computational problems. We design, develop, market and service high performance computer systems, commonly known as supercomputers. These systems provide capability and capacity far beyond typical mainframe computer systems and

address the world's most challenging computing problems for government, industry and academia. For scientific applications, the increased need for computing power has been driven by highly challenging problems that can be solved only through numerically intensive computation. Cray systems are used to design safer vehicles, create new materials, discover life-saving drugs, predict severe weather and climate change, analyze complex data structures, safeguard national security, and a host of other applications that benefit humanity by advancing the frontiers of science and engineering.

The recently introduced Cray X1 TM supercomputer is available with up to 52.4 trillion calculations per second of peak computing power and 65.5 terabytes of memory. The high-efficiency, extreme-performance system is aimed at the critical computing needs of classified and unclassified government, academic research, and the weather-environmental, automotive, aerospace, chemical and pharmaceutical markets. Cray has accepted the challenge, as stated in a 1999 report of the President's Information Technology Advisory Committee, to provide actual, sustained (not merely "theoretical peak") petaflop computing speed—1,000 trillion calculations per second—for critical next-generation applications by 2010. The Cray X1 system represents a major milestone on the path to reaching this goal of delivering a supercomputer capable of sustained petaflops speeds on a variety of challenging applications.

Supercomputing Requirements for Life Sciences

Cray systems provide a powerful platform on which software applications can be developed and run to handle leading-edge problems being pursued by life scientists today: from processing and analyzing large volumes of data to handling increasing levels of complexity introduced by higher levels of abstraction.

The life sciences industry is just beginning to embrace the tremendous benefits that computational power can bring to advancing their efforts. The mapping of the human genome was just the beginning of a new era in drug discovery and development. With advances in laboratory technology like high-throughput sequencing, x-ray crystallography, NMR structure determination, micro-arrays, and mass spectrometry, the field is experiencing a deluge of data. The amount of data being generated is growing faster than Moore's Law, creating terabytes of information today and rapidly moving to petabytes. The true value of this information is not in the data itself, but what we do with it. In order to effectively process this amount of data, application performance must move into the teraflop and petaflop range. This is where high-performance computing and Cray Inc. play a key role. Teraflop (trillions of calculations per second)—and in the near future, petaflop (thousands of trillions of calculations per second)—computing is a crucial ingredient to advances in modern biology and Cray is, and always has been, an acknowledged leader in high-performance supercomputing.

Today, the industry is working with a handful of genomes, generated at a high cost. To date, there are genomes available for seven major organisms. And with a current sequencing rate of 60 billion base pairs per year, it is expected that there will be 50 to 100 in the next five years. Lab sequencing technology is rapidly advancing which will allow not only higher throughput, but also lower cost. Today we have one human genome mapped—the future promises the ability to rapidly and inexpensively process individual human genomes. Better life science research and drug discovery and development will come from the ability to examine not one, but many genomes. But computational boundaries are already stressed in dealing with the comparison and manipulation of a few genomes, needed to decode and understand their components and functions. Running an analysis with hundreds or thousands of human genomes will be a supercomputing application.

The impact of high-performance computing on the industry is even more profound when you look beyond genomics. With genomics, we can determine the DNA sequence of an organism or animal/human. But DNA is just the information carrier—proteins are the structural and functional molecules within a cell. Understanding under what conditions proteins are produced by a cell, what their functions are, and how they interact is key to understanding how diseases are manifested as well as how best to fight them. This area of computational biology holds the greatest promise for impact on the drug discovery and design process. Teraflop and petaflop computing is required to support such areas as molecular modeling, rational drug design, structure prediction and structural genomics. For example, current applications can only support simulations of small molecules (hundreds of base pairs) and for relatively short periods of time (picoseconds). But the ability to simulate large molecules or sets of molecules (thousands of base pairs) for longer periods of time (microseconds) is required to support the drug discovery process and crucial to support systems biology.

The ultimate goal is to utilize computer applications to understand life beginning at the cellular level and ultimately develop models of whole organisms. The complexity of these simulations—from data volume to variations in simulation time scales—will require well-balanced and highly efficient computer systems. It is only through supercomputing vendors like Cray, focused on these extreme requirements, that these systems will be available.

Advancement Through Collaborations

Cray's high-performance computing systems are used by research institutes, government laboratories and universities throughout the world to support projects focused on advanced computational biology.

The advances and innovations produced by these organizations will ultimately be moved into the commercial biotech and pharmaceutical industries, allowing them to reduce drug discovery and development time, decrease overall drug discovery cost and create more effective and safer medicines.

Organizations like Oak Ridge National Laboratory, Sandia National Laboratories, Pacific Northwest National Laboratory and the Arctic Region Supercomputing Center all have significant research efforts targeted at advanced computational biology. All expect that the level of investment by their organizations in the area of biotechnology will continue to increase.

A good example of the type of work these organizations are involved in is the Genomes-to-Life program under the Department of Energy.

Oak Ridge National Laboratory and Sandia National Laboratories, both significant Cray customers, are working with nine other institutions on a $19.1M project under the Genomes-To-Life program. This particular project, titled "Carbon Sequestration in Synechococcu Sp.: From Molecular Machines to Hierarchical Modeling," focuses on developing new algorithms, simulation methods, software, and computing infrastructures for computational biology applications. The team will develop and apply experimental and computational methods to understand proteins, protein-protein interactions and the gene regulatory networks that control the production of these proteins. They will prototype these capabilities on Synechococcus, a marine micro-organism which plays a significant role in the earth's carbon cycle.

Cray has also facilitated multiple collaborations around the world to provide high-performance computing expertise to researchers developing new life science applications as well as work with experts in the field to enhance Cray's product offering in support of application development work. One such collaboration is with the Arctic Region Supercomputing Center in Fairbanks, Alaska and the Institute for Systems Biology in Seattle, Washington. This collaboration has resulted in support for enhancements to the Cray Bio-informatics Library, a library of routines to perform searching, sorting, alignment, and low-level bit-manipulation operations useful in the analysis of nucleotide and amino acid sequence data.

Commercial Adoption

We are just beginning to see the early adoption of computational biology in the commercial sector.

Early demonstration of the impact of supercomputing on actual drug development and discovery is on the horizon. A prime example of this achievement is BioNumerik Pharmaceuticals, a company focused on the discovery and development of agents for the treatment of patients with cancer and a key Cray customer.

BioNumerik has been a Cray customer for several years, and received a Cray SV1TM system in December of 2000. They have been utilizing the system to model and simulate molecular systems at a scale and speed unattainable with other systems. Their approach demonstrates the significant impact that supercomputing can have on the drug discovery and development process by providing a means to assess the efficacy and safety of new drugs before the expense and time of clinical trials.

BioNumerik's founder and CEO, Dr. Fred Hausheer, believes that his "mechanism-based" drug discovery can be effectively used to cut the overall drug discovery time. "Mechanism-based" drug discovery utilizes a combination of chemistry, biology, and quantum physics to identify and simulate the mechanisms by which potential drugs and their targets interact. Using high-performance computing technology, these simulations can be turned rapidly, allowing for quick iterations not possible in a lab environment. This predictive approach allows for focus on drug candidates that have a higher likelihood for success, thus eliminating some expensive and ultimately unsuccessful lab testing.

Dr. Hausheer is on his way to proving this theory with BioNumerik's BNP7787 product candidate, currently in Phase III clinical trials. BNP7787 was developed to prevent the damaging side effects associated with widely used cancer drugs, allowing for higher dosage levels leading to greater effectiveness with lower risk.

BioNumerik has two other product candidates in the clinical trial phase: Karenitecin BNP1350 and MDAM.

BioNumerik is a prime example of how Cray systems can be used to develop new computational methods in bioinformatics. The company is an early adopter of computational methods for drug discovery as demonstrated by the investment the company has made in personnel (computational biologists and programmers) as well as computing environments. The application development within BioNumerik is similar to activity within universities and government research labs throughout the world.

Interest level in the methodology behind BioNumerik's success is increasing as their product candidates get closer to approval. With fierce competition in the pharmaceutical industry to bring new drugs to market as quickly and inexpensively as possible, it can be expected that the mainstream commercial pharmaceutical and biotech industries will rapidly move to a proven methodology.

Economic Development

Computational biology is a multi-disciplinary field that will require teraflop and ultimately petaflop computing platforms as well as advanced software applications. New tools and methods are being developed within universities and research labs today and once proven, will rapidly move to support the commercial industries.

Historically, all examples of rapid growth in job creation have occurred when you have a critical mass of different skills in one geographic location. The Pacific Northwest has the basis for creating such an environment for biotechnology. The region has several prominent research facilities like the Fred Hutchison Cancer Research Center and the Institute for Systems Biology, high-performance computing facilities like Pacific Northwest National Laboratory and the Arctic Region Supercomputing Center, an academic source of students and researchers at the University of Washington and other Northwest institutions to provide the necessary educated workforce, and high-performance computing experts like Cray Inc.

Continued investment in these anchor organizations can create a biotechnology hub through the synergies that are more easily developed through close physical proximity and interaction.

Summary

The field of life sciences, affecting everything from drug discovery and development to agriculture and national security, is going through a revolutionary change which requires a more tightly integrated set of disciplines: biology, computer science, and computer engineering. Recent technological advancements are creating data at rates that exceed current processing capabilities. Teraflop to petaflop computing has become critical to the advancement of biology—from drug development and discovery to agriculture and national security.

Cray Inc., the premier provider of supercomputing solutions for the most challenging technical problems, is positioned to provide the computing platform on which advanced application software development to meet the demanding needs of biotechnology can occur. Together with research institutes, government laboratories and universities, advanced life sciences applications can be developed, proven, and launched into full commercial use to support higher productivity in the pharmaceutical and biotech marketplace.

In the Pacific Northwest, there is an abundance of organizations which together provide all of the necessary components to build a geographic center of excellence in biotechnology. Cray Inc.'s supercomputing technology supports this vision with its track record of providing supercomputing power for challenging scientific problems.

Senator CANTWELL. Thank you.

Dr. Overell?

STATEMENT OF ROBERT W. OVERELL, PH.D., GENERAL PARTNER, FRAZIER HEALTHCARE VENTURES

Dr. OVERELL. Well, Senator Cantwell and Senator Wyden, thank you for your indulgence on these points. I think they are of great importance to the region as well as nationally. We are a healthcare venture capital group. We have been in business for over 10 years. We invest in seed stage companies as well as later stage of private investment, so we can speak with some conviction about the forma-

tion as well as financing of private biotechnology and medical device companies.

We have been involved in about 15 companies locally, including Bruce's company, ZymoGenetics. And many of the people here at Frazier were from Immunex originally, so we have got a lot of operating experience. We invest nationally, and about 15 percent of our investments are in the Seattle area.

I thought it would be helpful to stand back and ask the question why we or any other venture capital group invests in biotech. And I think it is helpful to stand back and ask that question, and obviously it goes back to the tremendous morbidity and mortality that is associated with disease that today is intractable to drug therapy. So this costs the economy, you know, hundreds of billions of dollars a year, and there is really a dire need for new medicines.

Second, the pharmaceutical industry needs drugs to fuel its pipeline. About half of those drugs, it turns out, are actually licensed by pharmaceutical companies. They do not come out of their internal research and development, and finally drug development is hard. It has about a 95 to 97 percent failure rate.

So the biotechnology industry really has the capability to address not only the need for new medicines, but also the need for new technologies. And that is really why investors such as ourselves invest. A point I will come back to later is we should not lose sight of the fact that what we are really investing in here is drugs, and drugs are made of chemicals and chemicals are made by chemists. I would like to come back to that point a little bit later.

We have wonderful top-tier institutions in both Washington and Oregon. We have some of them represented here from Washington State. As has been pointed out, the biotech community has grown dramatically over the last decade, and I am sure it will continue to grow. Many of those institutions and, just as importantly, the people in those institutions can be traced back to either the UW or to the Hutchison.

I believe we now have a critical mass not only of academic research activity in the area, but also commercial activity. We have a large number of public as well as private biotech companies and a lot of experienced executives that are able to go around and found new companies. And that is incredibly important to the region.

