Guest Editorial Disruptive Beam-Steering Antenna Technologies for Emerging and Future Satellite Services

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I. Introduction

HIGH-GAIN antennas with beam-steering capabilities no doubt act as one of the crucial subsystems to realize worldwide high-throughput Internet connectivity via satellites [1], [2], [3], [4], [5], [6]. The importance of satellite-based connectivity has become obvious after the massive increase in the Internet usage during the COVID-19 pandemic, which strained existing terrestrial connectivity infrastructure and further exposed the negative impact of the digital social divide to remote areas across the globe, not only in developing countries but also in the developed countries. A low-cost, energy-efficient, high-gain beam-steering antenna terminal is paramount in making space-based Internet services an affordable reality of people living in remote areas.

In addition to wireless links between satellites and Earth, high-gain antennas with beam steering are required for interspace communications, e.g., forming wireless links between spacecrafts such as intersatellite links, and various other satellite-based services such as Earth observation using synthetic aperture radars in certain imaging modes, such as the spot mode.

For satellite communications, many users demand low size, weight and power (SWAP)-constrained beam-steerable antennas that can be installed unobtrusively on various platforms, including civilian and defense aircrafts, unmanned aerial vehicles, submarines, ferries and other marine vehicles, trains and many other land vehicles including coaches/buses, caravans/motor homes, cars, sport utility vehicles and high mobility multipurpose wheeled vehicles. Due to various restrictions imposed by spectrum sharing and physical constraints, these antennas are required to conform with stringent regulatory standards. One of the most challenging requirements comes from effective isotropic radiated power density masks that limit the pattern shape including side-lobe levels to reduce radio-frequency interference to others, while transmitting. Other requirements are related to dimensions, such as low drag on high-speed platforms, low power consumption in battery-powered platforms, ease of transportation and folding in portable/manpack platforms, and a small visual signature for aesthetics or concealing.

Researchers from both academia and industry have been working on innovative solutions to meet these requirements. The solutions that have been proposed used many promising technologies, including but not limited to transmitarrays, reflectarrays, digitally controlled metasurfaces, electronically controlled arrays, mechanically rotated metasurfaces, and mechanically rotated and tilted antennas (reflectors or flat-panel antennas). This Special Cluster aims at compiling the state-of-the-art of applied and analytical research, including the latest technological advancements and the use of innovative materials and methods to disrupt the way beam-steering antennas are designed and to reveal novel approaches for the design and analysis of antennas for the next generation of satellite communication systems.

II. Contribution

This Special Cluster consists of 16 peer-reviewed letters from several academic institutes around the world, which are summarized in Table I. These letters covered various topics that addressed different research questions and are broadly divided into two groups based on the fundamental beam-steering approach employed: electronic and mechanical.

A. Electronic Beam Steering

In electronically steered antennas, the beam is steered to the desired direction without physically moving the antenna. One of the classic examples of electronically steered antennas is the phased array, where the phase of the signal being fed to each antenna element of the array is varied to change the beam direction. Classical electronically steered antennas have a low profile, and they can steer the main lobe at a very high speed. It is because of these advantages, these methods are mostly used in high-end applications including radars, 5G, and radio astronomy.

In [A1], Yang et al. present the concept of increasing the maximum elevation angle of the end fire Yagi-based design by reducing the antenna width. A 1×8 array design has demonstrated a scanning range of up to 60° elevation angle.

In [A2], Xu et al. improve the scanning performance of a leaky-wave antenna by via scanning. The design presented has achieved a scanning rate of 8.84° per percentage with a continuous beam-scanning in a range between $-56°$ and $+48°$.

In [A3], Doucet et al. present a methodology to reduce the maximum height of a parallel-plate-waveguide-based antenna by a factor of 3. The design aims at reducing the height of the antenna system and making it compact by introducing an additional cavity to the parallel-plate waveguide.

