Subcommittee on Networking and Information Technology Research & Development (NITRD)

Wireless Spectrum R&D Senior Steering Group
Interim Report #1

June 2011

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Executive Summary

The Wireless Spectrum R&D (WSRD) Senior Steering Group (SSG) has been formed under the auspices of the NITRD Subcommittee to coordinate spectrum-related research and development activities across the Federal Government. The purpose is two-fold: to help coordinate and inform ongoing activities across Federal agencies; and to facilitate the identification of potential improvements to the Government's R&D portfolio with respect to the overall goals of the Presidential Memorandum on Unleashing the Wireless Broadband Revolution. This interim report covers the work of the WSRD SSG from its inception in late 2010 to the present. During its first seven months, WSRD has created an initial inventory of approximately 670 spectrum R&D projects across the Federal government and has planned a workshop to solicit input from beyond the Federal government on the strengths and weaknesses of the Federal R&D portfolio. The results of the inventory and a preliminary analysis of its findings are presented below. A few of the projects are highlighted in this report, and are particularly indicative of the government's investments in innovative spectrum sharing technology. The activities undertaken to date are consistent with the guiding principles of WSRD (discussed more fully below), which are transparency, smart investment, and the solicitation of opportunities for technology transfer across and beyond the Federal Government.

Smart Investment: Public Safety

In times of emergency, it is essential that law-enforcement personnel be able to access all available wireless networks to communicate with one another, the community, and service providers as quickly and reliably as possible. By improving radio channel (spectrum) management, providing dynamic aggregation of wireless data network resources, and facilitating optimal use of available communications resources, a new wireless radio system developed at the Stevens Institute of Technology will provide law enforcement and emergency responders with communication channels when traditional means are unavailable.

--- *funded by the DOJ-NIJ (National Institute of Justice)*

1. Committee Background, Purpose, and Initial Work

In June 2010, President Barack Obama released a Memorandum entitled *Unleashing the Wireless Broadband Revolution*.[1] Noting that "America's future competitiveness and global technology leadership depend, in part, upon the availability of additional spectrum," the Memorandum concludes that

> [A] New era in global technology leadership will only happen if there is adequate spectrum available to support the forthcoming myriad of wireless devices, networks, and applications that can drive the new economy. To do so, we can use our American ingenuity to wring abundance from scarcity, by finding ways to use spectrum more efficiently. We can also unlock the value of otherwise underutilized spectrum and open new avenues for spectrum users to derive value through the development of advanced, situation-aware spectrum-sharing technologies.

Among the tasks assigned to federal agencies in the Memorandum, section 3 requires that

> The Secretary of Commerce, working through NTIA, in consultation with the National Institute of Standards and Technology, National Science Foundation (NSF), the Department of Defense, the Department of Justice, NASA, and other agencies as appropriate, shall create and implement a plan to facilitate research, development, experimentation, and testing by researchers to explore innovative spectrum-sharing technologies, including those that are secure and resilient.

The Office of Science and Technology (OSTP) called on the National Coordination Office (NCO) for the NITRD Program to form and facilitate a SSG of relevant agency researchers and program officers to complete this task for the agencies named in section 3. As a result, the Wireless Spectrum Research and Development Senior Steering Group was formed under the auspices of NCO/NITRD. The initial meeting of the SSG on November 18, 2010 in Washington, D.C., was attended by 24 representatives from the following 12 federal agencies and laboratories:

- Army
- Defense Advanced Research Projects Agency (DARPA)
- Department of Commerce, National Institute of Standards and Technology (NIST)
- Department of Commerce, National Telecommunications and Information Administration (NTIA)
- Department of Commerce, NTIA Institute for Telecommunication Sciences (NTIA ITS)
- Department of Energy, Idaho National Laboratory (DOE INL)
- Department of Energy, Oak Ridge National Laboratory (DOE ORNL)
- Department of Justice, National Institute of Justice (DOJ NIJ)
- Federal Communications Commission (FCC)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)
- Navy

At that meeting, the participants decided that an appropriate first step was to inventory relevant research, development, experimentation, and testing that is already taking place within the Federal Government. Each participating agency was asked to provide a list of current and recently-completed research and development activities within their organization; the results have been collated into an evolving master inventory, which is described in section VI of this report. A separate list of wireless testbed activities will also be created at a later date. The purpose of creating these inventories is two-fold: 1) To help coordinate and inform ongoing activities across federal agencies, which can help foster information interchange among agencies and cost savings to the government and taxpayers; and 2) To facilitate the identification of potential improvements to the government's R&D portfolio with respect to the overall goals of the Presidential Memorandum.

