

9th issue

6G WAVES

MAGAZINE

6G

6G

FLAGSHIP
UNIVERSITY
OF OULU

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FLAGSHIP PROGRAMME

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FOREWORD

Since the early stages of the 6G Flagship proposal, technologies and hardware have been identified as key research areas. In the early days of 4G and even 5G research, these were not obvious priorities. However, the importance of hardware has become clear in recent years, with specialised processors driving huge data computations for AI solutions, and systems-on-chip (SoC) and RF transceivers powering large telecom antenna arrays. Securing technological sovereignty requires initiatives such as ChipActs and skilled professionals. Global developments have also highlighted the strategic importance of dual-use technologies.

This issue of 6G Waves presents compelling stories of success in device and circuit research, from antenna innovations to 300 GHz amplifiers and silicon-based receivers - breakthroughs I couldn't have imagined contributing to earlier in my career. Research does more than support industry; it pushes the boundaries of both technology and thought. Both are essential to progress. Our future will be shaped by well-trained engineers capable of tackling complex, sometimes seemingly impossible challenges.

International collaboration is also essential, and this issue shows that in action. Our Amatera project with Panasonic is an example of how initial collaborations can develop with trust, breaking down barriers between industry and academia and fostering both local and global connections.

It has been some time since the first visions of 6G emerged. The early targets were ambitious, even talking about THz communications. Some of the more grounded visions initiated serious research into the upper mmW frequency range, now known as sub-THz. Meeting future data rate demands will likely require bandwidths beyond the mmW frequencies of 5G. This has led us to investigate the feasibility of technologies that once seemed like science fiction. In many cases, we've made the leap from concept to concrete

development, taking the first step towards commercial solutions. However, there is still a long way to go. As we turn our attention to 6G, researchers in academia and industry will focus on ambitious but achievable goals at slightly lower frequencies. Far from being wasted, the lessons we've learned can be applied to technologies with broader, more viable commercial applications.

The cumulative expertise gathered so far has laid the foundations for future sensing and high-speed applications that would be impossible without this fundamental research.

6G Waves Magazine offers a window into these exciting technologies, with additional scientific insights for those seeking more detail. And as a highlight, this issue features the story of industry pioneer, Honorary Doctor Veijo Kontas. I hope his journey inspires us all to look beyond the obvious, to embrace challenges and to consider every opportunity with care.



Prof. Aarno Pärssinen

Professor of Radio Engineering,
Head of Devices and Circuits
Research Area,
University of Oulu, Finland

FINNISH-US RESEARCH A COLLABORATIVE FUTURE

Finland values partnerships with the US to advance scientific research and innovation. The US offers a unique ecosystem with flexible support and significant United States Department of Defense-funded research, which has historically led to breakthroughs like GPS and the Internet. Collaboration gives Finnish researchers access to this dynamic environment, while US institutions gain from Finland's strengths in fields like 6G. This cooperation fosters innovation in shared areas.

In 2021, the Finnish Ministry of Education and Culture launched an internationalisation programme to enhance cooperation with global partners. The Global Pilot Networks Programme facilitates collaboration between Finnish and international actors across governments, institutions, and research communities. As part of this initiative, the Finnish-

American Research and Innovation Accelerator (FARIA) focuses on fostering partnerships between Finnish and US institutions and researchers. Scheduled to run until the end of 2024, FARIA has supported diverse activities at the University of Oulu and 15 other Finnish higher education institutions. Key focus areas include bioeconomy, welfare, artificial intelligence, and 6G technologies, with Finland's 6G Flagship coordinating 6G collaboration efforts.

Wireless researchers throughout Finland have had close ties to the US for a long time. Since 2013, the first NSF international pilot programme on wireless research (Wireless Innovation between Finland and the US - WiFiUS) collaboration has been intense, with about 40 individual projects funded so far. Finland's joining NATO in 2023 has further increased



collaboration to address issues like dual-use technologies and the resilience of commercial networks.

The Global Pilots programme is a catalyst for collaboration rather than a direct research funder. Its primary objective is to connect researchers, organisations, and infrastructures and facilitate partnerships to attract ongoing external and industry funding for collaborative projects. This focus on securing external funding is crucial, especially in the technology sector, where the ultimate goal is to commercialise promising technologies and generate income rather than solely invest in research.

The University of Oulu has collaborative research activities in 10 different states in Global Pilots FARIA. In addition,

several activities are related to large-scale collaborations at the administrative level, including the Memorandums of Understanding (MOUs) agreement between Finland and the US. Although the individual FARIA activities are relatively small due to limited funding, they offer a wide range of research topics that open doors for individual researchers to collaborate with their US counterparts and possibilities to apply for more extensive research grants from NSF and Research Council Finland joint programmes.

Read more about our US collaboration on [page 28](#).

UNIVERSITY OF OULU EXPANDS

**6G COLLABORATION
WITH SOUTH KOREA**

The University of Oulu and its 6G Flagship programme have strengthened their research ties with South Korea. Recently three new memorandums of understanding were signed with Yonsei University, the Korea Advanced Institute of Science and Technology (KAIST), and the Electronics and Telecommunications Research Institute (ETRI). These partnerships support goals set by European and Finnish research agencies to increase 6G collaboration with South Korea. Working alongside South Korea's technology leaders, the University of Oulu is advancing 6G research with global impact.

Since 2016, the University of Oulu has partnered with ETRI on several projects, beginning with the 5G Champion project. An initial collaboration demonstrated 5G capabilities at the 2018 Winter Olympic Games and led to a series of joint research efforts. Today, ETRI is the University of Oulu's primary non-European partner in wireless research. The latest projects focus on advanced 6G technologies, including integrated communication and sensing, as well as AI-driven Radio Access Networks (RAN) for 6G. These areas represent some of the most promising directions in 6G innovation. Other existing projects are studying 6G network architectures and security challenges in 6G.

Balancing security with privacy is as much a philosophical challenge as it is a technical one.

The Institute for Information & Communication Technology Planning & Evaluation (IITP) and Business Finland have made integrated sensing and communication (ISAC) a priority area for 6G research. This focus has led to the launch of a new three-year project, Development of Wireless Technology for Integrated Sensing and Communication (WISEC). Key Korean participants include the ETRI, KAIST, and Dankook University. Together, the project team will develop ISAC techniques, suitable channel models, and multimodal sensing technologies.

ISAC techniques will enable networks to sense their surroundings while transmitting data, a dual capability that could allow 6G systems to adapt in real time to their environment. Channel models, in turn, are critical for predicting how signals will interact with different environments, which informs the design of more reliable and efficient networks. Meanwhile, multimodal sensing—drawing on LIDAR, video cameras, and visible light communication (VLC) alongside radio signals—aims to improve how networks detect and interpret complex scenarios, like urban landscapes or indoor spaces.

The projects' findings will be shared in scientific forums and incorporated into 3GPP standardisation. Finnish and Korean partners will jointly prepare ISAC-related channel models for 3GPP contributions to strengthen their international acceptance.

The EU-funded project 6GARROW strengthens collaboration between the European Union and the Republic of Korea, focusing on the future of Radio Access Networks (RAN). The project aims to advance AI-driven RAN technology and develop integrated approaches that connect devices more seamlessly with networks.

The project, set to run for three years from January 2025, is led by CEA-LETI and Aalto University as part of a consortium of eight partners, including 6G Flagship. In Korea, Yonsei University leads the project with contributions from five Korean partners, including LG Electronics.



NOKIA'S SOC GURU VEIJO KONTAS MADE

HONORARY DOCTOR

BY THE UNIVERSITY OF OULU

Hailed by the media as “the man who saved Nokia”, Veijo Kontas has been an important link between academia and industry in the Oulu ecosystem.

Veijo Kontas has received the highest honour a university can grant a person outside of academia. Kontas has been conferred as an Honorary Doctor by the University of Oulu.

Kontas is held in high regard in both industry as well as in university and research circles. His knowledge and expertise on microchips is profound, and he has worked at the helm of Nokia's System-on-Chip technologies for a considerable time. Over three billion mobile devices carry microchips that were designed by Kontas, and he has been called the man who saved Nokia's network business by Finnish media. He has strong ties to the University of Oulu and the Oulu region

in general: he studied in and graduated from Oulu and has spent nearly 40 years in the area, not including a few years' stint in Southern Finland.

His expertise is world-class, and he is equally passionate about research and education. Due to Kontas' initiative, the University of Oulu has two sponsored SoC professorships, one of which is funded mostly by Kontas' Nokia budget.

Professor **Markku Juntti** from the Centre of Wireless Communications says Kontas' achievements in the Nokia ecosystem are incontestable.

“Veijo is well-deserving of the title of Honorary Doctor, no question. He has pushed Nokia's technology and product lines forward, and he and his team have also recruited many engineers and doctors who have graduated from our



university. He is in large part responsible for the fact that Nokia has a major R&D centre here in Oulu.”