A wideband multibeam beam-steering design is presented by Xu et al. [A4] for 5G millimeter-wave communications. The

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TABLE I
CLASSIFICATION OF THE MANUSCRIPTS BASED ON THE PRINCIPLE OF BEAM-STEERING TECHNIQUE

No	Authors	Technology	Concept
1	Teng et al.	Mechanical	Height-adjustable antenna array
2	Yang et al.	Electronic	End-fire array of quasi-Yagi elements
3	Xu et al.	Electronic	Leaky wave antenna with high-Q resonators
4	Doucet et al.	Electronic	Parallel-plate waveguide lens
5	Xu et al.	Electronic	Substrate integrated waveguide
6	Zetterstrom et al.	Electronic	Half-Luneburg lens
7	Wang and Rahmat-Samii	Mechanical	Simplified Risley prism
8	Wang and Dong	Electronic	T-shaped split ring resonator
9	Trzebiatowski et al.	Electronic	Passive lens-based antenna for CubeSat
10	Kim et al.	Electronic	Stacked Yagi-Uda for CubeSat with circular polarization
11	Li et al.	Electronic	Folded reflectarray with switches
12	Zhao and Dong	Electronic	Circularly polarized microstrip leaky-wave antenna
13	Kampouridou and Feresidis	Electronic	Reconfigurable metasurface antenna
14	Tornero et al.	Electronic	Passive frequency beam scanning method using a leaky-wave antenna
15	Li et al.	Electronic	Phased array of dual-polarized aperture-coupled patch elements
16	Sun et al.	Electronic	Folded reflectarray

measured bandwidth of the antenna is 15.4% and its maximum beam angle is 55°.

In [A5], Wang and Dong present a miniaturized antenna for sub-6 GHz applications. The antenna has the dimensions of 0.36 $\lambda_0 \times 0.36\,\lambda_0 \times 0.07\,\lambda_0$ and can switch its beam in azimuth along four different directions that are separated by 45° angles.

In [A6], Trzebiatowski et al. present a switched beam antenna. This design is realized using a 3-D printed dielectric lens with an array of a planar patch antenna. The antenna can switch its beam in 16 different directions and maintains a gain value between 14–16 dBi.

A self-deployed Yagi–Uda antenna is presented for CubeSat by Kim et al. [A7]. The antenna when folded occupies 69% less volume. The antenna support structure makes use of planar hinges, and the antenna deploys into the desired shape without using any actuator or power source.

In [A8], Li et al. report an interesting element for a reflecting-metasurface-based design. This design intentionally uses an asymmetric cell to achieve different phase shifts by twisting the polarization of the incident field. With this design approach, the number of switches needed in the metasurface is reduced by half. This design can provide beam steering to a maximum 60° elevation angle with a high gain of more than 27 dBi.

In [A9], Zhao and Dao discuss a circularly polarized frequency scanning leaky-wave antenna using a novel square patch and stub. The design demonstrates about 11% 3 dB axial ratio bandwidth, and the antenna steers the beam between $-4°$ and 18° elevation angles through the broadside direction.

In [A10], Kampouridou and Feresidis use the concept of holographic metasurface to design a multibeam antenna in which each beam can be steered independently with varactor diodes. The theory of the design is verified through full-wave simulations.

In [A11], Tornero et al. report a compact leaky-wave antenna design for wide-angle frequency scanning. The design reported in the letter demonstrates a scanning range of 130° (±65°) with a peak gain of 9 dBi.

In [A12], Li et al. propose a scalable planar array design for low-Earth-orbit satellite applications. The aperture-coupled patch design used with the array can provide dual-linear and dual-circular polarization to meet the dynamic requirements of communication systems. The steering range of the design reported in the letter is ±50° with low cross-polarization levels.

In [A13], Sun et al. investigate and report another similar design. The design uses the concept of polarization twisting to achieve the phase shift for a reflecting metasurface. The concept is demonstrated with two designs with the beams in the broadside direction and at a maximum elevation angle of 60°.