A schedule of deliverables from the WSRD SSG was also established at the SSG's initial meeting. The first deliverable is this interim report. A workshop is planned in late July that will bring together representatives from the commercial and academic sectors to review and discuss the WSRD SSG's findings. A second interim report is tentatively scheduled for the November 2011 timeframe. The second report will summarize the SSG's efforts to identify opportunities for research projects not currently addressed by the federal agencies, potential areas for collaboration, and opportunities for technology transfer and the commercialization of key technologies. A synthesis of the workshop outcomes will also be included in Interim Report #2. An annual planning meeting will then be held to consider activities for FY2012 and determine the need for subsequent reports.

Although the primary work of NITRD and its WSRD SSG is by and for the federal agencies, the SSG will operate under three guiding principles that benefit both the government and the private sector:

- **Transparency:** Make visible to both Federal Government agencies and the private sector what federal R&D activities are currently underway or planned, and identify what still needs attention.
- **Smart investment:** Provide information that could lead to collaborations and other efforts to improve efficiency of current and future investments.
- **Solicit Opportunities:** Provide information that could lead to spectrum technology transfer among Federal Government agencies and to the private sector.

The following sections provide additional details on the initial steps that have been taken to accomplish the goal outlined by the Presidential Memorandum.

2. Value of Spectrum to Federal Agencies and America at Large

Radio spectrum supports a wide array of commercial and federal, state, and local government applications. In the past decade, the dramatic evolution of technology and the subsequent development of radio frequency-based applications have placed a new premium on spectrum. Traditional spectrum allocation policies assign spectrum on a long-term basis and allow limited flexibility to free up new resources. Yet today's bandwidth-hungry applications often require greater throughput than currently available spectrum can support. Radio spectrum, once viewed as unlimited, has become a scarce resource. This has sparked a new sense of urgency to address the long-running concerns among federal users, commercial service providers, equipment developers, and spectrum management professionals on how best to manage and use the radio spectrum.

Radio communications and other spectrum-dependent applications provide critical support to federal agency missions. Federal agencies have stated that they will need increased data throughput in the future[2] and that they plan to move increasingly to wireless broadband applications. It follows that many of the agencies' strategic spectrum plans indicate that they will require "greater, dynamically available data throughput and mobility, often requiring additional spectrum or significant advances in technology."[3]

Smart Investment: Public Safety Testbed

The public safety community has long struggled with effective cross-agency communications and lags far behind the commercial sector in data capability. Recognizing this, Congress set aside spectrum for public safety use that will enable nationwide communications interoperability. However, many of this community's unique requirements are not met by current broadband technologies, and it is difficult to test industry claims. The Public Safety Communications Research (PSCR) program is helping address this by building a 700MHz public safety broadband demonstration network that will serve as a vendor-neutral environment where public-safety, industry, and other stakeholders can observe how new broadband technologies can meet public safety's communication needs.

---funded by a joint effort between NIST/OLES and NTIA/ITS

Non-federal (i.e. private, commercial, state and local government) wireless applications and services are also increasing at a dramatic pace. The networking company Cisco projects that average mobile wireless connection speeds will increase at a compound annual growth rate (CAGR) of 40 percent over the next five years, from about 400 kbps to nearly 4 Mbps.[4]

Yet much of the spectrum currently assigned is often idle, sitting unused for significant periods of time. Thus efforts must be made not only to find and re-assign more spectrum, but to permit more efficient use of spectrum that has already been licensed. The challenge is to identify these spectrum "holes" and to devise policies, methods, practices, and technologies that will maximize their use.

