U.S. ICT R&D Policy Report:
The United States: ICT Leader or Laggard?

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OVERVIEW:

The United States has long stood as the unrivaled leader in information and communications technology (ICT). ICT is ubiquitous, supporting every industry sector, improving the capabilities and productivity of every business, and providing benefits to every home and individual. As much progress as the ICT industry has seen over the last several decades, expanding from plain old telephone service (POTS) to advanced fiber optics, cable, and wireless technologies, the ICT industry remains immature with significant opportunities for innovation and growth. The role of the federal government facilitating innovation in the ICT sector has been absolutely critical in supporting a robust ICT research ecosystem both through direct federal investment in ICT research and facilitating commercialization and private research investment.

As Congress and the Administration make difficult funding decisions in the midst of the current recession, TIA stresses the necessity of continued funding for ICT research as a national priority. Research is the backbone of the ICT industry and the building block for the future development of advanced telecommunications products and services. In recent years, the need for federally funded telecommunications research has dramatically increased. As a result of the telecommunications market crash of 2000, intense market competition and a focus on low price points keeping profit margins at a minimum, long term research has lagged. Over a decade later, in the midst of our current recession, companies remain focused on survival. This has translated into an era of deep cost cutting and lean workforces, as well as a focus on product development and incremental research, rather than innovating for the future and seeding technology development. The result is a research gap that threatens U.S. leadership in the ICT sector with repercussions for the U.S. economy and national security. Maintaining U.S. leadership in the ICT sector will require active engagement by the federal government to create a framework to unlock private R&D investment, to direct federal funds to ICT research in targeted areas, to encourage broadband deployment, and to better coordinate and account for research efforts across federal research agencies.

TIA recommends the following policies to advance U.S. leadership in the ICT sector:

- **Recommendation 1**: Facilitate greater private investment in basic research through enactment of a permanent, simplified, R&D Tax Credit.
- **Recommendation 2**: Fully fund the Wireless Innovation Fund (WIN) and increase future funding for targeted ICT research. Funding for ICT research should encourage multi-year federal research plans and demonstrate a commitment to basic research.
- **Recommendation 3**: Continue appropriations to fulfill the authorization levels included in the COMPETES Act (PL 111-358) and remain on the path to double the basic science budget by FY2015.
- **Recommendation 4**: Improve coordination and accounting of ICT research throughout the federal government. There needs to be a better coordinated effort including all agencies conducting ICT research that allows all entities to understand what efforts are occurring at all levels as well as better accounting to verify funds directed to ICT research are in fact being used for ICT research.
- **Recommendation 5**: Promote polices that stimulate broadband deployment and research. Identify innovative research breakthroughs that will decrease the cost of broadband deployment, which would further the goal of Internet access for all Americans. The National Academy of Sciences should convene a panel to investigate gaps in broadband research.
- **Recommendation 6**: Institute policies that encourage cooperation and information sharing with other nation's research efforts to ensure that there is a coordinated approach to solving problems and thus avoid the allocation of scarce research resources in a duplicative fashion.
- **Recommendation 7**: Facilitate greater ICT industry input into agency funding priorities, so that there can be better coordination between research and commercialization.

I. INTRODUCTION:

Over the last several decades, the development of the ICT industry has made a positive impact on nearly every facet of the U.S. economy. Advances in telecommunications dramatically transform the way in which people live, work, learn, communicate and conduct business. Spanning every industry sector, ICT has a far-reaching multiplier effect throughout many specific industry sectors such as electric utilities, transportation, agriculture, health, financial services, machine building, distribution and retail to name a few. Numerous examples and studies demonstrate and document the degree to which the multiplier effect of ICT directly benefits other industries and the U.S. economy as a whole.

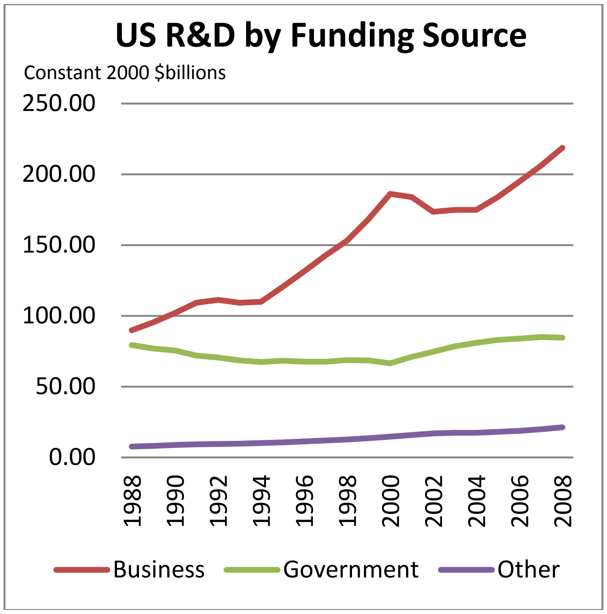
In 2009, the ICT industry contributed $1 trillion to U.S. GDP, or 7.1% of GDP, including $600 billion from the sector itself and $400 billion in benefits to other sectors that rely on ICT.[1] The ICT sector's direct contributions to GDP have increased 25% since the 1990's, growing from 3.4 percent in 1991-1993 to 4.2 percent in 2005-2009, the highest gains of any industry sector.[2] The National Research Council found that the ICT industry accounted for 25 percent of U.S. economic growth from 1995 to 2007 measured as real change in GDP.[3] Over the last two decades, the development and use of ICT has accounted for as high as 60% of annual U.S. labor productivity gains.[4] From 1995 to 2005, use of ICT technologies were largely responsible for productivity in the U.S. growing by more than 3 percent per year (essentially twice the rate of the preceding 20 years), persisting through the recession of the early 2000's when "productivity grew at the impressive—and counterintuitive—rate of 4.8 percent."[5] The ICT industry is also an important source of high-paying jobs. In 2009, ICT firms accounted for 3,535,000 jobs with full-time employment compensation averaging $107,229, 80.6% higher than the national average.[6] On job creation, a mere 1% increase in broadband deployment has the potential to directly lead to the creation of as many as 300,000 new jobs, not including the jobs that would inevitably result from new access to broadband and the benefits it brings to all types of business.[7] The development and deployment of a public safety broadband network, specifically would lead to the creation of 100,000 new jobs and produce indirect benefits of up to $8 billion per year.[8] The U.S. economy benefits tremendously from the ICT industry, and there is significant potential moving forward for ICT to be a key economic driver to exit the recession and pave an innovation leadership position for the U.S. The magnitude of the positive impact of ICT on the broader U.S. economy as well as the amplitude of the ICT industry's multiplier effect moving forward will be determined significantly by the federal government taking the necessary steps to buttress an historically unmatched, but now eroding U.S. ICT research ecosystem.

