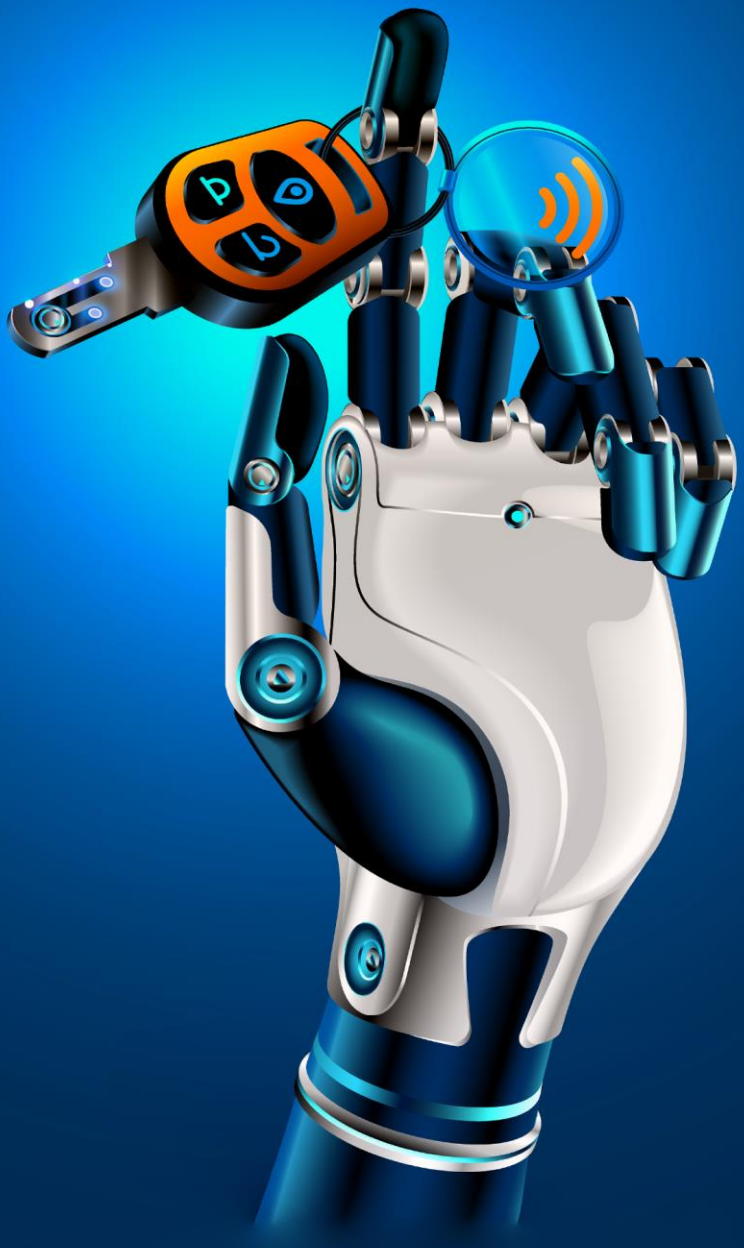
# THE NETWORKING AND INFORMATION TECHNOLOGY RESEARCH AND DEVELOPMENT (NITRD) PROGRAM



*Transformative Power of 5G*

**Newsletter May 2020**

## DISCOVER NITRD INNOVATIONS FOR YOU!

# The Director's Corner - Kamie Roberts

I am pleased to present NITRD's revised newsletter that offers insight into the Nation's priorities and what activities NITRD's member agencies conduct to achieve the President's priorities. Along the way, I hope to provide the background of some of the networking and information technologies that have become so important in improving Americans' daily lives. This revamped newsletter includes many interesting areas for you to explore:

- ***Snippets***: Well, they are exactly that, snippets (with links) to fascinating agency projects in networking and information technology.
- ***Topic of the Day***: This month we are examining wireless spectrum, 5G, and related technologies, but first we explain to our readers in the *Topic of the Day* section what exactly is 5G and importantly, how it will benefit the American public.
- ***Agency Corner***: For our first revised newsletter, we chose DARPA to highlight in our *Agency Corner* section because they have brought to fruition many of the technologies that we associate with our ***Topic of the Day***, wireless spectrum and communications.
- ***Innovation through NITRD***: We also introduce our readers to NITRD's Wireless Spectrum Research and Development Interagency Working Group who coordinates Federal agency wireless spectrum activities.
- ***Event Highlights***: We highlight here two workshops recently held on this important and timely topic.
- ***NITRD Staff***: Lastly and certainly not least, we acquaint our readers with three NITRD staff members and a recent intern. NITRD strongly supports ***STEM education*** and workforce development in the information technology fields and so we are proud to draw attention to their accomplishments at NITRD.

We invite you to take a look at this newly revised newsletter to see the transformative innovations that have found an important place in the American life. As the Director of NITRD, I challenge you to ***Discover NITRD Innovations for You!***

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# Snippets . . . Discover NITRD Innovations for You!

*What NITRD's Federal agency members are doing in advanced communication technology!*

**DARPA, NIST & NASA: INNOVATION THROUGH COLLABORATION!** Current communication and navigation applications use atomic clocks that are costly and high in energy use. New technologies will need precise timekeeping on miniaturized portable platforms. Read about the collaborative work:

**DARPA's** project ***MAKING PROGRESS ON MINIATURIZED ATOMIC CLOCKS FOR FUTURE PNT APPLICATIONS***
**NIST** collaboration on ***ARCHITECTURE FOR THE PHOTONIC INTEGRATION OF AN OPTICAL ATOMIC CLOCK***
**NASA** developed an atomic clock unaffected by environmental factors, e.g., temperature.

***DARPA ASSURED AUTONOMY SEEKS TO GUARANTEE SAFETY OF LEARNING-ENABLED AUTONOMOUS SYSTEMS***
The Assured Autonomy program improves how computing systems learn and adapt to environmental variations to advance maneuverability.

***NIST'S ANTENNA EVALUATION METHOD COULD HELP BOOST 5G NETWORK CAPACITY AND CUT COSTS*** – NIST's ***'5G and Beyond'*** program is developing optimal antenna designs such as the "smart" antenna that narrows and steers a beam in different directions.

***Alliance for 5G Networks*** – To promote public/private partnerships, NIST brought together different stakeholders in industry, government, and academia to accelerate the next-generation communication technology development. See ***5G mmWave Channel Model Alliance***

***Advanced Wireless Research @ NSF*** – As part of public/private collaborative wireless research effort, NSF is funding regional testbeds [Platforms for Advanced Wireless Research ('PAWR' - pronounced "power")], that are the size of a small city. A ***new PAWR testbed***, in North Carolina's research triangle, will focus on vehicular and unmanned aerial wireless communication systems.

**STEM-Related Snippets . . .** ***Suffolk Girl Scouts Launch Patch Program*** – DOE BNL and the Suffolk County Girl Scouts encouraged girls to explore science, technology, engineering and mathematics (STEM) while earning cool Girl Scout badges as part of a broader effort across DOE to promote women in STEM.

[*Agency names and other abbreviations are found **here** / Sources & suggested readings are found **here**.*]