Access to capital, I think it is important to point out that there is a large amount of private equity capital that is available for investment in biotech, both locally here in town as well as nationally. In 2001 alone, $5 billion of private equity funds was raised. Our $400 million fund was about 10 percent of that. So the point I am trying to make is there is no shortage of capital for investment in the biotech sector.

I think the dynamic you have in the marketplace and the capital crunch that Senator Cantwell was alluding to earlier really has to do with a market dynamic in which the public market for biotech companies today is relatively weak. There has not been an IPO market since the year 2000–2001 of any significant magnitude, and so venture firms such as ourselves that founded companies in the 1999–2000 time frame are now experiencing difficult follow-on

financings for those companies. And that has had, if you will, a flow-back effect to company formation.

So I think it has really slowed the pace of company formation, and I think that is a national challenge. It is not just a local challenge. Finally the point of company formation is that, I would say, the focus is increasingly on therapeutics.

Academic links are vital to us. Almost all the companies that we found involve either people or technology from academic centers. It is absolutely vital. We have local institutions which are gems and we need to protect them from State budget cuts and fund them well.

I think it is important to realize that some academic areas are more likely to give rise to commercial entities than others. And so I applaud the initiatives that Senator Cantwell and Senator Wyden are sponsoring.

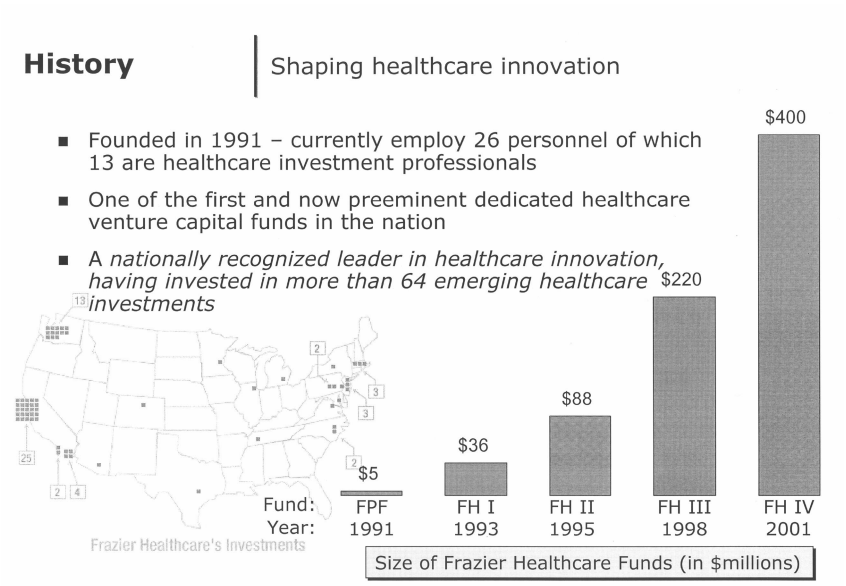
If I had to add anything, I would say that chemistry is incredibly important, and I believe that the integration of biology and chemistry will underpin some very important commercial enterprises, and I would love to see some focused funding in that area locally.

Finally cross-training is very important. And that applies both between chemistry and biology and between the basic sciences of genomics and translocational research.

Thank you for giving me the opportunity to speak here today.

[The prepared statement of Dr. Overell follows:]

PREPARED STATEMENT OF ROBERT W. OVERELL, PH.D., GENERAL PARTNER, FRAZIER HEALTHCARE VENTURES



Biotech Venture Investment Thesis

- There is a dire need for new medicines
- The pharmaceutical industry needs new drugs to fill pipelines
- New tools are needed to reduce the >95% failure rate of drug development
- Independent biotech companies are efficient vehicles for developing new therapeutics and technologies, and can provide good returns for their investors

Pacific Northwest

- Top-tier research institutions in WA and OR
- Biotech community has grown significantly over last two decades – in WA it directly employed 10,800 people in 2001, up 20% from 2000
- The origin of major local biotech companies (Immunex/Amgen, Corixa, Zymogenetics, Rosetta/Merck) was the UW or FHCRC
- We now have a critical mass of academic research and commercial biotech in the region

Access to capital

- Venture investors have raised large funds committed to life science ($5B in 2001)
- The current poor market is resulting in difficult follow-on financings for startups that is slowing the pace of seed investment
- There is a 'flight to quality', with capital being more concentrated in fewer companies
- There is plenty of capital for financing startups with quality innovation in areas of need, in the region and nationally
- The focus is increasingly on Rx

Academic Links

- Academic links are vital to company formation – intellectual property and institutional technology are a key foundation for biotechs' success
- Local institutions are gems: we need to attract and retain top people – and fund them well
- Some academic areas are more likely to spawn commercial entities than others
- All cross-training is critical, but especially between
  - Chemistry and biology
  - Basic science and translational research

Senator CANTWELL. Well, thank you all panelists for those succinct but enlightening remarks about the opportunity before us.

I will just start in with some questions. It sounds like the future looks bright for us, at least from the opportunity perspective of what is already here as far as investment and where we are as far as capital flowing in at least from the Federal level.

It raises a question when you think about the concept of a potential quadrupling of a work force, what do we need to do here to prepare for those opportunities in the Northwest? That is, having been an employer myself and knowing what it is like to have to ship a product and get it out the door, you hire the best skilled work force you can find, and you would love it if they were right here, but sometimes they are not.

And that opportunity of quadrupling sounds very exciting, but how do we make the right investments so that the Northwest reaps the benefit of employing people who are here in those opportunities for the future?

Any one of the brave panelists can answer.

[Laughter.]

Dr. OVERELL. I will take a whack at that. I think if I go back to something Lee said which I agree with is there is a real funding gap between the type of basic sciences going on in institutions and the ability of people like ourselves to really fund ventures that are going to have a solid foundation.

Again, if you have a pool of capital that is committed to making that technology evolve to a point where it can be funded either through ATP grants or some other type of grants, I think that is quite important.

And the second point I would add to Lee's comment is that many of the projects that we see tend to be very biology-oriented, which is good, but, again, unless you have the chemistry involved, you do not have the drug aspect of it, and that is really the missing component on a large number of them.

Dr. CARTER. I think it is very important that the INS allows people like Bob and myself into this country.

[Laughter.]

Dr. CARTER. But one of the things that I have heard Paul Ramsey say, and maybe Susan could comment on it, is that while we have a very strong medical school here, we perhaps do not train as many researchers as peer organizations.

Dr. WRAY. Yes, one of the challenges that we have is that we are the only medical school for a five-state area, and so you wind up really having the challenge of how do you grow your academic capabilities enough to supply the industry? And that is a challenge.

BIO has some figures showing that the majority of science Ph.D.s in Washington State are actually hired from outside the state, and that is because we just do not have a big enough university system here to create the needed people to fill those jobs.

So on the academic side, we need to really pump up our universities in their ability to train more people in computer science as well as the biological sciences.

Senator CANTWELL. Well, what can we do to be more creative on that front given that we have faced this dilemma, you know, from a broader perspective being that we have 110,000 dislocated workers and we have so many slots at the educational institutions as controlled by the State budget, but there is a dilemma because you are showing job growth and creation, and yet, yes, I think the INS should definitely let Dr. Carter and Dr. Overell into the State, but we also want the opportunities for people here, and we do not want to be, I think it is 42nd in the country as far as the number of four-year degree people that we graduate. We have to own up to the fact that we have imported this population because of the companies like Microsoft and Amazon and others, and employers would rather hire locally if they could, but how do we grow that?

So part of the problem is that the entity in charge for that expansion is the State, and yet we are pumping in Federal dollars for

the research and development side of it. How do we become more flexible?

Dr. WRAY. Well, certainly Federal support for more buildings on campus would help throughout the nation. The university infrastructure throughout the country has a lot of problems just maintaining the old buildings that they have, and there is no money for that even in the private institutions, as well as the public institutions.

So I know that in the past, there have been NIH grants, there have been DoD monies for actual buildings and infrastructure support, and that would be a good area to look at in terms of how do we grow the building infrastructure so that we can train more students.

Senator CANTWELL. Dr. Hartwell?

Dr. HARTWELL. Just to add one thing, you mentioned the fact that we import a lot of our work force, which is certainly true, and one of the things that is very important to the young, bright people who we try to recruit is education for their children. And although it is not a Federal issue, it is a State issue, the K through 12 education system really needs to be strengthened.

Senator CANTWELL. Anybody else on this subject? Well, I think we need to engage more on it. When I was in the State legislature, we worked with Steve Duzan at Immunex to create the first targeted sector education program on biotechnology at the community college level just to get entry-level people trained in that area because we saw a growth opportunity.

While I think people are well aware of what the educational needs are and the infrastructure needs, we have to figure out a way to free this flow between the State limitations that we now have.

I mean, we cannot allow the quadrupling of the work force and the opportunity in the Puget Sound area to slip away to outside residents just because we cannot figure out how to get that infrastructure funding or educational access question solved. So hopefully we can come back and engage you on more creative ideas.

I am going to turn it over to my colleague Senator Wyden for questions.

Senator WYDEN. Well, all of you have been excellent, and let me start by soliciting your ideas on how Oregon and Washington might be able to work together. I mean, I think when we look at the competition, talk for example about California, you know, we mentioned San Diego, we mentioned Silicon Valley. Oregon has five Members of Congress, I think Washington has something like eight or——

Senator CANTWELL. Nine.

Senator WYDEN. Eight or nine. Okay. So we have 14 in the Pacific Northwest. Together that is less than a third of what they have in the State of California. So clearly in magnifying our voice as a region in Oregon and Washington, a coalition would be helpful.

Do the panelists have any ideas on how Oregon and Washington could team up to enhance our clout?

Mr. ROTTSOLK. It is unfortunate that appropriations do not come from the Senate. Things would be more balanced.

Senator WYDEN. Senator Murray has done an excellent job in that regard. We can certainly use ideas on that front.

Mr. ROTTSOLK. I think you might also consider, you know, there are—the entire Northwest—I do not know if you include Alaska in the Northwest, but it is clearly collaborative efforts that are going to result and be more fruitful than each State going out on its own. Looking—I mean, I should think in order to create a center of excellence, you are going to have to avoid squabbles between relatively small States such as Oregon and Washington are compared to the Californias and New Yorks and Massachusetts.

Senator WYDEN. I do not know of any squabbles. I mean, I would like to see, for example, the Oregon Health Sciences Center and the University of Washington teaming up more. I think that would be an attractive way to take on, for example Harvard and institutions in the East.

Is that going on? Are you all working on any projects?

Everybody is looking at their shoes at this point, and I am curious about whether I am hitting a sore spot or we just have not talked about it or——

Dr. Hartwell?

Dr. HARTWELL. I think we have a lot of respect for our colleagues at the University of Oregon and the Oregon Health Sciences, but we do not see very much of them. And I am just trying to think about why that is, and I think it is really transportation. It is that—you know, it is a long ways. And you see people who are close to you. And, you know, if we had a fast train between here and there, we would see each other more.

Senator WYDEN. Alright. It is sort of hard to think that a two-and-a-half-hour car ride even is the principal obstacle, but certainly Senator Cantwell and I can help on trains as well.

[Laughter.]

Senator WYDEN. We are anxious to do that. It just seems to me that we have got to figure out a way to magnify our clout, to magnify our voice. And if you look at the numbers of Members of Congress and you look at population, for example, alone, you see there are some challenges.

Dr. Hartwell, Bayh-Dole, I am convinced that Bayh-Dole did not work for anybody. I do not think it works for taxpayers who are concerned about the rate of return. I do not think it works for companies that get caught up in the morass of the bureaucracy and red tape, and I think it does not work very well for the universities who are frustrated and would very much like to have more of these partnerships.

Tell me if you could wave your wand over Bayh-Dole, and you mentioned it in your testimony, you could see that I was interested in it, what would you do to improve Bayh-Dole for the big stake holders companies, taxpayers, and universities?

Dr. HARTWELL. Well, I do not feel that I am an expert in this area or have studied it very well, but the thing that I think Bayh-Dole probably has had an effective catalytic role in developing academic research to the commercial sector, but I think we need to make a distinction between things like products and molecules and things that take a lot of money to develop and require investment

and things like methods and reagents and platforms that everybody needs to get their work done.

I think it is a failure to make that distinction that is causing unnecessary problems that the whole system could be helped by.

Senator WYDEN. Others on Bayh-Dole?