The health of the ICT sector in the U.S., along with the other industry sectors that it benefits, depends on a healthy ICT research ecosystem. A primary reason for U.S. primacy in ICT innovation has been a strong, unparalleled research ecosystem consisting of robust university and industrial research institutions, emerging start-ups, mature technology companies, private financing, federal funding and a pool of talented researchers. Research is a key factor in enhancing innovative performance and productivity, as well as long-term economic growth. All sectors depend on and derive benefits from ICT research, which is precisely why the federal government should be alarmed by the poor state of federal funding for ICT research and demonstrate greater support for the sector.

While the U.S. still boasts the strongest research ecosystem in the world, we are beginning to see signs of erosion as competing nations take strong steps to attract investment in ICT research and development to build innovation-based economies. The consequences for the ICT sector in the U.S. from a less competitive ICT research ecosystem are very real. The National Academy of Sciences observed, "The nation risks ceding IT leadership to other nations within a generation unless the United States recommits itself to providing the resources needed to fuel U.S. IT innovation."[9] We have still not seen a strong enough commitment from the U.S. government to avoid that forecast. Overall, the U.S. share of global R&D spending continues to decline.[10] Federal investment in ICT funding remains relatively low compared to other scientific fields.

Federal and industry R&D funding are critical and complementary components of the US ICT R&D ecosystem, with industry R&D primarily focused on applied research and federally-funded

R&D providing a stable source of funding for basic research. Looking at R&D funding in the U.S. for all sectors combined, the federal government and industry provide 93% of all U.S. funding for R&D with industrial R&D activities accounting for approximately 70% of all R&D performed in the U.S.[11] Over the last five decades industrial R&D has increased significantly, but federal funding for research has not kept pace. From 1988 to 2008, industry investment in R&D increased over 140%, while federal investment has essentially remained flat increasing only 6.5% over a 20 year period.[12] This gap is significant given the federal government's role in funding basic research.



Source: NSF National Patterns of R&D Expenditures Data

This result is somewhat surprising given the fact that federally-funded research has led directly to breakthroughs that have spawned entire industries, creating new markets that have helped drive the U.S. economy. Nowhere have the benefits and return on investment of federal research dollars been more apparent than in the field of ICT. A small sample of the ICTs whose pedigree is directly linked to federally-funded research include: the Internet, web browsers, search engines, GPS, fiber optics, internet routers, data encryption standards, speech recognition and the mouse, to name a few.

As impressive as ICT advances over the last several decades have been, greater opportunities lie ahead with potential to make significant advances in the field of ICT itself and in the more robust application of ICT in other sectors. The ability of the U.S. to lead and reap the benefits from the ICT innovations of the future will depend largely on the health of the U.S. ICT research ecosystem. This ecosystem will require sustained private and public funding in basic and applied research above current levels to successfully compete with other nations eager to attract R&D investment.. In terms of research funding, the two primary threats to the U.S. ICT research ecosystem are insufficient federal support for ICT R&D and correspondingly a growing gap in private and public investment in basic ICT research. If not addressed, competing ecosystems will attract R&D investment and the U.S. will cede leadership in the ICT sector.

II. Current State of Federal Funding for ICT Research

For years, when compared with other industries, ICT research has not been well supported in the U.S. Government's federal budget. While the overall federal budget for science, which has increased significantly thanks to a commitment to the goals set out by the America COMPETES Act (PL 110-69) that included doubling the budget for the federal research agencies over 7 years, there is still a significant need for additional federal funding targeted for ICT research.

Numerous voices, including PITAC, PCAST, the National Academy of Sciences, TIA and other groups have long expressed concerns over the level of federal support for ICT research. In 1999, PITAC described the level of federal investment in ICT research as "dangerously inadequate" and argued that federal investment in ICT research should be doubled over a period of 5 years.[13] In terms of percentage, the ICT research budget has increased, but the actual investment remains low in comparison to other industries and considering the needs of the ICT sector in the U.S. The National Academy of Sciences pointed out in a 2009 article that "not only does the federal investment in IT R&D included in "Math and Computer Science" (including ICT) pale in comparison with the investment in "Biomedical Sciences," but it is smaller than the investment in "All Other Life Science," "Engineering," "Physical Sciences," and "Environmental Science"—exceeding only the investment in "Psychology" and "Social Science.!"[14] The current level of federal focus on ICT research is insufficient to maintain U.S. leadership in the sector.

The Networking and Information Technology R&D Program (NITRD) is the primary vehicle for the coordination of U.S. federal investment in ICT research. While the NITRD program's funding has increased in recent years, the problem is that much of the funding dedicated to ICT research is not actually being used for ICT research. The mission of the NITRD program is to accelerate progress in the advancement of computing and networking technologies and to support leading edge computational research in a range of science and engineering fields, including high-end computing systems and software, networking, software design, human-computer interaction, health IT, and cybersecurity and information assurance research activities. A multi-agency program created through the High Performance Computing Act of 1991 (P.L. 102-194), 13 Federal agencies contribute funding to the NITRD program, and additional agencies participate in planning activities.

The FY12 NITRD budget request is $3.9 billion, a two percent increase over the FY10 actual level.[15] This is a minute fraction - about 2.5 percent - of the total FY12 proposed federal research and development budget of $147.9 billion, not counting one-time spending on R&D through the "American Recovery & Reinvestment Act (PL 111-5). The FY12 proposed total budget for large scale networking (LSN) research – the part of the NITRD budget that includes communications and high-performance networking research and development in leading-edge technologies and services – totals about $393 million, or about 0.26 percent of the federal government's total research and development budget. Given the fact that LSN includes more than just communications-focused basic research, and this figure includes both research AND development spending, as well as spending on infrastructure and applications, only a fraction of this number is actually spent on communications basic research. Moreover, between fiscal years 2002 and 2012, while the actual dollar amount dedicated to large scale networking increased, the percentage of U.S government research funding under NITRD allocated to the large scale networking program area declined by almost ten percentage points, from 18 percent to 10 percent.[16] The federal government has not viewed communications-sector basic research with sufficient importance in light of its impact on the economy and security of the United States; this despite the fact that communications is a critical infrastructure and it is the backbone for all information technologies. Communications are an indispensable part of every other industry, from automobile manufacturing to healthcare to financial services and more.

In addition to the already low investment in ICT research, the December 2010 PCAST report found that these numbers are actually significantly inflated and that the federal investment in ICT research is far less than what is shown in the budget.[17] PCAST found "that a substantial fraction of the NITRD multi-agency spending summary represents spending that supports R&D in other fields."[18] A large percentage of the $1.5 billion dollar High End Computing Infrastructure and Applications budget is spent on computing infrastructure used to conduct R&D in other fields. Additionally, confusion in classification of NITRD investment by participating agencies also suggests that a dramatically smaller amount of the NITRD budget is actually going to ICT research. Specifically, a review of the NIH ICT research budget for 2009 found that only four of 100 research projects were definitely focused on ICT research, representing only 2% of the NIH ICT research budget.[19] PCAST observed that, "Although other agencies do not report NIT R&D spending in sufficient detail to make the same analysis possible, it seems likely that in many cases a similar confusion in classification of NITRD investment occurs."[20] Given the lack of detail specific to how NITRD funds are being spent by participating agencies, it is difficult to know how much federal investment is being made into actual ICT research, but it appears to be extremely low.

