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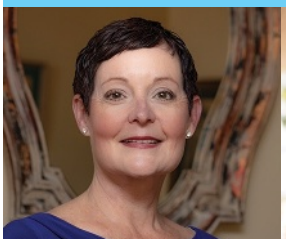

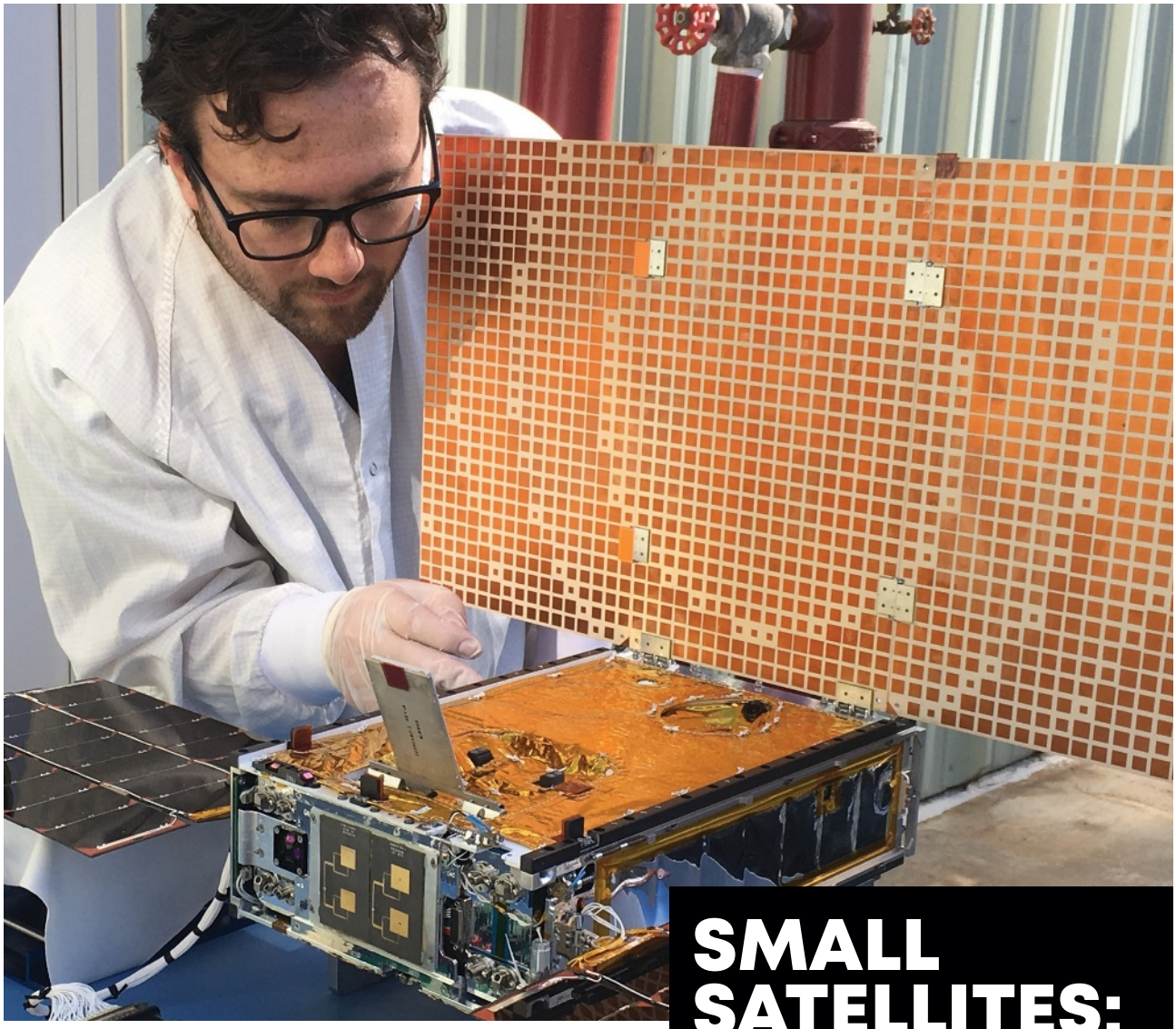

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president's column

Our Time of Transition
Enhancing member value

By José M. F. Moura, IEEE PRESIDENT AND CEO

AS PRESIDENT, I want to reaffirm IEEE as a member-based organization, built and led by volunteers. There are several topics I would like to address, including membership and transparency. Let me focus this column on the first. I will come back to transparency in a later column.

I have made it my priority to work with volunteers and staff from regions, societies, and councils to deliver value to our members and the professionals in our areas of interest. Last year I had the opportunity to meet members at several region and section meetings held throughout the world. Three main points were often the focus.

First, IEEE needs to deliver value to its members and focus on member development rather than membership development. Second, members joined IEEE because it is a professional organization, not a social-service organization. Third, IEEE should focus more on members and not on promoting its various products.

For example, IEEE should better communicate that the bulk of our activities is focused on our profession and on delivering value to our professionals rather than on humanitarian activities. We also need to redirect IEEE communications to address member needs more.

MEMBER VALUE

IEEE needs to understand what members value. Here lies our opportunity. IEEE is a 422,000-member professional organization, of which 50 percent are from Canada, Latin America, or the United States, while 18 percent are from Europe, the Middle East, or Africa, and 31 percent are from Asia or the Pacific region. Viewed in a different way, 71 percent of our members are higher-grade, and 29 percent are student members. Of our higher-grade members, 47 percent work in industry, 29 percent in educational institutions, and 9 percent in public and governmental organizations; 6 percent are retired; and 9 percent are undeclared [see chart].

To deliver value, IEEE needs to better understand the breadth and diversity of the many segments of our professional communities—academics, practicing engineers, different age groups and career stages, and gender, geographic, and industry segments. There is no single answer and no single value.

IEEE's current suite of products and services reaches a community of professionals far larger than our dues-paying membership. For example, every year nearly 5 million distinct users access the IEEE Xplore Digital Library, a repository of more than 4 million technical papers and 1,300 active standards. How do we inspire the other 90 percent of IEEE Xplore users to be more engaged with the organization?

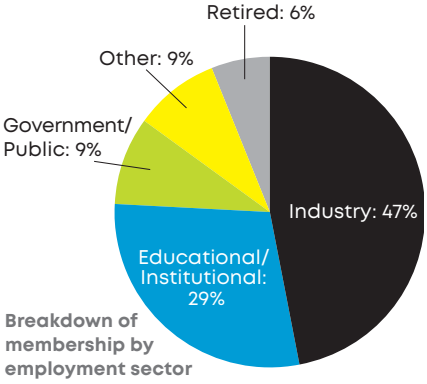
Nearly 500,000 professionals attend our 1,800 annual conferences. IEEE Future Directions' technical communities engage more than 100,000 professionals, of which only half are IEEE dues-paying members.

Every year, between 15 and 20 percent of members do not rejoin, even with the tremendous yearly effort undertaken to keep membership at its current level.

THE 4 MILLION-MEMBER CHALLENGE

Does our association provide value for young professionals, industry practitioners, female engineers, or geographically diverse constituents? Is the value we provide the value that today's varied audiences need and want?

The decision to join and renew membership, or being engaged with IEEE, is deeply linked to value. But addressing this challenge and constantly demonstrating our value proposition to our current and prospective dues-paying members is actually an opportunity to serve and engage the much broader community of well over 4 million professionals who currently touch IEEE products, services, or initiatives.