3. Role of Federal Government

In June 2010, President Obama stated in his Presidential Memorandum that "few technological developments hold as much potential to enhance America's economic competitiveness, create jobs, and improve the quality of our lives as wireless high-speed access to the Internet," and that "spectrum and the new technologies it enables also are essential to the Federal Government." In January 2011, in his State of the Union Address, the President laid out a Wireless Innovation and Infrastructure Initiative[5] as a means to achieve his goal of high-speed wireless services to 98 percent of the population by 2016. This Initiative calls for allocating $3 billion to a Wireless Innovation Fund (WIN) for research and development in innovative wireless technologies and applications. This was followed in February by a request for the WIN funds in the FY 2012 proposed budget.[6] The WIN initiative demonstrates the importance the Administration places on finding new and innovative technologies to facilitate the critical infrastructure of the future, wireless broadband access.

Unlike wired broadband, where extending the network primarily involves raising enough capital to build the infrastructure and getting the rights-of-way to lay the wires, wireless broadband is uniquely tied to spectrum. Re-allocation of spectrum is key, but so is the discovery and development of more efficient ways to use it. Just as the acceptance of alternative fuels is dependent on the development of engines that can run on them, the availability of spectrum is dependent on a new generation of technologies that can use spectrum in new and innovative ways.

It is the role of the Federal Government through such agencies as NSF and DARPA to invest in the type of fundamental research that is required to develop these new spectrum-efficient technologies. This is research that private-sector laboratories often cannot justify because the return on investment is risky and very long-term. But it is also the type of basic research that breeds innovation and has proven time and again to yield dramatic returns—such as the Internet—for the benefit of consumers, businesses, and the government itself.

Smart Investment: Exploring New Spectrum Frontiers

The communications requirements for space missions, both robotic and human, are always increasing. Scientists and explorers always seek more data from more distant locations. To meet these future requirements, while also moving out of the radio frequency spectrum, NASA is pursuing optical communications. The first demonstration mission, the Lunar Laser Communications Demonstration (LLCD), is an experiment to provide the proof-of-concept for laser-based communications from lunar orbit. During the experiment, NASA plans to transmit more than 600 megabits of data per second using a 4-inch telescope and a half-watt laser installed on the Lunar Atmosphere and Dust Environment Explorer (LADEE), which NASA plans to launch in 2013 to characterize the Moon's wisp-thin atmosphere and dust environment.

---*funded by NASA*

4. Current Status of Federal R&D Investments

As described above, the WSRD SSG adopted an inventory template and asked its participating agencies to submit a list of all relevant federal research projects either recently completed or currently underway. The template identifies an initial set of 23 broad, general topic areas. These include methods and processes that engender efficient spectrum use, modeling and simulation, technological developments that enable spectrum use efficiencies, dynamic spectrum management, networks, policy and regulation, education and outreach, testing environments, and others.

The agencies were asked to organize their projects under the general topic areas, as follows:

1. Advancing dynamic mechanisms to share spectrum, including both cooperative and non-cooperative models, and mechanisms to manage spectrum resources across functions and systems

2. Advancing situational awareness, including spectrum sensing, geo-location, real-time monitoring

3. Create wireless test beds and demonstrate new concepts

4. Development of methods to create and maintain a comprehensive spectrum survey and inventory

5. Development of programs to promote collaboration among spectrum stakeholders (e.g., industry, academia, government agencies)

6. Development of simulation tools relevant to spectrum efficiency, access, and sharing

7. Development of systems and models to transition from legacy architectures to new spectrum-sharing architectures, hardware, protocols, and policy

8. Energy-efficient or "green" spectrum technology

9. Enforcement of spectrum rules

10. Integration of dynamic spectrum management (DSA) networks and the Internet or other communications infrastructure

11. Mechanisms to make better use of the spectrum allocations and assignments

12. Methods to improve spectrum efficiency, including antenna design, modulation, interference mitigation, channel bonding

13. Methods to operate at higher frequencies where spectrum is more readily available

14. Metrics to quantify spectrum parameters relevant to efficiency, access, and sharing

15. Models to predict propagation, signal strength, or interference

16. Next-generation developments in smart radio hardware, including software-defined radios and cognitive radio systems

17. Security, vulnerability of spectrum-sharing technologies, counter measures to access spectrum despite adversarial actions

18. Spectrum allocation/assignment: economic factors

19. Testing of spectrum-efficient technologies to qualify against specific regulations, environments (e.g. space), or mission requirements

20. Dynamic spectrum management across multiple warfighting functions (e.g., communications, electronic attack, electronic support [SIGINT], radar)