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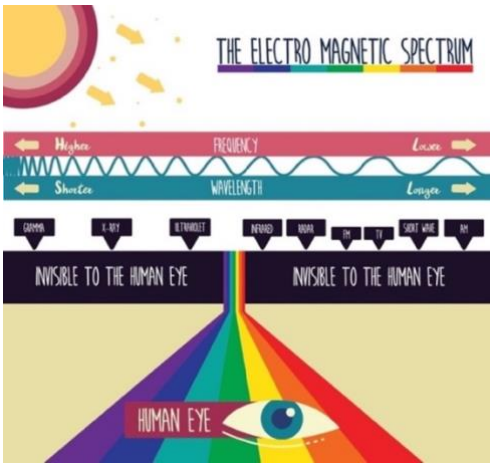
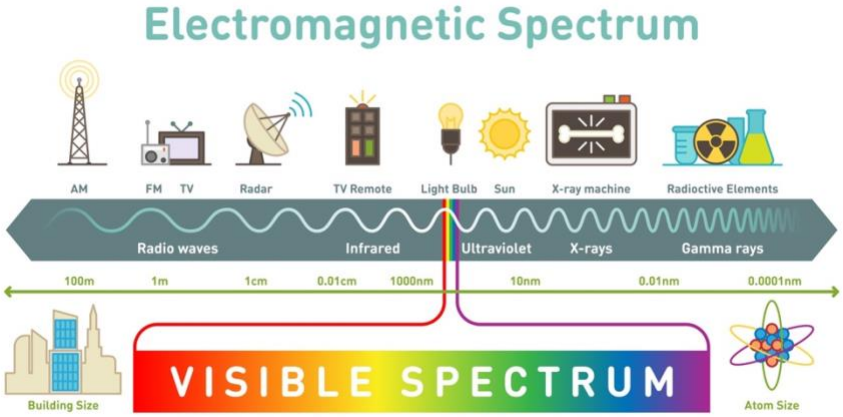
# Topic of The Day - Wireless Spectrum & Fifth Generation (5G): What Do They Mean?

We are hearing about 5G and wireless spectrum constantly in the media and advertising. The term 5G has become an effective marketing term to gain consumer's attention, but what really is "5G"? Advanced wireless spectrum covers 5G and the next generation of mobile networks, which will be 6G. Here, NITRD strives to explain what 5G is and how it will impact people's lives.




The *electromagnetic spectrum* refers to the frequencies of the electromagnetic waves and their associated wavelengths. The low end of the frequency bands (long wavelengths) includes radio, microwave, and infrared light; the middle of the spectrum consists of visible light (light/colors the human eye sees, i.e., 'visible spectrum'). The high end of the spectrum is the short wavelengths (ultraviolet light, x-rays, and gamma rays). Radio waves, the portion of the electromagnetic spectrum used for communications, are wireless signals used by devices, such as phone, GPS, radio, and TV. These invisible signals transmit what you see and hear on these devices.



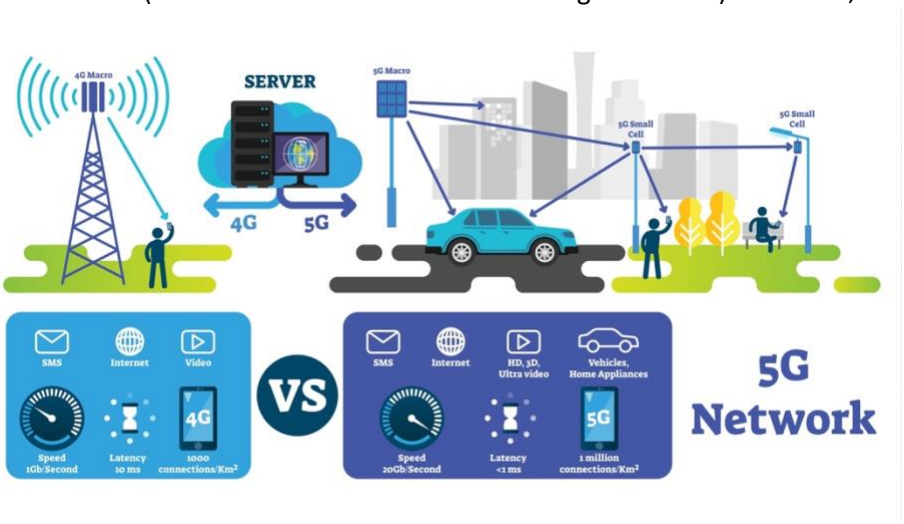

The electromagnetic spectrum is arranged into frequency bands that have different properties – *i)* low-band spectrum (less than 3 gigahertz (GHz)) consists of waves that travel over a relatively long distance with nominal disruption in the signal; *ii)* high-band spectrum (above 24 GHz) consists of

