

Statement of

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**Before the
United States Patent and Trademark Office**

**Hearings on
The Study of Underrepresented Classes Chasing Engineering and Science Success
(SUCCESS) Act**

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Director Iancu, Chief Economist Toole, and U.S. Patent and Trademark Office Staff:

My name is Susie Armstrong, and I am a Senior Vice President, Engineering at Qualcomm, Incorporated. Thank you for holding these hearings on the Study of Underrepresented Classes Chasing Engineering and Science Success (SUCCESS) Act. I appreciate the opportunity to testify before the USPTO on this critical topic of diversity in innovation.

Qualcomm is a leading U.S. company engaged in ground-breaking research and development of next-generation wireless technologies, and is the undisputed leader in developing foundational 5G technology. Since its founding in 1985, Qualcomm has been at the forefront of wireless R&D, and its technology has driven major cellular wireless standards. The company was the first to recognize and realize the potential of the wireless Internet and mobile broadband, and has helped pioneer other transformative smartphone technologies, including GPS, digital camera and video streaming, and mobile graphics.

Research and development essential to every generation of “G” takes close to a decade, beginning long before the new standard is developed and commercialized. In order to ensure that Qualcomm can continue to fund research in wireless R&D, we patent our inventions, and license them to device makers that incorporate those inventions into their products. Today, Qualcomm holds over 130,000 patents on its technology, and its patent portfolio is the most widely and extensively licensed in the wireless industry, with over 300 licensees.

I joined Qualcomm in 1994 as an engineer working on Globalstar satellite communications. I then worked on the team that developed and commercialized packet data technology—which permits transmission of data over the Internet over cellular links—in the late 1990s. This resulted in the first web-surfing on a cellular phone in 1997.

Since then I have held various positions at Qualcomm, including responsibility for the development and commercialization of all of the software that drives Qualcomm’s chipsets. I served as the head of worldwide Customer Engineering, the group that integrates and commercializes the company’s products in phones and other wireless devices. My responsibilities included engaging extensively with base station makers, carriers, and phone and other device makers in the United States, Asia and Europe to bring those technologies to market.

Although I have held multiple roles within the company, I first and foremost consider myself an engineer and inventor. Sometimes people think that inventors and patent holders are brilliant people working in their garage on their own, coming up with “light bulb” ideas. But more often, invention is a team effort that requires “out of the box” and creative thinking to recognize a technical need or opportunity and solve it. For example, my invention in the late 1990s of “simple packet data”—the technology that allows cellular phones to connect to the Internet—was the result of working on a team where I was able to come up with a new idea based on my background in computer communications. I was able to bring a unique perspective, and this demonstrates what can happen when someone with a different background is included as part of a diverse team.

At the time, code division multiple access (CDMA) was being promoted for high quality, high capacity voice calls, and my team was working on digital fax. However, my background prior to working at Qualcomm was in the computer communications industry (*i.e.* Ethernet and the internet data protocols TCP/IP). So to me, the digital CDMA voice link looked like just another Ethernet, or dial-up modem link, well suited for carrying Internet packet data wirelessly. So I invented a way to get a base station to set up a packet data call—essentially a wireless phone call for connecting to the Internet—leveraging the work we were already doing for “digital fax.” My invention involved minimal changes to the then-existing base stations and other infrastructure, further simplifying the process of connecting mobile devices to the Internet.

That insight resulted in the first wireless Internet surfing, on a Qualcomm mobile phone, at the February 1997 Cellular Telecommunications Industry (CTIA) show. The download speed was 14.4 kbps, which, by comparison, is over 20,000 times slower than the 300 Mbps download speeds of today’s 4G networks. And 5G networks will be significantly faster delivering up to 20 Gigabits-per second peak data rates and 100+ Megabits-per-second average data rates.

Within one year of our successful mobile web connection, infrastructure manufacturers adopted the technology and had commercialized it in multiple markets. Qualcomm and others in the industry then began focusing on research in “airlinks” that were optimized to carry packet data rather than just voice, and mechanisms for internet connections in a moving phone. Twenty years later, mobile Internet has revolutionized the way we communicate; expanding capabilities from simple web surfing to mobile email, to high-speed browsing, media streaming, and navigation; creating whole new industries, from on-demand services to online content creation, and paving the way for 5G and the wireless economy of the future.