Breakdown of membership by employment sector

CHANGING NEEDS AND EXPECTATIONS

The essential model of membership is in flux. Shifting membership models mean that associations must do more than just deliver valuable information. IEEE Xplore, with its millions of articles, can significantly expand its functionality, with content curation

COVER: CLOCKWISE FROM TOP: KATHY LAND; DEJAN MILOJICIC; JPL-CALTECH/NASA ISTOCKPHOTO. THIS PAGE, CARNEGIE MELLON

and intelligent answers to technical and research queries. Beyond our successful "academic" conferences, we need new types of events that combine technical sessions with networking and fun opportunities, mentoring and career guidance, and exposure to new technologies and trends.

But all that is not enough. People are no longer willing to pay for the privilege of belonging. They need more tangible value. Facebook, for example, could be considered the world's largest association, with its billion members. Its networking extends locally and internationally. Self-promotion is intrinsic. Anyone can start a group focused on their interests. And it's free to join.

NEW MODELS OF ENGAGEMENT AND MEMBERSHIP

IEEE needs the infrastructure to keep ties with the 70,000 professionals who drop their membership every year. IEEE cannot ignore the many other millions of professionals it touches in various ways. My goal is to set up infrastructure that will keep those professionals engaged—in the meaningful ways that they themselves choose. This will lead to new forms of engagement, products and services, and possibly to new types and tiers of membership.

This is the discussion I am promoting. Because IEEE is a strong organization, we can dare to imagine the possibilities that we should consider pursuing.

Please join me as I refocus IEEE as a member- and volunteer-led organization and strive for an open institute. Share your thoughts with me at president@ieee.org. ■

RANDI KLETT

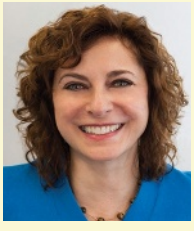
editor's note

Welcome to the latest iteration of *The Institute*

FOR THE PAST FEW YEARS, I've been trying out different methods to raise the visibility of the publication's award-winning content. What better way to do that than joining forces with IEEE's flagship publication and most popular member benefit?

Starting with this issue, the quarterly print version of *The Institute* will be published in *IEEE Spectrum's* March, June, September, and December editions. We'll continue to republish a selection of our most popular online articles in the print edition.

We kick off this issue with IEEE President Moura's column [left] about his work to improve the organization's value to members and engineering professionals.



Throughout this year, IEEE will be commemorating the 50th anniversary of the Apollo program and spaceflight in general. Our main feature, "How Small Satellites Are Providing Low-Cost Access to Space" [p. 6], describes miniature satellites that are driving innovation and excitement in space systems. A pair of CubeSat microsatellites flew alongside NASA's InSight lander on its way to Mars. The lander arrived on the Red Planet in November and is now relaying data back to Earth, including stunningly clear pictures of the Martian landscape.

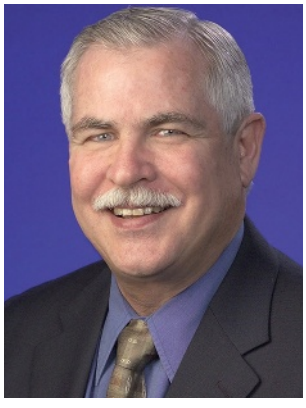
One of our articles on crime-fighting technology caught a lot of readers' attention. The startup Thorn is working to combat child exploitation and trafficking [p. 8]. IEEE Member Ruben Van der Dussen, director of the nonprofit's Innovation Lab, is developing tools to assist law enforcement with identifying victims, software to help companies spot and eliminate child pornography and other sex-abuse materials from their platforms, and programs to raise awareness of the problems.

The Institute has come full circle some 55 years after it started off as a column, "News of the IEEE," in *IEEE Spectrum's* first issue.

I look forward to working with *IEEE Spectrum's* editor in chief, Susan Hassler, and her team to help make this new version of *The Institute* a success. Tell us what you think by emailing institute@ieee.org.

—KATHY PRETZ
Editor in chief of The Institute

IEEE Medal of Honor Goes to Life Fellow Petersen



IEEE Life Fellow Kurt Petersen will receive this year's IEEE Medal of Honor "for contributions to and leadership in the development and commercialization of innovative technologies in the field of MEMS."

Petersen began his career at IBM, where he established a micromachining research group, which ran from 1975 to 1982. Micromachining is a technique for the fabrication of 3D and 2D electromechanical structures on the micrometer scale in silicon.

He left IBM to help found several companies that work to advance microelectromechanical systems technology.

NovaSensor, launched in 1985, was the first to commercialize widely used MEMS processing technologies such as silicon fusion bonding and deep reactive ion etching. The company now is known as Amphenol.

Founded in 1996, Cepheid transformed the field of molecular diagnostics using microfluidics and the polymerase chain reaction.

SiTime, launched in 2004, sells MEMS electronic oscillators, which replaced quartz crystal oscillators.

Since the launch of Profusa in 2008, it has become a leading developer of biointegrated sensors. It is developing a small, injectable *in vivo* chemical sensor. The plastic sensor is read fluorescently through an optical bandage, and the technology is designed to determine the quantity of multiple chemicals simultaneously.

More than 100 of his articles have been published. He has been granted over 35 patents in the MEMS field.

He was awarded the 2001 IEEE Simon Ramo Medal "for contributions to microelectromechanical systems (MEMS) science and technology and their integration into systems applications."

Petersen is a member of the Silicon Valley Band of Angels, an organization that supports startups. He mentors, consults with, and invests in early-stage high-tech companies.

The IEEE Foundation sponsors the Medal of Honor. The award is scheduled to be presented at the annual Honors Ceremony during the IEEE Vision, Innovation, and Challenges Summit, to be held on 17 May at the Marriott Marquis San Diego Marina.

–JOANNA GOODRICH

Milicevic to Receive First Outstanding Young Professional Award

Member Mario Milicevic was selected to receive the first IEEE Theodore W. Hissey Outstanding Young Professional Award "for contributions to the technical fields of error correction and quantum cryptography, engineering education, and the IEEE member experience."

Milicevic is a communication systems engineer at MaxLinear, in Irvine, Calif., where he is responsible for the development of algorithms and system-on-chip architectures for high-performance broadband and networking semiconductor products.

He received a doctoral degree in electrical engineering in 2017 from the University of Toronto, where his research focused on the design of error-correction decoders for low-power integrated circuits and quantum cryptography. His research introduced new techniques to overcome CMOS technology scaling limitations in error-correction circuits to support the expected multigigabit-per-second data-rate demands of 5G networks.

In addition, he designed error-correcting codes to reduce the computational latency of key reconciliation in quantum key distribution—a secure form of cryptography based on quantum mechanics—over optical fiber for distances beyond 100 kilometers.

Milicevic has taught several engineering courses at the University of Toronto, and has mentored undergraduate student design teams.

KURT PETERSEN; MARIO MILICEVIC

Chair of the IEEE Young Professionals committee in 2015 and 2016, he has played an instrumental role in growing the visibility and sustainability of the IEEE Young Professionals program. While chair, he spearheaded the development of a three-year business plan. He worked to expand the presence of Young Professionals activities at SXSW and at IEEE flagship conferences including GLOBECOM and the International Symposium on Circuits and Systems.

He helped launch the IEEE Entrepreneurship Initiative and its N3XT summit.

Milicevic is the incoming chair of the IEEE public visibility committee and a member of the IEEE Awards Board's presentation and publicity committee. He was on the team that helped develop the IEEE mobile app.

As an IEEE technical expert, he provides commentary to the news media about blockchain technology, cybersecurity, the Internet of Things, and other topics. He contributes blog posts to *The Institute* and *IEEE Transmitter*.

The Hissey Award was created to honor young professionals for contributions to the technical community and IEEE fields of interest. Hissey, an IEEE Life Fellow, supported the IEEE Young Professionals community over the years.

