RESEARCH AND DEVELOPMENT

CHAPTER 7

IN THE 1970s, RESEARCH FUNDED by the Defense Advanced Research Projects Agency and later the National Science Foundation (NSF) was an important part of the development of the Internet. In the late 20th century, American companies led in the development of digital switching technologies, optical communications, cellular communications, Internet hardware and Internet applications. Federal investments in research and development, coupled with private firms' innovative research and product development, have led to the robust broadband ecosystem users enjoy today. Such investments have also made possible the creation of multibillion-dollar companies that are global leaders in networking, search and other Internet-based businesses.[1]

This R&D activity drove innovation and productivity gains, which aided economic growth. The National Research Council found that in the case of information technology (IT), "The unanticipated results of research are often as important as the anticipated results," "The interaction of research ideas multiplies their impact," and "Past returns on federal investment in IT research have been extraordinary for both United States society and the United States economy."[2]

America's top research universities and laboratories continue this R&D effort today in their experiments with very fast 1 Gbps networks (gigabit networks). For example, Case Western Reserve University in Cleveland, with 40 institutional partners, vendors and community organizations, is planning a University Circle Innovation Zone in the economically impoverished area around the university to provide households, schools, libraries and museums with gigabit fiber optic connections.[3] Case Western expects this network to create jobs in the community and spawn software and service development for Smart Grid, health, science and other applications, as well as foster technology, engineering and mathematics education services.[4]

The private sector continues to invest in high-speed networks, as revealed in several recent announcements during the course of the National Broadband Plan proceeding. Google has announced a plan to provide 50,000 to 500,000 consumers in a small number of test communities with gigabit connections.[5] And Cisco Systems is deploying a telemedicine pilot solution to 15 medical sites in California to spur e-health application development.[6]

All of these efforts aim to accelerate the pace of innovation by placing next-generation technology in the hands of individuals and entrepreneurs, and allowing them to discover the best uses for it. Very fast networks may lead to unanticipated discoveries that will change how people connect, work, learn, play and contribute online.

The federal government must continue to do its part to foster the development of research networks and wireless testbeds through a clear R&D funding agenda that is focused on broadband networks, equipment, services and applications. These efforts should include expanding access to ultra-high-speed connectivity through regulatory policy and direct action in communities where the federal government has a long-term presence, such as Department of Defense (DoD) installations.

The broadband ecosystem—networks, devices and applications—has benefited from research breakthroughs in a broad variety of areas such as networking, software, semiconductors, material sciences, applied mathematics, construction and engineering. Advancement in all these fields and many others is essential for continued innovation and improvement. For U.S. companies to continue to be leaders in high-value areas of the global broadband ecosystem, they must continue to generate and benefit from scientific innovation.

Although measuring the effects of R&D is difficult, studies find that firms earn 20% to 30% returns on their investments.[7] R&D returns to society are even higher as innovators beyond original research teams are able to access research and take work in new directions.[8] The gap between R&D returns for private companies and those for society presents a challenge for funding and conducting R&D.[9]

Government can help fill the R&D investment gap by funding research that would yield net benefits to society but that would not earn sufficient returns to be privately profitable.[10] This approach should include funding for direct research, for R&D at universities and other institutions, and for subsidizing private R&D through mechanisms such as the R&D tax credit.[11] Alongside direct funding, the government can take an active role in creating new next-generation applications and uses by linking DoD locations with ultra-high-speed broadband connectivity.

The federal government needs to create a clear agenda and priorities for broadband-related R&D funding, focused on important research that would not be conducted absent government intervention. The government can also promote R&D through regulatory policies allowing increased use of government resources. Examples include establishing research centers or allowing access to spectrum in order to evaluate new technologies in ways that theoretical studies and simulations do not support.

RECOMMENDATIONS

- The government should focus broadband R&D funding on projects with varied risk-return profiles, including a mix of short-term and long-term projects (e.g., those lasting 5 years or longer).
- Congress should consider making the Research and Experimentation (R&E) tax credit a long-term tax credit to stimulate broadband R&D.
- The federal government should provide ultra-high-speed broadband connectivity to select DoD installations to enable the development of next-generation broadband applications.
- The National Academy of Sciences and the National Academy of Engineering (National Academies) should develop a research road map to guide federal R&D funding priorities.
- NSF should establish an open, multi-location, interdisciplinary research center for broadband, addressing technology, policy and economics. Center priorities should be driven by the agenda identified in the National Academies research road map.
- NSF, in consultation with the Federal Communications Commission (FCC), should consider funding a wireless testbed for promoting the science underlying spectrum policymaking and a testbed for evaluating the network security needed to provide a secure broadband infrastructure.
- The FCC should start a rulemaking process to establish more flexible experimental licensing rules for spectrum and facilitate the use of this spectrum by researchers.