21. Innovations that can lead to improvements in spectrum efficiency

22. System testing and development of testing methods

23. New frontiers and research that may lead to transformational improvements in the use of the radio spectrum

To date, the WSRD inventory has identified 671 federal R&D programs that reside within the following nine federal agencies[7]:

- Department of Commerce
- Department of Defense (Includes each military department's R&D activities, i.e. Army, Navy and Air Force, and also includes DARPA)
- Department of Energy
- Department of Homeland Security
- Department of Justice
- Federal Aviation Administration
- Federal Communications Commission
- National Aeronautics and Space Administration

- National Science Foundation

Preliminary Observations

A summary of the WSRD inventory is presented in Table 1 (Pg. 8). The inventory includes projects that have been funded in the last five years (FY 2006 – FY 2010), and projects that are presently funded in FY 2011.

Preliminary evaluation of the inventory reveals that:

1. Nearly 60 percent of the projects are distributed over the following three topic areas:
   - Methods to improve spectrum efficiency, including antenna design, modulation, interference mitigation, channel bonding;
   - Advancing dynamic mechanisms to share spectrum, including both cooperative and non-cooperative models, and mechanisms to manage spectrum resources across functions and systems; and
   - Next-generation developments in smart radio hardware, including software-defined radios and cognitive radio systems.

2. 90 percent of the projects fall into 50 percent of the topic areas.[8]

Table 1: Summary of Federal Wireless R&D projects by Topic Area	Federal Agencies								
	Department of Commerce	**Department of Defense**	**Department of Energy**	**Department of Homeland Security**	**Department of Justice**	**Federal Aviation Administration**	**Federal Communications Com.**	**National Aeronautics and Space Administration**	**National Science Foundation**
(1) Advancing dynamic mechanisms to share spectrum, including both cooperative and non-cooperative models, and mechanisms to manage spectrum resources across functions and systems	8	*8*	*2*		*1*				*101*
(2) Advancing situational awareness, including spectrum sensing, geo-location, real-time monitoring		*1*	*3*						*37*
(3) Create wireless test beds and demonstrate new concepts	2	*7*	*7*	*2*					*15*
(4) Development of methods to create and maintain a comprehensive spectrum survey and inventory	1	*1*	*1*						*2*
(5) Development of programs to promote collaboration among spectrum stakeholders (e.g., industry, academia, government agencies)	1	*1*	*1*						*5*
(6) Development of simulation tools relevant to spectrum efficiency, access, and sharing	6	*1*	*2*						*1*
(7) Development of systems and models to transition from legacy architectures to new spectrum-sharing architectures, hardware, protocols and policy		*3*	*1*						*5*
(8) Energy-efficient or "green" spectrum technology		*3*	*1*		*1*				*10*
(9) Enforcement of spectrum rules									
(10) Integration of DSA networks and the Internet or other communications infrastructure		*2*							*3*
(11) Mechanisms to make better use of the spectrum allocations and assignments	2	*1*				*1*		*3*	*6*
(12) Methods to improve spectrum efficiency, including antenna design, modulation, interference mitigation, channel bonding		*6*	*1*		*2*				*164*
(13) Methods to operate at higher frequencies where spectrum is more readily available		*4*						*4*	*26*
(14) Metrics to quantify spectrum parameters relevant to efficiency, access, and sharing	3		*1*						

Table 1: Summary of Federal Wireless R&D projects by Topic Area	Federal Agencies								
	Department of Commerce	**Department of Defense**	**Department of Energy**	**Department of Homeland Security**	**Department of Justice**	**Federal Aviation Administration**	**Federal Communications Com.**	**National Aeronautics and Space Administration**	**National Science Foundation**
(15) Models to predict propagation, signal strength, or interference	6	*3*						*4*	*6*
(16) Next-generation developments in smart radio hardware, including software-defined radios and cognitive radio systems		*6*	*1*	*1*	*4*	*2*		*31*	*47*
(17) Security, vulnerability of spectrum-sharing technologies, counter measures to access spectrum despite adversarial actions		*8*	*1*		*1*				*28*
(18) Spectrum allocation/assignment: economic factors		*2*							*27*
(19) Testing of spectrum-efficient technologies to qualify against specific regulations, environments (e.g. space), or mission requirements								*2*	*1*
(20) Dynamic Spectrum Management across Multiple Warfighting Functions (e.g., Communications, Electronic Attack, Electronic Support [SIGINT], Radar)	5								
(21) Innovations that Can Lead to Improvements in Spectrum Efficiency		*5*							
(22) System testing and development of testing methods	1								
(23) New Frontiers and Research that May Lead to Transformational Improvements in the Use of the Radio Spectrum		*5*							*1*