The Diversity Gaps in Patenting

Despite the economic benefits of patents, not all inventors have equal access to the innovation pipeline. Multiple studies have shown that women inventors, inventors of color, and inventors from lower-income families patent their inventions at lower rates than male, white, and wealthier inventors.¹

In 2016, the Institute for Women’s Policy Research (IWPR) found that just 18.8 percent of U.S. patents, as of 2010, listed one or more women as an inventor.² A USPTO study just last month made similar findings, reporting that only 20 percent of U.S. patents list a woman

¹ See generally, Holly Fechner and Matthew S. Shpanka, Closing Diversity Gaps in Innovation: Gender, Race, and Income Disparities in Patenting and Commercialization of Inventions, *Technology & Innovation* 19:727 (2018).

² Institute for Women’s Policy Research, *Equity in Innovation: Women Inventors and Patents* (2016), <https://iwpr.org/wp-content/uploads/wpallimport/files/iwpr-export/publications/C448%20Equity%20in%20Innovation.pdf>.

inventor.³ The USPTO also reported the alarming finding that in 2016, only 12 percent of U.S. inventors who were awarded a patent were women.⁴

Racial and ethnic minority groups also patent at lower rates. According to IWPR, among college graduates, African Americans and Hispanics hold nearly half as many patents as whites—about one percent. African Americans and Hispanics also apply for patents at nearly half the rate of whites as compared with Asian American and Pacific Islanders, who seek patents at nearly double the rate of white men.⁵ African Americans, Hispanics, and white women apply for patents at comparable, and much lower, rates (0.3, 0.3, and 0.5 percent of women college graduates within each racial/ethnic group).⁶ Other studies, including research by Dr. Lisa Cook at Michigan State University, who testified during these hearings, have found that African American inventors are awarded patents at a much lower rate than the general population: from 1970 to 2006, African American inventors received just six patents per million people, compared to over 40 patents per million for women, and 235 patents per million for all U.S. inventors⁷

Inventors from low-income families also experience a wide gap in inventing: for every 10,000 children born to families with incomes below the U.S. median, just 2.2 will receive a patent in their lifetime, compared with over 22.5 children born to families in the top one percent of income.⁸

Despite the efforts of these scholars, it remains extremely difficult to study gender, race, and income gaps in patenting and commercialization. The USPTO does not currently collect any demographic information on its patent applicants. Legislative or administrative changes that would require the USPTO to collect this data would facilitate efforts by government agencies, academia, and private sector companies to monitor their progress in closing the patent gaps and inform ways for these entities to pursue policies that encourage full participation in innovation and entrepreneurship.

Qualcomm looks forward to the forthcoming report required by the Study of Underrepresented Classes Chasing Engineering and Science Success (SUCCESS) Act last year,⁹ which will shed further light on the patent gaps among women, inventors of color, low-income inventors, and veteran inventors, and offer recommendations from USPTO, in consultation with

³ Office of the Chief Economist, U.S. Patent & Trademark Office, *Progress and Potential: A Profile of Women Inventors on U.S. Patents* (2019), <https://www.uspto.gov/sites/default/files/documents/Progress-and-Potential.pdf>.

⁴ *Id.*

⁵ Institute for Women's Policy Research, *Equity in Innovation: Women Inventors and Patents* (2016),

⁶ *Id.*

⁷ Lisa D. Cook, *The Idea Gap in Pink and Black: A Framework for Research and Policy*, Presentation at Inventing America Conference, July 12, 2017 (Washington, D.C.).

⁸ Alex Bell et al, *Who Becomes an Inventor in the United States? The Importance of Exposure to Innovation*, *The Quarterly Journal of Economics* (2019), 1–67, <https://doi.org/10.1093/qje/qjy028>.

⁹ Pub. L. No. 115-273 (Oct. 31, 2018).

the Small Business Administration, for how to facilitate participation in inventing and commercialization among these underrepresented groups. We appreciate your holding these hearings in furtherance of that goal.