waves that travel over shorter distances, prone to distortion, and rapid attenuation, but have a greater capacity (carry more data) and faster speed than low-band spectrum waves; and *iii)* mid-band spectrum (between 3 GHz and 24 GHz) has shared attributes of the other two bands. Fifth generation (5G) requires massive bandwidth to transmit large amounts of data. To accomplish this, the wireless signals for 5G operate on low, mid, and high-band spectra to give the signals improved speed, capacity, and latency. Low-band spectrum signals penetrate more effectively into buildings and transmit further, thus are beneficial for wider coverage, especially in rural areas.

As the name implies, "***small cells***" (small scale antennas) can be installed just about anywhere as they are compact base stations.

High-band signals provide higher speeds, rapid response time, and capacity not previously available – thanks to small cells placed in close proximity on different buildings and structures as illustrated in the photograph above.

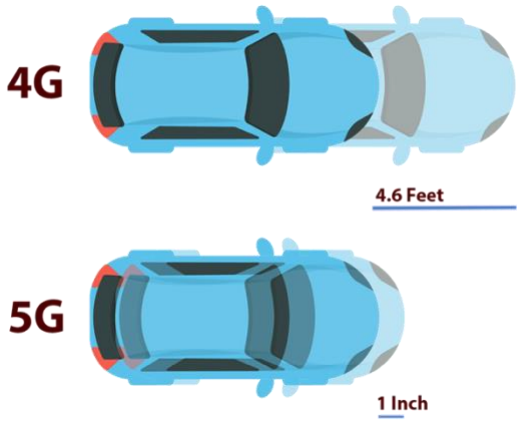
Most wireless networks are in the low-band spectrum and use frequencies that move voice and data between mobile devices and cell towers (4G cellular network - left side of diagram below). However, signals in the high-frequency spectrum transmit best with small cells, which is what the 5G cellular networks use as signals move between a cell tower, small cells, and a device (right side of diagram on right). The 5G system forms a pooled network of connections with large macrocells enhanced by small cells that increase the coverage and capacity.




To understand the 5G cellular network technology, it is important to grasp the steps that occurred before it. Approximately every decade a new generation of mobile networks has been launched starting with 1G in the late 1980's that brought voice communications and some data transfer. Second-generation (2G) network technology allowed for text messaging and improved voice quality. In the late 1990's mobile broadband (MBB) was introduced with 3G (high speed pocket access/HSPA) technology that brought faster data transfer speeds, which allowed for music streaming and internet searching. MBB continued its advancement in 2008, as 4G (long-term evolution/LTE) technology facilitated digital video and a variety of new data-dependent applications. All of these technologies operated on just low-band spectrum. The unleashed capabilities and combined attributes of low, medium, and high-band spectrum in this new generation of technology is what makes 5G so unique.

The Internet of Things (IoT)'s new and innovative applications, e.g., smart cities, smart manufacturing, autonomous vehicles ('self-driving cars'), drone delivery systems, virtual reality, and telemedicine (smart healthcare) will depend on extremely low levels of latency. Latency - the time

between when data is requested and when it is received – is what 4G is not proficient at, because the rates average between 10 and 50 megabytes per second (Mbps). So why is improved latency so important? It will mean fewer dropped calls, better video quality, faster downloads, and quicker response time. Information on road conditions, traffic patterns, and cars breaking ahead can be transmitted continuously to the cloud from the in-car sensors via 5G connectivity and low latency rates for real-time response. To illustrate this, below shows that a self-driving car using 4G will continue to travel 4.6 feet after it receives the signal to apply its breaks. Whereas, for 5G the response time from the signal to applying the breaks will mean the car will only travel one inch!