3. As shown in Table 2, NSF has the greatest number of projects (about 500) in the inventory, representing approximately 70 percent of the total. (This was expected since the primary mission of NSF is to fund scientific and engineering research.) NSF is followed by DoD, NASA, and DOC, which together represent about 20 percent of the total. The remaining 10 percent is distributed among the other five agencies.

Table 2. Distribution of Projects by Federal Agency

Agency	Percent of Total
NSF	≈70%
DoD, DOC, NASA	≈20%
All others	≈10%

4. As shown in Table 3, the vast majority of projects are at the Basic Research stage of development, while only about 6 percent are in the Demonstration stage.[9]

Table 3. Project Development Stage

Stage	% of Projects
Basic Research	78
Applied Research	14
Advanced Technology Development	10
Advanced Component Development	7
Demonstration & Validation	6

5. Table 4 summarizes the percent of projects funded in 2011, excepting NSF.[10]

Agency	Funded Projects for FY'11	Percent of Total Projects
DoD	43	6.4%
NASA	32	4.8%
DOC	10	1.5%
DOE	9	1.3%
FAA	3	0.4%
DHS	3	0.4%
DOJ NIJ	1	0.1%
Total	101	15%

Inventory Next Steps

Clearly, the work has just begun. In the months ahead, the WSRD SSG will strive to accomplish the following:

- Analyze the inventory data to gain greater insight into the scope and size of each project.
- Develop a succinct description of the desired outcomes for each of the projects.
- Engage the wireless stakeholders (federal and non-federal) in identifying key issues regarding the implementation of spectrum-sharing and determining which inventoried projects might apply and where future R&D might enable a solution.
- Further refine the inventory by considering such changes as: reducing the number of topic areas to ten or fewer, clarifying the scope of each topic area, and standardizing the entries for both the frequency range and the stage of development.

5. Synergy with Private Industry

Consistent with the role of the Federal Government in supporting R&D that benefits the nation at large, WSRD recognizes the importance of coordinating federal spectrum R&D with private industry. Some coordination involves direct support to private industry for spectrum R&D activities. For example, several of the WSRD agencies are required by statute to invest a portion of their R&D budget in Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) grants. NSF is preparing an STTR solicitation that will specifically target research that supports the goals of its broader "Enhancing Access to the Radio Spectrum" (EARS) program.[11] The NSF investment in the EARS STTR program will be $12 million, across both Phase I (≤$150k, ≤12-month) and Phase II (≤$500K, ≤24-month) awards.

To elicit private-sector views on the strengths and weaknesses of the federal spectrum R&D inventory, WSRD will sponsor a workshop in late July 2011. The workshop will be held in conjunction with the annual International Symposium on Advanced Radio Technologies (ISART) in Boulder, Col. We will ask private industry participants to suggest research avenues that they believe are presently underrepresented in the R&D inventory, are not being pursued in private industry research laboratories, and that may have large potential payoffs for the national wireless industry, if successful. WSRD believes it is a particular role of the Federal Government to sponsor "high-risk high-reward" research that is otherwise too risky to be undertaken solely by private industry.

6. Anticipating Interim Report #2

Through the November 2011 time frame, WSRD will be focused on the following activities:

- Further refining and analyzing the spectrum R&D inventory
- Planning and conducting the public workshop on coordinating R&D with private industry
- Creating an initial inventory of Federal wireless testbed capabilities
- Issuing a second interim report

[1] http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution

[2] Federal Strategic Spectrum Plan, October 2008, Pg. 4.

[3] *Ibid*, pg. 2.