Diversity Initiatives at Qualcomm

Inclusion and diversity form core corporate values at Qualcomm and act as major forces that drive our technological innovation, including in 5G. The development and deployment of 5G in particular requires a wide variety of perspectives to solve previously unimagined technological problems. In his keynote at the 2017 Consumer Electronics Show (CES), Qualcomm CEO Steve Mollenkopf said “With 5G, new and previously unsolvable problems will be solved, new generations of innovations and innovators will be born. And we need more great technology minds, and that means getting the next generation, in particular women and under-represented communities, excited and prepared for the world to come.”¹⁰

In other words, diversity and inclusion are not just core values, they are economic and innovation imperatives. If Qualcomm, and its customers, hope to build and commercialize transformational technology that solves new problems in new ways, we need engineers from all walks of life who can dream up new solutions, and we also need people to be inventing new ways to use these technology advances. We promote a corporate ethos that values diversity, and that encourages all of our engineers and employees to participate fully in our innovation, patenting, and commercialization processes.

STEM Pipeline and Talent Recruitment

Qualcomm is proud of our already diverse workforce. Our engineer employees represent 116 different nationalities and speak 74 different languages, and are involved in both internal and external programs to increase that diversity.

But there is more work to do. As countless scholars, including Dr. Lisa Cook at Michigan State University, and Barbara Gault and Jessica Milli at the Institute for Women’s Policy Research, have identified, there is a diversity challenge in the Science, Technology, Engineering, and Mathematics (STEM) pipeline. It is imperative that we continue to encourage STEM education for women and girls, children of color, and low-income children, both in formal and informal programs that expose them to careers in science and engineering.

However, in Qualcomm’s experience, STEM is only one factor in the equation. Over the past 25 years, we have seen the number of women employed in science and engineering occupations rise to nearly 30 percent in 2015 (and higher in some STEM fields) while the women inventor rate—the percentage of inventors awarded a patent in any given year who are women—hovers just above 10 percent.¹¹ Additionally, at Qualcomm, we’re finding that a lower share of women and people of color with STEM degrees are engaging in semiconductor R&D,

¹⁰ <https://www.qualcomm.com/news/onq/2017/01/05/ces-2017-steve-mollenkopf-keynote>.

¹¹ See USPTO, *Progress and Potential* at 5.

which typically attracts electrical engineers and computer scientists, those same fields applicable to such visible fields as machine learning, artificial intelligence and financial technology.

In order to attract more qualified applicants to our workforce, we have examined our hiring process, especially on-campus recruiting at colleges and universities. We want to make sure that we send teams of engineers and employees that reflect the existing diversity within our company, and the diversity we hope to achieve.

Employee Training and Networking: Engineering the Bias Out of Corporate Processes

Once we have recruited a diverse workforce, our focus is on preserving a diverse and inclusive environment. As an engineering company, our goal is always to engineer the potential bias out of our process to build diverse and inclusive teams that can most effectively attack some of the biggest engineering problems inherent to bleeding edge wireless R&D. As our former Executive Chairman and CEO Paul Jacobs has said, “Inclusion and diversity are at the very heart of innovation,” because “[i]t requires different perspectives to take an idea, perfect it, and turn it into world-changing technology.”¹² We strongly believe that diverse, mixed-gender teams are more successful and more innovative, and we strive to create a culture that encourages and rewards teams that embody these values.

Part of this process involves training senior management company-wide about the value of diversity and inclusion, and supporting the development of employee-led networks to promote professional development and collaboration among different employee groups. Qualcomm currently has employee networks for women, Africans and African Americans, Latinos and Latinas, military veterans, millennials, lesbian, gay, bisexual and transgender employees, and differently-abled employees and caregivers for individuals with special needs. We are working to continually and strategically expand these networks and ensure employees worldwide have access to them.

A key component of our training and networking program is ensuring that employees who identify with underrepresented groups have access to leadership, mentorship, and career development opportunities within the company and their functional group.

Qualcomm STEM Initiatives

As a company of inventors, Qualcomm purposefully takes a long term look at invention and diversity. One of our key programs is the Qualcomm Thinkabit Lab. The Thinkabit Lab is a tangible hands-on career engagement program, whose byline is “inspiring the next generation of inventors.” Thinkabit Lab was born four years ago after we observed that that students, regardless of age, are not likely to pursue a STEM career without exposure and inspiration. Moreover, students from underrepresented populations struggle to see themselves in science and technology careers that often generate inventors.

¹² DMBA New Team, Qualcomm Inc. – 2013 50 Out Front for Diversity Leadership, *Diversity MBA Magazine*, July 20, 2013, <https://diversitymbamagazine.com/50-out-front/qualcomm-inc-2013-50-out-front-for-diversity-leadership/>.