Dr. OVERELL. I would like to comment on that because I agree with what Lee is saying, and I think, however, we have to be very careful. The reason we have to be careful is that biotech and medical device companies are able to grow and thrive in large part is because of intellectual property.

So in meeting the needs that Lee is talking about, which I agree with, we have to be very careful that you do not undermine the, if you will, barrier to entry that a biotech or a medical device company has because if you take away that patent protection or you weaken it, you will effectively weaken the market position, and you will thereby weaken the enthusiasm of investors to invest in those companies.

I think I would make a little bit of a different observation with Lee. I do not think it is all technology platforms. I think that is where the problems are. I think there are one or two patents out there, and I do not want to name names, where the patent office has gone a little bit too far, in granting very broad claims.

In other words, somebody has got a very specific technology, and they have been able to get a very broad patent out of that, and, you know, that is a wonderful thing for that company, and if they are willing to license it in a constructive way, then that is positive, but it can have a very dampening effect on new investment in that particular area, and thereby you get whole tracts of new potential technologies that are not receiving private sector investment because of the patent. So I think it is actually a very careful balance that needs to be struck.

Senator WYDEN. Let me just invite the panel, this is an area I have been very interested in and one of the things I would very much like to do in the days ahead is essentially bring the three big areas of interest, you know, groups representing companies, technology companies, groups representing, you know, universities and the various taxpayer groups that have been concerned about the rate of return together for some informal discussions about ways in which we might improve Bayh-Dole.

I would welcome your ideas and suggestions. I chaired a hearing when I ran the Subcommittee in the last session where Hewlett-Packard and others basically said we are washing our hands of Bayh-Dole. It is just too cumbersome, too unwieldy, and we cannot make it work. So we would welcome your ideas and suggestions in that area.

Dr. Overell, the question of access to capital has come up, and you have heard me touch on it earlier with respect to how we get some of the private capital off the sidelines right now.

I mean, there seems to be an awful lot of money just really sitting out there waiting to see perhaps at the end of the war and other developments where our economy is headed. I suggested the idea of some sort of tax forgiveness, you know, for start-ups as a way to encourage risk takers.

Do you have other ideas with respect to how we can speed up the flow of private capital to biotech ventures and other innovation driven, you know, companies that require these risk takers?

Dr. OVERELL. Yes, I think it is a good question. The dynamic of the moment is that the capital—I would say it a little bit differently—is not so much sitting on the sidelines, it is being invested, but it is tending to be invested in established companies. In other words, the balance of investment between seed stage investing and investment in established private companies is shifting more towards the latter and less towards seed stage investment.

I think from the standpoint of the region, it is really the new investment that we need to nurture.

How can we help that? I think there are several things that we can do and potentially not do to nurture it. One of the big problems that we have in our companies is that because of the more stringent criteria that are being applied to investment in the biotech sector, companies are having to focus their programs on typically lead therapeutic programs, they are having to be pushed forward more rapidly, capital is being focused more on those lead programs. One of our companies in particular has been very successful at getting grants from the NIST through the ATP program, and I think that program is enormously important, and anything that can be done to fund through sizable grants inside of companies, things that are not quite ready for private sector investment yet I think can be enormously valuable.

It is a little bit like Lee was saying, it is kind of the other side of the coin from having some kind of fund that academic medical centers can invest. If biotech companies could be started with some kind of a grant that could get the technology to the next level, I think that could be quite important.

The other thing I will say which is not necessarily on point for this meeting, but what we are really talking about here is investment in making drugs. So to the extent we have regulation of prescription drug prices, we need to be very careful. I fully acknowledge all of the issues about being able to pay for medicines and all those types of things, but if you effectively reduce the pricing on drugs, you will cut down on investment in the sector.

Senator WYDEN. Well, the only thing I would say in response to that, having sponsored a major bipartisan prescription drug bill with Senator Olympia Snowe, the Republican Senator from Maine, that uses marketplace forces, it is hard to see how this will not be helpful for the drug companies who have an enormous market with the demographics and economy. So know that we are prepared to work closely with you and work in a bipartisan way on it. And our view is this is a chance for the companies to step up and have an extraordinary market both now and in the days ahead.

Dr. Wray, if I could, just one question for you: I think we need to have a very aggressive push to increase the number of women in math and science coming out of the universities. In 2002, out of the 1.2 million college graduates with degrees in math and hard sciences, 70,000 of them were women, and I think we have got to do better.

Do you have any ideas and suggestions given your having achieved great professional success on how we do that?

Dr. WRAY. Unfortunately I think it does go back to K through 12, as Lee was saying. Having a well-trained work force is important to all of us, and that can only start with the basic education. And certainly having girls and women trained so that they can actually go into the sciences is extremely important.

I know that the University of Washington and other universities have worked hard to get that balance, and, in fact, in some areas such as bioengineering, it is—I have the figures with me, it is surprising how many women have actually been enrolled in those programs. They just have to be mentored. They have to be encouraged.

And not being an education expert, I would not go further than that. But I know that there are studies in the field as to how you do encourage girls to participate in the sciences.

Senator WYDEN. Do you have any idea what the progress is at your program? I would be curious because we are looking for good models.

Dr. WRAY. No, but I know that there has been substantial progress, and I can provide that data to you today.

Senator WYDEN. I would like to have it. Thank you.

Madam Chair?

Senator CANTWELL. I would just note that a couple of weeks ago in Washington, Intel had their annual national science contest that they fund scholarship grants to high school students for science and math projects, and there were 40 finalists throughout the country who were honored at this, and then they selected the top 10 recipients, the number one recipient receiving a $100,000 scholarship to the institution of their choice and the others receiving anywhere from $10,000 to $20,000. But out of the 40 finalists, about 14 of them were women, so we were making some progress, but the best news is that out of the 10 finalists that were selected, that out of the 10, 7 of them were women, and the number one recipient of the $100,000 scholarship was a woman from Florida. So we are making some progress. When we compete, we compete well.

[Laughter.]

Senator CANTWELL. So we just have to increase our numbers. So we will be looking for that.

The sad news to that story, though, is that there were no finalists from Washington or Oregon in that competition, very heavily participated in by the East Coast. And so it may not be one of our foci here in the Northwest, but maybe we should make that Intel program an opportunity for us to catalyze the interest of young women in the Northwest.

Well, I want to thank the panelists for their input and for their ideas today. I want you to know as you are driving around the rest of this week, that we will be keeping our record open, so if something else pops into mind that you want to have officially made part of the record so that we can discuss with our colleagues, we appreciate that. We very much look forward to capitalizing on the opportunity that you see for the Northwest, continuing to make that investment from the Federal level, but also talking about how we can build the bridges on infrastructure and transportation and education that you have pointed out. So thank you very much for being here this morning.

So we will now move to our second panel. If I could have them make their way forward, I will start with their introductions.

The second panel, as I mentioned in my opening comments, is to explore ways in which composite and advanced materials and manufacturing can boost companies and expand our manufacturing base in the Puget Sound area.

We are going to be joined by Dr. Denice Denton from the University of Washington. Dr. Denton is the Dean of the College of Engineering and will testify not only to the University of Washington's lead in this particular area, but what our region is doing as a whole.

Believe it or not, I am going to keep talking because this is the way we get this done. Also we are going to be joined by Dr. Frank Statkus, Boeing's vice president of technology, and he will be discussing the important role of advanced materials.

Peter Janicki is the head of Janicki Industries and is specializing in advanced materials for aerospace, marine and transportation companies. Nona Larson is the senior technologist from PACCAR. Ms. Larson is responsible for the development of material standards and research in advanced cohesives and coatings.

And Rich Rutkowski is the CEO of Microvision and will talk about the collaborative efforts between academic institutions and private industries.

So as our panelists are moving up here, I am going to ask people who have questions and comments for your colleagues that are in the audience, if you can move those comments and discussions out into the hall, that would be helpful to us this morning before we get started.

Again, I want to thank our panelists for being here this morning and, again, apologize for our tight schedule, but this is the way we get this done in Washington, and we are very appreciative that you are spending your time with us this morning.

Obviously, manufacturing employs about 300,000 Washingtonians, but we know that those Washingtonians are facing some serious challenges. So part of this morning's panel was to talk about ways in which we can grow jobs in the future or better maybe yet to say "Keep jobs in this particular area of manufacturing by being aggressive about the type of investment in research and development and the investment that needs to be made so that we can continue to capitalize on the new materials that might be used in manufacturing."

This is something particularly important in aviation, but in my travels around the State, I am finding that it is an important aspect of material development in a whole variety of areas. I see no reason why we in the Northwest should not play a leadership role in this particular area.

So, Dr. Denton, we are going to start with you and thank you for being here.

STATEMENT OF DR. DENICE D. DENTON, DEAN, COLLEGE OF ENGINEERING, UNIVERSITY OF WASHINGTON

Dr. DENTON. Thank you for the opportunity to comment on these very important issues. I will first describe the role of higher ed vis-a-vis advanced manufacturing in the Pacific Northwest and then

describe the use of composite materials in manufacturing, and I will close with some comments on the impact of composites on the aerospace industry.

The Pacific Northwest has a long history of excellence in manufacturing. In order to continue this excellence, we must ensure that there is a steady supply of technicians, scientists and engineers to do the basic research required and the design and manufacturing work that are essential to economic development and stability in the region.

Higher education in the State of Washington plays a key role in ensuring that advanced manufacturing in the region thrives. First, we educate the technical work force, and, second, we generate the research and development that undergird advances in the field. And you heard a lot about the research activities at UW and WSU in the previous panel.

The UW produces 800 bachelors degrees and 400 advanced degrees in engineering and computer sciences each year. There are very strong research efforts at UW and WSU and, in addition, the Washington Technology Center or WTC plays an important role statewide with respect to advanced manufacturing.

The WTC helps Washington companies overcome the technical challenges of product development by linking them with the scientific and engineering resources of the State's universities.

Let me say a few words about composite materials and advanced manufacturing. They will play a key role in manufacturing in the Pacific Northwest. The WTC, UW and WSU have partnered with firms in the Pacific Northwest who are developing composite materials for applications in road construction, body armor, construction materials and recreational equipment.

In the past three years, the WTC has awarded over $1.6 million of State money in advanced materials and manufacturing projects. Other applications involving composites include micro-electronic device fabrication, filtration technologies, photonic materials for telecom and display and fabric treatment for biochemical threat protection.

One of the fastest-growing areas of advanced materials development in the Northwest is micro-electromechanical systems or MEMS. The WTC, WSU and UW have clean room facilities that are larger than 15,000 square feet, and the WTC's facilities are used by 35 companies for manufacturing applications such as fuel cells, image display and acquisition systems, artificial muscles, optical switches for photonics, biochips, cardiovascular implants, fuel delivery systems for aircraft engines, water purity monitors, Anthrax and other bio-agent detectors and medical devices.

The growing interest in nanotechnology research and development has created the UW's Center for Nanotech which has the Nation's first Ph.D. program in the field. Joint programs between the Center for Nanotech and the Pacific Northwest National Labs have an immediate focus on advanced materials for biomedical and environmental applications and will be extended to include programs in lighter, stronger aerospace materials utilizing self-assembly techniques.

Let me switch now to the use of composites in the commercial aircraft industry. The use of structural composites in commercial

transport aircraft is expanding rapidly. For example, the entire tail section of a Boeing 777 is produced using polymeric composites. The 777 tail section is the largest composite structure ever used in a Boeing transport aircraft. Structural composites will be used to an even greater extent in the Boeing 7E7.

At the same time, there are remaining concerns regarding the durability and maintainability of composite structures following long-term exposure to the low-temperature moisture cycles encountered by a commercial transport aircraft.

Further research is needed to fully explore the implication of aging composite structures so as to ensure long-term safety of aircraft composites. The UW is heavily involved in structural composite research used in the aerospace industry.

You have heard from Senator Cantwell that she has proposed legislation for a new center of excellence devoted to the use of advanced materials in transport aircraft that will be established in the Pacific Northwest. The founding members of the center would include the University of Washington, WSU, Oregon State and Edmonds Community College. The center personnel would be involved in research, education and technology transfer, and this center would play a key role in ensuring the Northwest's leadership position in manufacturing.