[4] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010–2015

[5] Winning the Future, State of the Union – Wireless Innovation and Infrastructure Initiative Fact Sheet, January 2011

[6] President's FY 2012 Budget request – Wireless Innovation Fund (WIN) Page 1230 and 1231 of the FY2012 proposed budget. February 2011

[7] The complete draft inventory and Attachment A (explanation of categories) can be downloaded at: http://www.nitrd.gov/nitrdgroups/images/f/f0/WSRD_Project_Inventory_15.pdf and http://www.nitrd.gov/nitrdgroups/images/b/bf/Wireless_Spectrum_R%26D_Inventory_Template_Attachments_-_Attachment_A_-_Topic_Areas.pdf

[8] The assignment of R&D projects to the general topic areas can be ambiguous, and that some projects fit more than one category. We expect that re-classification of some of the R&D projects will occur as WSRD continues to refine and improve the inventory.

[9] The total distribution is greater than 100 percent because some projects were identified in more than one stage of development.

[10] This accounting does not include NSF projects because projects funded by NSF were listed in the year the project was first funded (even though funding may be obligated through 2011). Relatively few NSF projects have been funded in FY11 to date due to the government operating under a continuing resolution.

[11] For more information on the NSF EARS program see http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503480

ATTACHMENT

This attachment contains short descriptions of twelve selected projects from the Project Inventory. The reader will notice that three of these were shortened and added to the body of the First Interim Report as highlights, to be read here in more detail. They are arranged in alphabetical order by funding agency.

1. 700MHz Public Safety Broadband Demonstration Network (DOC/NIST)

   The public safety community is experiencing a generational shift in technology that will revolutionize the way it communicates. Traditionally emergency responders have used land mobile radio technology that has limited data capabilities and suffers from a large installed base of stove-piped proprietary systems with non-contiguous spectrum assignments. As a result, public safety has long struggled with effective cross-agency/jurisdiction communications and lags far behind the commercial sector in data capability. Congressional legislation has made broadband spectrum cleared by the Digital Television (DTV) transition available to public safety. New public safety broadband communications will allow for a unified system operating on common spectrum bands that will foster nationwide roaming and interoperability and provide access to broadband data. This newly available 700-MHz spectrum will allow public safety to adopt broadband technologies that support high-speed data transmission across long distances creating access to video, mapping, GPS applications, and more. However, public safety has several unique requirements that are not currently reflected in broadband technology and has limited access to technical resources to verify the claims of industry.
   The Public Safety Communications Research (PSCR) program, a joint effort between NIST/OLES and NTIA/ITS that provides research, development, testing, and evaluation to foster nationwide communications interoperability, is helping public safety address these gaps by building a 700MHz public safety broadband demonstration network that will serve as a vendor-neutral environment where public safety, industry, and other stakeholders can observe how new broadband technologies can meet public safety's communication needs.

2. AFRL's "Dynamic Spectrum Access Assessment in Contested Environments" (DoD/Air Force)

   This project seeks to perform experimentation, measurement, and analysis of radio frequency (RF) spectral information as applicable to the mobile, highly-dynamic environments encountered by operations of today's US Air Force. In particular, AFRL has established a wireless network of ground- and aerial-based spectral sensors at geographically distinct locations within a 20-mile radius to observe the RF spectrum dynamics and transmit the measurements in real-time to a central location for processing and storage. Further, geographical position and time information are included with each measurement to facilitate the evaluation of the sensed RF power as a function of frequency, location, and time.

Critical to this evaluation, especially for mobile platforms at varying altitudes, are the timing delays introduced by the network overhead versus the evolving RF spectrum conditions. Additionally, the resolution and time the sensors take to sweep the spectrum also affect the timing delays and, thus, the usefulness of sharing spectral information within the network. That is, to enable spectrum efficiency and effectiveness, the network must adapt faster than the RF environment changes and sustain the user application(s).

To highlight the dependencies of spectrum measurements on frequency, location, and time, visualization tools are being developed to convey these spectral dynamics in a "weather map" fashion. The ultimate payoff of this effort is an increased understanding of network requirements and limitations to implement Dynamic Spectrum Access techniques to effectively adapt and control aerial military communications in contested operational environments.

Work on this project is being funded through both AFRL's Information Directorate and the Office of the Assistant Secretary of Defense for Research and Engineering.

POC: Jared Feldman, AFRL/RITF, 315-330-4714.