The Thinkabit Lab initiative brings a hands-on approach to engage students with cutting edge technologies. For example, in our program, students learn about 5G, the Internet of Things, and careers in technology, and then program a simple circuit board to act as the core of their own IoT invention. The program is not prescriptive, nor is it a competition, but a tool to expose young people to invention and technology.

Over the past three years, we have created Thinkabit Labs in libraries, school districts, and university hubs in underserved parts of the nation to both expand our reach, and to leverage these organizations expertise to promote STEM education. We have created public/private partnerships to create “hub” Labs with Virginia Tech in the National Capitol Region, in downtown Detroit with University of Michigan, with the Chula Vista Public Library in California, and with the Porterville Unified School District in the rural, agricultural central valley of California.

Since the launch of the “Inspired by Qualcomm Thinkabit Lab Toolkit” in May of 2017, we have created over 25 “Inspired by Thinkabit Lab” sites in schools throughout the nation. These districts, universities and libraries have integrated our Thinkabit Lab activities, reaching numbers of students far beyond what we could impact at our cornerstone facility in San Diego. For example, the Innovation Station at the Chula Vista Public Library has served every 6th grader in the Chula Vista Elementary School District for the past two and a half school years.

The teachers, librarians, and administrators implementing these activities have added both their expertise in education and know-how in implementing STEM education programs to further improve and inform our program. Each of the Inspired by Thinkabit Lab sites have implemented the program to be responsive to the educational needs of students in their area and their local workforce, and to showcase the breadth of possibilities in the IoT area for new applications and inventions in such areas. There is a large demand by these Inspired by Thinkabit Lab sites for additional activities, teacher professional development and best practices/lessons learned from the San Diego-based Qualcomm Thinkabit Lab.

Thinkabit Labs have focused on middle school students, though the program can be easily scaled down in age to 5th graders and up into high school. In conjunction with the San Diego Work Force Partnership, we have been discussing ways to use the successful program to engage adults in retraining programs – again, our observation is that some adults do not engage in STEM retraining because they have not been shown that these could be careers for them. As we “age” the program up, we are planning to introduce more specific invention and patent content. We are currently piloting a program at a community college for adults from 18 to 42, and will use this program this summer in Porterville, where we are partnering with ag tech companies to get students to both engage in STEM careers, and to create IoT inventions.

Qualcomm’s Invention and IP Culture

While building the STEM pipeline and attracting diverse talent is a key component of Qualcomm’s innovation culture, so too is encouraging patents for our inventions. These values work in tandem to ensure that every member of team, whatever their background, is participating fully in the innovation process. By working hard to attract a diverse and inclusive workforce,

then integrating every engineer fully into our inventing and patenting work, we help to ensure that underrepresented groups fully contribute to Qualcomm innovations.

Patenting can be a complex and intimidating process, especially to engineers who have different skills and training, even in a larger company. Our inventor development program includes both online and in-person classes that cover both the basics of patenting and advanced team-building. Given the importance of patents to funding and encouraging invention across the wireless technology ecosystem, we also host invention sessions with engineers from multiple technology areas to encourage cross-functional information sharing.

Because patenting and licensing is a core feature of Qualcomm’s business model, we highly value the contributions of our engineers and staff to the invention innovation process. We encourage and celebrate all our inventors, ensuring that they are adequately trained on how to obtain patents, and that they are recognized for their contributions to patented inventions. We also facilitate the submission of inventions to our internal database with a centralized web page that allows inventors and employees to search for Qualcomm innovations and submit new invention ideas to the repository.

It is particularly important to our invention culture to recognize contributions to Qualcomm’s innovations. We are leading the world to 5G, and want our engineers to be a part of a team—both within their individual working group and within the broader company—that is focused and united around working together to invent the best technology that changes the world.

To that end, we celebrate all of our inventors. Engineers who contribute to inventions or who are awarded patents are given special “IP cards” to recognize their contributions, and are entitled to a notation in the company directory and on their business cards as patent holders. Monetary awards are also available to incentivize and recognize invention activity. Senior executives also send a congratulatory letter to each inventor who obtains a patent. For the most significant contributions to Qualcomm’s patenting, we recognize “Master Inventors,” an achievement awarded just 15 times since 2011.