The proposed Wireless Innovation Fund (WIN) is an important step forward in buttressing the U.S. ICT research ecosystem. By dedicating funds for specific ICT research projects, the WIN fund targets ICT research to areas where there are specific needs. The long-term nature of the funding is also significant given the long-term nature of ICT research. The WIN fund is also significant in that it dedicates funding for basic research.

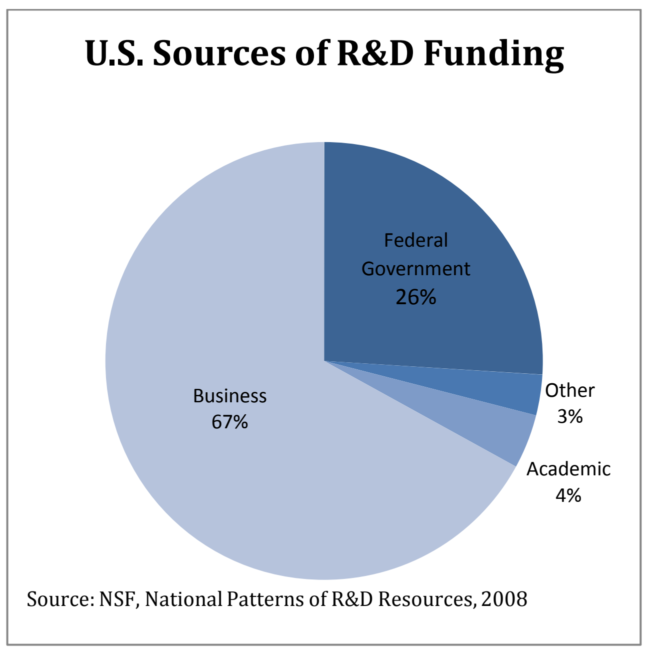
III. Basic ICT Research Gap

Federal funding in ICT research is critical, particularly given the government's role in funding basic research. We are seeing a growing research gap in basic ICT research in the United States. If not remedied, this research gap threatens U.S. leadership and innovation in the ICT sector, with consequences for both the U.S. economy and national security. ICT research can be divided broadly into two categories: 1) basic research and 2) applied research. Basic research is fundamental, theoretical, or experimental investigation to advance scientific knowledge without an immediate focus on practical or commercial applications. Basic research is focused on game-changing discoveries that by their nature are high-risk and require long-term investment. Applied research seeks to solve practical problems through investigation of the findings of basic research to determine how they can be applied to develop new products, technologies, or services. Applied research is short-term in nature with a clear commercial objective and a desired short-term return on investment. Stable and balanced investment flows in both categories is critical to the ICT industry with basic research providing innovation on core scientific discoveries, and applied research translating those discoveries to benefit society.

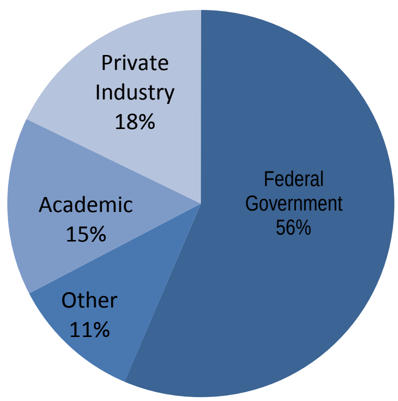
A well-documented example of the relationship between basic and applied research is the invention of the laser, which was funded substantially by federal research dollars. Charles Townes, co-inventor of the laser, remarked that some of his colleagues at the time criticized his work on the laser as "a solution looking for a problem."[21] In hindsight, history proved that the laser was in fact a solution for many problems, ultimately revolutionizing the telecommunications industry through fiber optics and making possible a seemingly endless chain of applications from laser guided weapons to laser corrective surgery.[22] The government provided critical support upfront for basic research and industry then funded the applied research to bring a myriad of other benefits. Townes observed, "As a society, we must be sure we don't focus all efforts just on things we are *sure* will pay off economically. We need to devote some resources to exploring things that may revolutionize our understanding. We must continually emphasize that, and take the risk."[23] Specific to the ICT industry, the National Academy of Sciences noted that in 1994, when authoring a report on Innovation in Information Technology, the authors were discouraged because they could not specifically identify ICT research advances that were likely to lead to new billion-dollar industries. Eight years later, when updating the report, over a half dozen such industries had already emerged.[24] Investment in basic ICT research has proven itself time and time again to yield significant advances in technology and subsequently benefit the U.S. economy. Despite this success, a combination of factors has led to a significant gap in basic, long-term ICT research in the United States. Both industry and federal investment in basic ICT research has become inadequate.

Industry Investment in Basic Research

Accounting for almost 70% of all research investment in the U.S., private industry will continue to account for a major portion of overall research investment and activity in the United States. Basic research, however, makes up a very small percentage of the research conducted by ICT companies. Overall, private industry investment currently only accounts for 18% of all basic research conducted in the United States. PCAST described this as "a situation that is both appropriate and un likely to change."[25] Most industry research can be classified as applied research or development as ICT companies operating in a highly competitive and commoditized environment invest limited resources in product evolution to quickly bring products to market.



U.S. Sources of R&D Funding for Basic Research

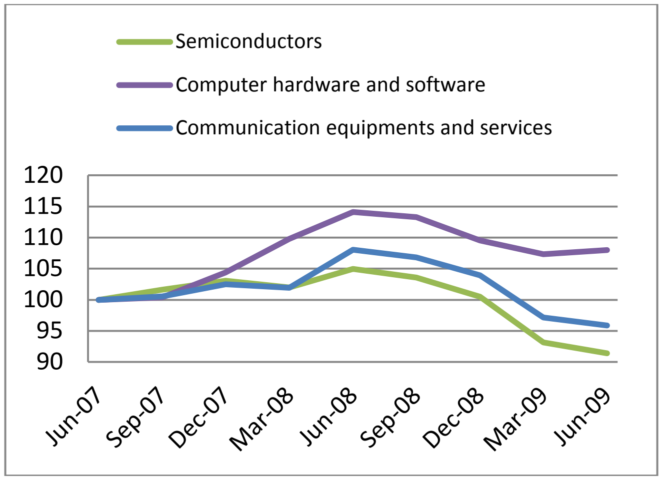


Source: NSF, National Patterns of R&D Resources, 2008 Data

Prior to restructuring in the 1980's, basic, long-term ICT research was conducted significantly by large industrial research laboratories, such as Bell research laboratories, which were funded by fees assessed on Bell operating companies. Within the Bell system, a stable flow of ICT research funds guaranteed stable investment of funding for basic research. Following restructuring, the large industry research laboratories began to downsize and place greater focus on applied research, shifting basic research up the supply chain as telecom operators began to rely significantly on telecom vendors to fund and conduct basic research. Like other sectors, the ICT sector has become increasingly commoditized over time allowing a range of companies to acquire the resources and expertise necessary to offer similar products and services. While the increased competition decreases prices for consumers, competing with lower production costs overseas requires rapid product evolution by U.S. firms to continue to offer cutting edge, high-value technologies in order to compete. As the NAS described, "long-term, fundamental research aimed at breakthroughs has declined in favor of shorter-term, incremental and evolutionary projects whose purpose is to enable improvements in existing products and services. This evolutionary work is aimed at generating returns within a couple of years to a couple of months and not at addressing the needs of the telecommunications industry as a whole in future decades."[26] In short, market forces have pushed industry to place greater focus on product evolution than technology revolution, creating a gap in basic research funding and in turn a gap in innovation in the ICT sector. In addition to the nature of the ICT market, the economics of investing in basic research limits industry activity. The fruits of basic research generally have broader applications than what would merit the required investment of an individual company. This is particularly true for the ICT industry, where benefits cross over significantly to other sectors.