Aarno Pärssinen, CWC’s Professor in radio technology worked in Nokia simultaneously with Kontas, but he never worked directly with him as a colleague. However, Pärssinen knew of his reputation and later also learned to know the person behind it.

“Veijo always had a major role in Nokia during the heyday of the company’s mobile phone era. He was a key player when Nokia’s cell phones and networks made the company number one in its field globally. Nevertheless, Veijo is not just a so-called ‘company man’ but a strong advocate of research and education. He realised early on that you can not be complacent with what you’ve got. Instead, you have to keep your eye constantly on the horizon.”

6G development is vital; Oulu is a key site in its development

Kontas himself, the modest man that he is, shrugs off any praise directed at him and his influence. As far as staying on the cutting edge of things, and in fact, having been on the cutting edge himself many times, he is quick to make a self-deprecating joke before going into a serious consideration of where we are and where we are headed as a society.

“Technological progress is a lot like ageing; there is no stopping it”, Kontas says with a chuckle. “The big trends today are digitalisation and artificial intelligence (AI), and these two things will have the most impact on society. This is reflected in research and in students’ interests, but I think it is equally important to put resources in traditional areas such as telecommunications and microchip design so that we will have skilled people in these areas in the future, too.”

The big trends are based on the continued development of telecommunications, which makes Oulu’s 6G Flagship a vital project, Kontas says.

“4G is coming to the end of its capabilities in the large cities of the world at the moment. 5G can carry us to 2027 or 2028, after which we will need much more capacity, which drives 6G. The technological challenges are significant, and the solutions we have today won’t solve them. In Nokia, 6G efforts are going ahead at full speed, and we will hit the market by the end of this decade. The industry opinion is that the commercial launch of 6G will happen mid-2029,” says Kontas.

Kontas believes Oulu will remain at the forefront of telecommunications. Oulu is currently the most important R&D centre for Nokia in mobile networks, and the most tangible evidence of this is the new campus, which is being built very close to the university. And as important as Oulu has been professionally to Kontas, the place holds deep personal meaning to him as well, which makes the honor bestowed to him by the university feel very special.

“I am extremely honoured by this recognition. I think that the people make the place. The skills and work ethic in Oulu have always been at the highest level. People are willing to work hard in Oulu, but they are also relaxed and open, even if they are not always the most talkative. But you can always trust people in the North: when they say they will do something, it is as good as guaranteed.”

The industry opinion is that the commercial launch of 6G will happen mid-2029.

EUROPEAN MICRO-ELECTRONICS & CHIPS

MORE THAN A ME-TOO CONTINENT?

As the European Union ramps up billions in funding for advanced microelectronics through initiatives like the Chips Act, the question arises: can Europe position itself as more than just a “me-too” player in this critical technology domain? Compared to other regions, what unique elements can the continent bring to the table?

According to **Jari Kinaret**, Executive Director of the newly launched Chips Joint Undertaking, Europe aims high. “The European Commission has launched a CHIPS Joint Undertaking, CHIPS-JU, to reinforce the European semiconductor ecosystem and Europe’s technological leadership,” he explained. This €43 billion programme, mobilising both public and private investments through 2030, sets its sights on challenging the likes of the \$53 billion U.S. CHIPS Act.

But as 6G Flagship’s Professor **Aarno Pärssinen**, Co-Chair of Microelectronics Finland, noted, Europe has some catching up to do in microelectronics. Pärssinen explained that in the 2G era, the focus was on miniaturising and optimising the electronics and radio system together, with highly limited computing resources and emerging RF capabilities. “In 2G we needed to optimise the phone and the electronics and the radio system in such a way that we were barely able to compute all that was needed. Similarly, we were barely able to do the RF at that time,” he said.

The good news is that Europe retains unique strengths to build upon. **Tauno Vähä-Heikkilä**, VP of Microelectronics & Quantum Computing at VTT, pointed to Finland’s expertise in areas like photonics, radio frequency technologies, power

electronics, and 3D integration – competencies that could feed into future 5G and 6G infrastructure. “We have people who are into some special technologies like photonics, radio frequency technologies, also some power electronics, 3D integration and packaging and so on,” he said.

Stephane Teral, CEO of Teral Research, emphasised the importance of Europe not putting all its eggs in one manufacturing basket. “We need to have the next level of intelligence because it’s really indeed designed in Finland.” He cited examples of European design prowess, even as the continent has lost ground in recent decades.

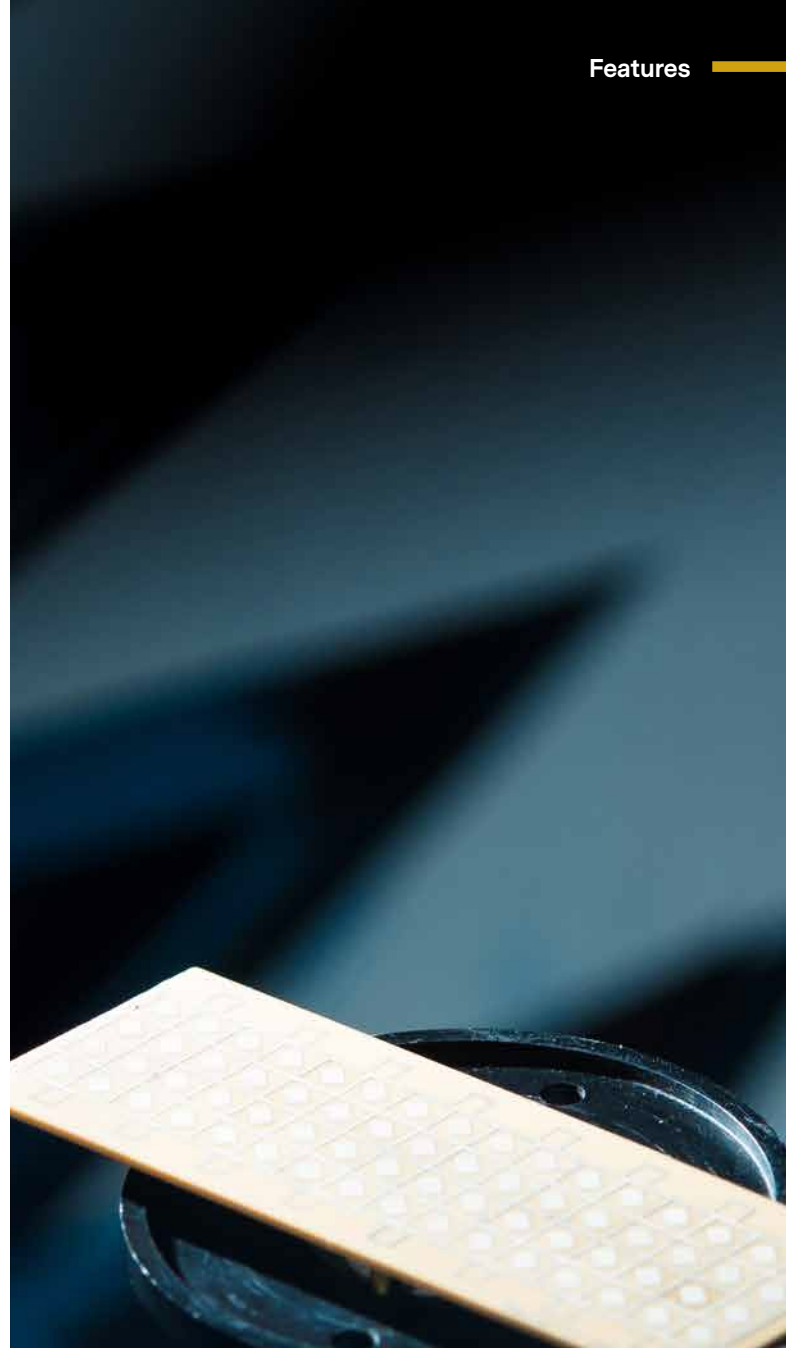
The panellists agreed that Europe faces a delicate balancing act – tapping into its specialised technical capabilities while also scaling up manufacturing to rival global giants. As Kinaret put it, the path to European leadership in microelectronics will require navigating a complex landscape of public-private partnerships, cross-border collaboration, and strategic investments.

One thing is clear: with the stakes so high, Europe is determined to be more than just a me-too player in the microelectronics race. By leveraging its unique strengths and charting its own course, the continent aims to cement its position as a global technology powerhouse in the years ahead.



View the panel recording

youtu.be/_yqrGnGpATg



HIGH-FREQUENCY ELECTRONICS FOR 6G RECEIVER

A groundbreaking achievement in the field of high-frequency electronics has been made with the successful implementation of a radio receiver front-end operating at an astounding 300 GHz. This research, supported by the Academy of Finland's 6G Flagship programme, paves the way for ultra-high-speed wireless communication and marks a milestone in the advancement of 6G radio implementation.