The award is scheduled to be presented during the annual Honors Ceremony, part of the IEEE Vision, Innovation, and Challenges Summit.

–J.G.

KATHY LAND; DEJAN MILOJICIC

Land and Milojicic Run for President-Elect

Susan K. "Kathy" Land
Program Manager
U.S. Missile Defense Agency

Dejan Milojicic
Distinguished Technologist
Hewlett Packard Labs

The IEEE Board of Directors has nominated Fellows Susan K. "Kathy" Land and Dejan Milojicic as candidates for IEEE president-elect. The candidate elected in this year's annual election will serve as IEEE president in 2021.

Land is a program manager for the U.S. Missile Defense Agency in Huntsville, Ala. She is responsible for advancing Command and Control, Battle Management, and Communications program objectives. She has more than 30 years of industry experience in the application of software engineering methodologies and the management of information systems, as well as leadership of software and systems product development teams.

She wrote or cowrote four books about software engineering principles.

She was elevated to IEEE Fellow last year "for leadership in software product development."

Land was the 2018 vice president, IEEE Technical Activities. She served two additional terms on the IEEE Board of Directors as Division VIII director/delegate in 2011 and 2012 and as Division V director/delegate in 2014 and 2015.

She was president of the IEEE Computer Society in 2009. In 2013 and 2016, Land was a member of the IEEE-USA Board of Directors.

Land has been an active member of the IEEE Standards Association for more than 20 years and served as the Computer Society vice president for Standards in 2004. She was the recipient of the 2007 IEEE Standards Medallion.

She has been active in Region 3 supporting local Future City competitions. She was also a member of the region's Executive Committee, serving as its awards chair.

In 2008 and 2010, she was a member of the IEEE Women in Engineering Committee.

Land is the recipient of several awards including the 2011 IEEE Huntsville Section Outstanding Engineer of the Year Award, the IEEE Computer Society 2017 Richard E. Merwin Award, and the Huntsville Association of Technical Societies 2018 Moquin Award.

Milojicic is a distinguished technologist at Hewlett Packard Labs in Palo Alto, Calif., leading software-stack development for deep learning accelerators. Previously, he worked as a research engineer at the Open Group Research Institute in Cambridge, Mass. Milojicic was technical director of the Open Cirrus cloud computing testbed, which had 16 academic, industry, and government sites in Asia, Europe, and the United States. He has authored two books and 180 papers, and has been granted 31

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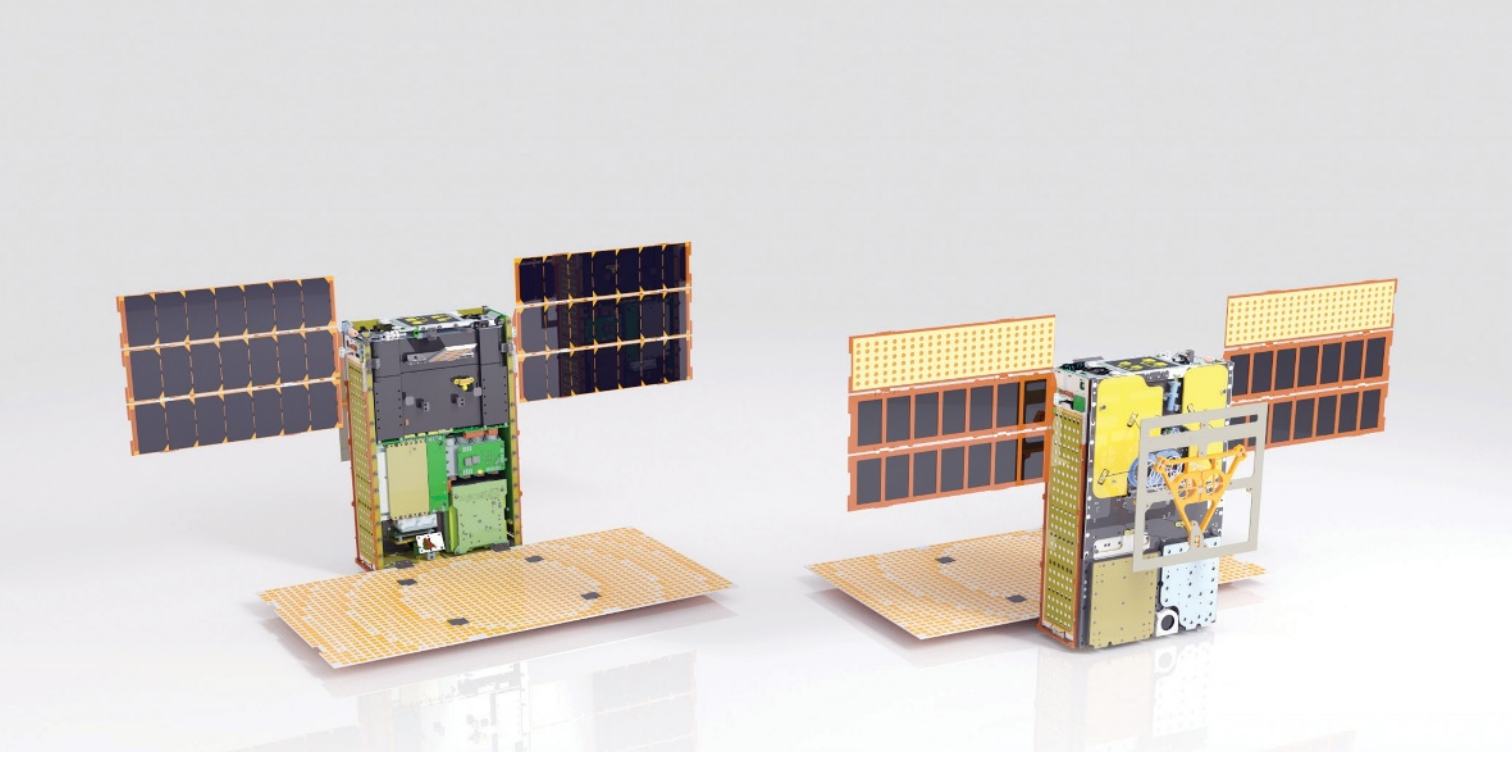


How Small Satellites Are Providing Low-Cost Access to Space

MINIATURE SATELLITES are driving a new wave of innovation in space systems and are generating excitement similar to that of the earliest days of space exploration. The global small satellite market is expected to grow to more than US $7.5 billion by 2022, according to *Market Watch*.

The tiny satellites are taking on increasingly complex missions. In May the Jet Propulsion Lab–Caltech Mars Cube One mission sent two CubeSats to fly alongside NASA's InSight lander on its way to Mars. The pair, the first microsatellites to support a deep space mission, has relayed data back to Earth about the interior of the Red Planet since InSight arrived there in November.

Small satellites are allowing commercial enterprises and educational institutions to perform space missions. Universities in Africa, China, Europe, India, and the United States have launched and operated small satellites, which are a fraction of the cost of traditional satellites that can weigh more than 1,000 kilograms and cost millions of dollars to launch. Some models are as small as the 10-square-centimeter CubeSat and weigh as little as 1.5 kg.

The tiny payloads deliver big impact.

Miniature satellites leverage advances in computation, miniaturized electronics, and packaging to produce sophisticated mission capabilities. Because the microsatellites can share the ride to space with other missions, they offer private companies, government space agencies, and universities a more affordable way to make observations about the Earth, conduct research, and test components and systems.

A number of commercial operators are envisioning large constellations of small satellites to open up markets for low-cost data communication, earth observation, and other services.

In "Modern Small Satellites–Changing the Economics of Space," published in the *Proceedings of the IEEE*, Member Martin Sweeting covers the history of small satellite development.