In closing, in order to ensure that advanced manufacturing in Washington State continues to thrive, we must also continue to educate the work force of the future and carry out the research needed to move manufacturing processes to the next level of competitiveness.

It is essential that the Federal Government continue to fund research in key areas relevant to manufacturing such as the development of advanced composite materials.

In addition, the State must provide additional resources to higher ed to educate students in the applied sciences, engineering and technology. We also need additional support for the recruitment and retention of prospective students, particularly those from under-represented groups, especially women and people of color.

The demographics of our State and our Nation are changing, but the demographics of our faculty and student bodies do not reflect this change around the country.

Senator Wyden has proposed that Title IX be used as a tool to increase the numbers of women in the sciences and engineering. This is one key mechanism to accelerate the required demographic shift nationally among those who study and teach in these disciplines.

The College of Engineering at the UW has a strong focus on and commitment to enhancing the ethnic and gender diversity of our student body and faculty, and we will continue to provide national leadership in this essential arena. For example, our faculty in engineering is 15 percent women. You might guess what that would be around the country at peer universities. It is only 4 to 8 percent nationally. So we are more than double and in some cases triple that peer group.

In closing, there is no doubt that the Pacific Northwest can continue to lead the Nation and the world in advanced manufacturing, but it will require a strategic partnership of the public and private

sectors, including local, State and Federal Government, K–12, higher ed and the corporate sector.

The proposed FAA Center of Excellence in advanced materials for transport aircraft is one very important component of this strategic partnership. Thank you.

[The prepared statement of Dr. Denton follows:]

PREPARED STATEMENT OF DENICE D. DENTON, DEAN, COLLEGE OF ENGINEERING, UNIVERSITY OF WASHINGTON

Introduction. The Pacific Northwest has a long history of excellence in manufacturing. In order to continue this excellence, we must ensure that there is a steady supply of technicians, scientists and engineers to do the basic research required design and manufacturing work that are essential to economic development and stability in the region.

Higher education in the State of Washington plays a key role in ensuring that advanced manufacturing in the region thrives. First, we educate the technical workforce and second, we generate the research and development that under gird advances in the field. The University of Washington (UW) is a leader in both of these arenas in that we produce 800 bachelors degrees and 400 advanced degrees in engineering and computer sciences each year. We also have a very strong effort in the research disciplines that support manufacturing in the region. Washington State University (WSU) is also a key contributor to this effort.

The Washington Technology Center (WTC) plays an important role state-wide with respect to advanced manufacturing. It is a state science and technology organization that helps Washington companies overcome the technical challenges of product development by linking them with the scientific and engineering resources of the state's universities. The WTC funds and fosters industry-university collaborations and connects entrepreneurs and scientists who often need each other to bring commercially promising ideas to fruition

Composite Materials in Advanced Manufacturing. Composite materials will play a key role in manufacturing in the Pacific Northwest. The WTC, UW and WSU have partnered with firms in the Pacific Northwest who are developing composite materials for applications in:

- Road construction
- Body armor
- Construction materials (e.g., replacement of forest product-based lumber)
- Recreational equipment (aluminum metal matrix bicycle wheels, laminated baseball bats).

In the past three years, the WTC has awarded over $1.6 million of state money and over $2 million of private industry money in advanced materials and manufacturing projects. In addition to projects in the composite materials areas mentioned above, other applications include:

- Micro-electronic device fabrication and packaging materials
- Filtration technologies (for internal combustion engine exhaust or purification of drinking water, for example)
- Photonic materials for telecommunication and display technologies
- Fabric treatment for bio-chemical threat protection.

One of the fastest growing areas of advanced materials development in the Northwest is micro-electromechanical systems (MEMS). The WTC's 15K sq. ft. user-supported cleanroom provides a full range of processing and characterization capabilities to academic and industrial users involved in the research, development and early stage manufacturing of MEMS products. Over 200 users from 40 different university research groups and 35 companies rely on these facilities to develop advanced materials and manufacturing methodology for application in such diverse fields as:

- Fuel cells
- Image display and acquisition systems
- Artificial muscles
- Optical switches and other devices for photonics-based telecommunications
- Biochips

- Cardiovascular implants
- Fuel delivery systems for aircraft engines
- Water purity monitors
- Anthrax and other bio-agent detectors
- Medical devices.

The growing interest in nanotechnology research and development has created the UW's Center for Nanotechnology, with the nation's first Ph.D. program in this field. Joint programs between the Center for Nanotechnology and Pacific Northwest National Laboratories have an immediate focus on advanced materials for biomedical and environmental applications, and will be extended to include programs in lighter, stronger aerospace materials utilizing self-assembly techniques. A proposal is being presented to the state's congressional delegation to further identify, quantify, and validate the State's economic development opportunity in micro and nanotechnology.

Commercial Aircraft Industry. The use of structural composites in commercial transport aircraft is expanding rapidly. For example, the entire tail section (i.e., the "empennage") of a Boeing 777 is produced using polymeric composites. The 777 empennage is the largest composite structure ever used in a Boeing transport aircraft. It is a virtual certainty that structural composites will be utilized to an even greater extent in the new Boeing 7E7. The expanding use of composites is the direct result of research performed throughout the 1970–1990 time frame at many institutions worldwide, not least of which was the University of Washington.

At the same time, there are nagging concerns regarding the durability and maintainability of composites structures following long-term exposure to the load/temperature/moisture cycles encountered by a commercial transport aircraft. Since these materials are relatively new, practical experience with composite aircraft structures over long-times simply does not exist. Consider that the Boeing 777 began revenue service with United Airlines in 1995, or only about 8 years ago. In contrast, the service life of a transport aircraft usually exceeds 25 years. Under these circumstances the durability of composite structures will naturally be suspect following any serious airliner accident for the next decade or two. This point is illustrated by the tragic crash of American Airlines flight 587, which occurred near New York City in November 2001. The aircraft involved was an Airbus model A300–600. The vertical stabilizer on this aircraft, a large graphite-epoxy composite structure, broke off nearly intact in mid-air just prior to the crash. There were initial suspicions that the crash had been caused by the failure of this composite structure, and these suspicions were widely reported in the public media. Results from subsequent investigations by the FAA, NASA, and others indicate that failure of the vertical stabilizer was not the root cause of the accident. Still, many issues involving aging or damaged composite structures were uncovered during the investigation of this accident. Further research is needed to fully explore the implication of aging composite structures, so as to ensure long-term safety of aircraft composite structures.

Faculty and students at the University of Washington remain heavily involved in structural composite research used in the aerospace industry. Senator Maria Cantwell will propose legislation for a new Center of Excellence devoted to the use of advanced materials in transport aircraft that will be established in the Pacific Northwest. Founding academic members of the center would include the University of Washington, Washington State University, Oregon State University, and Edmonds Community College. Center personnel will be involved in three main activities: research, education, and technology transfer. The integrated result of these activities will be to help ensure that structures used in the transport aircraft fleet operating within the USA continue to be safe and reliable.

Summary. In order to ensure that advanced manufacturing in Washington state continues to thrive, we must continue to educate the workforce of the future and carry out the research needed to move manufacturing processes to the next level of competitiveness. It is essential that the Federal Government continue to fund research in key areas relevant to manufacturing such as the development of advanced composite materials. In addition, the state must provide additional resources to higher education to educate students in the applied sciences, engineering and technology. This will also require additional support for recruitment and retention of prospective students, particularly those from under-represented groups, especially women and people of color. The demographics of our state and our nation are changing, but the demographics of the faculty and student bodies do not reflect this change. Senator Wyden has proposed that Title IX be used as a tool to increase the numbers of women in the sciences and engineering. This may be necessary to accelerate the required demographic shift nationally among those who study and teach

in these disciplines. The College of Engineering at the UW has a strong focus on and commitment to enhancing the ethnic and gender diversity of our student body and faculty and we will continue to provide national leadership in this essential area.

In closing, there is no doubt that the Pacific Northwest can continue to lead the nation and the world in advanced manufacturing, but it will require a strategic partnership of the public and private sectors including local, state and Federal Government, K–12, higher education and the corporate sector. The proposed Center of Excellence in advanced composite materials is one very important component of this strategic partnership.

Senator CANTWELL. Thank you.

Mr. Statkus?

STATEMENT OF FRANK D. STATKUS, VICE PRESIDENT FOR TECHNOLOGY, THE BOEING COMPANY

Mr. STATKUS. Good morning, Senators. I appreciate the opportunity to talk to you about advanced materials today and provide that for the record. I have made a statement. I will just summarize that statement.

About 100 years ago on the other side of this continent, a place called Kill Devil Hills, Kitty Hawk, North Carolina, there was a couple of brothers, and they had set out on a path to try to find a way to handle manned aircraft flight.

The first thing that they had to learn, of course, and they knew this, was something about aerodynamics, what made lift, so they worked that in their wind tunnels.

They decided that control would be the third thing they needed to learn because they did not have any reason to search for those answers until they had an airplane that could fly.

So the second thing they worried about was materials. Materials was important then because the aerodynamics that they knew suggested that the materials had to be extremely light and strong. The things that they have learned and the impetus for development of new materials through research and development, that remains today. And in those hundred years, we have improved those materials through research and development, associated research with organizations, universities, other industries to the point where we have the capability now to produce some of the best aircraft in the world.

I want to take just a couple of minutes to talk to you about the next best airplane and the relationship of the needs and values of that airplane to materials development today and in the future.

When the Wright brothers were worrying about Sitka spruce and white ash and Irish linen, those were their composites of the time and those provided them the strength-to-weight ratios that they needed to fly.

Today competitiveness in our business is measured in not just the performance of the product, but the cost of the product. And that performance of the product can be measured in the weight, can be measured in the payload, it can be measured in the performance of engines, but generally to the customers that we serve, it is measured in the economic value of that product.

First and foremost, the economic value of these products is predicated on how well you have done in achieving the development of the kind of materials that would provide you that performance and

give you that weight advantage and allow your customers to carry either more passengers or more payload. It will allow the performance of engines with specific fuel consumptions to drive those airplanes further because they are lighter.

So the technologies of the materials we talk about today are a lot about the most advanced composites, the most advanced aluminum alloys, the most advanced titanium alloys, refractory kind of metals. It is all about finding the kind of material that you could put in an airplane today that absolutely provides the competitive advantage for both you and your customers.

If we are intent on making sure that the Great Northwest continues to build these best airplanes and continues to carry on heritages of folks like the Wright brothers, we had better first make sure that we are capable of providing the kind of materials technology in general that would allow you to continue to do that.

It pleases me to no end that folks like the Senators have taken this effort on in detail. It is absolutely critical that in the Northwest we not just have capable institutions, but we have capable people ready to take on those kinds of tasks that would allow industries like the Boeing Company to be competitive for the next 100 years. Thank you.

[The prepared statement of Mr. Statkus follows:]

PREPARED STATEMENT OF FRANK D. STATKUS, VICE PRESIDENT FOR TECHNOLOGY, THE BOEING COMPANY

I appreciate this opportunity to discuss the value of new material forms on behalf of The Boeing Company and our new commercial product development activity, the 7E7. Over time, improvement in material forms together with the development of new materials and their applications have been the basis for continuing benefits to commercial aviation platforms. My personal background in composite and metal alloy development in this industry spans approximately 30 years. My composite work has involved graphite epoxies, various toughened Thermoset materials and also thermoplastics. Metals development for material forms and applications has involved titanium alloys, stainless steels, and more recently, newer aluminum alloy development and application. I believe the importance of material improvements and development in support of new airplane programs to improve capability and competitive value has not diminished over time. On the contrary, The Boeing Company continues to increase its reliance on new and improved material forms as we improve airplane capabilities for our customers. As a leading developer for commercial airplanes, Boeing expects 30 percent or more of the improvements made to airplane efficiency and performance to come from new materials and their applications, and every product we develop relies on a greater percentage of applied, improved material forms. Research and development, with regard to material forms, is not limited to Boeing labs or other Boeing resources, but is an amalgamation of results from private and public research labs, related industry research, and government sponsored state of the art programs. Research funding directed toward local institutions with state of the art labs and staff is a very positive step toward improving statewide capability for new materials development. As the future competitiveness of our products increasingly rely on the values and benefits of the newest materials, these investments help provide the foundation for a technically competitive great northwest.