The primary focus of the research is the design of the radio receiver's front end, which combines the principles of analogue circuit theory, microwave theory, and radio engineering. In his dissertation, **Sumit Singh** developed a highly efficient receiver front end capable of operating close to the maximum oscillation frequency of semiconductor technology.

In modern radio systems, information is transmitted through semiconductor material and the atmosphere. However, signal transmission efficiency is often hindered by the parasitics of semiconductor technology and natural phenomena in the environment. While this thesis does not delve into improving semiconductor technology or the radio propagation channel, it presents an architecture and design methodology of radio frequency integrated circuits (RFICs) to enhance signal transmission efficiency within the radio receiver front end.

The layout of signal paths and the choice of semiconductor technology play a crucial role in mitigating the parasitics associated with high-frequency carrier signals. Through meticulous architectural choices, circuit topologies, and layout



strategies, RF researchers of 6G Flagship have successfully implemented a receiver front-end that operates at an impressive 300 GHz while maintaining exceptional sensitivity and efficiency. This accomplishment represents a significant technological breakthrough that contributes to the advancement of 6G radio implementation.

“The successful implementation of the radio receiver front-end at 300 GHz opens up new possibilities for ultra-high-speed wireless communication. With an increased frequency, more bandwidth becomes available, enabling faster and more reliable data transmission. This achievement brings us one step closer to realising the potential of 6G technology and its transformative impact on various industries,

including healthcare, transportation, and entertainment”, **Sumit Singh** muses.



Read the thesis:

urn.fi/URN:NBN:fi:oulu-202405083216

CELEBRATING 6G FLAGSHIP'S TRIUMPHS

IN GENERATIVE AI AND ANTENNA INNOVATIONS

The University of Oulu has recently achieved significant recognitions from IEEE. 6G Flagship's work on mitigating hardware impairments with generative AI algorithms won the Best Paper Award at the 2024 IEEE Wireless Communications and Networking Conference (WCNC 2024), while their innovative antenna designs have become the most-read article in IEEE Transactions on Antennas and Propagation.

A Landmark Achievement at IEEE WCNC 2024

At the prestigious IEEE Wireless Communications and Networking Conference (WCNC) 2024 in Dubai, the 6G Flagship team's **Mehdi Letafati** achieved a remarkable feat by winning the Best Paper Award in the Resource Allocation and Machine Learning track. Their paper, entitled Denoising Diffusion Probabilistic Models for Hardware-Impaired Communications, presents a novel approach to address the challenges imposed by transceivers' residual impair-

ments in communication systems by using advanced generative AI techniques.

The award-winning paper discusses the use of denoising diffusion probabilistic models (DDPMs) for practical wireless communication systems plagued by hardware impairments. Their generative AI-based approach stands out for its ability to effectively mitigate the impact of hardware impairments such as noise and distortion on communication systems – a critical challenge in developing reliable communication networks.

Recognition in IEEE Transactions on Antennas and Propagation

Another success for 6G Flagship is a paper titled Dual-Band Dual-Polarized Planar Antenna for 5G Millimeter-Wave Antenna-in-Package Applications by **Zeeshan Siddiqui** and his

team, which became the most-read article in the prestigious IEEE Transactions on Antennas and Propagation for 2023. The work, which focuses on innovative antenna design for millimetre-wave communication systems, has garnered significant attention from the scientific community, with an impressive 18,872 reads and a well-deserved feature as one of IEEE's Monthly Featured Articles on IEEE Xplore.

When you invest immense energy and creative thinking into an endeavour, it's incredibly rewarding to have those labours appreciated by esteemed peers.

The paper discusses the design and implementation of a cutting-edge dual-band, dual-polarized planar antenna specifically tailored for 5G millimeter-wave applications. Operating within the frequency range of 24 GHz to 40 GHz, this antenna targets the 5G New Radio (NR) millimetre-wave Frequency Range 2 (FR2), positioning it as a key enabler for high-efficiency, high-performance 5G communication systems that demand robust and reliable wireless connectivity.

Zeeshan Siddiqui, who recently defended his doctoral dissertation on antenna designs for sub-6 GHz and millimetre-wave communication systems, commented: "I'm truly elated that our team's tireless efforts to advance antenna technology have garnered this recognition from the scientific community. When you invest immense energy and creative thinking into an endeavour, it's incredibly rewarding to have those labours appreciated by esteemed peers."



Mehdi Letafati, flanked by colleagues Raed Shubair (General Chair) and Marco Di Renzo (TPC Co-Chair), proudly receives the Best Paper Award at the IEEE WCNC 2024 25th Anniversary Conference in April 2024.



Read Mehdi Letafati's paper

arxiv.org/abs/2309.08568v1



Read Zeeshan Siddiqui's paper

ieeexplore.ieee.org/document/10034461



Read Zeeshan Siddiqui's thesis

oulurepo.oulu.fi/handle/10024/49196



From the left: custos Professor Aarno Pärssinen from the University of Oulu, Zeeshan Siddiqui, and opponent Associate Professor Tim Brown from the University of Surrey at Siddiqui's doctoral dissertation in May 2024.

AMATERA

WITH PANASONIC

The cooperation between 6G Flagship and Panasonic began in 2019 at the first 6G Summit held in Levi, Finland. As 6G Flagship researcher Dr Kimmo Rasilainen put it, the initial discussions were “something of an extracurricular activity”—a casual yet intellectually charged exchange that would ultimately lead to formal cooperation.

Before a more structured collaboration, Panasonic had been a trusted supplier of PCB materials to the university’s RF

team. By 2022, conversations matured into formal cooperation. The result was AMATERA, a project driving PCB-based RF design advancements at sub-terahertz frequencies. Named after the Japanese sun goddess Amaterasu, AMATERA symbolises light, growth, and innovation, reflecting its ambitious goals in advancing 6G technology.

The collaboration enables two of the University of Oulu’s doctoral researchers to focus full-time on solving com-

plex challenges in PCB-based RF design and integration at sub-terahertz frequencies. Panasonic's expertise in materials R&D is critical. Professor Aarno Pärssinen of 6G Flagship explains, "By working closely with Panasonic, we can explore new material properties and approaches that we wouldn't have been able to achieve on our own. Their knowledge of the manufacturing processes gives our designs a path to real-world applications."

Panasonic focuses on understanding scientific fundamentals and market trends for future PCB materials. Through innovative approaches such as substrate-like PCBs (SLP), the project is investigating new possibilities in miniaturised antenna design for 6G applications.

"We have recently entered the second year of the project and have been able to come up with new antenna solutions that are outperforming the state-of-the-art in many key performance metrics," says Professor Aarno Pärssinen, 6G Flagship's Devices and Circuit Technology Lead, and continues, "This project is allowing us to push the boundaries of what can be achieved with PCB technology at sub-terahertz frequencies, an area that holds immense potential for the future of wireless communications."

Pekka Laukkala from Panasonic adds, "SLP is a breakthrough for us because it allows for a much higher level of integration while maintaining the high-frequency characteristics and volume manufacturability requirements we need for future 6G networks."

A More Global System Than 5G

The collaboration between 6G Flagship and Panasonic extends beyond technical research. It positions both partners as significant contributors to the future of 6G on a global scale. Panasonic's involvement brings substantial industrial credibility and aligns 6G Flagship's scientific research with market needs. According to Laukkala, "6G will be a much more 'global system' than 5G or previous generations. Seamless integration of different technologies, including hardware, software, and protocols, is critical."

The collaboration also gives the University of Oulu deeper insights into aligning theoretical research with practical applications. Professor Pärssinen reflects, "What makes this partnership stand out is how it bridges academia and industry. It ensures that the innovations we develop don't remain in the lab but can be transformed into practical solutions for real-world deployment."

Laukkala concurs, noting, "Already at the early stage of research, it is very important not to lose sight of industrial applications."

Spectrum, Standards, and Market Adoption

The 6G Flagship - Panasonic collaboration is contributing to discussions on global standardisation, particularly in defining the specifications needed for practical 6G systems. Currently, the available spectrum in the upper millimetre-wave and sub-terahertz frequencies offers significant freedom for research. However, as the technology moves towards commercialisation, close cooperation with international standardisation bodies will be crucial.