"Although microsatellites are physically small, they are nevertheless complex vehicles that exhibit virtually all the characteristics of a large satellite," Sweeting says. "This makes them particularly suitable as a focus for education and training of

JPL-CALTECH/NASA

scientists and engineers by providing them with hands-on experience at all stages of a real satellite mission—from design, production, test, and launch through to orbital operation."

Miniaturization comes with tradeoffs, though, he says. Small satellites that use commercial off-the-shelf components are cheaper to build, faster to upgrade, and financially less risky if they don't work as expected. But their capabilities are limited.

EARLY VERSIONS

Miniature, short-lived satellites, which are traditionally launched into a low Earth orbit, are nothing new, Sweeting says. The history of small satellites is as old as space exploration itself, dating back to the first Earth satellite, Sputnik 1. Launched by the Soviet Union in 1957, it weighed 83 kg and had a radio transmitter, batteries, a remote switch, and a fan. The first U.S. satellite, Explorer 1, launched in 1958. It weighed 14 kg and carried a cosmic-ray detector, temperature sensors, and a microphone.

The first nongovernment small satellites were built by amateur radio operators who wanted to extend their hobby into space. The first amateur radio satellite, Oscar 1, was a secondary payload aboard the Thor-DM21 Agena B, launched in 1961 from Vandenberg Air Force Base, near Lompoc, Calif. The 30- by 25- by 12-centimeter box weighed 10 kg and was the world's first satellite to piggyback on a launch. Despite its size, Oscar 1 included an antenna, batteries, and a transmitter and engaged the imagination of radio amateurs around the world.

AFFORDABLE OPTION

In the 1980s, small-satellite builders began to include reprogrammable microcomputers to enable them to reconfigure capabilities remotely. Amateur radio operators were the first to include such computers, which they were already using on the ground in their communications equipment. The first to launch was the 54-kg UoSAT-1, built in 1981 at the University of Surrey, England. More were launched throughout the 1980s and 1990s, including Amsat-Oscar 10, Fuji-Oscar 12, and UoSAT-2.

In the mid-1980s, the U.S. Defense Advanced Research Projects Agency started the LightSat initiative to reduce the costs and development time of spacecraft in the 50- to 1,000-kg range, according to Sweeting. The Global Low Orbit Message Relay microsatellite was the first developed under the program. Its goal was to demonstrate the feasibility of building a two-way, digital data communication satellite capable of performing important military missions in less than a year and for less than $1 million. It weighed 62 kg, was launched in 1985 from the *Challenger* space shuttle, and operated for 14 months.

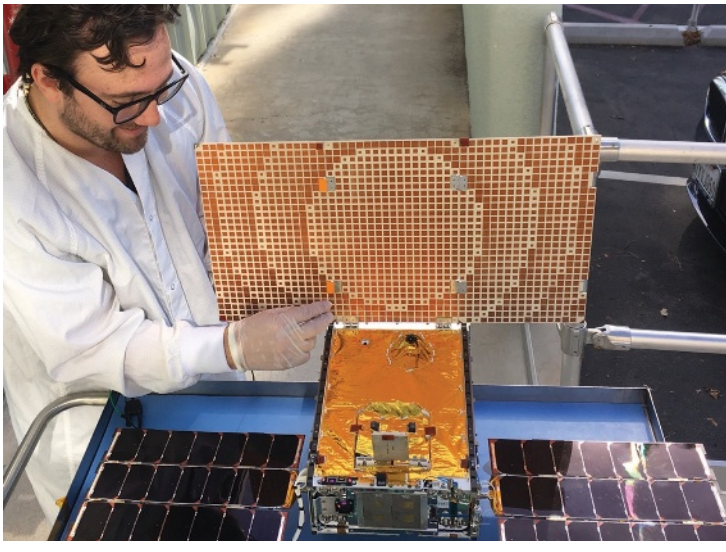
Despite such efforts, many observers still doubted the mission utility of microsatellites, Sweeting says. Larger satellites were becoming more impressive, and microsatellites were seen as an unwelcome distraction. But it wasn't long before private businesses, space agencies, the military, and universities recognized the small satellites' potential.

"Small satellite missions will not replace large satellite missions, as their goals and issues are different," Sweeting says. "Rather, they complement them."

A POPULAR NEW CLASS

A big boost to the small satellite industry occurred in 1999, when California Polytechnic State University and Stanford introduced CubeSats so graduate students could rapidly build nanosatellites with standardized interfaces. CubeSats are made up of one or more modules of 10 cubic cm units, each with a mass of about 1.5 kg.

The two schools also developed the Poly-Picosatellite Orbital Deployer and the QuadPack 2 multideployer, Sweeting says. The systems demonstrated the interfaces and mechanisms required to support the safe launch of CubeSats as ride-along payloads.



An engineer at the Jet Propulsion Lab uses sunlight to test the solar arrays on one of the Mars Cube One spacecraft.

JPL-CALTECH/NASA

To date, more than 800 CubeSats have been sent to space. They have tested navigation and control technologies that could make space experiments more affordable, for example, and demonstrated the feasibility of tracking a nearby spacecraft with an off-the-shelf automobile anticollision system.

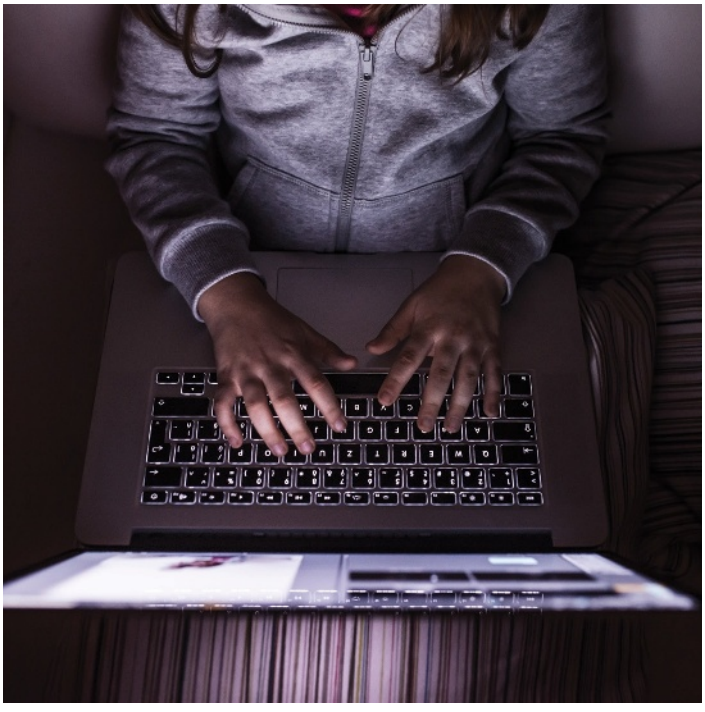
Small satellites are enabling new applications and business models, just as their terrestrial counterparts—the laptop and smartphone—have done, Sweeting says.

"The emerging 'NewSpace' sector is vibrant, innovative, and with strong potential to change the face of the space industry and the space-enabled services for the greater benefit of the global population," he says.

– KATHY PRETZ

Tech Startup Thorn Takes Aim at Child Exploitation

The company develops tools to help catch criminals



ISTOCKPHOTO

THE SEXUAL EXPLOITATION and trafficking of children is a serious problem worldwide. Children account for nearly one-third of identified trafficking victims globally, according to UNICEF. Today's technology provides traffickers with convenient ways to reach abusers around the world. The traffickers use the Web, mobile devices, and social media to advertise, schedule, and purchase sexual encounters with minors.

Smartphone cameras, portable video recorders, and image-creation tools are used to produce child pornography, which is then shared on the Internet, collected on thumb drives, and traded through the cloud. Tools that provide anonymity and encryption have enhanced the offenders' ability to evade detection by law enforcement.