3. Coalition Joint Spectrum Management Planning Tool (CJSMPT) (DoD/Army)

Engineers with the U.S. Army Communications-Electronics Research, Development, and Engineering
Center (CERDEC) have focused on solving the problems that arise when managing spectrum, which is the range of frequencies used in radio communications. The challenge of managing spectrum to ease communications in operational environments has recently come to the forefront of Army communications. With the inundation of commercial wireless products and the variety of communication devices used by deployed military personnel, spectrum is in high demand with finite supply.

Recognizing the number of systems that use spectrum and the amount of spectrum available to warfighters requires an understanding of the operational environment and an environment's policy requirements to use spectrum. One technology, the Coalition Joint Spectrum Management Planning Tool (CJSMPT), is software that maps out a mission plan, taking into account the spectrum resources of the force structure, background emitters in the area of interest, and the terrain and propagation of the operational environment. By looking at the physical aspects of an operational environment and taking into account topography and mission requirements, CJSMPT helps to take the guess work out of determining available RFs. Depending on the unit in a given environment, the kinds of radios, and spectrum requirements, the software user maps out the unit locations and movement, and the software creates a frequency proposal that satisfies the mission requirements.

This summary contains extracts from an article published at
http://www.army.mil/-news/2009/08/25/26559-cerdec-labs-set-sights-on-smart-technology-for-the-warfighter-part-ii-spectrum-management/.

4. Integrated Topside - Open, Scalable, and Integrated Electronic Warfare, Radar, and Communications (DoD/Navy)

The Integrated Topside (InTop) program is developing a scalable family of Electronic Warfare (EW), radar and communications capabilities to support multiple classes of ships and other naval manned and unmanned platforms.
Using a modular RF (Radio Frequency) design to facilitate best-of-breed technology, InTop is promoting an open architecture and open interface standards to be used throughout industry to allow plug-and-play integration and cost-effective upgrades.

Several technologies that are critical enablers for efficient use and sharing of spectrum are under development:

1. Electronics technology to improve linearity, efficiency and noise, while reducing size, weight and cost;
2. Compact, nested designs for multi-function (EW, communications and radar), multi-beam, and multi-frequency band antenna arrays
3. Innovative Spectrum Resource Allocation Manager that can dynamically allocate RF resources on these arrays to different functions and, as required, pre-empt less important functions in support of specific mission objectives or to address inbound threats to the ship.
4. Non-contiguous frequency-division-multiplex across very wide (frequency) bands to exploit stealth, while vastly reducing the probability of interference to primary users.

InTop is an Innovative Naval Prototype (INP) funded by the Office of Naval Research."

5. Spectrum Research and Large Scale Wireless Outdoor National Testbed Capabilities at the Idaho National Laboratory (DOE/INL)

Idaho National Laboratory (INL), a Department of Energy (DOE) national laboratory and a Federally Funded Research and Development Center (FFRDC), has been engaged in wireless, cyber and control systems research, development, experimentation, integration, demonstration and deployment for several years. Our capabilities and expertise bridge government, industry and academia, and use both open-air field and controlled laboratory environments. INL has a unique 890 square mile wireless test range, providing a controlled, isolated radio frequency (RF) spectrum experimentation environment, with minimal interference from rural/urban areas, airports or military test ranges. INL forms a unique national asset for integrated wireless testing of networks, handsets, sensors and applications, with nation-wide remote connectivity for research and experimentation.

6. Multi-Band Radio (MBR) Initiative (DHS)

To provide a successful coordinated response, emergency responders must be able to effectively communicate with all partners across jurisdictional lines including local, regional, state, and Federal entities. Today, many agencies often cannot communicate with those outside of their jurisdiction because they use different radio bands. The Science and Technology (S&T) Directorate's First Responder Group is partnering with responders and industry to determine requirements and inform manufacturers in the development of a single mobile radio capable of operating across disparate radio bands. The Multi-Band Radio (MBR) Initiative has helped spark the marketplace since it began, there are now four manufacturers developing MBR equipment.

The MBR, a hand-held radio, allows emergency responders to communicate with partner agencies—regardless of the radio band on which they operate. Upon completion, data and user feedback collected during the test and evaluation phases will be published in a detailed procurement guide that will assist emergency response agencies in identifying equipment functionality offered by various manufacturers that meets their mission requirements.