In addition to internal recognitions, we publicize our inventions publicly. Our “Qronicles”¹³ page offers an interactive visual display of over 30 years of Qualcomm patenting, allowing visitors to learn about all of the innovations Qualcomm has contributed to wireless and mobile communications throughout its history.

About Qualcomm, Inc.

Qualcomm was founded in San Diego, California by Dr. Irwin Jacobs and Andrew Viterbi, two University of California at San Diego professors, along with five other leaders in the emerging field of wireless communications. It is the quintessential American success story of a highly innovative startup, whose deep commitment to R&D have positioned mobile as the largest and most transformative communications platform in history. In his 2011 testimony before

¹³ <https://www.qualcomm.com/invention/qroniclesofinvention/index.html>

Congress, Dr. Jacobs explained that Qualcomm “started small . . . but with the determination to innovate in digital wireless communications.”¹⁴

Efforts to promote commercial adoption of the CDMA standard, however, were not easy. Even after Qualcomm had successfully built and demonstrated a small CDMA system in the 1980s, a Stanford University professor decried the technology, stating that it “defied the laws of physics.” Yet the company persisted, by relentlessly anticipating the future of technology and investing in bringing it to fruition. For example, Dr. Jacobs was among the very first to envision that every person would eventually have their own phone number and communicate wirelessly. One of Qualcomm’s earliest products was a satellite-based vehicle tracking and communications system—an early precursor to GPS technology usage that millions of mobile phone users rely on daily to hail a ride or track their deliveries. Qualcomm recognized early on the ability of the digital cellular link to carry data as well as voice, leading to their development of communications optimized for data, and the first “smart phone.” Qualcomm also invented one of the early mobile “app stores,” a mechanism for safely downloading and running third party software on a phone.

In the three decades since Qualcomm’s founding, the mobile phone first used for simple voice communication has become an extraordinarily powerful mobile computer, thanks to Qualcomm’s innovative CDMA technology—the foundational cellular technology that has enabled every “G” of wireless technology and that continues to underlay the 5G revolution.

Today, the majority of Qualcomm’s employees are engineers whose focus includes long-term R&D on core wireless capabilities. Most of the research work is done at the company’s San Diego headquarters, and in New Jersey, North Carolina, and Texas. Qualcomm’s significant R&D projects require considerable investments of time and resources and may not be commercialized for up to a decade, if ever. Qualcomm’s dedication to R&D results in transformative inventions, including most recently with respect to 5G.

Broad licensing of Qualcomm technology has given rise to a healthy ecosystem consisting of smart devices, networks, and applications. The patenting of innovative technology ensures that this basic technology is publicly disclosed, allowing others to incorporate the technology into their own devices and innovations, and also to improve upon it. Qualcomm participates in and contributes substantially to standards-setting organizations, international bodies of engineers who contribute technology to standards that allow devices and products from different manufacturers and different countries to interact with one another, further encouraging innovation and collaboration.

No other company in the U.S. or Europe has made the same long-term commitment to 5G R&D. Revenue from Qualcomm’s licensing business is invested back into R&D to continue the cycle of innovation. For the past several years, the company has invested over 20 percent of its total annual revenue in R&D, bringing the company’s total R&D expenditures to over \$53 billion.

This level of private sector investment in wireless R&D—which is now being applied to the development of 5G wireless—is unparalleled anywhere in the world. No other U.S. company or government has made a commitment to developing 5G that rivals Qualcomm’s investments. This unique role in the development of 5G means that Qualcomm’s technology has critical importance to U.S. economic and national security interests.

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Qualcomm’s leadership in long-term R&D in foundational technologies like CDMA, 3G, 4G, and 5G is only possible because of our talented engineering workforce and a strong patent system that protects the intellectual property of our company. As our competitors overseas strengthen their own intellectual property rights, it is an economic and technological imperative for Qualcomm in particular, and the United States at large, to ensure that inventors from all background and perspectives can participate fully in our innovation ecosystem. Qualcomm is committed to ensuring that women, people of color, low-income individuals, and other inventors from other underrepresented groups can bring their talents to our innovation economy. We appreciate the opportunity to share our experience and best practices with the USPTO and other policymakers to support and develop policies that engineer the biases out of innovation, so the United States can continue to lead the world into the future.