But technology also can be used to combat the scourge by helping police identify victims faster and reduce the spread of child pornography. Through its products and awareness programs, Thorn, the nonprofit technology company founded six years ago by actors Ashton Kutcher and Demi Moore, has helped identify nearly 6,000 child sex-trafficking victims and more than 6,550 traffickers, and rescue 100 victims of child abuse.

"Our goal is to eliminate child sexual abuse from the Internet," says IEEE Member Ruben Van der Dussen, the director of Thorn's innovation lab. "We support companies, law enforcement, and nongovernmental organizations by building technology."

THE TOOLS

Thorn develops tools to help law enforcement identify victims, software to help companies spot and eliminate child pornography and other sex-abuse materials from their platforms, and programs to bring awareness to the problems.

Van der Dussen says he can't describe how the tools work in detail, because that could jeopardize investigations. But he does say that the company's Web-based law enforcement tool Spotlight is being used by more than 7,000 officers in the United States and Canada and that they report it has reduced case investigation time by as much as 65 percent in some cases.

"Spotlight helps the officers figure out where to focus their investigation," Van der Dussen says. "We help them prioritize and build out the case, but it's the officers who complete

the last mile. By providing the tools, we've been able to have quite a bit of success in finding victims."

Any company that lets its customers or the general public upload content can be a platform for abuse. That's why Thorn is also developing a product for small businesses and midsize companies to automatically identify and remove inappropriate material from their websites and social media platforms.

"Oftentimes these smaller companies don't have the time and resources to figure out whether content that's been uploaded is child sexual-abuse material," Van der Dussen says. "Our software can be easily integrated into their product, and doesn't require them to develop a new technology. This enables the company to focus on its core product while keeping its website safe from abusers."

Thorn has helped rescue 100 victims of child abuse.

PARTNERSHIPS

Previously Thorn worked with researchers at Texas Christian University and other institutions to survey survivors about their experiences. That led to a better understanding of the role technology played. The institutions have produced several reports and materials that Thorn has used to help those who are working to combat child trafficking, according to Van der Dussen.

Thorn also has partnered with Amazon Web Services, Digital Reasoning, Facebook, Google, Microsoft, Pinterest, Tumblr, and other companies. With its partners, Thorn works on best practices for screening platforms for child pornography and stays on top of emerging technologies to combat child trafficking and exploitation.

Van der Dussen says engineers need to be cognizant of the fact that their systems can be leveraged by traffickers and other bad actors who are adept at exploiting emerging technology.

"It is important to think about the impact of the technologies we build," he says, "not only on an organizational level but also on an individual level."

Although Thorn workers do not always encounter the best side of humanity, Van der Dussen says he is heartened by the dedicated community of people working together to combat child trafficking and abuse.

"It does give me a lot of hope and energy that together, we will be able to solve this problem," he says.

– KATHY PRETZ

Land and Milojicic Run for President-Elect

continued from page 5 |

patents. He has led multimillion-dollar projects with teams in Brazil, India, and the United States collaborating closely with many universities around the world.

Milojicic was elevated to IEEE Fellow in 2010 "for contributions to distributed systems software and mobile programming abstractions."

He served as the 2014 president of the IEEE Computer Society (CS) and most recently the Division VIII director and member of the IEEE Board of Directors. He has held key leadership positions to drive IEEE industry engagement, chairing the IEEE Industry Engagement Ad Hoc Committee from 2015 to 2017. He also established the first IEEE Industry Advisory Board and formalized the IEEE Industry Engagement Committee, a standing committee of the IEEE Board. In addition, he helped found the industry-focused IEEE Infrastructure Conference.

He was the first editor in chief of *IEEE Computing Now*, an online CS magazine. He further initiated CS Tech Trends, which predicts technologies that will have broad impact, and Scorecards, which grade those predictions. He helped establish the Special Technical Communities, a CS organization of professionals with common technical interests.

He received bachelor's and master's degrees from Belgrade University, Serbia, and a Ph.D. from the University of Kaiserslautern, in Germany.

–J.G.

career guidance

ISTOCKPHOTO

Quantum Computing's Researcher Shortage

Expert wants to open up the field to software developers

THE RACE IS ON TO BUILD quantum computers and associated technologies. But U.S. businesses and universities are growing concerned there aren't enough qualified engineers and researchers to meet demand, according to an article published in October in *The New York Times*. In fact, there might be fewer than a thousand people in the world who are doing leading work in the field, the story says.

That could pose a problem for businesses that want to build fast computers—as well as governments that want to maintain national security and their country's technological edge. Quantum computers could be exponentially faster than today's supercomputers for a number of applications including factoring large numbers used to encrypt communications. Some observers say the computers could be especially useful for advancing artificial intelligence and handling the deluge of data that is expected to accompany Internet of Things technologies.

The Institute asked IEEE Senior Member William Hurley, chair of the IEEE Standards Association Quantum Computing Working Group, about the reasons for the shortage and where the field is headed. Whurley, as he is known, is founder and CEO of Strangeworks, a quantum computing company in Austin,

Texas, that is writing a software subscription service where developers can run quantum experiments on a number of simulators, emulators, and one of several quantum computers. This Q&A has been edited and condensed.

WHAT IS CAUSING THE SHORTAGE?

The reason is a lack of foresight by people in academia and industry. We've known about quantum computing since 1981 and its potential to change the world, even more so than artificial intelligence. There's a famous quote from MIT from the 1970s where it said that in three to eight years there would be a computer that had the intelligence of a human being. We still don't have that, but it didn't stop people from exploring AI, investing in startups, or teaching about it in schools, did it?

Unlike AI, we didn't talk about quantum computing, nor did we teach it or write books on how it will revolutionize the world—it didn't get that love. And I can't put my finger on why, but it could be because of the quantum physics, which is complicated by nature and requires a lot of heavy math, or that it involves another branch of science altogether.

We have ignored its potential as a technology. And now that the dawn is upon us, everybody is kind of freaking out. Who will work on the computers? Who will program them? How are we going to use them? We should have been thinking about this for the last 20 years, and definitely for the past five.

WHAT IS THE RESPONSIBILITY OF INDUSTRY?

When a company claims it's lacking a workforce, what it's really saying is that it lacks workers for its particular type of quantum computer. My argument is that even if there were hundreds of quantum computing scientists available for hire, you couldn't possibly train them on every variety of computer.

By the time you train a workforce large enough to do the things we need done now, the technology will have already advanced. This field is changing so fast I don't even know how you would train someone other than on the basics of quantum and some of the computer science behind it.

WHAT AREAS WILL QUANTUM COMPUTING REVOLUTIONIZE?

First, there will be tremendous advancements in areas like chemistry, materials science, and drug discovery. And then there will be advances in computational power, with the potential to make huge, existing problems that we aren't able to solve now—like climate change, cancer, and street traffic—all things of the past.

We have ignored quantum computing's potential. Now that the dawn is upon us, everybody is freaking out.

But what excites me most are all the things we haven't even dreamed of yet. Once you have this tool, people will start experimenting across different industries. That's why I'm involved in this—I think there is a ton of opportunity that I can't even imagine.

TELL US MORE ABOUT YOUR COMPANY.

I founded Strangeworks to democratize quantum computing, humanize it, and make it so that software developers can do quantum computing. Right now, you have to be a physicist to use a quantum computer. We're lowering the barrier to entry by writing software that extracts some of that physics to take advantage of the millions of people who are software developers. Eventually, you won't know you're using a quantum computer—you'll just be processing an algorithm.

Strangeworks' Quantum Computing Stack Exchange is the largest question-and-answer site in the world for engineers, scientists, programmers, and computing professionals.