7. Public Safety Wireless Radio System (DOJ-NIJ)

In times of emergency, it is essential that Law Enforcement personnel be able to access all available wireless networks to communicate with one another; the community; and service providers as quickly and reliably as possible. With funding from the Department of Justice's (DOJ) National Institute of Justice (NIJ), Dr. Chandramouli of the Stevens Institute of Technology has developed a wireless radio system which, for the first time, makes such communication possible.
By improving radio channel (spectrum) management; providing dynamic aggregation of wireless data network resources; and facilitating optimal use of available communications resources, this system will provide law enforcement and emergency responders with alternative resources when primary channels may otherwise be unavailable. The research product of this effort is an example of NIJ funded research intended to fulfill communications needs as defined by criminal justice system practitioners and other public safety wireless data users.

8. Space Optical Communications: Communicating by Laser Beam (NASA)

The communications requirements for space missions, both robotic and Human Space Flight are always increasing. Scientists and explorers always seek more data from more distant locations. To meet these future requirements, while also moving out of the RF spectrum, NASA is pursuing Optical Communications. The first demonstration mission, the Lunar Laser Communications Demonstration (LLCD), is an experiment to provide the proof-of-concept for laser-based communications from lunar orbit. During the experiment, NASA plans to transmit more than 600 megabits of data per second using a 4-inch telescope and a half-watt laser installed on the Lunar Atmosphere and Dust Environment Explorer (LADEE), which NASA plans to launch in 2013 to characterize the Moon's wisp-thin atmosphere and dust environment.

9. The Space Communications and Navigation Testbed: An Orbiting Platform for Software Defined Radio Experimentation (NASA)

NASA's Space Communications and Navigation Testbed (SCAN Testbed), known internally as, the Communications, Navigation, and Networking re-Configurable Testbed (CoNNeCT) project will provide an on-orbit, adaptable facility to conduct a suite of experiments to advance the Software Defined Radio (SDR) Space Telecommunications Radio Systems (STRS) Standards, reduce risk for candidate spaceflight hardware/software, and demonstrate space communication links critical to future NASA exploration missions. The CoNNeCT project will provide NASA, industry, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on reconfigurable, software defined radio platforms and the STRS Architecture.

10. Delay/Disruption Tolerant Networking (DTN): Networking without End-to-End Connections (NASA)

    NASA is continuing the development of Delay/Disruption Tolerant Networking (DTN) for the spaceflight applications that take missions to great distances (long delays) and/or have non-continuous connections to Earth. This effort will allow for the operational deployment of networking capabilities while taking more advantage of the communications links available. This more bandwidth efficient method of data transfer provides for increased autonomy for future missions and brings the promise of a future Solar System Internetwork.

11. RFID: On Paper, it's a Great Idea! (NSF)

    Radio frequency identification (RFID) tags are on virtually everything these days, from store merchandise to library books to credit cards to industrial parts and supplies. No doubt, then, that finding a way to make the tags cheaper and easier could really be a boon for manufacturers, businesses, and consumers alike.
    To this end, a federally-funded research project is investigating whether RFID tags could be printed on paper, using presently available inkjet technology and conductive inks. The paper-based tags would be environmentally friendly by using low-cost commonly-available components with exceedingly low power requirements. By incorporating cognitive radio technology in the devices, the tags would also be spectrally efficient, making adaptive use of particular spectrum bands based upon local requirements.
    Development of the inkjet-capable paper RFID tags is being funded by the National Science Foundation through a research award to Georgia Tech Research Corporation.

12. Disaster Communications: The DAWN of a New Era in Wireless Communications (NSF)

    Paradoxically, wireless communications are often needed the most during times of disaster, but disasters often stress or destroy the infrastructure needed to provide critical communications. Now, federally-funded researchers are actively pursuing new technologies that could help rapidly re-establish vital wireless links during times of trouble.
    Disaster Area Wireless Networks, or DAWN, would aggregate a large number of local-area radio communications links, including Wi-Fi, and upload them to a hovering balloon-borne node using free space optical links. The system would be capable of restoring some voice and data services over a broad geographic area during a disaster situation, without requiring new spectrum resources. For backhaul purposes, the aggregated wireless traffic would be up converted to free space optical links operating at exceedingly high frequencies, where available data throughput is measured in gigabits per second, and which presently are not subject to regulation by telecommunications authorities.
    Work on DAWN is funded by the National Science Foundation through a research grant to the University of Oklahoma.