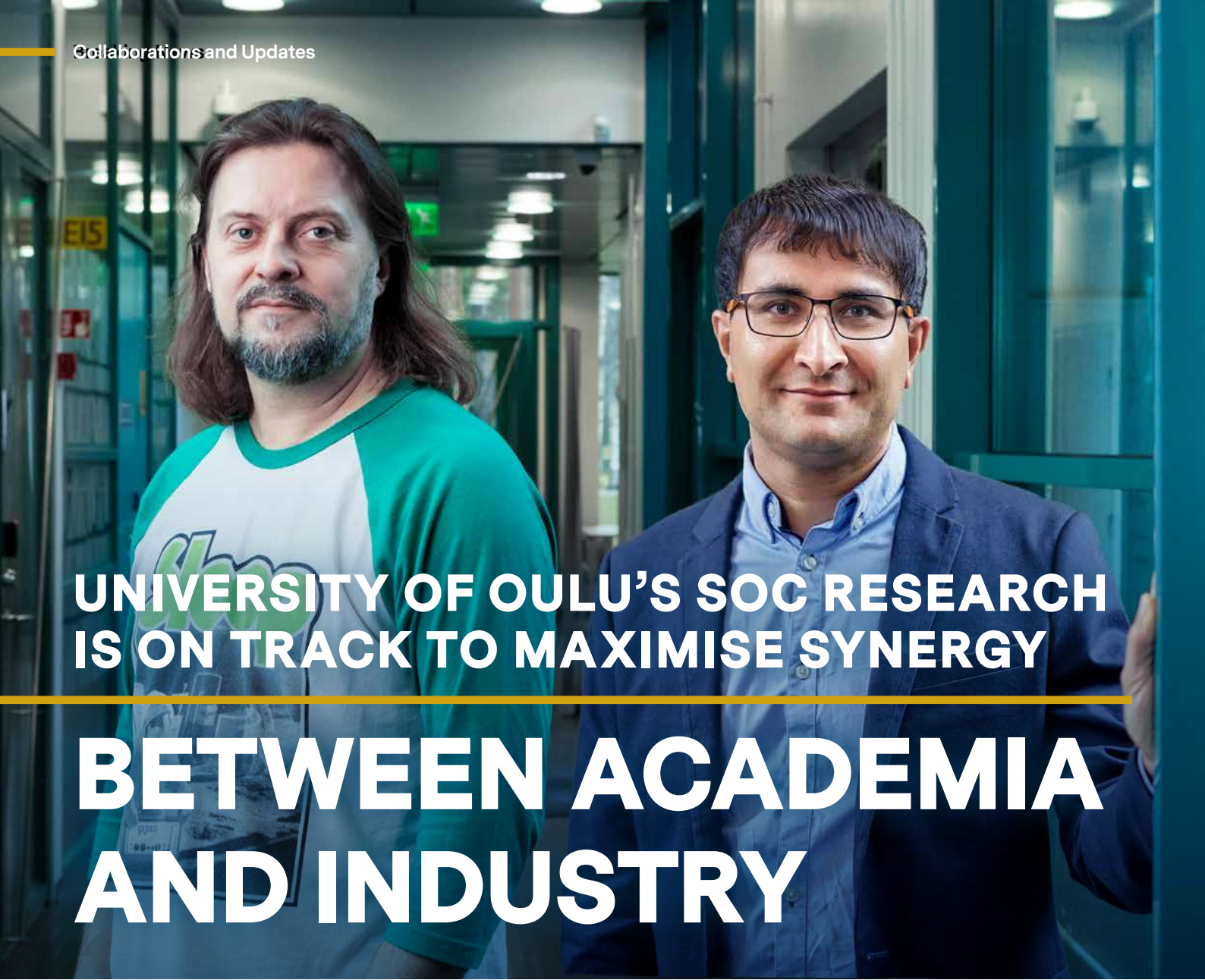
Professor Pärssinen highlights this point: "We are fortunate to be working in a relatively open spectrum now, but as 6G progresses, the importance of engaging with standardisation bodies will only increase. The

work we do today sets the foundation for the 6G systems of tomorrow."

"Antenna arrays, either broadside or end-fire, with beam forming or beam steering, must first be understood at a theoretical level. Afterwards, the actual physical implementation can be optimised to respect the requirements of laminate materials and the manufacturing process," Laukkala points out.

Ensuring the technology's scalability for 6G is crucial. Panasonic's involvement is important to maintaining a focus on practical, scalable solutions. "By understanding the requirements from both a material and manufacturing perspective, we are ensuring that our solutions can be adopted industry-wide," says Laukkala. Professor Pärssinen adds, "The close alignment between our academic research and Panasonic's industrial focus gives our project a unique advantage over purely academic initiatives. It allows us to address market realities right from the research phase."

This project is allowing us to push the boundaries of what can be achieved with Printed circuit board technology at sub-terahertz frequencies.



UNIVERSITY OF OULU'S SOC RESEARCH IS ON TRACK TO MAXIMISE SYNERGY BETWEEN ACADEMIA AND INDUSTRY

In 2023, two new professors started at the University of Oulu in system-on-chip technologies (SoC) for wireless systems. The professors, Zaheer Khan at the Centre for Wireless Communications (CWC) and Lauri Koskinen at the Circuits and Systems research unit (CAS), are now a year into their five-year positions. Their aim is to investigate and develop the design of SoC technologies.

Teaching is naturally a large part of the professorships, and Khan and Koskinen were tasked with designing and teaching a full-length course last year. Khan is keen to familiarise students with SoC architectures and the intellectual property designs used in them and also to make the most of the connection between academia and industry.

“Designing the course was a huge undertaking in terms of time because we were trying to cover things that have not been covered previously. We were including circuit theory and circuit systems as classical research topics and bringing in electronics and the way things actually work in an

overall SoC architecture and what glues them together,” Khan says.

One of the big players in telecommunications, Nokia, is among the sponsors of the professorships, along with Nordic Semiconductor, MediaTek and the City of Oulu. Both Khan and Koskinen have been working with Nokia with their courses, and they have a couple of Master’s students from the company.

When focusing on real-world solutions, one very important aspect in designing chips is the ability to tapeout, or to complete an integrated chip so it can be sent to a foundry for manufacturing. This is a costly but essential part of the process, says Lauri Koskinen.

“It takes time and money, but in the industry you always have to finish the product, the chip, which is why this is a very valuable skill to have. We will most likely be able to tapeout next year, thanks to the new ‘1,000 doctoral researchers’

systems a boost in Europe, and the goal is to also introduce a broad swathe of projects that make use of those technologies. This innovation boost is also speeding up 6G research in its own part.

“Chips JU is creating competence centres in all of the participating countries, and a part of the Finnish competence centre is coming to Oulu. The centre itself will be located and operated mostly in Tampere and run by the University of Tampere, but we will have a lot of the business-related and startup-related activities here,” Koskinen says.

6G research is well-established now

Even if teaching and research are keeping both SoC professors busy, Khan and Koskinen do keep an eye on 6G development as 6G research is maturing not only in Oulu but around the world.

“I think things are picking up internationally. Professor Matti Latva-aho has said the next three years will be very good for 6G development, and I see that many countries have ramped up activities in it since the Flagship started in Oulu in 2018,” Khan says.

“Now, almost every country has some kind of activity around 6G research, and the research domain has expanded. Not everywhere has research going on at the same level, but the number of 6G research centres has cropped up, certainly,” he continues.

Lauri Koskinen, who has been heavily involved in improving the energy efficiency in processors, says that the fundamental challenges haven’t changed in the meantime.

“Power requirements and restrictions are not going anywhere. In the time of 6G we will have so much data that power will be a problem. AI is going to be pretty much everywhere and we need to take that into account in designing 6G and the servers that can run those algorithms. Moore’s Law is slowing down, or maybe it’s already gone, and we need new ways of thinking,” Koskinen says.

Zaheer Khan agrees with Koskinen’s assessment.

“The low-hanging fruit have been picked by now. There are no significant advantages in transitioning from 60-something nanometers to three or two nanometers. The gains are diminishing, which is why you have to look at other architectures and platforms.”

Text by Janne-Pekka Manninen

Professorships supported by

NOKIA

MEDIATEK

NORDIC
SEMICONDUCTOR

OULU

programme from the Ministry of Education and Culture,” Koskinen says.

Collaboration is both essential and natural

Nokia and the other companies in the field are important research partners, and while it may take a while to sort out the legal paperwork, the partners are generous in opening up their IP for further research.

“There are limits to what we can do and build in the university in terms of resources, so it makes sense for us to work on designing accelerators and wireless data processing and so on, and then collaborate with our partners to build an SoC containing ARM IP. It is a chance to see how things work in a real-world scenario,” Khan says.

Koskinen points out that in terms of 6G research, one interesting lead is the European Union Chips Joint Undertaking (Chips JU) Act. Chips JU is intended to give the development of advanced nano-electronic chip-technologies and



**JOINT STATEMENT
ENDORSORING PRINCIPLES FOR 6G**

**SECURE, OPEN, AND
RESILIENT BY DESIGN**

On February 26, 2024, Finland, the United States, Australia, Canada, the Czech Republic, France, Japan, the Republic of Korea, Sweden, and the United Kingdom united to release a Joint Statement laying down the guiding principles for the development of the next generation of wireless communication systems, 6G. This joint proclamation, “Joint Statement Endorsing Principles for 6G: Secure, Open, and Resilient by Design,” signifies a collective dedication to advancing 6G technologies. It highlights a mutual aspiration for a future of global connectivity characterised by openness, freedom, interoperability, reliability, resilience, and security.