In [A14], Zetterstrom et al. report a half-Luneburg lens, as a compact alternative to planar beam forming antennas. The reported design only has a 1 dB reduction in gain value despite being half in size compared to a conventional Luneburg lens antenna. The antenna uses multiple feeds distributed around the lens periphery, and by switching these feeds, the beam can be steered to a maximum elevation angle of 50°.

B. Mechanical Beam Steering

Mechanical beam steering is achieved by physically rotating or laterally translating the parts of the antenna system to align the beam in the desired direction. In many cases, mechanical tilting is also required. A classic example of mechanically steered antennas includes reflector "dish" antennas, where the whole antenna is rotated and tilted in 2-D angular space to steer the beam toward the intended direction. There are other variants where only parts of the antenna system are rotated and/or moved to steer the beam. For the sake of classification, in this editorial, we refer to all of them as mechanically steered antenna systems. Mechanical steering methods have historically been used because of good system performance such as gain and pattern quality when compared with electronically steered antennas. Recent years have seen an enthusiastic response from the researchers for this class of beam-steering method and some have been developed to commercial products, for example for providing inflight connectivity to airplanes and connecting ships in oceans.

In [A15], Wang and Rahmat-Samii report a simpler configuration of Risley prism antenna. The antenna design uses a gradient-phase feed source and a gradient-phase transmitarray. This configuration reduces the profile, weight, and complexity of the classic Risley prism antenna systems. The performance of the new configuration is verified through numerical simulations.

In [A16], Teng et al. demonstrate a design based on an 8×8 antenna array, where the array elements (U-slot microstrip patches) are physically moved up and down using 64 stepper motors. The height movement of the array elements adjusts the relative phase between the antenna elements and hence, points the beam to the desired elevation angle. The proposed design effectively steers the beam between $\pm 40°$ elevation angles.

III. Conclusion

There is considerable interest in the research community in addressing the challenges of beam-steering antenna technology. Although it is not comprehensive, this Special Cluster has covered a great variety of them and complements a previous publication by Guest Editor K. Esselle in which some of these and other beam-steering methods have been reviewed but in less depth [1]. A few other relevant beam-steering methods that are not directly featured in this Special Cluster can be found in [2], [3], [4], [5], and [6].

Acknowledgment

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Appendix
Related Articles

[A1] Y. Yang, Y.-L. Ban, X. LiSun and C.-Y.-D. Sim, “Millimeter wave end-fire wide angle scanning circularly polarized antenna array,” *IEEE Antennas Wireless Propag. Lett.*, early access, 17 Jun. 2022, doi: 10.1109/LAWP.2022.3184391.

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[A3] F. Doucet, N. J. G. Fonseca, E. Girard, X. Morvan and R. Sauleau, “Compact planar beamformer using multiple continuous parallel plate waveguide delay lenses,” *IEEE Antennas Wireless Propag. Lett.*, early access, 20 Jun. 2022, doi: 10.1109/LAWP.2022.3184395.