What you'll be seeing is this shift—and it might be somewhat of a rough shift at first—from physicists to computer scientists. Some physicists will scoff at this idea, while others will love it.

WHAT IS THE SALARY RANGE AND WHERE CAN ONE GET TRAINING?

Some researchers are making hundreds of thousands of dollars. Those working for large companies can easily make six figures. We're in the early days, similar to when Web developers were making US $200,000 a year.

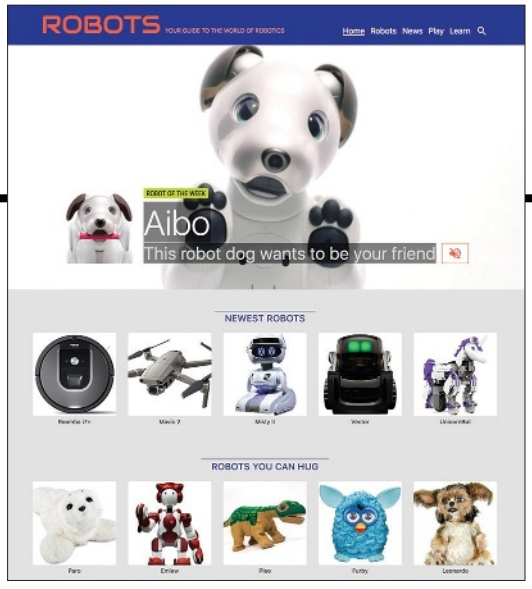
There are dozens of architectures to pick from in quantum computing, so you'll probably have to specialize in one area. The University of Texas at Austin and Texas A&M have great classes, for example. MIT offers several online courses as well.

In this transitional time, there will be this person—this unicorn called a *quantum computing scientist*—who is a quantum physicist who also understands software development and computer science. And it will be these scientists who help improve the field and bring it into the world of computer programmers, like me and the rest of the Strangeworks team.

–KATHY PRETZ

IEEE Spectrum Website Is All About Robots

It's a great way to get kids interested in STEM subjects



CALLING ROBOT enthusiasts of all ages and backgrounds: IEEE recently launched its Robots website (https://robots.ieee.org), a guide to all manner of machines including androids, drones, exoskeletons, and self-driving cars. The massive guide—which contains more than 800 photos, nearly 700 videos, and 40 interactive animations—is a resource for anyone interested in robotics, including students, teachers, and professionals.

"Our plan is to add every major robotics project—commercial, research, startup—on the planet," says Erico Guizzo, a senior editor at *IEEE Spectrum* who covers robotics. He, along with *Spectrum's* photography director, Randi Klett, built the site. There are more than 200 projects from nearly 20 countries represented, with new ones added every week.

The site is an expansion of the award-winning iPad app that *IEEE Spectrum* launched six years ago—which has been downloaded more than a million times. The responsive Robot site is designed to work on phones, tablets, and desktop computers.

COMPREHENSIVE GUIDE

Clicking on a robot's image on the site brings up a profile, which includes its country of origin, the year it was built, and information about its creator. You can see photos and videos of the robot performing different tasks. For some bots, the site features a 360-degree view or interactive animation.

"We send photographers around the world to capture these robots in action," Klett says.

Visitors can rate each robot based on its capabilities and appearance. The votes are tallied to create rankings, which show the top-rated, most-wanted, and creepiest robots on the site.

STEM STEPPING STONE

One of the site's main objectives is to get children interested in science, technology, engineering, and math, Guizzo says. "We think robotics is a great entry point into STEM for kids," he says. "This site lets them look at robots and see them move. They get very excited."

When *IEEE Spectrum* released its original Robots iPad app, schools rapidly became one of its primary users.

"The app took on a life of its own, especially among educators," Guizzo says. "We now want to expand that audience, and this website gives even more schools access."

To get the word out, IEEE has been working with Project Lead the Way, a STEM education nonprofit. Thanks to the partnership, Robots is already being used in hundreds of U.S. schools, Guizzo says.

Teachers are incorporating it into their curricula, he adds. Students could select a robot to describe to their classmates, for example, inspiring a discussion about tasks that robots might accomplish.

"I love that this guide can help make children curious about automation technology, so that they can learn, understand, and embrace robots," says IEEE Senior Member Dominik Boesl, vice president of industrial activities for the IEEE Robotics and Automation Society, one of the project's supporters.

EVERYDAY ROBOTS

Another goal of the website is to get people excited about real robots—not the ones of sci-fi movies but ones we're going to encounter in our daily lives, Guizzo says. Examples include the da Vinci surgical robot, the Phantom video drone, the Roomba vacuum, and the Waymo self-driving car.

"This technology will soon be everywhere," Guizzo says, "so it's critical that we guide its development in ways that can benefit society."

The site is supported in part by donations to the *Spectrum* Robots Guide Fund of the IEEE Foundation. Sponsors include Walt Disney Imagineering, Universal Robots, Mouser Electronics, and Newark Element14, along with the IEEE Robotics and Automation Society.

– KATHY PRETZ

ROBOTS.IEEE.ORG

sparking conversations

OUR BLOG POSTS INSPIRED COMMENTS FROM READERS

Should Employees Get Paid for Working While Commuting?

Some people who commute to work via bus or train use that time to answer email, call clients, or take care of items on their to-do list. Many don't consider that to be work time, but some say they should.

A survey of commuters conducted by researchers at the University of the West of England, in Bristol, found that more than half read their work email or business documents on their trip.

A New York City councilman introduced a right-to-disconnect bill last March. It would make it unlawful for private employers to require workers to check and respond to email and text messages during nonwork hours, except in emergencies. A similar bill was passed in France in 2017.

Many companies try to push the definition of salaried exempt to make you a 24/7 employee. Now, if you choose to work outside regular office hours to make your job easier or more rewarding in some way for you, then that's fine. But it should not be a company requirement, unless there is a commensurately large compensation package. Also, those who choose to or are required (and paid) to work continually at all hours, every day, should not expect the rest of us to go along just because they do. My particular gripe is with certain managers and executives who are compensated extremely well for accepting the responsibility of working in this way, and then expect everyone who reports to them to fully share that responsibility but without the compensation.
—pjgeneva

Is all the work conducted on employer-provided devices? Then the employee should receive some kind of compensation. If the work is being done on employees' personal devices, then it is their choice. My comments are applicable only if there are no privacy issues with doing the work while commuting. Sensitive information should be protected.
—Marc Apter

As a professor of computer science, I try to make myself available when my students are doing homework, and that's frequently late at night. I'll answer them anytime I am at a computer (or sometimes on a phone) and have the time. I note that some of my colleagues say in their syllabi that they will not respond outside of work hours. I think that's their right, but unless they lean on their teaching assistants to respond in the evening, it may adversely affect the experience of their students.
—Ed Gehringer

ISTOCKPHOTO

Is Excessive Video-Game Playing a Medical Disorder?

The World Health Organization in June added gaming disorder to its updated International Classification of Diseases, a system that is used to monitor medical trends and assist in the collection of health statistics.

The video game industry's biggest trade group—the Entertainment Software Association—argues that the WHO decision is based on "contested and inconclusive" research. Experts have warned that gaming disorder's inclusion in the classification could lead to the misdiagnosis of other established mental health conditions, the ESA says.

