Investing in Telecom for Tomorrow's Innovations:
Recommendations for Telecommunications Research and Development

Background

Research is the backbone of the communications industry, a critical national resource. It is 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. Almost 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. While the United States, has been and continues to be, regarded as a leader internationally in technology research, the innovation of recent years cannot be taken for granted.

The nature of telecommunications industry investment is long-term, capital intensive and generally, non-cyclical. At the same time, the process of conducting communications research is extremely complex, involving time, money and foresight that must be sustained for a decade or more to yield the full fruits of investment.[1] Yet in recent years, both the changing face of the U.S. telecommunications industry and the competitive demands on those companies have created a scenario where companies are spending less on long term basic research. According to the National Research Council's report *Renewing U.S. Telecommunications Research* , "U.S. leadership in telecommunications did not come by accident—success at the physical, network, and applications levels was made possible by the U.S. investment in decades of research and the concomitant development of U.S. research leadership in communications-related areas".[2]

Further, one of the key findings in this report noted that according to researchers' testimony before the Council, "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."[3] This is precisely why the federal government's budget for research has become an increasingly important source of funding for U.S. telecommunications research and the targeting of such funds on relevant programs within the federal research agencies is critical to our country's future and long-term growth.

Telecommunications Research: A Worthwhile Investment

Investment in telecommunications research benefits the broader economy. Advances in telecommunications dramatically transform the way in which people live, work, learn, communicate and conduct business, and long-term research is essential to insure that these transformations serve human needs, are productive for society and sustainable over the long term.[4] Telecommunications, as an industry, represents about 7.4% of our Gross Domestic Product and in terms of job creation alone, a mere 1% increase is broadband deployment could mean the

[1] See PITAC presentation at http://www.itrd.gov/pitac/meetings/2004/20041104/compsci.pdf.
[2] See http://books.nap.edu/openbook.php?record_id=11711&page=9
[3] See http://books.nap.edu/openbook.php?record_id=11711&page=23
[4] See http://www.nsf.gov/home/crssprgm/itr/.

creation of as many as 300,000 new jobs.[5] This includes jobs in the telecommunications sector, manufacturing jobs created to meet the added demand of network equipment and customer premise equipment (CPE) – but does not include the jobs that would inevitably result from new access to broadband and the benefits it brings to all types of business.

Moreover, long-term communications research has significant positive effects, in terms of technical and economic spillovers. Research is a key factor in enhancing innovative performance and productivity, as well as long-term economic growth. This is because telecommunications is a supporting sector for the economy as a whole and for many specific industry sectors, such as distribution, retail, agriculture, financial services and machine building, among others. In fact, all sectors depend on and derive benefits from telecommunications research, which is precisely why the federal government should be concerned about the poor state of funding for telecom research and exhibit more support for the sector.

Research in this area is the principle source of fundamental advances in the digital technologies powering vital national defense, national security and homeland security capabilities. A strong, well-funded telecommunications research program benefits innovation in vital infrastructure protection measures, such as increased information security, reliability and survivability of networks, as well as facilitates development of the technologies and tools used to detect and prevent terrorist attacks.[6]

Current State of Federal Telecommunications Research Funding in the U.S.
For years, when compared with other industries, telecom research has not been well supported in the U.S. Government's federal budget. While today we have a positive story to tell regarding 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 basic telecommunications research.

For fiscal year 2009, the U.S. Government budgeted **$3.8 billion across relevant agencies for networking and information technology research and development.**[7] This is a minute fraction - about 2.5 percent - of the $147 billion[8] in total estimated federal research and development Fiscal Year 2009, not counting one-time spending on R&D through the "American Recovery & Reinvestment Act (PL 111-5).

To further illustrate the lack of federal focus on communications basic research, the total amount of federal funding budgeted for large scale networking (LSN) research – the part of the National Coordination Office for Networking and Information Technology Research and Development that includes communications and high-performance networking research and development in leading-edge technologies and services – **total about $448 million in fiscal year 2009**, or about 0.3 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.

[5] See http://www3.brookings.edu/views/papers/crandall/200706litan.pdf
[6] See Networking and Information Technology Research and Development FY2004 report.
[7] See http://www.nitrd.gov/pubs/2010supplement/FY10Supp-FINALFormat-Web.pdf
[8] See Congressional Research Service Report, Federal Research & Development Funding: FY2010, September 23, 2009

Moreover, between fiscal years 2002 and 2008, while the actual dollar amount dedicated to large scale networking increased, the percentage of U.S government research funding allocated to the large scale networking program area declined by over four percentage points, from 18 percent to 13.8 percent.[9] All of these statistics suggest that the federal government does not view 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. No industry today could survive without communications technologies and services.

U.S. Telecom Research Compared to Other Countries

Telecommunications is a global, highly competitive industry. 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."[10]

For example, Europe is in a competitive race with the U.S. and Asia for a leadership position in technology, especially technology that will impact global markets. In the European Union's (EU) 7th Framework Programme, 9 billion euros of funding has been prioritized for information society technologies (IST) research, making it the main source of EU funding for IST research projects.[11] This is part of the EU's overall goal to increase research and development expenditures to 3 percent of GDP by 2010, and **this also makes IST research the largest funding priority in the entire EU research program.** According to the European Commission, "Europe can lead the world if it can develop a common vision embracing researchers, industrialists, governments and societies across Europe."[12]

China has developed a five-year plan for the 2006-2010 period, which seeks to continue establishing the telecommunications industry as the leading industry among all other industries in its national economy.[13] In fact, between 2000 and 2006, China's science and technology research and development funding, as a share of gross domestic product, rose from 0.9 to 1.4 percent[14], with a target of 2 percent by 2010.[15] Further, China's government has made a commitment to improving the country's competitive position. China's Medium and Long-term S&T Strategic Plan (2006-20) provides a blueprint for further developing the nation's innovation capacity and for becoming an innovation oriented country by 2020[16]. This will continue to put pressure on U.S. entities to compete.