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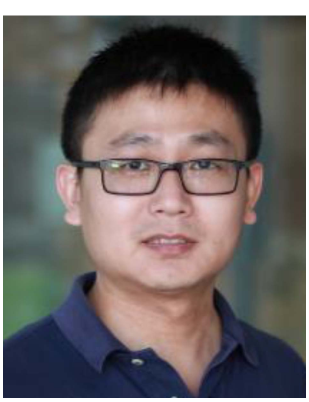
Dr. Esselle is a Fellow of the Royal Society of New South Wales and Engineers Australia. He was the recipient of the 2004 Innovation Award for best invention disclosure, 2009 Vice Chancellor's Award for Excellence in Higher Degree Research Supervision, 2011 Outstanding Branch Counsellor Award from IEEE headquarters (USA), 2012 and 2016 Engineering Excellence Awards for Best Published Paper from IESL NSW Chapter, 2017 Certificate of Recognition from IEEE Region 10, 2017 Highly Commended Research Excellence Award from Macquarie University, 2017 Engineering Excellence Award for Best Innovation, 2017 Excellence in Research Award from the Faculty of Science and Engineering, 2019 ARC Discovery International Award, 2019 Macquarie University Research Excellence Award for Innovative Technologies, 2019 Motohisa Kanda Award (from IEEE USA) for the most cited paper in IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY in the past five years, 2020 IEEE NSW Outstanding Volunteer Award, Runner-up to the Australian Defence Industry Awards in 2020, 2021 IEEE Region 10 (Asia-Pacific) Outstanding Volunteer Award, Finalist for 2021 Australian national Eureka Prize for Outstanding Mentor of Young Researchers, Excellence Award and the Academic of the Year Award at 2021 Australian Defence Industry Awards, Engineers Australia 2022 Sydney Professional Engineer of the Year, Academic of Year Award at the 2022 Australian Space Awards, and the top space award in Australia—the "Best of theWinners" Excellence Award. His mentees were the recipient of many fellowships, awards, and prizes for their research achievements. In total, 58 international experts who examined the theses of his Ph.D. graduates ranked them in the top 5% or 10%. Two of his students were awarded Ph.D. with the highest honor at Macquarie University the Vice Chancellors Commendation, and one was the recipient of the University Medal for Master of Research. In addition to the IEEE Kanda Award abovementioned, several of his papers have been among the most cited or most downloaded. Often one or two of his papers are ranked by Web of Science and Clarivate as Highly Cited Papers (top 1% in the academic field of Engineering). For example, two papers are ranked so, for citations received in January/February 2022. Some papers have been ranked as Hot Papers as well (top 0.1% in Engineering), e.g., A Scientific Reports paper for citations received in January–February 2022. He is currently shortlisted as one of the five finalists for the forthcoming Australian National 2022 Professional Engineers of the Year title. According to the Special Report on Research published by The Australian national newspaper, he is the 2019 National Research Field Leader in Australia in both microelectronics and electromagnetism fields. He is or was a Senior Editor for IEEE ACCESS, an Associate Editor for IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, IEEE ANTENNAS AND PROPAGATION MAGAZINE, and IEEE ACCESS, and the Lead Guest Editor for several journals, including IEEE ANTENNAS & WIRELESS PROPAGATION LETTERS.

From 2018 to 2020, he chaired the prestigious Distinguished Lecturer Program Committee of the IEEE Antennas and Propagation (AP) Society, the premier global learned society dedicated for antennas and propagation, which has close to 10 000 members worldwide. After two stages in the selection process, he was also selected by this Society as one of two candidates in the ballot for 2019 President of the Society. Only three people from Asia or Pacific apparently have received this honor in the 68-year history of this society. He is also one of the three distinguished lecturers (DL) selected by the society in 2016. He is the only Australian to chair the AP DL Program ever, the only Australian AP DL in almost two decades, and second Australian AP DL ever (after UTS Distinguished Visiting Professor Trevor Bird). He was on the IEEE AP Society Administrative Committee in several elected or ex-officio positions from 2015 to 2020. He is also the Chair of the Board of Management of Australian Antenna Measurement Facility, and was the elected Chair of both IEEE New South Wales (NSW) and IEEE NSW AP/MTT Chapter in 2016 and 2017, respectively. He is with the College of Expert Reviewers of the European Science Foundation (2019–2022), and he has been invited as an International Expert/Research Grant Assessor by several other research funding bodies as well, including the European Research Council and funding agencies in Norway, Belgium, the Netherlands, Canada, Finland, Hong Kong, Georgia, South Africa, and Chile. He has been invited by the Vice-Chancellors of Australian and overseas universities to assess applications for promotion to professorial levels. He has also been invited to assess grant applications submitted to Australia's most prestigious schemes, such as Australian Federation Fellowships and Australian Laureate Fellowships. In addition to the large number of invited conference speeches he has given, he has been an invited plenary/extended/keynote/distinguished speaker of several IEEE and other venues more than 30 times, including EuCAP 2020 Copenhagen, Denmark, URSI19, Seville, Spain, and 23rd International Conference on Applied Electromagnetics and Communications 2019, Dubrovnik, Croatia. He is a Track Chair of IEEE AP-S/URSI 2022 Denver, 2021 Singapore and 2020 Montreal, Technical Program Committee Co-Chair of International Symposium on Antennas and Propagation 2015, Asia-Pacific Microwave Conference 2011, and IEEE International Conference of IEEE Region 10 2013, and the Publicity Chair of International Conference on Electromagnetics in Advanced Applications /IEEE APWC 2016, International Workshop on Antenna Technology: Small Antennas and Novel Metamaterials 2014, and Asia Pacific Microwave Conference 2000.