Every human being is capable of becoming addicted to video games under the right circumstance, but not everyone becomes addicted. That's because they grow up in a healthy environment and are taught to enjoy things in moderation. The classification of the disease is misleading because it suggests that we as consumers should be devoid of the responsibilities of controlling ourselves.
—Frank Wang

Any addictive behavior, including gaming, could be "coping strategies to deal with other underlying psychological challenges," as the expert quoted in the article says. The book *The Hacking of the American Mind* by Robert Lustig describes the physiology behind addiction.
—Ken

The benefit of playing video games is that the gaming industry is becoming rich at the cost of impaired couch potatoes.
—Shiva

Games help to improve language skills.
—AntGu

The 2018 Election Results

THERE IS THE TELLERS COMMITTEE tally of votes counted in the 2018 annual election and approved in November by the IEEE Board of Directors.

IEEE president-elect, 2019

Toshio Fukuda	20,865
Jacek M. Zurada	15,378
Vincenzo Piuri	12,993

IEEE division delegate-elect/ director-elect, 2019

Division III

Sergio Benedetto	1,988
Alexander D. Gelman	972
Adam T. Drobot	763

Division V

Thomas M. Conte	3,270
Jean-Luc Gaudiot	2,415

Division VII

Miriam P. Sanders	2,742
Miroslav M. Begovic	1,981

Division IX

Rabab Kreidieh Ward	2,525
Ferial El-Hawary	2,056

IEEE region delegate-elect/ director-elect, 2019-2020

Region 2

Barry C. Tilton	1,360
Philip M. Gonski	1,081
Emilio M. Salgueiro	654

Region 4

Johnson A. Asumadu	1,194
Tarek Lahdhiri	1,008

Region 6

Timothy T. Lee	2,737
Charles M. Jackson	2,293

Region 8

Antonio Luque	4,993
Rafal Sliz	4,706

Region 10

Deepak Mathur	6,697
Norliza M. Noor	3,964
Ziauddin "Zia" Ahmed	3,099

IEEE Standards Association board of governors member-at-large, 2019-2020

Mark Epstein	702
Glenn W. Parsons	635

IEEE Standards Association board of governors member-at-large, 2019-2020

Robby Robson	894
Jun Yu	458

IEEE Technical Activities vice president-elect, 2019

Kazuhiro Kosuge	15,372
F. D. "Don" Tan	13,290

IEEE-USA president-elect, 2019

James M. Conrad	10,797
Maura Kathleen Moran	9,280

IEEE Power & Energy Society Board-proposed constitutional amendment

For	4,396
Against	371

Countdown to the 2019 IEEE Annual Election

ON 1 MAY, the IEEE Board of Directors is scheduled to announce the candidates to be placed on this year's ballot for the annual election of officers, which begins on 15 August. Those elected take office next year.

The ballot includes IEEE president-elect candidates, who are nominated by the Board, as well as nominees for delegate-elect/director-elect openings submitted by division and region nominating committees.

The ballot also includes nominees for IEEE Standards Association president-elect and members-at-large, IEEE Technical Activities vice president-elect, and IEEE-USA president-elect.

IEEE members who want to run for an office but have not been nominated need to submit a petition to the IEEE Board of Directors. The petition must include the necessary number of valid voting members' signatures, and the petitioner must meet other requirements as well. Petitions should be sent to the IEEE Corporate Governance staff, in Piscataway, N.J. The IEEE Board of Directors is also responsible for placing any proposed constitutional amendments on the ballot.

For more information about the process for getting on the ballot, visit the IEEE annual election Web page (https://www.ieee.org/elections) or write to elections@ieee.org.

UP FOR ELECTION IN 2019

Chosen by all voting members

- IEEE president-elect

Chosen by members of all technical societies

- IEEE Technical Activities vice president-elect

Chosen by members of the respective technical divisions

- IEEE Division I delegate-elect/director-elect
- IEEE Division II delegate-elect/director-elect
- IEEE Division IV delegate-elect/director-elect
- IEEE Division VI delegate-elect/director-elect
- IEEE Division VIII delegate-elect/director-elect
- IEEE Division X delegate-elect/director-elect

Chosen by members of the respective regions

- IEEE Region 1 delegate-elect/director-elect
- IEEE Region 3 delegate-elect/director-elect
- IEEE Region 5 delegate-elect/director-elect
- IEEE Region 7 delegate-elect/director-elect
- IEEE Region 9 delegate-elect/director-elect

Chosen by members in Regions 1–6

- IEEE-USA president-elect

Chosen by members of the IEEE Standards Association

- Standards Association president-elect
- Standards Association board of governors members-at-large

DEADLINES AT A GLANCE

15 March
Deadline for organizational units to submit slates of candidates to the IEEE Board of Directors for inclusion on the annual election ballot.

15 April
Deadline for submitting an intention to file a petition to run for an office on the annual election ballot.

1 May
IEEE Board of Directors submits to the voting membership a list of nominees for IEEE president-elect, delegate-elect/director-elect, as applicable, and other positions to be elected by voting members for the coming term. The Board also announces whether it intends to put forward any constitutional amendments.

10 May
Signed petitions nominating an individual for placement on the annual election ballot must be received by noon EDT USA/16:00 UTC.

15 August
Annual election ballots are sent to all voting members on record as of 30 June. Voters also may begin accessing their ballots electronically.

1 October
Ballots must be received by noon EDT USA/16:00 UTC.

Nominate the Next Leaders of IEEE

IEEE IS governed by volunteer members and depends on them for many things including editing its publications, organizing conferences, coordinating regional and local activities, writing standards, leading educational activities, and identifying individuals for IEEE recognitions and awards.

The Nominations and Appointments (N&A) committee is responsible for developing recommendations for staffing many volunteer positions including candidates for president-elect and corporate officers. Its recommendations are sent to the Board of Directors and the IEEE Assembly. Accordingly, the N&A committee is seeking nominees for the following positions:

2021 IEEE president-elect
(who will serve as president in 2022)

2020 IEEE corporate officers
- Vice president, Educational Activities
- Vice president, Publication Services and Products
- Secretary
- Treasurer

2020 IEEE committee chairs and members
- Awards Board
- Election Oversight
- Employee Benefits and Compensation
- Ethics and Member Conduct
- European Public Policy
- Fellow
- Global Public Policy
- Governance
- History
- Humanitarian Activities
- Industry Engagement
- New Initiatives
- Nominations and Appointments
- Public Visibility
- Tellers

DEADLINES TO NOMINATE

The deadlines are 15 March for corporate officers and committee chairs and 15 June for committee members.

WHO CAN NOMINATE?

Anyone may submit a nomination. Self-nominations are encouraged. Nominators do not need to be IEEE members, but nominees must meet certain qualifications. An IEEE organizational unit may submit recommendations endorsed by its governing body or the body's designee.

A person may be nominated for more than one position. Nominators need not contact their nominees before submitting the form. The IEEE N&A committee will contact all eligible nominees for the required documentation and for their interest and willingness to be considered for the position.

HOW TO NOMINATE

For information about the positions, including qualifications and estimates of the time required by each position during the term of office, visit https://www.ieee.org/about/corporate/nominations/guidelines.html. To nominate a person for a position, visit https://www.ieee.org/about/corporate/nominations/nomination-form.html.

NOMINATING TIPS

Each year many ineligible candidates are nominated. Make sure to check eligibility requirements at the N&A committee website (https://www.ieee.org/about/corporate/nominations) before submitting a nomination.

The positions for which the N&A committee makes recommendations represent IEEE's uppermost governance levels. Volunteers with relevant prior experience in lower-level IEEE committees and units are recommended by the committee more often than volunteers without such experience. For example, candidates for the Awards Board have a greater likelihood of being recommended if they have already served on an awards committee of a society, section, or region or on another IEEE board.

Individuals recommended for president-elect and corporate officer positions are more likely to be recommended if they possess a strong track record of leadership and relevant accomplishments within and outside IEEE. Recommended candidates often have significant prior experience as members of IEEE boards and standing committees.