Periods of economic recession exacerbate ICT industry underinvestment in basic research as firms conserve cash and devote funds to projects with a shorter investment horizon. For the ICT industry, recessions result in the reduction of available funds through venture capital or IPOs while simultaneously decreasing consumer confidence and overall revenues, which further decrease funds available for industry investment in R&D.

Quarterly R&D expenses, ICT industries 2007-09



Source: OECD STI Scoreboard 2009

Recessions hit both large and small firms, creating an environment where companies are pushed to find lower cost alternatives to bring products and solutions to market. The recession in 2000 created an environment that accelerated the growth of the ICT sector in developing countries, most notably China and India. Importantly, just as the recession in 2000 accelerated the development of ICT manufacturing in other countries, the current recession could act as a catalyst to push R&D to other, lower-cost countries as well.

The U.S. government can help bolster private industry investment in basic research through increasing the revenues of ICT companies by adopting policies that encourage broadband deployment as well as by making the R&D tax credit permanent. Continued direct federal investment in basic ICT research is also critical to preserve the health of the U.S. ICT research ecosystem.

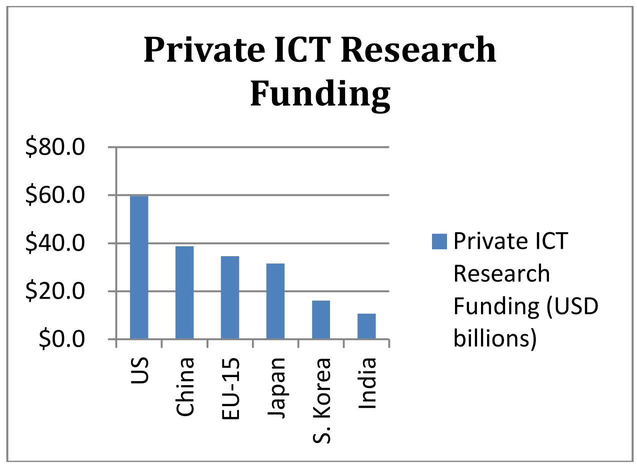
Federal Investment in Basic Research

The need for federal funding for basic ICT research has increased dramatically to sustain an adequate level of stable investment in basic research. Federal investment in basic research has played a key role in advancing numerous ICT breakthroughs and the multiple billion-dollar industries that followed them. PCAST observed, however, that "the Federal NIT R&D portfolio is currently imbalanced in favor of low-risk projects; too many are small scale and short-term efforts. The number of large-scale, multidisciplinary activities with long time horizons is limited and visionary projects are few."[27] Given the low amount of industry investment in basic research, it is critical that federal investment be allocated to fill the gap.

Federal research dollars are critical to buffer and offset the decline of private research funding during periods of financial crisis, such as our current recession. During recessionary periods, industry R&D funding noticeably dips. During these periods, federal funds are critical to buffer the research ecosystem. Decreasing federal R&D funding during a recession would compound the damage to the ecosystem. ARRA funding acted as a buffer in maintaining R&D investment. Without ARRA funding, research investment in the United States would actually decline in real terms in 2011.[28] Historically, federal policymakers have appreciated the necessity for federal R&D investment. Federal R&D has been cut in real terms only three times in the past thirty years: 1991, 1994 and 1996.[29] In the current recession, TIA strongly recommends continued funding for ICT research to maintain U.S. leadership in the sector.

IV. U.S. Leadership & International Competition

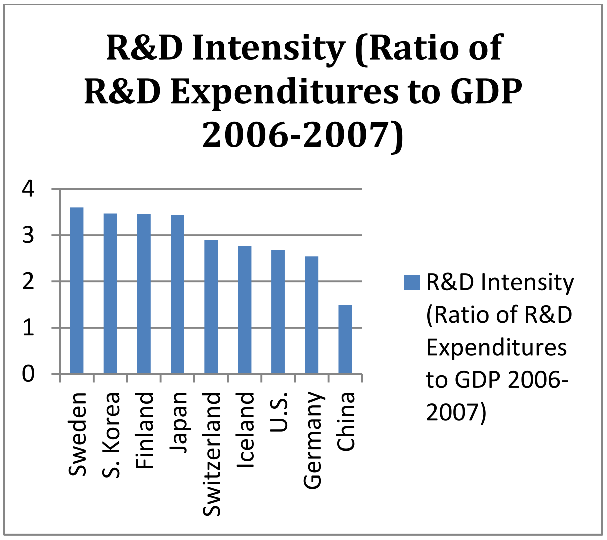
Telecommunications is a global, highly competitive industry where U.S. leadership is threatened as other countries identify the ICT sector as a key economic driver. It was noted in the report, *Rising Above the Gathering Storm,* that "as we enter the 21st century, however, our leadership is being challenged. Several nations have faster growing economies, and they are investing an increasing percentage of their resources in science and technology. As they make innovation-based development a central economic strategy, we will face profoundly more formidable competitors as well as more opportunities for collaboration. Our nation's lead will continue to narrow, and in some areas other nations might overtake us."[30] The U.S. remains the most significant investor in R&D, but other regions are aiming to close the gap with a laser-like focus on the ICT sector.



Source: OECD Information Technology Outlook 2008 & French Ministry for Education & Research

In the ICT sector, U.S. leadership has been maintained by a healthy research ecosystem bolstered by unparalleled financial investment from the private and public sector, a strong pool of talented researchers, and continually being the largest market for ICT, which resulted in attracting companies, investment and product innovation to meet commercial and individual consumer demands. Based on increased investment in other countries, more available talent, and demographic growth rates and expanding markets, the U.S. is gradually losing these advantages. Failure by the U.S. to focus on ICT as a key industry sector will lead to the U.S. yielding leadership.