Senator CANTWELL. Thank you, Mr. Statkus.

Mr. Janicki?

STATEMENT OF PETER JANICKI, JANICKI INDUSTRIES

Mr. JANICKI. Thank you. About in the time of the Civil War——

Senator CANTWELL. Peter, you might have to move that a little bit closer to you.

Mr. JANICKI. During the time of the Civil War, coal miners would go into these big coal mines after they had set dynamite in there, and as they walked in, they would see these carbon strings hanging from the ceiling. They could not break them, they did not know what they were, but they knew they were very, very strong, and that was the first time that anyone had ever created carbon fiber.

Another gentleman a little bit later on actually learned how to synthesize this. Thomas Edison created a carbon fiber in the creation of his light bulb. He did not really know what it was, but he knew that it could go to 5,000 degrees Fahrenheit and not fall apart.

In the 1960s, they first figured out how to synthesize carbon fiber for production, which was a big deal, and a carbon fiber laminate made with epoxy resins can be stronger than the very best steel and at one-fifth the weight. So it is an incredible material. But in 1960, it cost $200 a pound for carbon fiber, and so it was used only in the most exotic applications.

The next big step in that technology was the creation of the B2 bomber. That was the first all-composite airplane. I think the reason they called it a B2 was because it cost $2 billion.

[Laughter.]

Mr. JANICKI. I do not know. But it was a very expensive airplane.

Over a period of time, I think last year I was buying carbon fiber for about $20 a pound, today it is $15 a pound, and they are predicting by sometime in the next two years, that it will be $3 a pound.

So we are looking at the same kind of thing that happened in the computer industry where computer chips were so expensive that only IBM mainframes were made from them. Nobody ever predicted or ever thought that you could produce a PC for $1,000.

Well, that is where the composite industry is going. It is going to happen and someplace on God's green earth is where this technology is going to find a home, just like Detroit is the home of the automobile, Pittsburgh is the home of metal, Bellevue happens to be the home of the software industry, and I think the last time I said this, Maria told me Redmond was the center.

[Laughter.]

Mr. JANICKI. The bottom line is some place on earth is going to be this technology center from which composites become home. And what I like to call it is critical mass. I heard some of the people earlier today talk about groupings, they called it. I call it critical mass. You have to have—I think Albert Einstein is the first one came up with that term when he was creating nuclear energy, they said that if you do not have enough mass, the thing will never, ever do anything. But as you get over a certain mass of fuel, it explodes into something as brilliant as the sun.

Well, that is where we are here. The State of Washington is leading that technology, not just with Boeing, although Boeing is a major player, the marine industry, the recreational industry, all kinds of areas are utilizing composite technology.

But we need a big push. An example that I have is there is a company right next door to me, and they know me because they are next door to me. And they build—the name of the company is Team Corporation, and what Team Corporation builds is vibration equip-

ment where they have these tables that shake in different directions for a multitude of different applications, and they sell their product worldwide.

Well, with vibration equipment, you need the table to be very lightweight and very, very stiff. And they have competitors like everyone else and they struggle against their competitors.

But because I am next door, and they know me, they walked into our building, and we figured out how to create—all the other tables in the world are made with metal. They are made out of magnesium. We created a table for them out of carbon fiber. That carbon fiber table will give them more than two-and-a-half times the performance of anybody else in the world.

So now all of a sudden Team Corporation which was struggling to survive is going to explode, okay, but it is just me and it is them. And I see—bear with me on my lack of knowledge with the universities, but when I went to the universities, composites were either not talked about or were a very, very small part. There was whole departments about metal and metal technology and how you test it, how you know if it is going to work, how it is going to fatigue over many, many years. I mean, it was so mature. In the metals technology, you know, they started building steam locomotives in 1830. That is a very, very mature technology.

With composites, we are looking at a baby. This thing is in its infancy. I meet on a daily basis with engineers from a multitude of technologies of different industries. None of them went to college and studied composites. We have all learned it since we got out of school.

So I am really glad to see that the universities are coming on, but there is a huge, huge gap in goal from the educational side, particularly higher, higher education, the very top, the people that write the books that say how we do this stuff, there is a big gap there.

Once we create jobs in the composite technology, what I find the most inspiring about this particular area is that you talk about 100,000 unemployed, well, the problem with that 100,000 is they are very diverse. You have some highly educated, highly intelligent individuals all the way down the spectrum. And when you create jobs in composite technology, you are creating jobs for everyone.

When you look at somebody that is manufacturing composites, they have really top engineers, they have chemists, they have a whole spectrum of people on the high end, and then you have people actually building the product who have very little education that are putting parts together, they are fitting things, so it employs everybody, and it is a neat area to expand into.

Senator CANTWELL. Thank you very much.

Ms. Larson?

STATEMENT OF NONA LARSON, SENIOR MATERIALS ENGINEER, PACCAR TECHNICAL CENTER

Ms. LARSON. Good morning everyone. My name is Nona Larson, and I am a senior materials engineer at the PACCAR Technical Center which is in Mount Vernon (WA). Thank you for inviting PACCAR to participate in this hearing. We appreciate the opportunity to talk about some of the advanced materials we use on our

trucks. The technical center provides materials expertise to PACCAR's worldwide truck brands, including Kenworth and Peterbilt in North America and DAF and Foden in Europe.

PACCAR products are used in a broad range of applications, from long distance hauling, regional and local deliveries, refuse collection and heavy construction. Last year, PACCAR produced 92,000 trucks worldwide.

PACCAR is recognized as the technological leader in our industry for use of electronics, aerodynamic design and innovative use of materials. Composites play an important role in medium and heavy-duty trucks. The lighter weight when compared to metals improve vehicle fuel economy and performance. For example, a 1,000-pound weight savings will save at least $350 per year in fuel costs for a truck. Weight savings are also important as many operators can carry more goods which results in greater revenue. As a result, customers place a value in dollars for each pound of weight that advance composites can save.

The formability benefits allow more complex shapes for better aerodynamic performance and styling options. Aerodynamic performance is important because it improves fuel economy, reducing the fuel consumed by the truck, which is an important strategic goal for our country.

PACCAR's T600, the first aerodynamic truck on the market, resulted in a fuel consumption savings of 22 percent through a number of design changes which include greater use of composites on exterior aerodynamic surfaces. The T600 received the 1995 Department of Transportation award for advancement of Motor Vehicle Research and Development.

In the 1950s, we started using composites to produce parts with shapes difficult or impossible to build out of metal. By the 1980s, the majority of our roofs and hoods were composite. Currently the exterior surface of our trucks range from 20 to 40 percent composites depending on the truck model.

Because these advanced materials can be molded precisely, they give us the additional advantage of more consistent parts which lend themselves to robotic assembly methods. The cabs of our two newest truck models are assembled robotically. This improves the quality and durability of our trucks, making them a better value for our customers.

The improved part properties of advanced composites include smoother appearance and the ability to optimize weight and strength resulting in more durable, cost-effective parts.

Our customers typically run their trucks 120,000 miles per year for well over a million miles in the lifetime of a truck, so those composites we use on our parts must be very strong.

Additional properties advanced composites provide are conductivity and molded-in color options. Our customers request many different colors of paint each year, making the development of viable in-mold color attractive. Both conductivity and molded-in color reduce the amount of paint used on our trucks, thus reducing emissions from our plants.

Two of our most recent Class 8 truck models, the Kenworth T2000 and the Peterbilt 387 make extensive use of composites. For

example, both trucks use SMC for doors, door openings and the firewall which separates the cab from the engine compartment.

The T2000 roof is the largest SMC part ever molded for a production application. The tool for this part weighs 30,000 pounds and would fill a two-car garage. The floor material is also very unique. It uses a vinyl ester skin and a balsa wood core. This gives you maximum strength with minimum weight.

This technology is also used in the aerospace industry, so this is an example of where developing these materials can benefit both industries.

We have active projects with State universities, including the Virtual Reality Technology Consortium with Washington State University. This consortium is working on developing virtual reality tools for improving manufacturing efficiencies and ergonomics.

We share materials and research projects with Western Washington University. A couple of examples of completed projects include a recyclability project for thermoplastic forming and a project on building composite suspension parts. The PACCAR foundation also provides an endowment to the University of Washington to fund the PACCAR Professorship in the College of Engineering.

We have active material development cost-share projects with the Government. These projects range from forming new materials to commercializing potential assembly methods. We fully support the continuing cooperation of Government and industry in the development of new material technologies.

We recognize the universities and national laboratories as excellent sources of basic research. This research, when developed with input from private industry regarding viability and commercialization, should be a significant asset to both the trucking industry and the industries we serve. Thank you for your attention.

[The prepared statement of Ms. Larson follows:]

PREPARED STATEMENT OF NONA LARSON, SENIOR MATERIALS ENGINEER, PACCAR TECHNICAL CENTER

Good morning everyone. My name is Nona Larson, and I am a Sr. Materials Engineer at the PACCAR Technical Center which is located in Mount Vernon, Washington.

Thank you for inviting PACCAR Inc. to participate in this field hearing. We appreciate the opportunity to talk about some of the advanced materials we use on our trucks. The Technical Center provides materials expertise to PACCAR's worldwide truck brands including Kenworth and Peterbilt in North America and DAF and Foden in Europe. PACCAR products are used in a broad range of applications including long distance hauling, regional and local delivery, refuse collection and heavy construction. Last year, PACCAR produced over 92,000 trucks, worldwide.

PACCAR is recognized as the technological leader in our industry for its use of electronics, aerodynamic designs and innovative use of materials. Composites play an important role in medium and heavy duty trucks. The lighter weight when compared to metals improves vehicle fuel economy and performance. For example, a 1,000 pound weight savings will save at least $350 per year in fuel cost for a truck. Weight savings are also important as many operators can carry more goods that produce revenue. As a result customers place a value in dollars for each pound of weight that advanced composites can save. The formability benefits allow more complex shapes for better aerodynamic performance and styling options. Aerodynamic performance is important because it reduces the fuel consumed by the truck, an important strategic goal for our country. PACCAR's T600, the first aerodynamic truck on the market, was able to reduce fuel consumption by 22 percent through a number of design changes, which included greater use of composites for aerodynamic exterior surfaces. The T600 received the 1995 Department of Transportation award for advancement of Motor Vehicle Research and Development.

In the 1950's we started using composites to build parts with shapes difficult or impossible to form in metal. By the 1980's the majority of our hoods and roofs were made of composites. Currently the exterior surface of the truck is about 20 to 40 percent composite, depending on truck model.

Because these advanced materials can be molded precisely, they give us the additional advantages of more consistent parts which lend themselves to robotic assembly methods. The cabs of our newest two truck models are assembled robotically. This improves the quality and durability of the trucks, making them a better value for our customers. The improved part properties of advanced composites include smoother appearance, and the ability to optimize weight and strength resulting in more durable, cost effective parts. Our customers typically run their trucks 120,000 miles each year and well over 1 million miles in a lifetime, so any composite used in our trucks must be very strong.

Additional properties advanced composites provide are conductivity and molded in color options. Our customers request many different colors of paint each year, making the development of viable in-mold color attractive. Both conductivity and molded in color reduce the amount of paint used on a truck, thus reducing emissions from our plants.

Two of our most recent class 8 truck models, the Kenworth T2000 and the Peterbilt 387 make extensive use of composites. For example, both use sheet molding compound for parts such as doors, door openings, and the firewall which separates the cab from the engine compartment. The T2000 roof is the largest SMC part ever molded for use in a production application. The tool for this part weighs 30,000 pounds and would fill a 2-car garage. This trucks floor material is also very unique. It uses a vinyl ester skin and balsa wood core for maximum strength with minimum weight. This technology is also used in the aerospace industry, so developing advanced composites can benefit both.

We have active projects with State Universities, including the Virtual Reality Technology Consortium with Washington State University which is developing virtual reality tools for improving manufacturing efficiencies and ergonomics. We share materials research programs with Western Washington University. Some examples of the research projects completed are a recycling study for thermoplastic forming and building composite suspension parts. The PACCAR Foundation also provides an endowment to the University of Washington to fund the PACCAR Professorship in the College of Engineering.

We have active material development cost share projects with the government. These projects range from forming new materials to commercializing potential assembly methods. We fully support the continuing cooperation of government and industry in the development of new material technologies.