Some high-risk, high-return R&D initiatives or projects requiring sustained, long-term collaboration across highly diverse fields may be underfunded by the private sector. Federal research funding should close any potential gaps due to private sector risk-reward expectations or inability to coordinate and cooperate.

RECOMMENDATION 7.1: The government should focus broadband R&D funding on projects with varied risk-return profiles, including a mix of short-term and long-term projects (e.g., those lasting 5 years or longer).

In September, the White House Office of Science and Technology Policy (OSTP) found that, in regards to R&D policy, "[a] short-term focus has neglected fundamental investments."[12] The National Research Council's report, *Renewing U.S. Telecommunications Research*, states, "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."[13]

Similarly, in FCC workshops, researchers repeatedly noted that, like industry funding, federal funding is now focused more on short-term work than on long-term fundamental research projects.[14]

The academic community also noted the lack of funding for research that has a high probability of failure, even when success would lead to significant advances in technology. Researchers have indicated that the current review process for government research grants takes a conservative approach to project review and more risky projects are rarely funded.[15]

RECOMMENDATION 7.2: Congress should consider making the Research and Experimentation (R&E) tax credit a long-term tax credit to stimulate broadband R&D.

A number of economic studies have shown that R&D tax incentives are a cost-effective way to spur private sector research and investment. These types of tax incentives may help move the United States toward the goal of developing and building world-class broadband networks.

The Research and Experimentation tax credit, established in the 1980s, stimulated about $2 billion in research per year while costing about $1 billion in lost tax revenue.[16] Bronwyn Hall has estimated that a permanent 5% R&E tax credit would lead to a permanent increase in R&D spending of 10% to 15%. Similarly, Klassen, Pittman and Reed have found that R&D tax incentives stimulate $2.96 of additional R&D investment for every dollar of lost tax revenue.[17]

The long-term R&E tax credit applies broadly across and will benefit many industries.

RECOMMENDATION 7.3: The federal government should provide ultra-high-speed broadband connectivity to select DoD installations to enable the development of next-generation broadband applications.

The nation's military installations "are the platforms from which America's military capability is generated, deployed and sustained."[18] These installations house, train, educate and support tens of thousands of service personnel and their families.[19] There is no doubt that the nation's military personnel deserve to have access to the latest technology, the most resilient and cost-effective methods of communications and services, and ultra-high-speed broadband connectivity.

As a start, DoD, in consultation with OSTP, should consider expanding the deployment of ultra-high-speed connectivity to a select number of DoD installations in a manner consistent with the missions and operational requirements of the Armed Forces.

DoD installations are ideal communities for ultra-high-speed broadband due to their scale and the variety of services they provide to military personnel and their families. Expanded access to ultra-high-speed connectivity will further enable educational applications such as advanced distance learning. In addition, base personnel will have greater access to distance learning content from military staff colleges to better prepare the them to be the next generation of officers, while enhanced distance post-secondary offerings can smooth the transitions of those looking for new careers in civilian life.

Typical base medical facilities treat thousands of soldiers, retirees and their families every year. Next-generation health applications, such as high-definition video consultations and continuous remote monitoring of patients, can improve quality of care for these patients.

Bases are also intense users of energy. DoD is the nation's single largest energy user, accounting for nearly 1% of all energy consumed by the United States in FY2006.[20] Broadband capability and advanced information services allow deployment of Smart Grid and smart meter technologies. If deployed on military installations, these technologies would facilitate improved power management that will reduce energy consumption, allow for incorporating more renewable generation on site and enable new continuity of operations capabilities like micro-grids.[21]

Because of bases' large population under the age of 25, including families and children, increased access to ultra-high-speed Internet would act as a catalyst for the development of increasingly sophisticated applications that would support military personnel and their families. Indeed, as these applications evolve, DoD installations would be showcases for advanced educational, training and other uses of broadband.