Ladislau Matekovits (Senior Member, IEEE) received the degree in electronic engineering from Institutul Politehnic din Bucureti, Bucarest, Romania, and the Ph.D. degree (Dottorato di Ricerca) in electronic engineering from Politecnico di Torino, Turin, Italy, in 1992 and 1995, respectively.

Since 1995, he has been with the Department of Electronics and Telecommunications, Politecnico di Torino, first with a postdoctoral fellowship, then as a Research Assistant, as an Assistant Professor in 2002, a Senior Assistant Professor in 2005, and an Associate Professor in 2014. In February 2017, he obtained the Full Professor qualification (Italy). In late 2005, he was a Visiting Scientist with the Antennas and Scattering Department, FGAN-FHR (now Fraunhofer Institute), Wachtberg, Germany. From 1 July 2009, for two years he was a Marie Curie Fellow with Macquarie University, Sydney, NSW, Australia, where, in 2013, he also held a Visiting Academic position and, in 2014, was appointed as Honorary Fellow. Since 2020, he has been an Honorary Professor with Polytechnic University of Timisoara, Timisoara, Romania, and an Associate of the Italian National Research Council. He has been appointed as a Member of the National Council for the Attestation of University Degrees, Diplomas, and Certificates (CNATDCU), Romania, for the term 2020–2024. He has been invited to serve as a Research Grant Assessor for government funding calls (Romania, Italy, Croatia, Kazakhstan, and Iceland) and as an International Expert in Ph.D. thesis evaluation by several universities from Australia, India, Pakistan, Spain, etc. He has authored or coauthored more than 400 papers, including more than 110 journal contributions, and delivered seminars on these topics all around the world: Europe, USA (AFRL/MIT-Boston), Australia, China, Russia, etc. His research interests include numerical analysis of printed antennas and in particular development of new, numerically efficient full-wave techniques to analyze large arrays, and active and passive metamaterials for cloaking applications. Material parameter retrieval of these structures by inverse methods and different optimization techniques have also been considered. In the last years, bio-electromagnetic aspects have also been contemplated, as for example design of implantable antennas or development of nano-antennas for example for drug delivery applications. Design and experimental validation of antennas for space applications are other active research lines of his.

Prof. Matekovits was the recipient of various awards in international conferences, including the 1998 URSI Young Scientist Award (Thessaloniki, Greece), the Barzilai Award 1998 (Young Scientist Award, granted every two years by the Italian National Electromagnetic Group), and the Best AP2000 Oral Paper on Antennas, ESA-EUREL Millennium Conference on Antennas and Propagation (Davos, Switzerland). He was the recipient of the Motohisa Kanda Award 2018, for the most cited paper of the IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY in the past five years, and more recently he was the recipient of the 2019 American Romanian Academy of Arts and Sciences (ARA) Medal of Excellence in Science and by the Ad Astra Award 2020, Senior researcher, for Excellence in Research. He was the recipient of the Outstanding Associate Editor Award for the IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS (for year 2020). He serves as an Associate Editor for the IEEE ACCESS, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, and *IET Microwaves, Antennas and Propagation* and as a Reviewer for different journals. He has been Assistant Chairman and Publication Chairman of the European Microwave Week 2002 (Milan, Italy), and General Chair of the 11th International Conference on Body Area Networks (BodyNets) 2016. Since 2010, he is member of the organizing committee of the International Conference on Electromagnetics in Advanced Applications, and he is member of the technical program committees of several conferences.