We recognize Universities and National Laboratories as excellent sources of basic research. This research, when developed with input from private industry regarding viability and commercialization, should be a significant asset to both the trucking industry and the industries it serves.

Senator CANTWELL. Thank you. And we will get to questions in a moment, but we want to hear from Mr. Rutkowski. I appreciate you being here this morning.

STATEMENT OF RICK RUTKOWSKI, PRESIDENT AND CEO, MICROVISION INC.

Mr. RUTKOWSKI. Thank you. Thank you Senator Cantwell and Senator Wyden for the opportunity to address the Committee this morning. And I do have a written statement, although, I think what I will do is summarize and perhaps amplify with the benefit of some of what we have heard.

One thing I think that is a common theme here is we are all looking for ideas with how to create jobs and what kind of industries will drive those. And I wanted to applaud the Committee's role, and we are asking what can be done. Certainly nothing can be done without communication, without dialogue, and your leadership in taking this initiative is much appreciated.

Microvision is a company I am Chief Executive Officer of and cofounder of. We also cofounded a second company in late 1999 called

Lumera. Both companies operate in the electro-optics domain, and Dr. Denton during her statement actually made reference to two technologies: One is micro machining technology and another is polymer materials technology in which we have collaborated with the University of Washington.

Both companies have supplied two of the largest commercial research contracts to the University of Washington that the University of Washington has received. And this is really interesting in this context. These are both relatively early-stage companies.

I think that when we speak to the issue of job creation, Senator Wyden made the point that jobs are not stamped out of printing presses in his office or any other office. But what does create jobs? Jobs are created by economic activity. There have been several statements sort of made around the notion of the types of economic activity that are created here, but I think it is a fair statement that if we look at periods in history where we saw profound acceleration of economic activity, you can almost always trace those back to something that we would call a disruptive technology.

So there are really two terms that appear in my statement that I think are key to this: One is this notion of disruptiveness and the other is a notion of a platform. A platform technology is one that has the kind of breadth of application that micro-electronics does. We see micro-electronic chips in everything from refrigerators to automobiles and cellular phones and, of course, personal computers.

The economic revolution that surrounded the micro-electronics era was indeed profound and an example, certainly within recent history and recent memory, to draw on.

We see the same kinds of potentials here in advanced materials, certainly the kinds of structural materials that we are talking about with respect to composites.

In the case of Lumera, the electro-optic materials that we are working with can be used in everything from telecommunication switches to next-generation computer back planes. Indeed, we are working with the Intel group out of Oregon on how we interconnect high-speed chips. We have a bearing on the aerospace industry, both with respect to phased array antenna that can be enabled by these kind of polymers at high speeds and also integrating them into the actual skins of aircraft to form what we call a smart skin so that these can—stealth can be achieved through active electro-optic activity of the skin of an aircraft.

So these are very powerful technologies, but thematically the job creation comes from the economic impact. The economic impact comes from ultimately a benefit to consumers.

We have to stimulate the economy through this sort of disruptive innovation, and that is the power of these kinds of technologies. So I am here to offer and put on a couple of different points. I think that is sort of the broad view.

Two is in addition to materials biotechnology, we work a lot with the whole arena of nanostructures in the molecular level engineering that we do at Lumera. These are very important technologies, and that is the fine point here really is that in order to create this kind of impact, we have to identify those types of technologies

which are leverageable, those types of technologies which give us those opportunities.

We also believe that electro-optics technologies is key in this domain and offers great potential for the region in this regard.

The other area that I think we bring to bear, and I touched briefly on our collaboration with the University of Washington, I think it is essential that these kinds of collaborations continue. We have benefitted greatly. We have benefitted with the Human Interface Technology Laboratory, with the chemical engineering department at the university as well as with the Washington Technology Center and the micro fabrication facility there.

There is, in fact, an issue of a funding gap that these entities encounter, although, we have had some good news in the last year in that the National Science Foundation designated University of Washington one of six national centers in the area of technology. With this particular designation, they were rewarded a reward in photonics at a rate of about $16 million over the next five years, and certainly this level of Federal support is going to be significant in enabling that technology to advance.

So I think key to many of these things are creating a forum for the dialogue, identifying those technologies that are strategically important, and I think, Senator Wyden, you made a very good point about what can we do to foster collaboration. And I am not so sure either that trains are the answer. I think a lot of it really is about creating opportunities to interact and collaborate and to encourage those collaborations through other kinds of structural elements.

In fact, it was interesting to sort of hear the notion of how do we as a region sort of create some critical mass, to borrow your phrase, politically in order to sort of bring these resources to bear on the region. I think there are tremendous opportunities.

One area that we are trying to exercise some initiative in is simply bringing other participants within that industry together, so reaching out to other folks who are in the electro-optics domain and the advanced materials domain and forming industry coalitions that can facilitate those kinds of communications.

But we have had enormous success to date. We think we can be a tremendous job creator going forward in the electro-optics industry. We actually believe there will be another Silicon Valley centered around the electro-optics industry. We believe that in the Northwest we do have a leg up on the creation of that. Technologies like advanced materials and the chemical engineering foundation for that are important to it as well as nanostructures.

So these things really do come together, and it is about creating that community around them to drive the ideas because I think key to this is we are going to be faced with the fact that we are going to have, to a certain extent, fewer resources than some other regions in the country.

So it is incumbent upon us to be resourceful and creative in the application of those resources, and I think that is going to be critical to how we do it. It is not us looking to Federal Government saying what can you do, but I think more to the point how we can create an effective partnership between Federal Government, State

government, industry and academia to make these things realizable.

I thank you for taking a leadership role in doing that.

[The prepared statement of Mr. Rutkowski follows:]

PREPARED STATEMENT OF RICK RUTKOWSKI, PRESIDENT AND CEO, MICROVISION INC.

Thank you very much Senator Cantwell and Senator Wyden. It is my pleasure to be here today to discuss Microvision, our subsidiary, Lumera, and their role in advanced electro-optic component and materials technologies. Most importantly it is a great honor to be here to support Senator Cantwell in her efforts to develop public policy that will help create and maintain a more robust advanced materials industrial base in the Pacific Northwest by providing stimulus for broadly enabling technologies such as these. I would like to begin by thanking Senator Cantwell for her efforts in initiating a public dialogue about this critical issue.

As we all well know, the State of Washington and the Puget Sound region are facing difficult and uncertain economic times. The decisions and actions taken by Washington state political and business leaders today will determine whether we return to a more vibrant, diverse, and prosperous period of economic growth.

Washington State is fortunate and proud to have a leader like Senator Cantwell whose experience and expertise in technology, business, and public policy allows her bring a different level of focus to these critical future economic issues. Senator, bringing us together today to discuss these important industrial base issues is a clear example of that leadership and is greatly appreciated.

We at Microvision and Lumera are committed to doing our part to help enable your vision of a robust Northwest-based advanced materials industry that will serve as a key next-generation employment and revenue driver in the State of Washington and provide a consistent, quality vendor base and workforce to support existing regional industries such as commercial aircraft production and others

Let me now move on to provide you with a brief overview of our companies and how I believe we fit into this vision.

Microvision has become a leader in the emerging photonics industry by developing and patenting high-value, high-precision micro-optical scanning components and products for a wide range of applications across a broad range of aerospace, defense, medical, industrial, professional, and consumer applications.

Lumera, a Microvision subisidiary, is focused on developing a new and highly superior class of electro-optic materials that will enable optical component devices to deliver unprecedented levels of performance while achieving significant gains in reduced system complexity and overall system cost.

When I joined Microvision in 1994, part of what guided me was a notion that I had developed over several years that the next industrial tidal wave to emerge in the technology world would be in the area of electro-optics and photonics.

The microelectronics revolution, simply put, has been about making devices "smaller, faster and cheaper" at an alarmingly fast rate, and the economic benefit to the consumer has been absolutely extraordinary. When such compelling benefits exist for consumers, they are motivated to buy these products and the industry thrives and grows at an equally dramatic rate. One could make the assertion that most cases of profound structural change or growth in global economies can ultimately be traced back to disruptive technologies—be it the internal combustion engine, electrical transformers or vacuum tubes or the transistor.

At Microvision, I saw the potential to impact information products of all kinds in a powerful way through such a disruptive innovation. We have developed optical scanning microchips based on micromachining techniques that can perform the same display and imaging functions that today require substantially larger and more complex—and therefore more expensive—solid-state devices. As a result, we can achieve dramatic improvements in cost and performance to enable a broad range of products that can be applied in markets ranging from healthcare, to military, to consumer electronics, and commercial aviation—all based on the same core technology.

That is really what we mean when we refer to a platform technology—one that can have a broad impact in the marketplace. When that broad impact also delivers more than just a marginal cost performance impact in these spaces, it will be disruptive to the status quo and the combination of the two can make for profound economic impact, as it has done in the microelectronics industry.

I had done my first work with Electro-optic polymers in 1988 and 1989 and that led me to see some distinct parallels between what was happening in Electro-optics and what had occurred at the birth of the microelectronics revolution. The techno-

logical power—and the economic power—of microlectronics has been fundamentally disruptive in nature. When we moved from vacuum tubes to transistors, and then from solid state electronics (based on discrete components) to integrated circuits, we saw powerful improvements in cost and performance that enabled improvements in many existing products as well as important new products like the calculator and ultimately the personal computer. This set off a chain reaction of continuing and rapid improvements based on having unlocked the enormous potential of silicon as a platform material capable of supporting the ever denser packing of millions of transistors into smaller and less expensive pieces of material, and the equally powerful potential of innovation in process and device design in this platform.

The reason that the economic impact of microelectronics has been so broad is because of the huge scope of applications and markets that have emerged to take advantage of integrated circuit technology. The entire electronics world, from refrigerators, to cars, to consumer products, and, of course, computers and mobile phones, has become a customer for the billions of chips that emerge each year from foundries the world over.

Today in electro-optics, while people have talked for many years about integrated optics, no one has yet achieved this kind of disruptive step, and, as a consequence, optical and photonic systems today resemble the electronics systems of many years ago in their size, cost and general utility. So the revolution has yet to occur, but there are many signs that it is near. At Lumera, while our first targets are dramatic improvements in the cost, performance, and size of discrete components used in a variety of systems, we are pursuing the goal of developing a platform material for integrated optics to set off a similar kind of technological and economic "chain reaction", and we believe that electro-optic and microphotonic systems will have the same kind of profoundly disruptive impact in enabling new products and improving existing ones.

Over the past several years Microvision has been fortunate to receive widespread support from our Washington State Congressional delegation and from Defense Department program offices, which have recognized the potentially significant impact of our technology in a variety of Military systems. More recently, we have been awarded contracts by companies such as Canon, Inc., BMW, and Ethicon Endosurgery and have collaborated on product development with Stryker, Siemens, and other industry leaders from around the globe.

Several things about this are gratifying. These companies not only possess very recognizable brands, but they are without exception, companies that are recognized for technological excellence and for leadership in innovation. We also like to make the point that each of these companies is pursuing distinct applications of a common core "platform" technology that emerged in large measure as a result of our work on these Defense projects, and that in each case the market potential for the underlying products is significant, and in many cases the products themselves potentially transformative. As a result, the potential economic impact for our company and for the region is also significant. We are also delighted to measure an accelerating rate of progress in our technology. One thing that defines a "disruptive" technology is the rate at which the technology can progress and provide greater and greater cost and performance benefits, and we have had great success in the past year in particular in collapsing the timelines between innovation milestones.

Finally, I would like to briefly touch on the importance of our partnerships and experience with local academic institutions, and I would also like to commend Senator Cantwell for introducing legislation to establish a federally financed aviation research center at the University of Washington. We have experience working in similar partnerships with the University of Washington, and we strongly believe that cooperation has generated great benefit to our company, the University, and the region and that still greater benefits lie ahead.

The University is home to the Washington Technology Center's micro-fabrication facility which has received important support from commercial partners like Microvision and from Washington State. Last May, the University of Washington was designated as one of six new science and technology centers in the nation, by the National Science Foundation. Dr. Larry Dalton was appointed as the Director of the new Center for Materials and Devices for Information Technology Research.