The first step in implementing this idea should be a task force led by DoD, with consultation from OSTP. This task force should make recommendations on installation selection, level of connectivity and potentially, next-generation applications—both commercial and military—that could be deployed to these installations. The task force must consider a variety of requirements in order to prevent adverse operational impact to force readiness. These requirements include information assurance, integration and governance with existing commercial and DoD networking capability, non-federal spectrum availability, identification of funding sources and a cost-benefit analysis. In selecting the initial sites, the task force should also explore whether this program should work in conjunction with DoD's existing "green bases" effort. DoD would of course retain operational control of the project to ensure that the technology and services deployed are consistent with the missions of the Armed Forces, and may terminate the project at any time based on mission impacts, capabilities delivered and cost.

RECOMMENDATION 7.4: The National Academy of Sciences and the National Academy of Engineering (National Academies) should develop a research road map to guide federal broadband R&D funding priorities.

The National Academies, which gather committees of experts across scientific and technological endeavors to offer advice to the federal government and the public,[22] should take the lead in developing a research road map to guide federal broadband R&D funding priorities. The road map should identify gaps, critical issues, competitive shortfalls and key opportunities in areas associated directly or indirectly with broadband networks, devices or applications. It should leverage the input of public and private stakeholder communities. Additionally, the President's Council of Advisors on Science and Technology, an advisory group of the nation's leading scientists and engineers, as well as the FCC's Technology Advisory Committee might play key advisory roles.[23]

Input from the Broadband Research Public Notice and Workshop[24] identified the following potential research priorities, which are summarized as input to the National Academies:

- *Breakthroughs in network price/performance.* Increasing price/performance and lowering unit costs fuel the computer industry. Research is needed to enable similar price/performance improvements in wired and wireless networks to make truly high-speed broadband more affordable. Closing gaps to achieve these breakthroughs may require research in networking, materials science, optics, semiconductors, electromagnetism, construction engineering and other fields.
- *Communications research to support national purposes.* In the Recovery Act, Congress defined key national purposes that broadband should support. Multi-disciplinary, government-funded communications research may be required to ensure progress in accessibility, health care, energy management, education and public safety networks.
- *Social science and economic research on broadband adoption and usage.* Lack of adoption is a larger barrier to universal broadband than lack of availability. Moreover, usage and acceptance of broadband varies greatly across population segments and the sources of this variation are not well understood. Social science and economic research may help explain the reasons underlying broadband non-adoption, as well as network evolution and its impact on the user.
- *Secure, trustworthy and reliable broadband infrastructure.* The vast complexity of today's networks has created massive vulnerabilities to security at the same time that society

has become increasingly dependent on these networks. Research is needed to improve the trustworthiness, security and reliability of these networks, the devices that attach to them and the software and applications they support. This is critical to continued growth of networks and applications.

- *Broadband network measurement and management.* Research is needed to provide the tools to measure network operations and to gain a better understanding of the Internet's "health."

Enabling new service models. Continued exponential improvements in processing power and storage, coupled with broadband networking, are enabling both new applications and more cost-effective means of providing those applications. Research is needed to support development of new architectures and operational breakthroughs in emerging issue areas like cloud computing, content distribution networks, content centered networks, network virtualization, social applications and online personal content—as well as topics of study that remain nascent.

RECOMMENDATION 7.5: NSF should establish an open, multi-location, interdisciplinary research center for areas related to broadband, addressing technology, policy and economics. Center priorities should be driven by the agenda identified in the National Academies research road map.

Creating new technologies often involves interdisciplinary collaboration. In networking, for example, scientists in fields such as dynamic spectrum access, robust wireless networking and applications might need to work together to develop breakthrough solutions.[25]

The NSF should consider establishing an interdisciplinary research center for broadband networking, devices, applications and enabling technologies. Such a center could be modeled on the Engineering Research Centers (ERCs) that the NSF established in 1984. ERCs are partnerships among universities, technology-based industries and the NSF that focus on integrated engineering systems and produce technological innovations that strengthen the competitive position of industry. They currently operate in a number of fields such as biotechnology, energy and microelectronics. The NSF funds each ERC for 10 years, and most centers become self-sustaining.[26]

Only 2 of the existing ERCs touch on broadband networking, and their current research is limited to optical technologies and integrated microsensor networks. The NSF should establish a broadband networking research center in partnership with the FCC. The involvement of the FCC, as the government's expert agency on telecommunications, would help assure that the ERC agenda includes topics that are relevant to broadband policy.