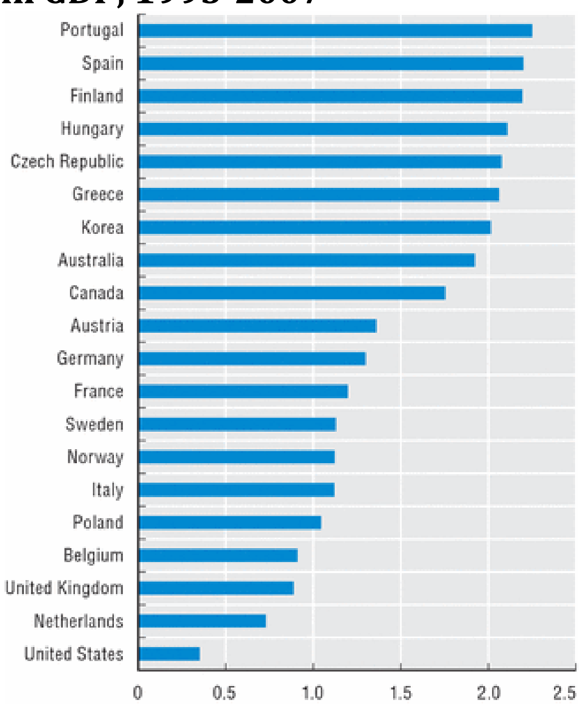
We are beginning to see signs of the U.S. ceding leadership in the ICT space. The U.S. has fallen to eighth place among OECD countries in R&D intensity, the ratio of R&D expenditures to GDP.



Source: NSF Science & Engineering Indicators, 2010

Other countries have made increased research intensity a key part of their economic growth plans, and many countries are increasing their research intensity at a rate much faster than the U.S.

Percentage increase in business R&D expenditure for 1% increase in GDP, 1995-2007



Source: OECD Regions at a Glance 2011

From an industry perspective, there are fewer U.S. based firms ranked in the top 250 ICT firms than in previous years.[31] Revenue growth from the top 250 ICT firms is one indicator that the U.S. is being outpaced by countries that have placed greater focus on growing their ICT sectors. Revenues from the top ICT companies in the United States increased 70% from $717, 249 to $1,216,576 (USD millions) from 2000 to 2009 while ICT revenue growth in other countries has increased much more dramatically: China (315%), Finland (101%), Germany (91%), India (473%), Norway (267%), Singapore (135%), South Korea (136%), Spain (206%), and Taiwan (428%).[32] Increased company revenues generally correlate with increased private research spending. For example, from 1996-2005, private industry research in the U.S. only increased 6% while ICT research in countries with a more pronounced increase in revenues grew much faster: South Korea (71% total increase from 1996-2005) and China (22% annual average growth rate from 1997-2007).[33] Other countries and regions are benefitting from government policies aimed specifically at growing their ICT sectors and attracting research investment at an unprecedented level. There is not currently adequate comparative data on government ICT research funding between countries to do a strict comparison, but trends in market growth, government focus on the ICT sector, and increased R&D investment demonstrate that the U.S. is being outpaced.

<u>Asia</u>

The Asia region includes three of the top five R&D spenders in the world and enormous potential to compete with the United States for leadership in the ICT sector. Asia generally and China specifically stand out for increasing R&D investment during the current recession. Over the last decade, China has increased R&D spending roughly 10% annually and has sustained this rate of increase through the current recession. The Asia region is benefitting from government policies focused on developing robust research ecosystems, an increasing pool of talented emigrant scientists returning to their home countries, and growing markets that are attracting both private and public investment. While investments are being made across a range of science and technology sectors, the ICT sector has drawn significant focus from the Asia region.

China

China has identified the ICT industry as a primary driver of their economic strategy. China's 10th Five Year Plan for the 2001-2005 period set a goal to establish the telecommunications industry to "become the leading industry among all other industries in the economy."[34] Since then, telecommunications has rapidly become a leading industry in China, and with a growing market, intense focus on development of the sector and a strong commitment to R&D, China is poised to become a global leader in the ICT industry.

China's leadership understands the importance of increased R&D investment to their future economy and in growing their ICT sector. In 2006, the OECD announced that China had become the second highest global investor in R&D.[35] By 2006, China's overall R&D spending had exceeded that of Japan and amounted to about 1.4 percent of its GDP—on a path to achieve a national goal of 2.5 percent of GDP by 2020.[36] In March 2011, China released their 12th Five Year Plan with a goal of further increasing the ratio of R&D to GDP to 2.1%.[37] China's investment in R&D parallels its annual economic growth rate, increasing 9-10% annually, which in terms of percentage is roughly four times that of the United States.[38]

The National Academy of Sciences described China's increased investment in R&D as it relates to the ICT sector as follows:

> "Chinese IT R&D will continue its rapid growth, given its past growth, the inherent commercial opportunities, and the importance given to it by the Chinese government. The enormous buildup in IT productive capacity in China will become a magnet for production engineering and higher-level R&D. Given the likely growth of China's domestic market, no major IT firm can afford to ignore the market, and it will be necessary to support that market with some domestic production. Given China's expanding labor pool of low-cost engineers, multinational corporation experiencing pressure on margins are likely to expand their engineering activities there. In terms of R&D, China is rapidly increasing its share of total global R&D. Some Chinese firms are already global competitors in the IT industry, and there are likely to be more."[39]

In addition to government policy focused on the importance of the ICT sector, China's research ecosystem is benefitting significantly from a factor that has long benefitted the U.S. research ecosystem, an ever-growing ICT market. After the United States, China had the largest telecommunications market in the world at $354 billion in 2010.[40] The United States is second in the world, behind China, in the number of broadband households.[41] In China, however, despite its large base, broadband penetration is still relatively low, leaving substantial room for growth. For example, TIA projects the number of fixed broadband subscribers to rise from 115 million in 2010 to 175 million in China by 2014,[42] and we project China to add 400 million wireless subscribers during the next four years increasing from 850 million subscribers in 2010 to 1.25 billion in 2014.[43] The result of this rapid growth will be increased investment, including investment in R&D.

In China, the government aims to expand Internet reach to 45 percent of the population by 2015 from 29 percent at the end of 2009. Part of that effort includes a $22 billion investment in a fiber network that will create 80 million broadband fiber ports by the end of 2011. Separately, China Mobile, China Telecom and China Unicom are spending $10 billion over the 2009–13 period on broadband infrastructure, an investment that will support 93 million fiber lines. In the mobile market, China Mobile spent $14 billion in 2010 on rolling out its 2G/3G network. China's domestic TD-LTE-Advanced (time division duplex LTE) 4G standard, which has a download speed of 100 Mbps, was selected by the ITU as one of its six approved 4G standards. China Mobile is increasing its R&D spending on 4G and launched three pilot networks that feature 100 TD-LTE cell towers each.[44]

The results of China's efforts in the ICT sector are best represented by the rapid ascent of Huawei Technologies. Founded in 1987, primarily starting as a domestic supplier for the Chinese market, Huawei has expanded globally to become the second largest provider of mobile network gear. Huawei won its first contract outside of China in 1997, and for 2010 international contracts now account for 65% of the company's revenue.[45] In short, China has become the second largest investor in R&D, the second largest telecommunications market, and their efforts have produced the second largest mobile network vendor generating a growing majority of its revenues from global sales. All of these factors combine to create a competitive research ecosystem that will rival U.S. leadership in the ICT sector unless the U.S. government devotes the necessary focus and resources to the ICT industry.