This designation has placed the university at the leading edge of research to develop groundbreaking technology in the area of photonics and will establish Washington as the epicenter of this groundbreaking work. The NSF is providing $16 million in funding for at least the next five years, without this level of federal support, we would not be able to realize the many benefits of this powerfully disruptive technology as quickly—if at all.

Federal investment is essential to the success of research and innovation. The Federal Government has the ability to apply the "patient capital" necessary to en-

able these strategically important technologies in ways that too often are not fully enabled by other sources of private sector investment.

Again, I want to thank Senator Cantwell and Senator Wyden for the opportunity to participate in today's dialogue. Establishing a strong and vibrant base for advanced materials and other technologies in the Pacific Northwest is critical not only for supporting the existing anchors of our economy such as commercial aircraft production, but also for the emergence of a more broadly based advanced materials industry that can have explosive economic impacts in its own right. I look forward to working with and supporting the Senator on this initiative going forward.

Again, thank you for the opportunity to join you here today.

Senator CANTWELL. Thank you. I want to thank all the panelists for your testimony this morning. You know, we have talked in this panel about fueling the Northwest economy through innovation, but it is clear that this focus on composites as it relates to aviation is really about domestic competition in aviation, or I guess my question is: Where do we stand as it relates to the major competitor in the aviation industry as it relates to composite materials?

Is their investment an advantage, where are they, what do we need to do to maintain our U.S. competitiveness in aerospace manufacturing?

Mr. STATKUS. Senator, I think in general in composites, we probably are the best in the world in the U.S. within the State of Washington, I would say we have some very good technical industries. The gentleman right here is an example. I think that we look to many of the petroleum companies to develop the kind of resin matrices that we would use for the composites that we need.

Around the world, there are fiber developers, carbon fiber-based elements. I think any number of—well, in the three major composite areas, epoxies, what we call VMIs, toughened carbon-based materials, and also in the very tough arena of, like, thermoplastics, we can look to the United States petroleum industries for most of those developments.

I think in general, the newer the material, the higher the price. If you go to fabrics that the resins are implanted on, those fabrics have been around for years. There are not too many new fabrics today that I could point to. There are different forms of the fabrics. But the resin systems, themselves, those are being developed and have been developed.

I think the institutes that would use the newer systems today should focus, in order to be very competitive, should focus on the—not just the system, itself, but the way the system is used, how it is applied, the form that it comes in, how it is cured. Many of the systems today require ovens, autoclaves, very precise cycles over long periods of time.

The cycles that we need for future products and competitive material applications likely will require short cycles, no cycles, room temperature cures and things like that.

So we should be developing materials, material forms, labs, structural activities, folks with the right kind of background that would allow us to research in those areas.

Senator CANTWELL. Dr. Denton, did you want to comment on that?

Dr. DENTON. I would just second what Mr. Statkus said, and I think that we are extremely competitive vis-a-vis our European colleagues in this arena of research in composites. So if we move for-

ward with the FAA Center, I think we would be able to move ahead.

Senator CANTWELL. And then you both are saying that it is more about where the materials are found and how affordable they are as to how often—how long they have been on the market?

Mr. STATKUS. That is certainly a large part of it. We are not going to be able to produce products that are competitive that would specifically be of large value to the Northwest unless we find those kinds of materials that have huge, large cost-to-weight advantages and are more on the order of in a raw material form $25 to $30 a pound.

Some of those materials which would provide the maximum strength-to-weight ratios are generally on the order of $100 to $200 a pound today in a raw form. That is before process. Then for any pound of that material, you could add as many as 20 to 40 hours of preparation.

So, as you can see, if you have a very high strength material that has large economic value to an industry like aviation or other structural purposes, then you would like to try to reduce not only the raw material costs, but also the applications and production costs in order to be truly competitive.

By the way, expectations should be that material costs continue to reduce over time just as Mr. Janicki had said earlier.

Senator CANTWELL. Mr. Janicki, you have won some of these contracts from a variety of sources and have a growing business in Skagit County and this area. What do you see as some of those challenges of maintaining our competitiveness?

Mr. JANICKI. First of all, on his comment about—I am sorry to change the subject just slightly, but as we are looking at the Boeing Company particularly, there is a huge shift from metal technology to composite technology. And as he states, currently the composite technology is very, very expensive on commercial airplanes. Okay. The rest of us are all using composite technology and getting all the benefits, but we do not have to deal with making a commercial airplane that puts 500 passengers in the sky and all the Federal regulations that go with that.

So there are materials out there that are really cool, do all the neat stuff, and there are processes to build product with this technology. The problem is that, maybe this is a place where the university could come in, is getting those new materials and new processes qualified for a commercial airplane is such an unfathomable problem that people who manufacture the resins, the processes, will not even try. Okay. It is just too big a hurdle to even make the attempt to try to qualify new materials.

So we are stuck with these old materials that ran on fighter jets or they ran on something else, and they have been tested, we know they work, and so the engineering body is just limited to using some of those materials.

So trying to be able to get people to be able to create stuff that they would be able to take is a big part of it.

Senator CANTWELL. Well, one of the reasons we think the center will be helpful in establishing that.

Dr. DENTON. We would really hope that the FAA Center would be able to partner with the smaller companies that would not be

able to take on these large challenges alone of qualifying materials and facilitate that process.

Senator CANTWELL. Senator Wyden?

Senator WYDEN. A question—a couple of questions, and thank you, Madam Chair. The gentleman from Boeing, your testimony is very helpful, and I was very interested in it. There is an article recently in the "Technology Quarterly" entitled "Desperately Seeking Lightness." The argument basically is the ball game in the aviation sector is about lightness and that that is really where you get the opportunity for innovation and a chance for us to get a leg up.

I am particularly interested in the way these areas intersect. Is this not a natural in terms of composites because composites ought to be a way to get rid of some weight?

Mr. STATKUS. Absolutely, Senator.

Senator WYDEN. Am I missing something?

Mr. STATKUS. No, no, you are right on point.

Senator WYDEN. How do we promote it?

Mr. STATKUS. First of all, I think the recognition that composites add strength-to-weight value to a product would suggest that possibly the strength is there because the weight is down. And that is exactly true in many material areas.

I think that to a point made just a minute ago, the qualification of that material is not just about its weight though. It is about its mechanical properties. It is about its manufacturability. It is about the way that you could apply it in certain areas. It is about its longevity, its life cycle. It is about its ability to act as maybe an insulator in some cases depending on whether you use honeycombs or not.

And so I think what we need to do, particularly with the university in areas like this is we need to partner to do the kind of research that would tackle some of the aspects of the values of this kind of technology in the industry.

There are many aspects, corrosion is a huge one, that when you put composites, a carbon next to aluminum, for instance, if you are not careful, you have created a battery in the midst of moisture. So knowing that, what you want to do is rather than generate a corrosive atmosphere, maybe figure out how to coat the materials to keep from allowing that to happen and have better applications.

I think there is any number of—20 or 30 areas of high technical value that if you just think of composites alone, that you could partner with the university on and have huge value to, not just our industry, but structural industry in general.

Senator WYDEN. Yeah, it sure would fit the theme of Senator Cantwell's hearing because this is an ideal way to innovate. I am looking at a diagram that basically shows that composites, you know, would change the rear of an airplane essentially, in effect replace some of the aluminum essentially, which is essentially the argument you are talking about. So excellent testimony.

Dr. Denton, I am going to ask you a question and get you and Mr. Rutkowski into this with respect to academic institutions and private industry and particularly roles.

By the way, before I start, Dr. Denton, thank you for your nice words with respect to Title IX and the fight to get more women in the sciences. You know, everybody in this country thinks Title IX

is a sports statute, and we held a hearing actually on it with our colleagues on the Republican side of the aisle, Senator Allen, and we were just amazed that Title IX is not, in its history, is not primarily a sports statute.

Title IX is primarily a lever, a kind of fulcrum to go out and get more women academic opportunities. And we are going to use Title IX until we get justice in the hard sciences, and I thank you for your nice words for it and I want to commend Senator Allen and our colleagues on the other side of the aisle with their help on it.

What I would like to do with you, Dr. Denton and Mr. Rutkowski, get your thoughts on this Bayh-Dole issue as well. I think you have heard some of my concerns early on. I have just been stunned at the frustration of essentially all of the stakeholders on this.

The companies have been frustrated, the universities have been frustrated, and people look at the rate of return, I mean, just at agencies like the Department of Energy and the National Institutes of Health. Billions and billions of dollars are spent on these programs, and people cannot find a whole lot that ends up getting commercialized. And I do very much want to bring all of the stakeholders together in some ways to be innovative.

Maybe we can start with you, Dr. Denton, and bring you into this as well, Mr. Rutkowski.

Dr. DENTON. I think it is really timely to review Bayh-Dole. It has been around for a while now, and we have had a lot of opportunity to attempt to apply it in ways that are appropriate and that lead to the results that we all hoped it would have.

I think that there are still some ambiguities around Bayh-Dole, and some of the interpretations of Bayh-Dole are different from one organization to another.

The thing that I observe as the dean of engineering is that whether it is because of Bayh-Dole or not, there has been a chilling effect on tech transfer and intellectual property in the academy. We have a very difficult time partnering with our corporate folks and transferring that technology because people cannot quite find a way to efficiently and effectively and legally move through that process.

And we see a lot of frustration on the part of our corporate partners, and a lot of the faculty are frustrated, so the stakeholders feel like they are just kind of frozen out, and it is tough to navigate through the system.

I am not an expert on Bayh-Dole, and I would really love to take the opportunity to get some of our best minds on campus to a meeting like the one you described where we could sit down and try to figure out why is it that we are in some ways paralyzed.

I mean, there are things that are working. Tech transfer is happening. But I think—and it is happening and some great things are going on like what you heard about this morning on the panel and today here, but I think we could do better, and I think we really need to follow up.

Senator WYDEN. Mr. Rutkowski?

Mr. RUTKOWSKI. Not only am I not an expert on Bayh-Dole, I am embarrassed that I am probably the only person in this room who

does not—is not familiar with that particular piece of legislation because you have referred to it several times.

Senator WYDEN. Well, put it then more generally just with respect to academic institutions and private industries. Set aside the statute. Wave your wand and talk about the relationship you want.

Mr. RUTKOWSKI. Well, there are lots of things that are highly productive, but I think one of the most interesting things is culturally you have two very different worlds coming together, and one of the challenges I recall we had early on dealing with the whole nature of intellectual property transfer, and I think Dr. Overell made reference to a similar kind of thing, is that in the university, the motivation, of course, is to publish your findings and so on, and, of course, in the commercial world, it is often very much counter to that. Now we are going to maintain this as proprietary and that is going to be a barrier to entry.

So I think we have had a lot of good success, although, it was an interesting dynamic over time, and we have had some practice at it. So I think there is just that whole, again, being cognizant of some of the different needs and how we accomplish this.

In this case, it was—there was some very simple protocols that we put in place just between ourselves and the university in terms of delaying publication until we had had an opportunity to patent and really ensuring that that is a collaboration and that both parties are recognizing the needs of the other institution, I think is key to that.

Similarly, we would get into situations where the question was we are trying to cooperate, but are we finding ourselves competing, for example, when going out for Federal dollars or other kinds of—responding to other kinds of solicitations?

So I think it is incumbent upon the institutions themselves working with industry to, again, find ways to make these kinds of things work. We are encountering some of these issues. It is sort of an interesting time in the relationship between Lumera and the University of Washington because Lumera is accessing capital from private equity markets, which are in a state of disarray today, and we have got a significant funding commitment to the university. The university has just run—won a very recent significant award.

So what is making that work, though, is the willingness to come together, sit down at the table and say, "OK. Where were we when we set out and had these intentions and these sort of arrangements and where are we now, how have things changed and how can we help each other?"

And I have to say it is working exceedingly well right now, and I attribute that in part to the fact that we have had sort of an experience at this one time around with Microvision, and I am hopeful that it has been an experience for the university as well. But they have been about as good a partner as you could ask for for an early stage company.

I suppose it goes without saying, but, one of the challenges here is that environments for these early-stage companies are very dynamic. Things are very fluid, you are trying to be agile, you are trying to be opportunistic. That is in very stark contrast, of course, to the more predictable and defined environment of a university.

So it is more of an accomplishment than it may seem to really make that dialogue work well. And it has been, I think, a very productive exercise for us.