More information about the duties associated with the different positions, qualifications, and eligibility requisites (such as prior service in certain positions or IEEE grade) can be found in the online nominations guidelines.

– KAREN BARTLESON
Chair, 2019 IEEE Nominations and Appointments committee

Introducing the 2019 Class of IEEE Fellows

THE INSTITUTE congratulates these 295 senior members named IEEE Fellows for 2019. They join an elite group of people who have contributed to the advancement or application of engineering, science, and technology.

Ali Abdi
Karim Abed-Meraim
Edward H. Adelson
Sonia Aissa
J .Stewart Aitchison
Elad Alon
Max Ammann
Leopoldo Angrisani
Yoshihiro Baba
Michael Backes
Matthias Bauer
Navakanta Bhat
William J. Blackwell
Pierre Blondy
Iustin Radu Bojoi
Silverio Bolognani
Gabriella Bosco
Jill M. Boyce
Lucien J. Breems
Olav Breinbjerg
Michael M. Bronstein
Walter W. Buchanan
Steven F. Butler
Bruce A. Campbell
Richard L. Campbell
Hui Cao
Antonio Capone
Richard E. Carson
Friedhelm Caspers
David A. Castañón
Mujdat Cetin
Meng-Fan Chang
Patrick L. Chapman
Deming Chen
Jie Chen
Jiming Chen
Xing Bi Chen
Zhe Chen
Kangguo Cheng
Kin Ping Cheung
Pei-Yu Chiou
Hyouk Ryeol Choi
Jong D. Choi
Sewan Choi
Paul Chow
Tommy W. Chow
Qing-Xin Chu
Brian K. Classon
Peter N. Clout
Jose A. Cobos
Michael W. Condry
Jose Luis Contreras
Kerstin Dautenhahn
Timothy N. Davidson
Bart De Schutter
Antonio Della Corte
Xiaotie Deng
Tayeb A. Denidni
Santosh Devasia
Thomas J. Dionise
Antun Domic
David G. Dorrell
Robert A. Durham
Nicola Elia
Christian Enz
Meng Hwa Er
Joseph Evans
Jiyuan Fan
Xuejun Fan
Luca Fanucci
Dejan Filipovic
Robert S. Fish
Dimitrios Fotiadis
Mark S. Fox
Emilio Frazzoli
Emilia Fridman
Yun Fu
Claudio R. Fuerte-Esquivel
Christophe O. Fumeaux
Alexander Gaeta
Jianfeng Gao
Kaizhong Gao
Shichang Gao
Julian W. Gardner
Simson L. Garfinkel
Anne E. Gattiker
Guido Gerig
Maysam Ghovanloo
Ali Ghrayeb
Bruce E. Gnade
Reuven Gordon
Timothy C. Green
Robert Greenberg
Warren S. Grundfest
Venkatesan Guruswami
A. L. Gutierrez Aitken
Qing-Long Han
Mor Harchol-Balter
Hossein Hashemi
Ahmed E. Hassan
Xiaodong He
Ahmed Helmy
Pin-Han Ho
Steven Chu-Hong Hoi
Keum-Shik Hong
Zeng-Guang Hou
Gang Hua
Tingwen Huang
Mei-Yuh Hwang
Daniele Ielmini
Syed M. Islam
Hiroshi Ito
Hans-Arno Jacobsen
Nitin Jain
Mona Jarrahi
Lijun Jiang
Tao Jiang
Hai Jin
Mihalo Jovanovic
Chia-Feng Juang
Christoph A. Jungemann
Wen-Chung Kao
Srinivasan Keshav
Ali Khakifirooz
Chris Hyung-Il Kim
Dong In Kim
Lee-Sup Kim
Irwin K. King
Farinaz Koushanfar
Ioannis Krikidis
Randall Lynn Kubena
Daniel M. Kuchta
Shrikrishna V. Kulkarni
Chih-Huang Lai
Roger K. Lake
Mark A. Lantz
Patrick Lecallet
Jaejin Lee
Juho Lee
Seung Jae Lee
Frank B. Leferink
Chih-Peng Li
Hai Li
Hongbin Li
Qi Li
Shutao Li
Yonghui Li
C. Steven Lingafelt
Alex X. Liu
Jinjun Liu
Shaoying Liu
Xiaoping Peter Liu
Xin Liu
Teng Long
Cristina V. Lopes
Marco Lops
Anant Madabhushi
Pui-In Mak
John E. Malinowski
Shiwen Mao
Charles P. Mc Shane
Dale P. McMorrow
Derek A. McNamara
Neelesh B. Mehta
Tao Mei
Erik Meijering
Tim Menzies
Bruno Michel
Miroslav Micovic
Joydeep Mitra
Theodore S. Moise
Sasan Mokhtari
Onur Mutlu
Katsufumi Nakamura
Jason Nieh
Anibal Ollero Baturone
Antonis Papachristodoulou
Evangelos G. Papadopoulos
Milorad Papic
Danilo P. Pau
Jan R. Peters
Daniel A. Pitt
Alessandro Piva
Maurizio Porfiri
Yi Qian
Hong Qiao
Xianming Qing
Arifur Rahman
Siddharth Ramachandran
Srinivasan Ramani
Mary Ellen Randall
Stewart E. Rauch
Gerhard Rigoll
Robert N. Rohling
Joachim Rosenthal
Matthew Roughan
Romit Roy Choudhury
Amit K. Roy-Chowdhury
Dan Rubenstein
Stuart H. Rubin
Roland Ryf
Walid Saad
Rajiv Sabherwal
Samar K. Saha
Tapan K. Saha
Sayeef Salahuddin
Murti V. Salapaka
Venkatesh Saligrama
Igal Sason
Andries Jan Scholten
Venkat Selvamanickam
Kyuseok Shim
Mei-Ling Shyu
Ramesh K. Sitaraman
Mikael Skoglund
Dawn Song
Lingyang Song
Maarten Steinbuch
Christoph Stiller
Fuchun Sun
Jonathan Sun
Yan Sun
Kenji Sunagawa
Bruce W. Suter
Jonathan A. Sykes
Mario Sznaier
Joseph Tabrikian
Munehiro Tada
Seishi Takamura
HarkHoe Tan
Yap-Peng Tan
Chi-Keung Tang
Jian Tang
Meixia Tao
Jan-Ulrich Thiele
Ioannis Tomkos
Carme Torras
David Torrey
Piero Tortoli
Jean-Yves Tourneret
Hon K. Tsang
Panagiotis Tsiotras
Zhuowen Tu
Deepak G. Uttamchandani
Murat Uysal
Benjamin Van Roy
Paul Vanoorschot
Dragica Z. Vasileska
Namrata Vaswani
Jelena S. Vuckovic
Jeffrey Phillip Walker
Liang Wang
Shuo Wang
Xiaofeng Wang
Yuanxun Wang
Simon K. Warfield
ShaoJun Wei
John Turner Whitted
Chee Wei Wong
Robert Wood
Guangning Wu
Min Wu
Naiqi Wu
Zhaohui Wu
Shengli Xie
Eric Xing
Zeshui Xu
Fan Yang
Ming-Hsuan Yang
Xiaokang Yang
Steve Yao
Hiroto Yasuura
Minerva M. Yeung
Eiichi Yoshida
Marwan Younis
Moustafa Youssef
Yizhou Yu
Pericle Zanchetta
Jared Zerbe
Bao-Hui Zhang
Cha Zhang
Daqing Zhang
Liangpei Zhang
Mengjie Zhang
Ping Zhang
Richard Zhang
Yanchao Zhang
Yimin D. Zhang
Weisheng Zhao
Lin Zhong
Donghua Zhou
Jingren Zhou
Lidong Zhou
Qifa Zhou
Michael J. Zyda

JEAN-LUC FORTIER