Japan

Japan is now the third largest global investor in R&D, recently surpassed by China as both the world's second largest economy and second largest R&D spender.[46] Japan has the second highest R&D to GDP ratio at 3.62%[47], and is one of only four OECD countries in which the R&D to GDP ratio exceeds 3%.[48] Japanese investment in R&D decreased in 2008-2009 for the first time since 1999 as a result of the current recession.[49] In an effort to further encourage R&D, legislation was introduced in Japan for more generous tax credits for companies engaging in R&D.[50]

Japan has long recognized the importance of the ICT industry and R&D for their future economy. With a more mature economy and ICT sector, Japan is focusing on increasing the ubiquity of ICT within the country as well as encouraging higher intensity use of ICT throughout the economy. Japan has the most advanced broadband infrastructure of any country in the world with average download speeds of 64 Mbps.[51] Japan also has the highest percentage penetration of fiber to the home subscribers.[52]

In 2007, Japan launched the u-Japan (Ubiquitous Japan) project and the USD 13.6 billion Zero Broadband Areas Elimination policy with a goal of increasing broadband availability to 100% across Japan by 2011.

South Korea

South Korea ranks 5th overall in the world in R&D investments. South Korea has made great strides in recent years to increase their R&D spending, including a 10% increase in 2009. South Korea's R&D to GDP ratio was 3.37% in 2009.[53] The South Korean government seeks to accelerate this growth rate, setting their sights on making R&D expenditures account for 5% of their GDP by 2012.[54] The South Korean government expects to double government investment in R&D, from $35 billion in 2007 to $66 billion in 2012 and to increase the number of researchers per 10000 citizens from 53 in 2007 to 100 by 2012.[55] South Korea has focused intensely on developing its ICT sector and currently has one of the most advanced broadband infrastructures with an average download speed of 40mbps.

<u>Europe</u>

Europe has identified the ICT sector as one key to lead the way out of the economic downturn identifying opportunities "to be in the lead to develop, master and shape the 'Future Internet' that will gradually replace the current web and fixed and mobile networks and service infrastructures…be at the forefront of the next-generation ICT components and systems…lead in radically new technological paradigms and in new multi-disciplinary R&D at the frontiers between ICT and other fields…lead the ICT transformations driven by its societal challenges such as ICT-based health systems and ICT-based monitoring and control tools that will help optimize energy efficiency, safety and security in buildings and transport."[56] The Digital Agenda for Europe sets a goal to provide basic broadband coverage for all EU citizens and businesses by 2013 and to provide internet coverage of 30 Mbps or above for all Europeans by 2020 with half of European households subscribing to connections of 100 Mbps or higher.[57]

Increasing both public and private research funding in the ICT sector is at the center of Europe's digital strategy. Historically, Europe has lagged behind the U.S. in R&D funding. In terms of total R&D investment (in all sectors), the gap between the EU and the US is €73 billion, of which almost half (€33 billion) is accounted for by the ICT sector.[58] Europe is seeking to close the gap through increased public investment as well as policies to leverage greater private R&D investment. The Europe 2020 report sets a target for 3% of the EU's GDP (public and private combined) to be invested in R&D/innovation by 2020.[59] Europe's fiscal austerity measures will limit their ability to achieve their goals in the short term to match overall R&D spending with other economies, but they have the potential to make progress in the ICT sector specifically.

The Seventh Framework Programme for Research and Technological Development (FP7) is the EU's main instrument for funding research in Europe running from 2007 to 2013. The FP7 budget is € 50.5 billion representing a 41% increase from FP6 at 2004 prices and a 63% increase at current prices.[60] The FP7 allocates € 9.1 billion to ICT research making it the single largest recipient of EU research funding demonstrating the ICT sector as the funding priority of the European Commission.[61] The European Commission plans "to maintain a pace of 20% yearly increase of the ICT R&D budget at least for the duration of FP7."[62] The Information Society Technologies Advisory Group (ISTAG) has also just issued its recommendations to the Commission on the orientation for EU ICT R&D and Innovation beyond 2013 with a strong focus on strengthening EU investment in ICT research.[63] In addition to EU-level funding, the European Commission also states that Member States should "by 2020, double annual total public spending on ICT research and development spending from €5.5bn to €11bn (which includes EU programmes), in ways that leverage an equivalent increase in private spending from € 35 billion to € 70 billion."[64]

Germany

The fourth largest R&D investor in the world, Germany leads Europe in R&D. Germany's R&D to GDP ratio was 2.5% in 2007, compared to the OECD average of 2.2%. The German government has taken a more active role in encouraging ICT R&D investment in Germany, through their ICT 2020 plan. ICT 2020 looks to encourage ICT R&D by providing approximately €3 billion in funding for ICT programs and research by 2011. ICT 2020 hopes to spur innovation in the ICT sector, while also encouraging private industry to increase their investment in ICT.[65]

U.K.

The U.K. has also set ambitious goals to increase ICT research. The UK has set a target to increase its share of publicly funded science and technology research and development from 1.9 percent to 2.5 percent of GDP by 2014. In their efforts to increase R&D intensity, the UK has devised a Strategic Investment Fund to encourage R&D in new areas of technology, including £250 million for low carbon technologies. The UK also offers tax credits for R&D projects worth up to £600 million per year.[66]

France

French ICT R&D investment has been steady over the last decade. The French Government has set a goal to devote 3% of their GDP to R&D. As of 2008 R&D accounted for 2.02% of the French GDP.[67] The French government has ambitious broadband plan with the intent is to connect 70% of their population to high-speed broadband by 2015, and 100% by 2025. The Government offers tax credits for R&D of up to 40% of expenditures for the first year, 35% for the second year, and 30% for subsequent years up to €100 million. [68]

Finland

Finland has been extremely successful in developing their ICT sector. Finland is one of the world leaders in R&D and ICT R&D intensity. Finland consistently has the highest R&D intensity in Europe, and R&D expenditure increased to 3.9% of their GDP by 2010.[69]

Sweden

Sweden has a similar ICT R&D intensity to Finland. Swedish R&D in general accounts for 3.74% percent of their GDP.[70] Sweden's commitment to ICT R&D and innovation is reflected by their national broadband plan. Sweden's 2009 broadband plan aims to expand Sweden's position as an ICT leader. Sweden has high broadband penetration rates in both the residential (79%) and enterprise (89%) setting.[71]

These are just a few examples of how other countries are investing the time, money and intellectual capital necessary to grow the ICT sector in their economy and to create attractive environments for science and technology research. In order for the US ICT industry to remain competitive for the long-term, TIA recommends the adoption of the following policies.