Senator WYDEN. For somebody who has never heard of an obscure Federal law, that was a great answer, and I thank you for it.

[Laughter.]

Senator WYDEN. Just one question for you, Mr. Janicki. It seems to me there are some potentially exciting intersections between nanotechnology and composites as well, composites and materials. I mean, all of the discussion about carbon, nanotubes and, you know, generally about nanotech, you know, spreading into materials. The argument is maybe sort of like plastics was in the 20th century.

What are your thoughts on that and the intersection between nanotechnology and the areas on which you have been testifying?

Mr. JANICKI. Well, you know, I am not real knowledgeable about the nanotech sector of things. I read about that in my mechanical engineering books, but it is an area that I am not real familiar with.

Senator WYDEN. OK. We will spare you.

Senator CANTWELL. I saw a couple of nods from——

Senator WYDEN. Are there others that want to get into that?

Mr. STATKUS. Let us see. At Boeing in the technology area in the commercial side, we probably spend in excess of a couple hundred million dollars a year, and some of that is in nano- and nanostructural areas. We foresee, not in the current products, but in the reasonably short distant future products that we would be employing nanotechnology.

We look to partner with people who have a whole lot more skill in that area than we do. By the way, I truly believe that this would be an excellent area for a university to pick up on because it is—not only is it new, it actually requires some fairly high mathematical skills in order to generate the—well, it would need to generate the polymers that we need to look at future products.

So I think a partnership in this area would be wonderful with the university.

Senator WYDEN. Thank you.

Madam Chair?

Dr. DENTON. I would just add that since we have one of the oldest centers for nanotechnology in the country, to partner that with the new FAA Center would be very synergistic and would allow us to explore the intersection that Senator Wyden talked about.

Mr. RUTKOWSKI. What we do at Lumera is an awful lot of this. We are engineering materials at the molecular level, so we are actually synthesizing materials for what we call particular structure function relationships. And I think that is certainly going to have a bearing.

As I mentioned, you are going to find some of these things coming together where we will actually have aircraft skins that are themselves active as opposed to just passive materials, and I think that is an exciting area.

Senator CANTWELL. I do want to mention, too, that Dr. Len Peters who is the new Director at the Pacific Northwest National Labs is with us as well, if you want to stand up.

Obviously the Northwest Lab has been involved both in nanotechnology, nanosciences and in composite materials and a great partnership of everybody that is up here on the stage. So we thank you and welcome to the Northwest in your new capacity.

Mr. PETERS. Thank you.

Senator CANTWELL. We are running down on time here, and we appreciate the focus that you have given to this, but one question that stuck in my mind about the last panel and this panel as well is, again: How do we make this all work for the Northwest economy and the work force in general?

We were successful last year in getting $500,000 from the Department of Defense budget to start this process with Edmonds Community College and the University of Washington in trying to develop a curriculum in composite manufacturing.

But what is our task in the sense of getting the transition of this work force who has become very skilled in aviation and manufacturing in general, to get them skilled in this area of composites, and what are the competitive advantages of having that work force skilled at this level?

Peter, you probably employ the biggest work force now in this area, so why do you not start?

Mr. JANICKI. Well, I just want to offer a suggestion, a very concrete idea here, is that there are a lot of small companies. The company that I am the founder of has 120 employees, so our resources are limited. A tremendous number of the companies that I deal with are even smaller than me. So we are limited in how much research we can do. We just do not have the funds.

Now, in the last two years, I have traveled all over the United States and seen a lot of companies, and what I am realizing is that the Federal Government has already spent the money. OK.

Last week I was at NASA in Huntsville, Alabama, and they are working on a cryogenic tank for the space shuttle. That great big tank that they strap the shuttle to currently is made out of aluminum, and every time they launch the shuttle, they throw that tank away. It is a $60 million tank. They are considering making that out of composites, and it would be able to be reused.

They have spent millions and millions of dollars doing research. I did not know, but that is all public information. OK. I happen to know that. My question is: How many of my colleagues in the State of Washington know that that is all public information?

At the same time, two weeks ago, I was at Wright-Patterson Air Force Base in Dayton, Ohio, they have a building full of scientists and chemists and all these engineers. I looked in their lobby, and there are all these books that are written on all this really cool stuff. I happen to know that now, but I did not know that two weeks ago, and I have engineers who are trying to figure out how to do something, and all this public information is already out there.

So my suggestion would be: Is there some way to put all of this information together? I will call it a library of some kind, and maybe you would have to have some kind of a membership, maybe

you have to be a citizen of the State of Oregon or Washington to get to have access to this library, but it is just simply summarizing all this data and putting it into some kind of a manner where people can look at it.

So when I tell one of my engineers "Tell me what the density of this particular carbon fiber is and what is its yield strength or whatever," this guy just goes to this place and that information is all there and all of the documentation is there.

We do not have that right now. We do not know where to go. And it is a huge effort for little, tiny companies to find this information.

Senator WYDEN. Peter, you are being too logical for the Federal Government——

[Laughter.]

Senator WYDEN.—because that is really, and correct me, Dr. Denton or others, that is what the Bayh-Dole law and the spirit of it was supposed to be all about is trying to get that kind of information out.

I mean, the Federal Government is to a great extent an information and technology treasure trove. There is an enormous amount of information exactly along the lines of the examples you gave with respect to NASA and other agencies, and somehow this information just sort of gets buried somewhere rather than getting into this kind of pipeline where once taxpayers have paid for it, it then gets out and it can be used in various kinds of ways for commercialization.

So I am very anxious to pursue this with you. I know Senator Cantwell is as well. We are going to try to make that kind of example sort of Exhibit A at some of these discussions we want to have with academia, with university researchers and with private companies because the Government has got it. It is a treasure trove of information and technology expertise, and I just think it is outrageous for the public and for companies and innovators and risk takers not to have it, and particularly not to have it when we are not talking about giving away proprietary secrets or national security or something of that nature. We are talking about information that ought to be in the public domain and for a variety of reasons it is not getting out.

Dr. DENTON. I would second what Mr. Janicki said, and I would indicate that this would be a role where the higher ed organizations in Washington and Oregon could partner around——

Senator WYDEN. Right.

Dr. DENTON.—how to harness this information explosion and use some of our very best research in areas like data mining to understand how we can effectively find what your folks need when they are solving problems.

Because we have, between Oregon and Washington State, some of the best work in the country in computer science and information retrieval and analysis. And I think putting all of that together would be a very powerful thing to do.

Senator CANTWELL. Mr. Statkus or Dr. Denton, my original question about the work force, how the investment that we need to make in creating skills——

Dr. DENTON. I think that vis-a-vis the work force, the kind of things that the Federal Government has done historically, graduate

training grants are very powerful, undergraduate scholarships, I know there is some movement in that direction in Washington, DC to enhance the numbers of scholarships for young people either in community colleges or four-year schools who are majoring in engineering and the physical sciences.

One thing I would mention is that there is a collection right now between Washington State, Alaska and Hawaii that we are calling the Pacific Alliance, and what we are doing there is we are leveraging the fact that we have a very large number of Native American indigenous folks in those three States, and we are building a pipeline from K–12 to undergrad to grad school for Native American and indigenous folks in the three States and perhaps Oregon, I am not familiar with the demographics of Oregon, but pulling Oregon into that might be—make it a more powerful alliance.

So those are some things about building capacity on the HR side.

Senator CANTWELL. Mr. Statkus?

Mr. STATKUS. Thank you, Senator. I would respond in this way: I think a lot of the knowledge that we have in the industry and certainly in the Federal Government is there because of a number of processes and activities that have taken place over time, and it, in many cases I believe, is part of the historic record. And I think there are ways to find it. And as long as it is not Government secrets or intellectual property in the area of industry, it is available.

To your specific point, I think if opportunities like the partnerships between an FAA and a Center of Excellence and a university with specific subject matter and specific charters takes place, then I think you have already proven to certainly a student body and likely the industry, too, that there is specific emphasis placed in certain areas, and I think it will draw people, those people of intelligence in those areas, to do that kind of work maybe at that site, for instance. And in the end, the obvious likelihood will be increased value to the industry.

I will say that, back to your question, Senator, at Boeing, for instance, we have a site, and if you go to that web site, you will find technology. And within those technology sites, you will find hundreds of activities that we are working on and status and even a person to call.

And it was not too long ago where the Chief of Technology for PACCAR called me, and this lady had gone to our web site, and she found, of all things, fluidic wall paper, and I will not go into that, but it is interesting in that it has values in terms of insulation, sound deadening, things like that, and we had a meeting on it.

So I think industry cooperation, institutional cooperation, Government cooperation, that is our future.

Senator WYDEN. Frank, all I am saying is all the more reason when a company like yours is doing that then and making sure that information gets out, that the Federal Government stop dawdling and pick up on the kind of idea that Peter is talking about. My point is that people in the private sector are doing a lot better job of no longer sitting on the treasure trove of information they sort of pick up along the way, they are getting it out, but somehow the Federal Government cannot figure out how to do it.

Mr. STATKUS. Well, I think the information is not all that obvious. I agree with that. It is hard to find.

Senator CANTWELL. Well, and certainly to smaller businesses it is definitely harder to find.

Mr. STATKUS. Absolutely. And then the archives are huge places.

Senator CANTWELL. Well, we are running out of time. We want to adjourn this at 11:00, and that hour is upon us. This has been a great field hearing of the Commerce Committee.

I think the staff that is here, I know you have done hearings across the country, but we have had a great turnout this morning, and I do not know that—they have had so many field hearings around the country at this size, so obviously it communicates a great interest in the Northwest by these two particular issues.

I want to give my colleague an opportunity if he wants to have any closing comments on either of these two panels or our hearing this morning.

Senator WYDEN. I would only say a couple of things: One, I want to express our thanks to the minority staff that is here, particularly Senator Brownback, Senator Allen, Senator McCain, you have been so helpful to us in advancing all of these issues. They could not be with us here today, but I want to express my thanks to them for their support.

And to all our witnesses, one of the things that has been enormously helpful to me is that I think between Senator Murray on the Appropriations Committee and Senator Cantwell on the Commerce Committee, the State of Washington is ideally positioned to help the Pacific Northwest, both Washington and Oregon, on these kinds of issues. As you can see, it is going to take this kind of partnership to maximize our clout.

So all of you have been excellent in terms of giving us very specific ideas. With the issues that Peter brought up and many of you, we can now take and walk through the system and look at ways to get them off the ground.

So you have been very helpful, and, Senator Cantwell, to your leadership in particular, I thank you for the invitation. And any time I can wangle an opportunity to work with you, I am interested in doing it. I thank you for the chance.

Senator CANTWELL. Well, Senator Wyden, we may have to entice the Committee to have a similar hearing in the Portland area, but I certainly appreciate your leadership on the Science, Technology, and Space Subcommittee, on aviation, particularly the work that you are doing on nanotechnology and look forward to looking at ideas and ways to combine our legislation, and certainly to your leadership on the Committee as it is related to investment and how to get the technology information out there in a better process.

We have heard today obviously about the investment in two particular areas for the Northwest that I believe have great benefit, continuation of biotechnology into the nanosciences and how we best capitalize on that by things as simple as transportation infrastructure and as complex as new relationships with the Northwest and with the Oregon Health Institute and the University of Washington and a variety of resources at the Federal and State levels.

We have also heard from the second panel about some very basic recommendations that I think could be helpful on the qualification

for new aviation materials that might be used in commercial airplanes that I think would be very helpful, and obviously the increased value to the industry that such a center could have if it existed here in the Northwest or, for that matter, if it existed in the United States, but we certainly would make the point that that center of excellence would be very well placed here in the Northwest given the type of work that has already been done.

So that has been very helpful information that we will carry back to Washington, and we will look forward for both panels in strategic ways that we really can come to greater terms with this issue about how we marry the work force in the Puget Sound area and in the larger Northwest with these opportunities.

We have some great infrastructure in the individuals who are here and the past and history that we have had in these particular areas, but we also want to capitalize on that in the future by giving more Washingtonians and Oregonians opportunities in these fields, and we will come back with recommendations on that.

So unless there is any further business before the Senate Commerce field hearing, this Committee will be adjourned.

[Whereupon, the hearing adjourned at 11:05 a.m.]

○