The research center could illustrate what can be accomplished by connecting multiple, geographically dispersed physical research centers through very-high-speed optical wavelength networking. Examples of such connectivity include Internet2 and National LambdaRail in the United States and SURFnet in the Netherlands.[27] As a platform for research and innovation, the center ought to collaborate with private research centers, academic research networks and the gigabit community testbeds referenced above that are being constructed by industry and the non-profit sector. The center should practice open research, and the networks connecting these locations should adhere to open network principles as defined by the FCC.[28]

The research center should be broadly interdisciplinary so that it can address not only the technical issues raised by broadband, but also the economic and policy issues it raises. Researchers should include not only technologists such as engineers, computer scientists and physicists, but also economists and other social scientists. Bringing together a large number of diverse researchers should allow the center to work on projects of a larger scale than is typical under NSF grants.

RECOMMENDATION 7.6: NSF, in consultation with the FCC, should fund both a wireless testbed for promoting the science underlying spectrum policymaking and a testbed for evaluating the network security needed to provide a secure broadband infrastructure.

Spectrum (along with fiber) will be critical to the effective operation of future communications networks. However, there is uncertainty about how spectrum can be most efficiently and innovatively used in such networks. Wireless testbeds could be valuable tools to develop the science to support modern spectrum policy principles, which could guide FCC rulemaking on spectrum matters. For example, today there is uncertainty about how best to establish technical rules for exclusive spectrum, unlicensed spectrum and shared spectrum. Wireless testbeds can permit empirical assessment of radio systems and the complex interactions of spectrum users, which are nearly impossible to assess through simulation or analytical methods. As a result, they can reveal a great deal about how sharing can best be facilitated, how spectrum rights might be established, and the impact of dynamic spectrum access radios on existing and future communications services.

A request for proposal should be made to build and assess a network testbed that is sufficiently secure. With sensitive information about almost all Americans available in computerized databases and with the recent growth of electronic commerce, cybersecurity has become a vital issue. Many of the tools exist for building secure networks, but from an end-to-end systems perspective, difficult problems remain to be solved (particularly those that cross technical and non-technical disciplines).[29]

RECOMMENDATION 7.7: The FCC should start a rulemaking process to establish more flexible experimental licensing rules for spectrum and facilitate the use of this spectrum by researchers.

For the most part, spectrum is lightly used outside major urban areas. This holds true for prime frequency bands such as 800 MHz cellular and 1850–1990 MHz Personal Communications Services. In non-prime frequency bands such as those above 20 GHz, use may be modest even in major urban areas and limited or nonexistent in most other areas. Allowing research organizations such as universities greater flexibility to temporarily use fallow spectrum can promote more efficient and innovative communications systems.

Currently, there are restrictions on market trials conducted under experimental authorizations.[30] The FCC, building on relevant ideas from the Wireless Innovation Notice of Inquiry,[31] should evaluate whether regulatory restrictions should be relaxed to permit research organizations to conduct broader market studies. Similarly, such organizations could be permitted to operate experimental stations without individual coordination of frequencies, conditioned on not causing harmful interference to authorized stations. Such a program could allow the FCC to work cooperatively with research organizations to identify topics and frequency bands for further study and to learn about new wireless technologies.

To facilitate the use of spectrum by researchers, the FCC should work with the National Telecommunications and Information Administration (NTIA) to identify underutilized spectrum that may be suitable for conducting research activities. It should also conduct workshops with NTIA to advance research activities involving spectrum use.

CHAPTER 7 ENDNOTES

1 Nat'l Research Council, Innovation in Information Technology 5–7 (2003).

2 *See* Nat'l Research Council, Innovation in Information Technology 2–3 (2003).

3 Case Western Reserve University, *A Smarter Region One Neighborhood at a Time: University Circle Innovation Zone* 2 (University Circle Innovation Zone), http://www.case.edu/its/publication/documents/BetaBlockPublic030210.pdf (last visited Mar. 4, 2010).

4 University Circle Innovation Zone at 6.

5 Minnie Ingersoll & James Kelly, *Think Big with a Gig: Our Experimental Fiber Network*, The Official Google Blog, Feb. 10, 2010 (Ingersoll & Kelly, *Think Big with a Gig*), http://googleblog.blogspot.com/2010/02/think-big-with-gig-our-experimental.html.