6G Flagship’s Role in Fostering Global Cooperation

6G Flagship’s endeavours to foster worldwide cooperation in advancing 6G technology are accelerating and earning global recognition. Dedicated to laying the groundwork for open and secure communication systems, 6G Flagship has consistently championed the principles the Joint Statement now embodies. The Joint Statement also mirrors 6G Flagship’s commitment to driving societal digitisation through innovative efforts.

“The Joint Statement, endorsing principles for secure, open, and resilient 6G, is exactly the kind of approach we’ve been advocating for,” says Professor Matti Latva-aho, Director of 6G Flagship. “This is a rallying cry for all of us in the tech community to roll up our sleeves and work together towards a future where our networks do more than connect us—they protect us, adapt with us, and bring us closer to a world where digital access is a given, not a luxury. It aligns perfectly with our mission to build a 6G network that’s as resilient as

it is revolutionary, ensuring secure, seamless connectivity for everyone, everywhere.”

Latva-aho continues: “This opens up exciting new avenues and funding opportunities. The national security sector, for instance, is an area ripe with potential and opportunities. This Joint Statement adds another layer to our collaborative efforts, denoting the vast possibilities in secure and resilient 6G development. We’re on board and eager to contribute to this global effort.”

This is a rallying cry for all of us in the tech community to roll up our sleeves and work together towards a future where our networks do more than connect us.

Blueprint for a Future-Ready and Inclusive World

Emphasising the importance of national security, privacy, and inclusivity, the guidelines outlined in the Joint Statement champion the creation of technologies pivotal for a globally sustainable, affordable, and accessible 6G ecosystem. These standards are designed to

propel the development of a technological landscape that is not just advanced but also attuned to the principles of sustainability and open access worldwide. By promoting the adoption of international standards and competitive market dynamics, the statement highlights resilience and swift adaptability as cornerstone qualities for future advancements.



Read the proclamation

www.whitehouse.gov/briefing-room/statements-releases/2024/02/26/joint-statement-endorsing-principles-for-6g-secure-open-and-resilient-by-design



6G FLAGSHIP AND BHARAT 6G ALLIANCE SIGN A MEMORANDUM

The 6G Flagship, led by the University of Oulu in Finland and the Bharat 6G Alliance in India, have announced a landmark Memorandum of Understanding (MoU) to foster collaborative research and development efforts on 6G wireless technologies. This strategic partnership marks a significant step towards aligning Finland's and India's 6G ambitions to accelerate the development of a resilient, secure, and globally interoperable 6G ecosystem.

Aligning 6G Priorities and Driving Innovation

The MoU outlines a comprehensive framework for collaboration, focusing on the following key areas:

Alignment of research and development priorities

The two organisations will work together to create a shared vision and roadmap for 6G, ensuring that their respective R&D efforts are complementary and synergistic.

Secure and trusted telecommunications

A crucial aspect of the partnership will be the joint development of technologies and standards that enhance the security, resilience, and trustworthiness of 6G networks, sup-

porting the development of a reliable and inclusive global telecommunications infrastructure.

Resilient supply chains

The collaboration will also explore opportunities to strengthen the supply chains for 6G-related components and equipment, promoting sustainability, diversity, and self-reliance in the production of next-generation wireless technologies.

Enabling global digital inclusion

By combining their expertise and resources, the 6G Flagship and Bharat 6G Alliance aim to develop innovative 6G solutions that can bridge the digital divide and empower communities around the world with advanced connectivity services.

Statements from Organisational Leaders

“This collaboration with the Bharat 6G Alliance is a strategic move to advance our research and development efforts and achieve our shared goals of driving societal digitisation through cutting-edge 6G technology. By aligning our priorities and pooling our resources, we can unlock new possibilities and accelerate the delivery of transformative 6G capa-

bilities on a global scale,” stated Professor **Matti Latva-aho**, Director of the 6G Flagship programme.

“Partnering with the 6G Flagship programme allows us to leverage our collective strengths in 6G research, development, and innovation. This MoU is an important step towards achieving India’s vision of empowering society through sustainable and advanced telecommunications while contributing to the global 6G ecosystem. Bharat 6G Alliance has already signed MoUs with NextG Alliance of USA, 6G SNS IA of European Union; and this MoU with 6G Flagship of Oulu University will further enhance these global collaborations for the development of 6G secure and trusted telecommunication technology including resilient supply chains,” said Mr. **N. G. Subramaniam**, Chairman Bharat 6G Alliance.

About the Collaborating Organisations

The 6G Flagship programme is a world-leading research initiative funded by the University of Oulu and the Research Council of Finland. It aims to develop key 6G technology components, establish a comprehensive 6G Test Centre, and drive the societal digitisation of the 2030s through groundbreaking 6G research and innovation.

The Bharat 6G Alliance is an initiative supported by India’s national research institutions, academia, and industry standards organisations. Its primary objective is to design, develop, and deploy 6G technologies and innovations that enhance the quality of life for citizens in India and across the world, with a

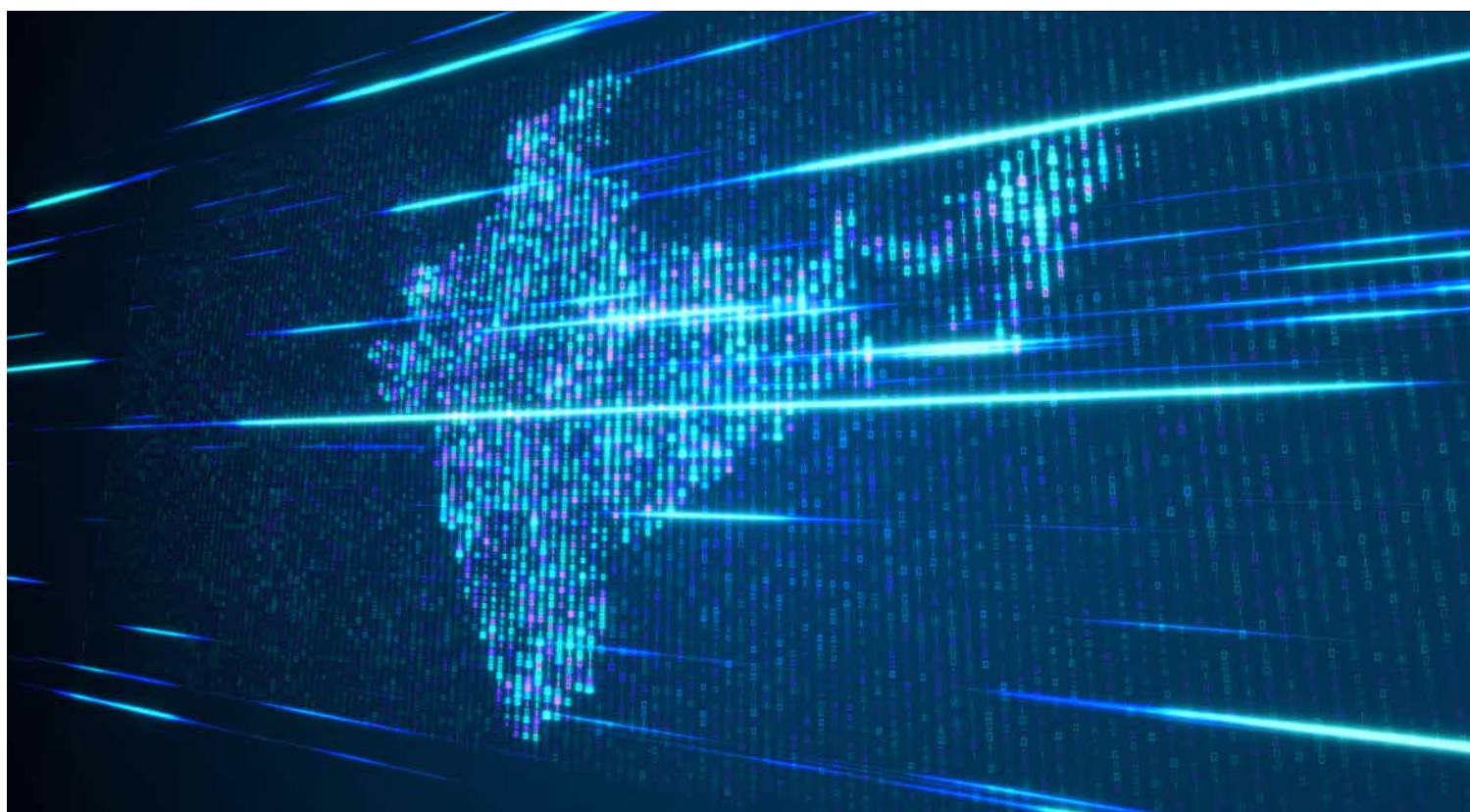
focus on sustainability, affordability, and ubiquity.

Partnering with the 6G Flagship programme allows us to leverage our collective strengths in 6G research, development, and innovation.