If you are traveling in a self-driving car at 60 mph, from the time the system detects a hazard to when it applies the brakes, the car will continue to move 4.6 feet using 4G.

*But*, **with 5G**, that detection to response time will be one inch in distance!

***Now that will reduce collisions!***

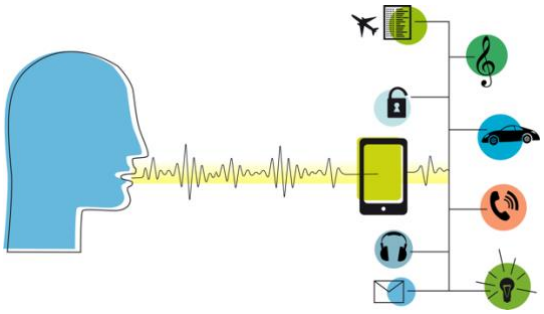
*This image was adapted from Sawanobori 2016 CTIA 5G The Next Generation of Wireless: 5G Leadership in the U.S. < https://www.ctia.org/news/next-generation-wireless-5g-leadership-us>. Accessed August 28, 2019.*

As images, video, and data are transmitted faster and more reliable, real time health monitoring, remote diagnosis, emergency treatments, and surgery would move from the realm of possibilities to the world of commonplace. A June 2019 Ericsson Mobility Report stated that LTE comprises 47 percent of all mobile subscriptions. This fast moving trend will continue as networks scale up and expand globally. The November 2019 Ericsson Mobility Report suggests that by 2025, mobile broadband will comprise 90 percent of subscriptions. Of this, 5G is expected to provide access for 65 percent of the world's population and generate 45 percent of global and 74 percent of North American mobile data traffic.

## Agency Corner: DARPA

In 1958, the U.S. Government established the ARPA (precursor to DARPA) to bring almost impossible cutting-edge innovations to fruition. DARPA's tagline, *Creating Breakthrough Technologies and Capabilities for National Security*, indicates the military focus but in reality, DARPA's research ultimately benefits all of society. DARPA is a funding agency in that it funds a portfolio of R&D programs but does not conduct the actual research. Likewise, DARPA does not fund the costs of bringing the concept to operation and instead uses "technology transition" and transfers the prototype to other government or industry entities. This means that the private sector can work with DARPA to commercialize technology. DARPA has been a driver of public-private partnerships and at times created new industries. The 1990s

"dual-use" philosophy spurred technologies to have a civilian as well as defense use, thus promoting collaborations between commercial, academic, and government entities.



As we all know, the phone plays an important role in Americans' daily lives today. But, did you know that DARPA developed the precursor to Siri and Alexa in the early 2000's? It was called PAL and it retrieved and synthesized data to work out a more efficient path to obtain and sort the information for the next time. Basically, it was a system designed to adapt to a user rather than the opposite – how cool is that! Still wondering how NITRD advances discoveries for Americans' daily lives? You probably take it for granted that your phone will find a restaurant or directions to your f riend's house *but* the GPS (geopositioning system) on your phone all started with DARPA and the USN in 1973. DARPA worked on *miniaturizing* the GPS receiver in 1983, as at that time it was the size of a large piece of furniture. The program, *Virginia Slims*, was successful as every smartphone user knows from the tailored-to-their-location search results their cell phone gives them.

Did you know your smartphone contains gallium arsenide (GaAs) that enables transistors to work at higher frequencies in the electromagnetic spectrum? Why is this important? GaAs in your phone facilitates the communication link to cell towers. DARPA's program on miniaturization of the technology led to the foundations for cell phone communication. DARPA provided funding for another innovation—AI and ML—to create new applications, such as data mining that allows for searching across the internet. AI and ML allow Siri to sift through massive amounts of information and provide input, so the person can make decisions. DARPA's game-changing technology advances can have far-reaching consequences for national security, be transformative for commercial interests, and beneficial for the general public as it improves technology for the Nation.