6 Cisco, *Cisco and Molina Healthcare Announce Transformative Telemedicine Pilot Program for Underserved and Underinsured Communities* (press release), Jan. 15, 2010, http://newsroom.cisco.com/dlls/2010/prod_011510b.html.

7 Bronwyn H. Hall et al., *Measuring the Returns to R&D* (Nat'l Bur. of Econ. Res. Working Paper No. 16522, 2009), *available at* http://www.nber.org/papers/w15622 (requires purchase).

8 David B. Audretsch & Maryann Feldman, *R&D Spillovers and the Geography of Innovation and Production*, 86 Am. Econ. Rev. 630 (1996).

9 A recent study prepared for the Technology Administration of the Department of Commerce noted the "persuasive research that shows that innovation drives economic growth and that the private sector will tend to underinvest in R&D, as the social value for innovation will outstrip private value." George S. Ford et al., Valley of Death in the Innovation Sequence: An Economic Investigation 2 (2007) (Ford et al., Valley of Death), *available at* http://www.ntis.gov/pdf/ValleyofDeathFinal.pdf. However, diffusion of basic research discoveries is not automatic—the study notes that government R&D efforts must be cognizant of and overcome "the roadblocks that may exist in the innovation process between basic research and commercialization." *Id.*

10 Ford et al., Valley of Death at 11–14. This seminal insight was first provided by Nobel Laureate economist Kenneth J. Arrow. Kenneth J. Arrow, *Economic Welfare and the Allocation of Resources for Invention*, *in* The Rate and Direction of Inventive Activity 609–25 (1962); *see also* Stephen Martin & John T. Scott, *The Nature of Innovation and Market Failure and the Design of Public Support for Private Innovation*, 29 Res. Pol'y 437, 438 (2000); Scott Wallsten, *The Effects of Government-Industry R&D Programs on Private R&D: The Case of the Small Business Innovation Research Program*, 31 RAND J. Econ. 82 (2000).

11 *See, e.g.*, Bronwyn Hall, *The Private and Social Returns to Research and Development: What Have We Learned?*, *in* Technology, R&D, and the Economy 140 (L.R. Smith & Claude E. Barfield eds., 1996); Paul David et al., *Is Public R&D a Complement or Substitute for Private R&D? A Review of the Econometric Evidence*, 29 Res. Pol'y 497 (2000).

12 *See* Office of Sci. & Tech. Pol'y, Exec. Office of the Pres., A Strategy For American Innovation: Driving Towards Sustainable Growth And Quality Jobs 1 (2009), *available at* http://www.whitehouse.gov/sites/default/files/microsites/20090920-innovation-whitepaper.PDF.

13 *See* Nat'l Res. Council, Renewing U.S. Telecommunications 23 (2006), *available at* http://books.nap.edu/openbook.php?record_id=11711&page=23.

14 *See, e.g.*, Adam Drobot, CTO & Pres., Advanced Tech. Solutions, Telcordia Techs., Remarks at FCC Research Recommendations for the Broadband Task Force Workshop (Nov. 23, 2009), *available at* http://broadband.gov/docs/ws_research_bb/ws_research_bb_transcript.pdf.

15 *See, e.g.*, David Clark, Senior Research Scientist, MIT, Remarks at FCC Research Recommendations for the Broadband Task Force Workshop (Nov. 23, 2009), *available at* http://broadband.gov/docs/ws_research_bb/ws_research_bb_transcript.pdf.

16 Bronwyn Hall, *R&D Tax Policy During the Eighties: Success or Failure?* (NBER Working Paper No. 4240, 1993). Nat'l Bur. of Econ. Res.

17 Kenneth J. Klassen et al., *A Cross-National Comparison of R&D Expenditure Decisions: Tax Incentives and Financial Constraints*. 21 Contemp. Acct. Res. 639 (2003).

18 Statement of Mr. Wayne Arny, Deputy Undersecretary of Defense (Installations and Environment) Before the Subcommittee on Military Construction, Veterans Affairs, and Related Agencies of the House Appropriations Committee (May 19, 2009), at 2.