Future Collaboration and Engagement

The partnership between the 6G Flagship and Bharat 6G Alliance is expected to generate a series of joint research projects, technology demonstrations, knowledge-sharing

workshops, and other collaborative activities. These efforts will foster the exchange of ideas, expertise, and best practices, ultimately setting new standards in global 6G research and development.





A PASSAGE TO 6G

The path to 6G innovation is not a solitary one; it requires cooperation, often driven by academic minds rather than political mandates. The FICORE project (Finnish Indian Consortia for Research and Education) proves that genuine progress rarely depends on government decrees or grand summits. Launched in 2022 without fanfare, it aimed to advance 6G technology through collaboration between Finland and India's academic powerhouses. The partnership has united sharp minds from Finland's universities and India's Institutes of Technology.

Spearheaded by Professor **Nandana Rajatheva** from the University of Oulu's Centre for Wireless Communications (CWC), the project has brought together researchers from both nations, resulting in joint publications, exchanges, and conference presentations. Contributors like **Teemu Myllylä**, **Marianne Kinnula**, **Erkki Harjula**, **Susanna Pirttikangas**, **Marcos Katz**, and **Onel Lopez** have played key roles. As the project wraps up in December 2024, its true legacy is just beginning—one that will resonate beyond academia.

Researcher Exchanges and Global Engagement

One of FICORE's prominent successes has been researcher exchanges. Through its Centre for Wireless Communications, the University of Oulu has hosted several visitors from India's IITs and IIITs. Prof. **Vimal Bhatia** from IIT Indore, who completed his stay in October, made valuable contributions to joint research on challenges in IRS and ISAC, and their standardisation for the next-generation wireless system, cementing ties between the institutions. His visit demonstrates how academic mobility drives progress and strengthens long-term collaboration. "These exchanges are vital for sharing expertise and building lasting relationships," Bhatia notes.

The collaboration extends beyond exchanges and joint publications. Finnish researchers have attended and contributed to joint workshop organisation in key conferences in India, including IEEE ANTS, held annually in December, and recently in WPMC. In 2023, FICORE participants Professors Rajatheva and **Sumudu Samarakoon** gave talks at the AllOT conference hosted by Vellore Institute of Technology. These interactions have proven critical, especially given India's growing role in global telecom standards.

In October 2024, Professors Latva-aho and Rajatheva attended the Bharat 6G Alliance event, India's first international 6G forum, following the unveiling of the Bharat 6G vision.

It's clear both nations view 6G as a strategic goal with real-world impact.

"India is a key player in shaping the global 6G roadmap," says Latva-aho, stressing the importance of events like this in setting global standards.

Building on Success

Recruitment has been another success. The 6G Flagship programme has attracted several postdoctoral researchers through FICORE, strengthening Oulu's CWC and enhancing Finland's tech ecosystem. Discussions to secure PhD funding from both nations are ongoing. Bhatia is working on a proposal to secure Indian funding to ensure the partnership's momentum continues.

"We're confident this project will lead to further recruitment and funding opportunities, particularly in 6G-related fields," says Rajatheva.

Funding has been a cornerstone of the collaboration. FICORE draws on a wide range of funding from both countries. Indian agencies have driven joint projects, while Business Finland (formerly Tekes) has facilitated efforts in Finland. A Business Finland-funded project led by Rajatheva brought together three IITs, showing that despite the buzz around private-sector innovation, sustained governmental support remains essential for long-term collaboration. There has also been additional support from the Indian government's SPARC program enabling mobility.

As the project nears its end, the real question is not whether to continue but how best to build on what's been achieved. The connections, progress, and collaborative spirit are too valuable to lose. Plans are in motion for a follow-up project, supported by Finnish industry and Business Finland, to ensure the momentum continues. Letting the cooperation fade now would be wasteful.

Both sides are optimistic. Discussions to secure more funding and extend researcher mobility will continue. The foundation built over the last two years ensures future projects will be even more ambitious and impactful.

"We're just at the beginning of what's possible. 6G is not only about faster speeds or more connectivity but about creating technologies that will transform industries, societies, and even everyday life," says Rajatheva, looking ahead to the future of this partnership.

These exchanges are vital for sharing expertise and building lasting relationships.

6G FLAGSHIP JOINS AI-RAN ALLIANCE

TO DRIVE AI-POWERED 6G NETWORKS

The University of Oulu's 6G Flagship has joined the AI-RAN Alliance. 6G Flagship's Director, Professor Matti Latva-aho, announced this strategic move on 19th August. Latva-aho emphasised the university's dedication to leading AI-driven innovations in next-generation wireless networks as the world moves toward 6G technology.

The AI-RAN Alliance, established at MWC Barcelona 2024, brings together industry leaders, technology giants, and academic institutions in a collective effort to harness the potential of AI within radio access networks (RAN). The alliance focuses on three critical areas: enhancing RAN capabilities through AI (AI-for-RAN), exploring the simultaneous deployment of AI and RAN on shared infrastructure (AI-and-RAN), and deploying AI-driven services at the network edge (AI-on-RAN).

Each focus area plays an important role in advancing the capabilities of next-generation networks. AI for RAN aims to improve efficiency and performance, allowing networks to adapt dynamically to changing conditions. AI and RAN seek to optimise the underlying infrastructure, making it more intelligent and responsive in sharing AI and RAN workloads. Finally, AI on RAN promises to bring powerful, real-time capabilities closer to the end user, transforming how we interact with technology.

The founding members of the AI-RAN Alliance include major industry players such as Nokia, NVIDIA, Arm, and Ericsson.

Their combined expertise and resources lay a strong foundation for the alliance's ambitious goals. Now, with 6G Flagship joining the ranks, the alliance gains a significant academic and research-driven perspective, further strengthening its ability to shape the future of AI-integrated networks.

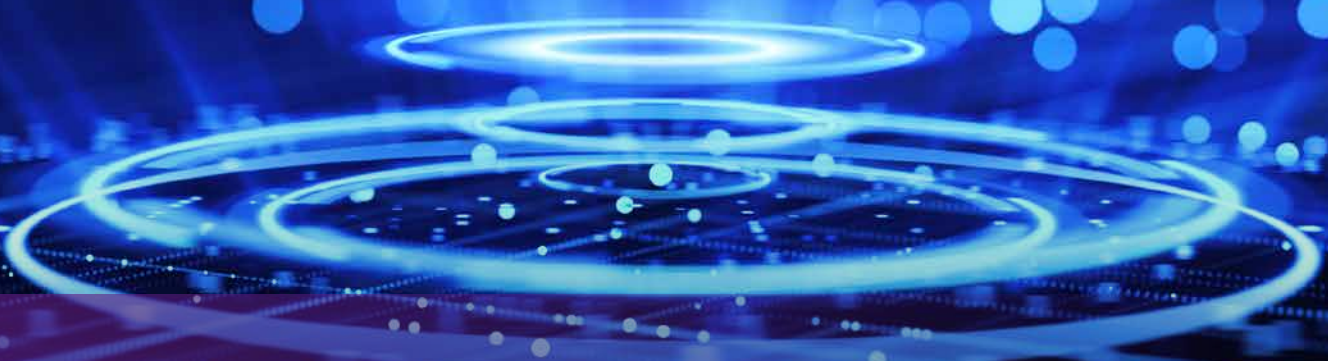
Since joining the alliance, the University of Oulu has been actively contributing to the workgroups, especially for activities in the AI-for-RAN working group. Doctoral Researcher **Dileepa Marasinghe** has been appointed as AI-RAN Research Manager for the 6G Flagship. Marasinghe will represent the university in alliance activities and ensure Oulu's research aligns closely with the alliance's goals.

By joining the AI-RAN Alliance, the University of Oulu is again positioning itself as an academic frontrunner in the future of global telecommunications. Today's AI-driven research and development investments will have long-lasting impacts as 6G technology becomes a reality. These efforts will shape next-generation networks and open up new avenues for innovation and economic growth.



Read more:
ai-ran.org

AI-RAN
ALLIANCE





GLOBAL VISIONARIES

SHAPING 6G NETWORKS

The 6G Flagship programme, spearheaded by the University of Oulu, has formed a strategic alliance with Virginia Tech's Commonwealth Cyber Initiative (CCI) that promises to forge significant discoveries in 6G technology. The collaboration is primed to blend Virginia Tech's cutting-edge research and educational prowess with the 6G Flagship's forward-thinking research ambition to fuel innovation.

These concerted efforts demonstrate a shared dedication to advancing mutual understanding and the technological bedrock upon which 6G will be built. Virginia Tech's CCI, renowned for its role as a catalyst for research, innovation, and workforce development, complements the 6G Flagship's objectives seamlessly.

Local 6G Networks for tomorrow

Today, local 5G, also called private networking, has huge economic potential. Some studies estimate its valuation will hit \$36 billion in 2030, up from \$1.1 billion in 2022. The next step, local 6G, is expected to be highly localised, with wireless connectivity enabling new applications in such wide-ranging fields as health care, manufacturing, and retail. This paradigm envisages a future where ubiquitous networks are tailored to the specific needs of communities and local entities.