V. TIA RECOMMENDATIONS

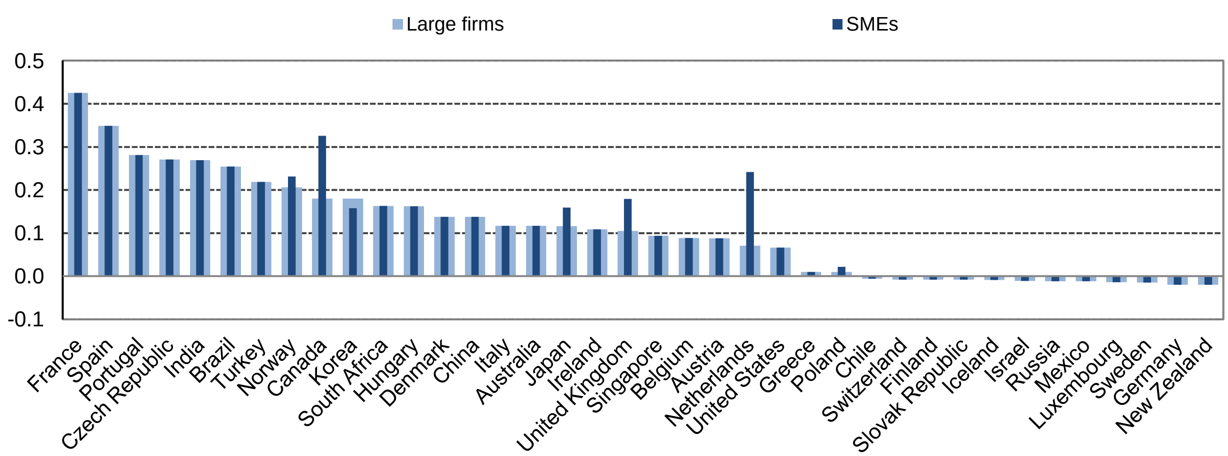
RECOMMENDATION 1: Congress should facilitate greater private investment in basic, long-term research through enactment of a permanent, simplified, R&D Tax Credit.

The R&D tax credit is a critical tool to provide incentives for private investment in research helping to maintain a stable source of funding for the U.S. research ecosystem. Initially enacted under the Economic Recovery Act of 1981 as an economic recovery incentive to encourage investment by companies in research, the credit has since been renewed 14 times. In 2008, 12,736 corporations invested $8.3 billion dollars and 64,000 individuals invested $463 million dollars qualifying for research credits.[72] The credit has proven to be cost effective in increasing the overall amount of research activity in the United States, found to produce "a dollar for dollar increase in research spending, although some studies find larger effects."[73]

As valuable as the R&D Tax Credit is in encouraging R&D expenditures in the United States, the effectiveness of the credit is significantly impaired for use by the ICT industry by both its temporary status and the complexity of calculating it. The temporary status of the credit largely restricts use of the credit to short-term research projects, which is particularly deleterious to use of the credit for basic research and ICT research generally, which is often long-term by nature. Simply put, a short-term credit provides incentives for short-term research, thereby broadening the gap in basic ICT research spending in the United States. When conducting basic research, firms are already committing resources to a higher-risk activity. Adding an additional layer of risk with the uncertainty of the credit being renewed discourages use of the funds for multi-year research projects. Making the credit permanent will provide firms with the certainty they need to make use of the credit for long-term, basic research.

In addition to the technology and innovation benefits of overall research funding taking place in the United States, the credit also supports the U.S. research ecosystem through supporting technology employment in the United States as approximately 70% of research costs that qualify for the credit are labor costs.[74] The Department of Treasury estimates that making the R&D tax credit permanent and increasing the alternative simplified credit rate "will fund more than $10 billion per year in research activity in the United States, supporting nearly 1 million jobs in research.[75] A permanent R&D tax credit is a critical pillar of the U.S. R&D ecosystem and in asserting U.S. leadership. Since the U.S. pioneered the R&D tax credit in 1981, other countries have recognized the value of the credit in attracting research investment. As of 2008, the U.S. ranked 24th of the 38 countries assessed by the OECD in R&D tax credit generosity.[76] Failure by the U.S. to adopt policies that encourage research spending will inevitably lead to research being performed in competing ecosystems.

Tax subsidy rate for USD 1 of R&D, large firms and SMEs, 2008



Source: OECD STI Scorecard 2008

RECOMMENDATION 2: Congress should fully fund the Wireless Innovation Fund (WIN) and dedicate future funds for ICT research. Funding for ICT research should encourage multi-year federal research plans and demonstrate a commitment to basic research.

TIA strongly supports full funding for the proposed Wireless Innovation Fund (WIN), a newly proposed $3 billion fund to help spur the development of new wireless technologies with 1/3 to support basic research, 1/3 to experimentation and testbeds and 1/3 to applied development in a number of areas, including public safety, education, energy, health, transportation, and economic development. The WIN fund includes several key elements beneficial to support the US ICT research ecosystem. First, the fund directs dollars directly to ICT research. The U.S. has underinvested in ICT research for years, and much of the funding labeled as ICT research in the federal budget is actually used for ICT equipment to conduct research in other fields. Second, the fund directs dollars to basic research and multi-year research projects where we continue to see a growing funding gap. Third, the fund directs dollars to key areas addressing research gaps in other sectors, where increased use of ICT will be key to solving some of the grand challenges ahead including energy, education, transportation, public safety and healthcare. As ICT use becomes more robust across our economy, it will continue to increase the scope of research challenges requiring greater commitment from both the public and private sectors. In their most recent report, PCAST recommended increasing the amount of federal ICT research funding and noted that "an investment of at least $1 billion annually will be needed for new, potentially transformative NIT research."[77] The multi-year nature of the projects addressed in the WIN fund, marks a significant step forward in filling the growing ICT basic research gap.

RECOMMENDATION 3: Congress should continue appropriations to fulfill the authorization levels included in the COMPETES Act (PL 111-358) and remain on the path to double the basic science budget by FY2015.

RECOMMENDATION 4: Improve coordination and accounting of ICT research throughout the federal government. There needs to be a better coordinated effort including all agencies conducting ICT research that allows all entities to understand what efforts are occurring at all levels as well as better accounting to verify funds directed to ICT research are in fact being used for ICT research.

NITRD is a critical mechanism for coordinating ICT research investment across federal agencies. Continual improvement in both the coordination and accounting of ICT research at the federal level will help buttress the US ICT research ecosystem. The more robust application of ICT to different sectors of the economy (smart grid, smart buildings, smart transportation, health IT, etc.) will result in the need for more active coordination from participating agencies as the various agencies will be addressing many similar issues ranging from cybersecurity to interoperability and reliability.