The United Kingdom (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. The

[9] See http://www.nitrd.gov/pubs/2008supplement/08-Supp-Web/TOC%20Pages/08supp-Budget.pdf
[10] See http://www.nap.edu/openbook.php?record_id=11463&page=204
[11] See http://europa.eu.int/information_society/research/index_en.htm.
[12] See http://europa.eu.int/information_society/research/index_en.htm.
[13] See http://www.oecd.org/dataoecd/39/19/37685541.pdf
[14] See http://puck.sourceoecd.org/vl=2696267/cl=49/nw=1/rpsv/factbook2009/07/01/01/index.htm
[15] See http://www.oecd.org/dataoecd/18/36/41559747.pdf
[16] See http://www.oecd.org/dataoecd/18/36/41559747.pdf

country's *Science and Innovation Investment Framework*[17] proposes that the public science budget increase 5.8 percent annually, in real terms, from 2004-2005 and 2007-2008.[18]

Japan raised the total amount of government research and development spending by over 7 percent between FY2006 and FY2007. Further, since 2000, R&D intensity in Japan has increased in Japan to 3.4% in 2006 and according to the OECD, from 2006-2007, Japan was one of only four OECD countries in which the R&D to GDP ratio exceeded 3%.[19]

An increasing number of OECD governments are offering special fiscal incentives to businesses to increase spending on research and development, largely because R&D and innovation are considered keys to productivity and growth performance. Since 2006, Spain, China, Mexico and Portugal provide the largest subsidies and their policies make no distinction between large and small firms. Emerging economies are also implementing these policy instruments to encourage R&D investments. Brazil, India, Singapore and South Africa provide a generous and competitive tax environment for investment in R&D[20].

These are just a few examples of how other countries are investing the time, money and intellectual capital to create attractive environments for science and technology research. The United States cannot afford to ignore the fact that U.S. industry needs federal government support in order to remain competitive for the long-term.

TIA's Solution

With this background, TIA's Communications Research Division (CRD) calls upon the various agencies to highlight the need for improved coordination of federal telecommunications basic research and to recommend the following items as priority research areas as they are essential to the next generation networks upon which the U.S. economy will increasingly rely. The CRD also makes the following policy recommendations for legislative action that should be taken to further our nation's R&D efforts and to continue to prioritize initiatives to improve America's competitiveness.

[17] See http://www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm.
[18] See OECD Science, Technology and Industry Outlook, 2004 p.56.
[19] See http://titania.sourceoecd.org/vl=1776560/cl=11/nw=1/rpsv/factbook2009/07/01/01/index.htm
[20] See http://puck.sourceoecd.org/vl=2925480/cl=41/nw=1/rpsv/sti2007/c-3.htm

Technical Areas Where Research is Needed:

1. **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:
        i. 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
        ii. Improving back haul for wired and wireless access networks.
        iii. Reducing power requirements to support data centers – how do we improve efficiencies to reduce power requirements, including energy devoted to cooling.
        iv. Spectrum utilization and repurposing.
        v. Access technologies (e.g.,BPL, wireless access, optical networks).
        vi. Interconnect speeds and reducing network bottlenecks.
        vii. Meeting escalating consumer bandwidth demands, beyond 100 and 400G (to 1 Terabit).
        viii. Test beds for next-generation networks

2. **Security – New authentication, encryption and monitoring capabilities for all public broadband networks to protect communications assets from attack.**
    - 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:
        i. Investment in secure operating systems – beyond preventing harm, but making sure operations work during crises
        ii. Security of wireless networks
        iii. Digital rights management
        iv. Restoration of complex networks
        v. Malicious software protection

3. **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.

4. **Telecommunications Research for Homeland Security, including interoperability, security, survivability and encryption.**
    - Homeland Security is a superset of several other listed visions. 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.

Overall Recommendations for Federal Activities:

1. Basic network research is being done on the federal level across a broad swath of agencies and it is being managed in a stove-piped manner. This is detrimental to the effort to approach issues and gaps in basic science that inhibit the development of next generation networks. There needs to be a better coordinated effort that allows all entities to understand what efforts are occurring at all levels.
2. Beyond the need for a coordinated effort for telecommunications research, there needs to be a long term commitment to basic research which includes: multi-year federal research plans; the commitment to a multi-year R&D tax credit; and a commitment to high-risk research that by its nature does not produce short term successes.
3. 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.
4. The National Academy of Sciences should convene a panel to investigate gaps in broadband research
5. Federal research agencies should improve processes for industry input on priorities so that there can be better coordination between research and commercialization.

Policy Recommendations:

1. Enactment of a permanent, simplified, R&D Tax Credit

2. Enactment of H-1B visa reforms to allow companies to hire the best and brightest minds in the world
3. Continued appropriations to fulfill the authorization levels included in the COMPETES Act (PL 110-69) and remain on the path to double the basic science budget by FY2015
4. A commitment and investment in Science, Technology, Engineering and Mathematics (STEM) education to help ensure that America is educating the workforce of the future
5. Identify innovative research breakthroughs that will decrease the cost of broadband deployment, which would further the goal of Internet access for all Americans

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