## Innovation Through NITRD Coordination: Interagency Working Group Corner Wireless Spectrum R&D IWG (WSRD)

Federal research and development (R&D) investment in emerging technologies is critical to promoting and protecting American innovation and international leadership. The NITRD Program focuses its work on strategic R&D imperatives because developing leading capabilities in cutting-edge technologies is intensely competitive globally. NITRD supports IT R&D activities across Federal agencies to help facilitate the transition of advanced networking and IT R&D into practical use. To do this, NITRD's IWGs coordinate activities with participating Federal agencies on Program Component Areas (PCA – budget categories that are 'overarching' topics) to support the Administration's IT priorities. WSRD is an acronym that is pronounced '*wizard*'. . . probably the coolest acronym out there in the government world. The WSRD IWG handles spectrum-related (which includes 5G) priorities for the benefit of the American public as we move into the next generation of wireless spectrum.

# Event Highlights

## *WSRD IWG Workshop*

With the advent of sophisticated wireless devices and IoT applications (drones, small satellites, driverless cars, wireless healthcare devices, etc.) security threats to wireless mobile communications systems are rapidly increasing. To address this, the NITRD WSRD IWG held a workshop, *Security from a Wireless Spectrum Perspective: Technology Innovation and Policy Research Needs*. A copy of this report can be obtained at **this link.** WSRD IWG also held a **workshop** in Rome, NY on August 28-29, 2019 (see photo left) on the application of existing and new AI techniques in wireless spectrum. The release of the report, *Artificial Intelligence & Wireless Spectrum: Opportunities and Challenges*, will be announced on @NITRDgov.


## *Grace Hopper Celebration*

Anh Quach (left) with LLNL and Kamie Roberts (right), the Director of NITRD celebrate the past, present, and future of women in computing at the AnitaB.org and ACM **annual Grace Hopper Celebration event** in Orlando, Florida. Rear Admiral Grace Hopper was a mathematician, computer scientist, and programmer when very few women were in these fields [**Find out more**]. She was recalled from retirement to active duty by the USN to standardize COBOL and other languages. RDML Hopper was a visionary and paved the way for other women to be in STEM fields. See you next year!

# STEM, Students & Thoughts on Training

Ever wonder '*What opportunities do I have?*' Opportunities can be difficult to come by but mentoring and internships do open doors and bring new paths toward career goals. Internships expand horizons, as a number of former interns at NITRD have gone on to work in government agencies, the private sector, and the medical field. Having an internship at NITRD means students are not just exposed to one area focused on one task but instead work in a variety of areas with people who have extensive experience in government. Interns learn about strategic planning, engage with agency personnel, and broaden their perspectives. It is this exposure to strategic thinking that helps each intern grow into their next job.

Case in point . . . Our newest staff member at NITRD is Jake Fries (right) who is a Technical Coordinator (TC) for three NITRD IWGs. Before Jake began this position, he was an intern at NITRD while completing his bachelor's in political science. Jake believes a crucial focus in the workplace is 'coordination' and teamwork, and to this end, he fosters an environment in the IWGs where all participants are comfortable in sharing ideas and working toward the goal. Jake's advice for students is to "*pursue every opportunity*, *keep an open mind*, *and leave your comfort zone"*.

An important skill a NITRD intern learns is how to navigate the professional office environment. Our most recent intern, Jacob Dienger (left photo, far right), is a third-year computer science major at Florida State University (FSU). Students are often intimidated when working as part of a team, but Jacob learned that working in a team provided a less stressful learning environment as he was able to check in with those who are experienced in the field. Jacob's internship experience contributed to his final piece of advice: "*Own your own training*."