6G Flagship and CCI researchers obtained funding from the Research Council of Finland and the National Science Foundation, respectively, to further the development of Local

6G Networks through a joint project titled 6G Connectivity: Controlled, Resilient, and Secure (6G-ConCorSe). The project aims to develop reliable, resilient, and secure connectivity solutions supporting the specific requirements of local 6G applications.

“Our research will focus on developing a novel neural-network-based method to represent the wireless environment and advancing reconfigurable intelligent surface (RIS) technology to secure local 6G connectivity,” said 6G Flagship researcher **Nurul Huda Mahmood**, the PI of the project’s Finnish component.

The three-year project, which started in January 2024, was kicked off through a project kick-off meeting held in Levi in April 2024 at the sideline of the spring 2024 edition of the 6G Symposium. The project has already achieved significant outcomes within the first ten months, including several bilateral research visits and five research publications. The active start to the project indicates the project’s productive potential.

Bridging continents through innovation

The unique strength of this collaboration lies in its capacity to drive transformative change in academic research and propel industry innovation on a global scale. It represents a bridge between continents, harmonising the future of 6G through dialogue and collaboration between the United States and Europe.

In essence, the collaboration between the 6G Flagship and Virginia Tech is more than a cooperative venture; it is a powerful affirmation of international unity. It heralds a new era where technology transcends its utilitarian roles to become a unifying force, linking diverse regions and fostering a connected global community.



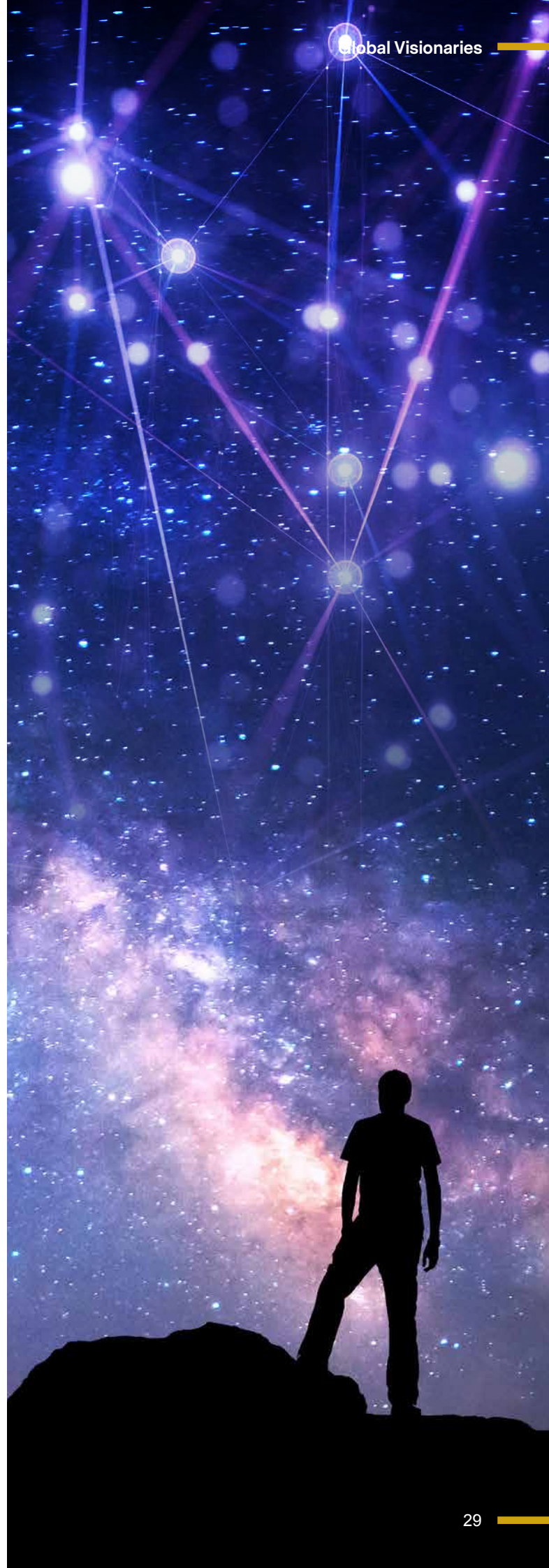
Explore 6G-ConCorSe

nsf-6g-concorse.vt.domains



Explode research publications

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NATO DIANA

6G TEST CENTRE

Finland's NATO membership has opened new avenues for 6G research. It has created valuable opportunities in dual-use technologies that serve both civilian and military purposes. At the forefront of this effort is the 6G Test Centre (6GTC) in Oulu. This state-of-the-art facility allows companies and research entities to test, evaluate, and validate products across commercial and defence sectors. Situated on the edge of the Arctic Circle, the 6GTC helps companies develop innovations like advanced encryption for secure communications or AI-driven surveillance, aligning with NATO's broader strategic goals.

Strategic Focus and NATO DIANA's Role

The 6G Test Centre's collaboration with NATO's DIANA programme serves a dual purpose: providing companies with vital resources through its innovation accelerators while addressing some of the most pressing challenges in modern defence. In July 2024, DIANA launched a call for applications in five challenge areas: data and information security, sensing and surveillance, energy and power, critical infrastructure, and logistics and human health and performance. These challenges are essential for ensuring the security and stability of nations in a world of increasing cyber and physical threats.

DIANA supports companies working at the 6G Test Centre through its accelerator programme, which includes boot camps, mentorship, and access to critical testing infrastructure. The programme allows companies to take their technologies through rigorous Proof of Concept (PoC) stages, with DIANA offering an initial €100,000 in funding. For those moving forward, an additional €300,000 is provided to refine their technologies, to help reach commercialisation.

Year 2023 DIANA challenge saw 44 companies selected. Each worked to ensure their innovations meet the dual requirements of commercial viability and military utility. In the 2024 challenge, with over 2,600 applicants, the expectation is that more companies than in the last round will be selected to advance these key defence innovations at the 6G Test Centre, ensuring the technologies developed meet real-world needs—both civilian and military.

Great value in the Arctic region

The University of Oulu's partnership with NATO DIANA brings excellent value to the region. It increases the global visibility of the region, fosters networking, and facilitates collaboration with key players in the defence and technology sectors.

While 6GTC provides the infrastructure for dual-use solutions, product testing, evaluation, verification and validation, DIANA ensures that resources are allocated to innovations addressing key defence challenges like energy resilience, secure communication, and surveillance. The partnership allows 6G Test Centre to facilitate the development of technologies essential for commercial success and enhancing global security capabilities.

Workshops and Training Programmes

Viewing the 6G Test Centre as a hub for technological tinkering would be a mistake. Through DIANA, the centre offers workshops and training programmes designed to sharpen the tools and minds of those engaged in the development of next-generation technologies.

Participants—whether fledgling start-ups or seasoned researchers—immerse themselves in an environment where military experts, industry giants, and tech innovators convene. The sessions prepare participants to confront the dual imperatives of commercial viability and military necessity. There is a clear and concerted effort to forge capabilities that extend beyond theory to ensure that these innovators remain tethered to the realities of both market demand and the battlefield.

Broader Benefits of DIANA

DIANA's collaboration with the 6G Test Centre goes beyond defence and security. It creates a foundation for a robust technological ecosystem in Finland. And it enables Finland to establish a foothold in the global marketplace, where civilian innovations often find applications in the military sector. The accelerator programme supports Finland's economic development by fostering a self-sustaining growth cycle.

Through DIANA, start-ups and established companies are encouraged to leverage technologies that can influence industries beyond defence. 6GTC serves as a launchpad for economic growth, job creation, and industrial power, all the while contributing to international advancements in the defence sector.

Ongoing Collaborations and Projects

The significance of the 6G Test Centre isn't confined to the technologies tested and validated within its walls. It's amplified through the strategic partnerships it fosters. One essential collaboration is with VTT Technical Research Centre of Finland, a Finnish state-owned research and development organisation. Known for its extensive work in

applied research, VTT advances technological innovations across sectors, including telecommunications, defence, and sustainability.

A recent agreement between the University of Oulu and VTT brings VTT's expertise into the 6G Test Centre's operations, which reinforces the centre's research ecosystem and expands its capabilities.

The 6GTC is also part of a broader European Regional Development Fund (ERDF) project aimed at applying 6G research to the defence sector. The project runs until the end of 2026 and focuses on communication, ecosystem development, and project management.

These efforts are designed to ensure that 6GTC remains a leader in integrating cutting-edge academic research with practical, real-world commercial and military applications.

AI-RAN Alliance and Future Collaborations

University of Oulu's latest partnership, which is very beneficial also for 6G Test Centre — the Artificial Intelligence for Radio Access Networks (AI-RAN) Alliance — is a significant step toward integrating advanced AI and machine learning (ML) into modern communication networks. The AI-RAN Alliance is a coalition of global leaders, including Nokia, ARM, Ericsson, and NVIDIA, working to embed AI into the very framework of communication systems.