Yang Yang (Senior Member, IEEE) was born in Bayan Nur, Inner Mongolia, China. He received the M.Eng. degree in telecommunications, the M.Sc. degree in digital communications, and the Ph.D. degree in electronic engineering from the Department of Electrical and Computer Systems Engineering and Faculty of Information Technology, Monash University (Clayton Campus), Melbourne, VIC, Australia, in 2007, 2008, and 2013, respectively.

In 2012, he joined Rain Bird Australia, serving as an Asia Pacific GSP Engineer, and worked with Rain Bird Corporation in Tucson, AZ, USA (from July to September 2012). In April 2015, he returned to academia, holding the position of Senior Research Associate in the field of microwave and antenna technologies with the Centre for Collaboration in Electromagnetic and Antenna Engineering, Macquarie University, Sydney, NSW, Australia. In April 2016, he was appointed as a Research Fellow with the State Key Laboratory of Terahertz and Millimeter Waves, City University of Hong Kong, Hong Kong. In December 2016, he joined the University of Technology Sydney (UTS), Ultimo, NSW, Australia. He is currently a Senior Lecturer and a Team Leader of 3-D Millimetre-Wave and Terahertz Circuits and Antennas with the UTS Tech Lab. He has authored or coauthored over 200 international publications in microwave, millimeter-wave, and terahertz circuits and antennas. His research interests include millimeter-wave and sub-terahertz technologies in 5G and beyond and biomedical applications.

Dr. Yang was the recipient of the CST University Publication Award 2018, by CST, Dassault Systems. During 2017 to 2019, he was the recipient of the UTS FEIT Blue Sky Awards in the field of 3-D printed microwave and millimetre-wave devices and antennas for 5G and biomedical applications. His Ph.D. student won the prestigious 2020 IEEE MTT-S Graduate Fellowship Award. He was selected as the Golden Reviewer of IEEE ELECTRON DEVICE LETTERS 2017 and 2019, respectively. He was the only recipient of the corporation 2014 Global GSP Success Award by Rain Bird Corporation. He was a recipient of the Linkage Infrastructure, Equipment and Facilities (LIEF) Award funded by the Australian Research Council to establish the Australian 3-D Terahertz Beam Measurement Platform, in 2021. He is currently an Associate Editor for IEEE ACCESS, and an Area Editor for *Microwave and Optical Technology Letters*. He is a current committee member of MTT-28 Biological Effects and Medical Applications and a current committee member of the AP-S Technical Committee on Antenna Measurements. His appointments at IEEE NSW Section, Region 10, include the committee member of the IEEE NSW Section, the Treasurer (2018–2019) and the Vice Chair (2020-2022) of IEEE NSW AP/MTT Joint Chapter, the Secretary (2019) of IEEE NSW PH/ED/SSC/CAS Joint Chapter, the Inaugural Committee/Treasurer (2020) and Vice Chair (2022) of IEEE NSW Electron Devices Chapter. He also served as a TPC member and session chair of many conferences in Region 10.

Dushmantha N. Thalakotuna (Senior Member, IEEE) received the B.Sc. degree in electronics and telecommunication from the University of Moratuwa, Moratuwa, Sri Lanka, in 2008, and the Ph.D. degree in electronic engineering from Macquarie University, Sydney, NSW, Australia in 2012.