It is critical for policymakers to know what federal investments in ICT research are actually being spent on ICT research and what investments are being used on ICT to support research in other fields. The current NITRD budget dramatically overstates how much the federal government is actually investing in ICT research. "A large portion of the High End Computing Infrastructure and Applications budget category, which accounts for roughly $1.5 billion of the$4.3 billion NITRD crosscut total, is attributable to computation infrastructure used to conduct R&D in other fields, and not to NIT R&D or to infrastructure for NIT R&D." [78] Also, as noted previously, only 2% of the NIH NITRD portfolio is actually being spent on ICT research, and the only reason we know this is because of detailed accounting by NIH. Policymakers need more detailed accounting regarding how the other 12 participating agencies are spending their ICT research funds.
TIA agrees with PCAST's recommendations that:
The NCO and OMB should redefine the budget reporting categories to separate NIT infrastructure for R&D in other fields from NIT R&D, and should ensure more accurate reporting of both NIT infrastructure investment and NIT R&D investment.[79]
TIA also agrees with PCAST's recommendation that NITRD should create a publicly available database of government funded NIT research, and should provide regular detailed reporting to the Director of OSTP.[80]

RECOMMENDATION 5: Promote polices that stimulate broadband deployment and research. Identify innovative research breakthroughs that will decrease the cost of broadband deployment, which would further the goal of Internet access for all Americans. The National Academy of Sciences should convene a panel to investigate gaps in broadband research.

RECOMMENDATION 6: Institute policies that encourage cooperation and information sharing with other nation's research efforts to ensure that there is a coordinated approach to solving problems and thus avoid the allocation of scarce research resources in a duplicative fashion.

RECOMMENDATION 7: Facilitate greater ICT industry input into agency funding priorities, so that there can be better coordination between research and commercialization.

Numerous bodies have identified and advocated the need for greater industry input on issues related to federal ICT research. The National Academy of Sciences in 2007 identified the need for greater input from the technology community "to the highest levels of the U.S. government the best possible advice on the transformational power of information technology would help ensure that the nation invests at appropriate levels in IT research and that these investments are made as efficiently and as effectively as possible—in part through improved coordination for federal R&D investments. This advice could be provided in a number of ways, including the augmentation of the current presidential science and technology advisory structure, the establishment of a high level IT adviser to the President, or the reestablishment of an IT-specific presidential advisory committee…the federal government should ensure that appropriate advisory mechanism are in place to guide investment within the IT R&D portfolio."[81] PCAST recommended, "OSTP should establish a broad, high-level standing committee of academic scientists, engineers, and industry leaders dedicated to providing sustained strategic advice in NIT."[82]

TIA agrees with PCAST that a special, high-level advisory committee focused on ICT will be critical to provide the Administration with strategic advice in the ICT sector. One mechanism for industry input would be the initiation of the Presidential Advisory Committee on High-Performance Computing as created and authorized by the America COMPETES Act (P.L. 110-69). Under the Federal Advisory Committee Act executive action must be taken to establish the Presidential Advisory Committee, which has not yet been put in place.

Technical Areas Where Research is Needed:

- **Universal Broadband – Affordable broadband access and connectivity, using all available media (copper, coax, fiber, spectrum, etc.), carrying all services (voice, data, video) to all customers everywhere (urban, suburban, rural, mobile) in order to enable a greatly upgraded "superhighway."**
    - Broadband Internet access is critical to support technology convergence and advanced communications. A forward-looking U.S. Government should support universal access for broadband Internet, as well as policies that promote widespread connectivity. Infrastructure upgrades create increasing returns to our economy and encourage the development of businesses, entertainment, education and e-government solutions and capabilities.
    - Additional *federally funded* research in this field is needed, particularly because special technologies will be needed for rural access and corporate and venture capital financing for research has dropped significantly over the last several years. Extremely significant cost reductions are necessary in order to meet the technology needs of rural areas. Additionally, the provision of broadband access in rural areas is costly due to challenges associated with terrain, low population density, etc.
    - Specific Areas Include:
        1. Deployment costs – for example, NIST should be performing research in these areas in order to create efficiencies in deployment & new technologies to make deployment

faster and less expensive. This is an area of national priority, and should be part of NIST's work in communications/network research
2. Improving back haul for wired and wireless access networks.
3. Reducing power requirements to support data centers – how do we improve efficiencies to reduce power requirements, including energy devoted to cooling.
4. Spectrum utilization and repurposing.
5. Access technologies (e.g.,BPL, wireless access, optical networks).
6. Interconnect speeds and reducing network bottlenecks.
7. Meeting escalating consumer bandwidth demands, beyond 100 and 400G (to 1 Terabit).
8. Test beds for next-generation networks

- **Security – New authentication, encryption and monitoring capabilities for all public broadband networks to protect communications assets from attack.**
  - The 2007 NRC report Toward a Safer and More Secure Cybserspace calls for "a broad, robust, and sustained research agenda at levels which ensure that a large fraction of good ideas for cybersecurity research can be explored…commensurate with a rapidly growing cybersecurity threat" and observes that "a substantial increase in federal budgetary resources devoted to cybersecurity will be needed."[83]
  - The U.S. is a post-industrial information society, and as such, its cyber-infrastructure is vulnerable to attack.
  - Continued research is needed to prevent systemic attacks to infrastructure and may provide an opportunity for university-based "centers of excellence."
  - Specific Areas Include:
    1. Investment in secure operating systems – beyond preventing harm, but making sure operations work during crises
    2. Security of wireless networks
    3. Digital rights management
    4. Restoration of complex networks
    5. Malicious software protection

- **Interoperable Mobility – The ability to access commercial mobile services and emergency services over any mobile network from any mobile instrument.**
  - Interoperable mobility enables public safety and law enforcement officials to use the various public safety and cellular mobile networks while avoiding the necessity of carrying multiple mobile devices. It also promotes coordinated communications between various public service agencies and allows higher priority use of scarce spectrum resources for emergency use.
  - Federally funded research is necessary because the emergency services market is critical for the common good. Also, bringing commercial technologies and emergency services technologies closer together will result in lower costs and more advanced features for critical emergency services.

- **Telecommunications Research for Homeland Security, including interoperability, security, survivability and encryption.**

  - Homeland Security is a superset of several core constituencies with a common objective, different missions, but often common and interconnected technology and data requirements. Security technologies can help protect public networks and other public infrastructure from malicious attacks. A large amount of economic activity today depends on the continued availability of public broadband networks and infrastructure. Successful attacks can significantly slow down national economic activity and can have other disastrous consequences (e.g. in case of identity theft).

- Research is needed in all areas (interoperability, security, survivability and encryption) because the needs of first responders and critical infrastructure protection far exceed the needs of "typical" commercial applications. Further research also is needed because new worms and viruses constantly are being invented, and new techniques are needed to prevent attacks before there is significant resulting damage.
- The country needs a broad program to address our vulnerabilities and ensure the integrity of first responders' systems. The government should support these "extreme case" applications, since they are unlikely to be sufficiently developed in normal commercial systems.
- The country also needs to consider network issues related to disaster response and long-term outages whether due to man-made or natural calamities that will shut down the system, including outages caused by various attacks including use of "electro-magnetic pulse" methods. In large measure, our success in leveraging tomorrow's information-based economy (and our national competitiveness) is directly related to the capabilities of our broadband infrastructure.

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