# Our Story at NITRD

## *Getting to know your NITRD staff*

Dealing with complex challenging issues is a trait for success at NITRD. Faisal D'Souza, the TC for AI R&D IWG and the IRAS R&D IWG, exemplifies these qualities. Faisal describes himself as one who enjoys solving complex problems and "never backs down from a challenge". The NSTC Executive Director, Chloé Kontos, recognized these talents when she requested that Faisal create a dashboard-like website for all of the NSTC internal webpages. This was no small feat, but the desired outcome would connect the collaborative effects of the different working group members, link materials and activities to the committees and subcommittees, and allow for quick and easy use. The Director of OSTP, Dr. Kelvin Droegemeier, was so happy with the final product that he said Faisal "ought to have a trophy" for providing such a useful and necessary tool that is constantly used by the White House. However, Faisal was quite happy to have his picture taken with the OSTP Director and NSTC Executive Director.

## *WOMEN'S HISTORY MONTH*

In honor of Women's History Month, NITRD proudly promotes the inclusion of those who have traditionally been underrepresented in leadership, research, and practitioner roles in science and technology. We strongly support contributions from diverse backgrounds, including women who have long been an underrepresented group in STEM. To this end, NITRD highlights Wendy Wigen for her 10 years of dedication, contributions, and exemplary performance to the NITRD. Wendy joined NITRD in 2010 as a Technical Coordinator to facilitate two new interagency groups, Big Data and WSRD. Her

prior experience as a teacher, and her work with Congress as an advocate for network neutrality and improved broadband access had prepared her well. She also attributes her organizational skills and her ability to build and maintain relationships as key factors in her success as a coordinator. Beginning in January 2019, Wendy retired from managing groups and is currently working as a Technical Writer and Consultant for NITRD. We appreciate all the hard work Wendy has done to advance communication and research partnerships that benefit all Americans!

## ***Agency Names & Other Abbreviations***

| | |
|---|---|
| ARPA | Advanced Research Projects Agency (precursor to DARPA) |
| BNL | Brookhaven National Laboratory, a US DOE national laboratory |
| DARPA | Defense Advanced Research Projects Agency |
| DOD | Department of Defense |
| DOE | Department of Energy |
| LLNL | Lawrence Livermore National Laboratory, a US DOE national laboratory |
| NASA | National Aeronautics and Space Administration |
| NSF | National Science Foundation |
| NSTC | National Science and Technology Council |
| NIST | National Institute of Standards and Technology |
| OSTP | Office of Science and Technology Policy for the White House |
| USN | United States Navy |
| AI R&D IWG | Artificial Intelligence Research & Development Interagency Working Group |
| IRAS IWG | Intelligent Robotics and Autonomous Systems Interagency Working Group |
| PAL | Personal Assistant that Learns |

## ***Sources & Suggested Readings***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Additional Links on 5G: https://www.nist.gov/topics/advanced-communications/what-5g
https://api.ctia.org/docs/default-source/default-document-library/enabling-the-wireless-networks-of-tomorrow.pdf
https://www.ctia.org/news/what-is-5g-a-brief-explainer / https://www.ctia.org/news/what-is-spectrum-a-brief-explainer

## *WHO IS NITRD AND WHAT IS THE PROGRAM?*

The NITRD Program is the Nation's primary source of federally funded research and development (R&D) on networking and information technology (IT). The NITRD Program seeks to maximize interagency coordination in providing the R&D foundations for continued U.S. technological leadership and meeting the needs of the Federal Government for advanced IT.

Now in its 28th year, the NITRD Program is one of the oldest and largest of the formal Federal programs that engage multiple agencies in R&D coordination activities. It was established by the High-Performance Computing Act of 1991 (P.L. 102-194) and reauthorized by Congress in the American Innovation and Competitiveness Act of 2017 (P.L. 114-329). The NITRD Program provides a framework and mechanisms for coordination among the Federal agency members that support advanced IT R&D and report IT research budgets in the NITRD crosscut. Many other agencies with IT interests also participate in NITRD activities. More information is available on https://www.nitrd.gov/about/.

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