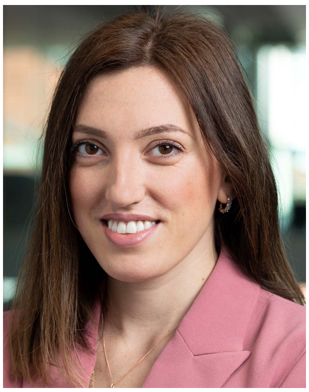
He is currently a Senior Lecturer with the School of Electrical and Data Engineering, University of Technology Sydney (UTS), Ultimo, NSW, Australia. From 2013 to 2019, he worked in multiple roles related to radio frequency and systems engineering designing antennas, monolithic microwave integrated circuits (MMICs), and RF systems for both commercial and defense industries. He is an inventor of three antenna patent applications and has authored over 40 refereed journal and conference publications. His research interests include metasurfaces, reconfigurable antennas, MMICs, Satcom antennas, base station antennas, reconfigurable microwave and millimeter-wave circuits, and periodic structures.

Dr. Dushmantha was the recipient of several prestigious awards including the VIRA Young Scientist in Electronics Award, International Macquarie University Scholarship, and CSIRO Ph.D. fellowship. He served in the capacity of Secretary role with the IEEE NSW section for over seven years and is currently a Branch Counsellor for the IEEE UTS Student Branch. He is a member of the IEEE Antennas and Propagation Society and IEEE Microwave Theory and Techniques Society.

Muhammad Usman Afzal (Senior Member, IEEE) received the bachelor's degree in electronics engineering (Hons.) and master's degree in computational science and engineering from the National University of Sciences and Technology (NUST), Islamabad, Pakistan, in 2009 and 2011, respectively, and the Ph.D. degree in electronics engineering from Macquarie University, Sydney, NSW, Australia, in 2017.

He developed the concept of near-field phase transformation during his doctorate research, which was demonstrated to enhance the directivity of low-gain aperture antennas in the *IEEE Transactions on Antennas and Propagation* article "Dielectric phase-correcting structures for electromagnetic band-gap resonator antennas." He has coinvented efficient antenna beam-steering technology referred to as Near-Field Meta-Steering. To commercialize the outcomes of his research, he led a team of colleagues in a CSIRO-sponsored ON Prime 2 in 2017, a preaccelerator program designed to commercialize outcomes of academic research in Australia. In 2010, he was a Lab Engineer with the Research Institute for Microwave & Millimetre-Wave Studies (RIMMS), NUST. In 2012, he was promoted to the position of Lecturer, until February 2013. He was offered a post-doctorate for three years on a project funded by the Australian Research Council (ARC) through the Discovery grant scheme at Macquarie University, in 2017. Apart from the project-specific research, he co-supervised one Ph.D., three Masters of research, and several undergraduate thesis students at Macquarie University. His research interests include the development of satellite-terminal antenna technology and electromagnetic phase-shifting structures, frequency selective surfaces, and similar metamaterials for microwave and millimeter-wave antenna applications.

Dr. Afzal was the recipient of the "Highly Commended" certificate in the Five Future-Shaping Research Priorities category in the 2017 Academic Staff Awards at Macquarie University for his co-invention of Near-Field Meta-Steering. He was the recipient of several awards and scholarships, including a merit-based scholarship in six out of eight semesters during the undergraduate degree, a scholarship of complete fee waiver during the postgraduate degree, and the international Macquarie Research Excellence (iMQRES) scholarship for Doctorate study from Macquarie University. He was the recipient of a competitive travel grant in 2015 to present his work at a flagship conference under the Antennas and Propagation Society (APS) in Vancouver, Canada. He assisted in preparing several grant applications, including a successful ARC discovery grant in 2018. He was the third CI in a team of five who received a grant of more than $20K from the German Academic Exchange Service in a funding scheme "Australia-Germany Joint Research Co-Operation Scheme."



Maria Kovaleva (Member, IEEE) received the B.S. degree (Hons.) in electrical engineering from the Moscow Technical University of Communications and Informatics, Moscow, Russia, in 2011, and the Ph.D. degree in electronics engineering from Macquarie University, Sydney, NSW, Australia, in 2019.