19 As noted in the 2007 Defense Installations Strategic Plan, this support is a "long-term, day-to-day commitment to deliver quality training, modern and well-maintained weapons and equipment, a safe, secure and productive workplace, a healthy environment, and good living conditions" for service personnel and their families. U.S. Department of Defense, *2007 Defense Installations Strategic Plan*, 10 (2007), available at: http://www.acq.osd.mil/ie/download/DISP2007_final.pdf.

20 Department of Defense, Facilities and Vehicles Energy Use, Strategies, and Goals, May 11, 2009.

21 Also known as "islanding," micro-grids are the concept of a base being able to disconnect from the grid and operate using only local renewable power and other on-base generation.

22 *See* The National Academies, About The National Academies, http://www.nationalacademies.org/about (last visited Feb. 18, 2010).

23 *See* The White House, Office of Science and Technology Policy: About OSTP, http://www.whitehouse.gov/administration/eop/ostp/about (last visited Feb. 18, 2010).

24 *See* FCC Research Recommendations for the Broadband Taskforce Workshop (Nov. 23, 2009), *available at* http://www.broadband.gov/docs/ws_research_bb/ws_research_bb_transcript.pdf.

25 *See* Charles Bostian, Alumni Distinguished Professor, Virginia Polytechnic Institute and State University, Remarks at FCC Research Recommendations for the Broadband Task Force Workshop (Nov. 23, 2009), *available at* http://broadband.gov/docs/ws_research_bb/ws_research_bb_transcript.pdf.

26 Note that total funding for the individual ERCs from all sources in 2009 ranged from $4.1 to $8.8 million. Nat'l Science Found., Engineering Research Centers: Linking Discovery to Innovation (2009), *available at* http://www.erc-assoc.org/factsheets/ERC%20Overview%20Fact%20Sheet_09-final.pdf.

27 *See* Internet2 Home, http://www.internet2.edu/ (last visited Mar. 4, 2010); LambdaRail Home, http://www.nlr.net/ (last visited Mar. 4, 2010) ("National LambdaRail (NLR) is the innovation network for research and education. NLR's 12,000 mile, nationwide, advanced optical network infrastructure supports many of the world's most demanding scientific and network research projects."). For a description of a number of research and education networks in the United States, see U.S. R&E Networks Comments in re NBP PN # 22, (Comment Sought on research Necessary for Broadband Leadership—NBP PN #22, GN Docket Nos. 09–47, 09–51, 09–137, Public Notice, 24 FCC Rcd 13820 (2009) (NBP PN #22)) filed Dec. 8, 2009, at 2–10 (describing Internet2, NLR, CENIC, FLR, GPN, GlobalNOC, MAX, MCNC/NCREN, MCAN, NYSERNet, OARnet, OSHEAN, PNWGP, The Quilt, 3ROX, and UEN); SURFnet, About SURFnet: Mission, http://www.surfnet.nl/en/organisatie/Pages/Mission.aspx (last visited Mar. 4, 2010) ("It is SURFnet's mission to facilitate groundbreaking education and research through innovative network services. SURFnet combines the demand of the institutions connected to SURFnet. In doing so we create advantages of scale, innovation and collaboration from which they benefit. The SURFnet network services comprise five focus areas: Network infrastructure, Security, Authentication & authorisation, Group communication and Multimedia distribution.").

28 *See* Digital Connections Council, Comm. for Econ. Dev., Harnessing Openness to Improve Research, Teaching, and Leaning in Higher Education (2009).

29 TIA states that "[s]trengthening the robustness and resilience of our broadband networks is necessary not only to protect against attacks, but also to reduce the current drag on productivity caused by malware and attacks." Letter from Carolyn Holmes Lee, Dir., Legis. & Gov't Aff., TIA, to Marlene H. Dortch, Secretary, FCC, GN Docket Nos. 09-47, 09-51, 09-137 (Dec. 18, 2009), App. at 2; *see also* Subcomm. on Networking & Info. Tech. Res. & Dev., Nat'l Sci. & Tech.Council, The Information Technology Research and Development Program: Supplement to the President's Budget for Fiscal Year 2010, at 6–9 (2009).

30 *See* 47 C.F.R. § 5.93 (2008). These limitations affect the size and scope of the marketing trial, as well as restrict ownership of equipment used in the trial to the licensee.

31 *See Fostering Innovation and Investment in the Wireless Communications Market; A National Broadband Plan For Our Future*, GN Docket Nos. 09-51, 09-157, Notice of Inquiry, 24 FCC Rcd 11322 (2009).