She was a Postdoctoral Research Associate with the Centre for Collaboration in Electromagnetic and Antenna Engineering, Macquarie University, and an External Lecturer of Antennas and Propagation with the University of Sydney, from 2018 to 2019. From 2011 to 2014, she was an Antenna Design Engineer with JSC NIIKP (Russian Space Systems), Moscow, Russia. She is currently a Lecturer with the Curtin Institute of Radio Astronomy, Curtin University, and ICRAR-Curtin, Perth, WA, Australia, and a Fulbright Visiting Scholar with Brigham Young University, Provo, UT, USA. Her research interests include phased array receiving antennas, radio interferometry, polarimetry, evolutionary optimization methods, AI and ML in electromagnetics, and electromagnetic education.

Dr. Kovaleva was the recipient of the Macquarie University Vice-Chancellors commendation for academic excellence for her Ph.D. thesis. She was the recipient of various national and international awards, including the 2016 Macquarie University Postgraduate Research Fund, the 2017 Macquarie University Entrepreneurial Enrichment Ph.D. Program, the 2017 Macquarie University Higher Degree Research Award, the TICRA Travel Grant at 2018 IEEE AP-S in Boston, the IEEE WIE Travel Grant in 2018, the 2019 Macquarie University Innovative Technologies Award, the 2021 Curtin University Research Team Award for Industry Engagement and Impact, and the prestigious 2022 Fulbright Future Scholarship. She has been a regular Reviewer for the European Conference on Antennas and Propagation (EuCAP) and for the *IEEE Transactions on Antennas and Propagation*.

Khushboo Singh (Member, IEEE) received the B.Tech. degree, with near-perfect GPA, in electronics and communication engineering from SHIATS, India, in 2012, the M.S. by research degree in electronics and communication engineering from LNMIIT, India, in 2014, and the doctoral degree in electronics engineering from Macquarie University, Sydney, NSW, Australia, in 2021.

She is currently is a Postdoctoral Research Associate with the University of Technology Sydney, Ultimo, NSW, Australia. From 2014 to 2015, she was an Assistant Professor with Pratap Institute of Technology and Science, Akhepura, Rajasthan, India. From 2015 to 2016, she was a Guest Lecturer with Swami Rama Himalayan University, Baksar Wala, Uttarakhand, India. Antennas and evolutionary optimization algorithms are the two key areas that best encapsulate the scope of her recent research activities. In the past couple of years, she has been working on projects individually and in collaboration. She is currently working on the development and optimization of satellite-terminal antenna technology for LEO and MEO. Her research interests include antennas, phase-gradient metasurfaces, beam-steering antennas, frequency selective surfaces, evolutionary optimization methods, artificial intelligence, and machine learning in electromagnetics, surface electromagnetics, waveguide polarizers, couplers, and frequency-modulated continuous wave radar.

Dr. Khushboo was the recipient of several awards and scholarships during her academic and professional career She was the recipient of a silver medal and a certificate of merit on completion of her undergraduate degree. She was the recipient of a prestigious merit-based LNMIIT scholarship during her master studies with a complete fee waiver and a stipend of INR 15 000 per month, from 2012 to 2014. She was the recipient of the highly competitive Australian government-funded iRTP scholarship for her Ph.D, the Choose Maths grant in 2017 from the Australian Mathematical Sciences Institute (AMSI) to present her work at the AMSI optimize conference in New Zealand. She was the recipient of a five-month paid internship with a total grant of $26K under the Australian Postgraduate Research Intern (APR) program funded by the National Research Internships Program in collaboration with AMSI, during her Ph.D. She was also a part of the team that received $24K from research collaboration under the "Australia-Germany Joint Research Cooperation Scheme." After completing her doctoral degree, she received a distinguished talent visa under Australia's global talent independent program.