This alliance aims to create networks that do more than connect; they learn. By integrating AI-driven systems, networks will monitor themselves, anticipate demand, allocate resources, and even make decisions that previously required human intervention.

The benefits of this approach are clear: faster, more efficient networks capable of adapting to variable demands, whether in a city during peak hours or a mission-critical environment. AI and ML in Radio Access Networks are expected to revolutionise industrial automation, enhance healthcare responsiveness, and support military applications with unparalleled speed.

Currently, the 6G Test Centre is negotiating with its first clients on secure dual-use information sharing and energy resilience projects. By incorporating advanced energy management into AI-driven systems, these technologies could make crucial decisions in milliseconds—decisions upon which entire infrastructures may one day depend.

The 6G Test Centre serves as a launchpad for economic growth, job creation, and industrial power.

FROM 3G TO 6G

THREE DECADES OF EU MOBILE NETWORK RESEARCH AT THE UNIVERSITY OF OULU

The University of Oulu has played an important role in European mobile wireless research for nearly 30 years. We've partnered in all major European Commission-funded projects since 1994. In fact, alongside Nokia and Ericsson, we are one of only three organisations that have consistently contributed to foundational developments, from 3G in the FRAMES project, 4G in WINNER, 5G in METIS, to 6G in Hexa-X and Hexa-X-II. No other individual but Professor Latva-aho, Director of 6G Flagship, has been involved in all these projects across each generation, serving as the Principal Investigator for the University of Oulu in each.

With the support of the 6G Flagship programme and a growing team at the Centre for Wireless Communications, our reach has expanded further into the Horizon Europe programme, enabling us to drive ambitious, transformative projects. So far, 6G Flagship has been engaged in 20 HE pro-

jects, with 5 new initiatives launching in January 2025. For partners, this means access to Europe's most advanced wireless research network, ready to collaborate on solutions that will define the next era.

One of our unique assets for advancing research is the live, operator-grade private 5G Test Network (5GTN), now evolving towards a 6G-ready network with the latest commercial equipment as well as AI-driven RAN enablers using GPUs with exploiting of open RAN technologies and recently also introducing FR3 RF frontends. The 5GTN supports leading-edge technologies, including reflective intelligent surfaces, sub-THz transceivers, ISAC applications with multimodal sensing approaches and autonomous systems, enabling partners to tackle complex 6G challenges within a secure, robust environment. The 5GTN has been used in 15 HE projects during the last four

years (including 3 SNS JU stream-C projects), and new ones are starting.

A set of new projects will begin in 2025, leveraging the advanced capabilities of the 5GTN to explore critical 6G applications. These initiatives are designed to address specific challenges in areas such as vertical-specific communications, AI-driven functionalities, sustainable electricity grid unconnected base station, KPI/KVI definition and autonomous systems, creating actionable insights for our industry and research collaborators. Together with our partners, we are transforming advanced concepts into impactful, real-world solutions for next-generation wireless networks.

For those who collaborate with us, 6G Flagship offers a world-leading research ecosystem.

As 6G standardisation begins with 3GPP in 2025, 6G Flagship—nominated by Traficom Finland to ITU-R WP5D—will be actively involved in defining IMT-2030 requirements. With a robust pipeline of ongoing and future projects and a global network of partners, we are positioned to shape the standards that will guide the future of 6G. For those who collaborate with us, 6G Flagship offers a world-leading research ecosystem where pioneering projects evolve into test-ready solutions that set the pace for next-generation connectivity. Join us in building the future of wireless.

For partnership inquiries, contact:

Professor Matti Latva-aho
Director, 6G Flagship
matti.latva-aho@oulu.fi

Professor Ari Pouttu
Centre for Wireless Communications
ari.pouttu@oulu.fi

20
Horizon Europe Projects

5
New initiatives launching in January 2025

15
Horizon Europe projects using 5G Test Network

6G Flagship's Horizon Europe Projects

- SASPE
- 6GStart
- HEXA-X-II
- SLICES-PP
- VERGE
- TERA6G
- ADROIT6G
- DESIRE6G
- CENTRIC
- RIGOROUS
- SUPERIOT
- 6G-SANDBOX
- RE-ROUTE
- TERRAMETA
- EVOLVE
- 6G-XR
- CONVERGE
- EXACT-6G
- 6G-MUSICAL
- SUNRISE-6G
- 6G-INTENSE
- INSTINCT
- ACMod
- METACITIES
- NEUROCLIMA
- 6G-VERSUS
- 6GARROW



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Deep Reinforcement Learning for Virtualized Radio Access Networks Orchestration



MUHAMMAD YASIR JAVED

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PRANEETH SUSARLA

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LEATILE MARATA

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CONSTANTINO ÁLVAREZ CASADO

Biosignal Extraction and Analysis from Remote Video: Towards Real-world Implementation and Diagnosis Support



JEAN MICHEL DE SOUZA SANT'ANA

Increasing the Performance of Low Power Wide Area Networks through Replication, Coding, and Non-Orthogonal Schemes



SNEHAL BHAYANI

Sparse resultant-based methods with their applications to generalized cameras

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- PHY - Physical Layer and Fundamentals
- WOS – Wireless, Optical and Satellite Networks
- NET – Network Softwarisation
- AIU – Applications, IoT, Use cases
- OPE – Operational & Experimental Insights
- AI4C – AI/ML Solutions for Communications
- SAQ – Security Aspects and Quantum Communications
- CMA – Components, Microelectronics, Photonics & Antennas
- NVS – Next-Generation Visions & Sustainability

All calls and full list of topics:

eucnc.eu

Deadlines:

Full Papers

24 Jan 2025 Full paper submission
31 Mar 2025 Notification of acceptance
11 Apr 2025 Final paper submission

Tutorials

24 Jan 2025 Tutorial proposal submission
7 Mar 2025 Notification of acceptance
25 Apr 2025 Tutorial presentation submission

Posters

7 Mar 2025 Extended Abstract submission
31 Mar 2025 Notification of acceptance
11 Apr 2025 Extended Abstract final version

Workshops

24 Jan 2025 Workshop proposal submission
7 Mar 2025 Notification of acceptance
11 Apr 2025 Workshop final paper submission

Special Sessions

24 Jan 2025 Special Session proposal submission
7 Mar 2025 Notification of acceptance
11 Apr 2025 Special Session paper submission

Exhibition & Demos

28 Mar 2025 Exhibition and Demonstration proposal submission
14 Apr 2025 Notification of acceptance

We look forward to your submissions and proposals!

Contacts:

Hanna Bogucka, Poznań University of Technology, Poland, Local Organiser and Technical Programme Co-Chair

Pawel Kryszkiewicz, Poznań University of Technology, Poland, Local Organiser and Technical Programme Co-Chair

Ari Pouttu, University of Oulu – 6G Flagship, Finland, Technical Programme Co-Chair

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6G Talks

6G Talks is a curated collection of videos diving deep into the future of 6G technology, where an array of respected speakers explore pivotal aspects of 6G.



6G Symposium 2024 playlist

Explore cutting-edge insights into 6G technology from the 2024 6G Symposium hosted by 6G World, 6G Flagship, and Business Finland.



6G Demo series

6G Demo series highlight 6G Flagship's innovation in four domains: 6G radio, 6G optical communication, 6G edge, and 6G verticals.



6G Blog

Launching in January 2025.



6gflagship.com/tag/blog

INNOVATION UNDER THE NORTHERN LIGHTS

WHY CHOOSE FINLAND, OULU AND THE 6G FLAGSHIP?



Happiest Country in the World

Finland has been ranked the world's happiest country for seven years in a row. It is a land where world-class research and innovation thrive; where life is safe and easy. The crime rate is low, the social safety net is strong, the air is clean and pollution-free, and the water is safe to drink straight from the tap.

Finland has excellent public services and a strong economy. Children attend school free, and municipal childcare and universal healthcare are available to all residents. 6G Flagship employees receive occupational healthcare. And the University of Oulu has a special Spouse Programme, which helps the whole family to adjust to the Finnish society.



High Tech Up North

The city of Oulu is the home of 6G Flagship. The city is located in northern Finland, which is widely regarded as one of the world's safest and most stable regions. With only 250 000 residents, Oulu is quite compact, but it is also very smart! A whopping one third of the residents has a university degree.

Oulu is a major high-tech hub, with 50 years of experience in ICT and related operations – technologies used by almost 3 billion people every day. The university of Oulu has a long history with telecommunications technology, and particularly wireless telecommunications research. It has been a strength of the university since the 1st G in the 1980s.

The big pro of Oulu is an optimal life-work balance, I think it's one of the best - better than Stockholm, better than Helsinki. Why? Life is so easy and simple. You don't have to commute. My gym, my supermarket, my house, my office are within half an hour's walk. I don't have to drive, I just bike to work. To me this is unbeatable.

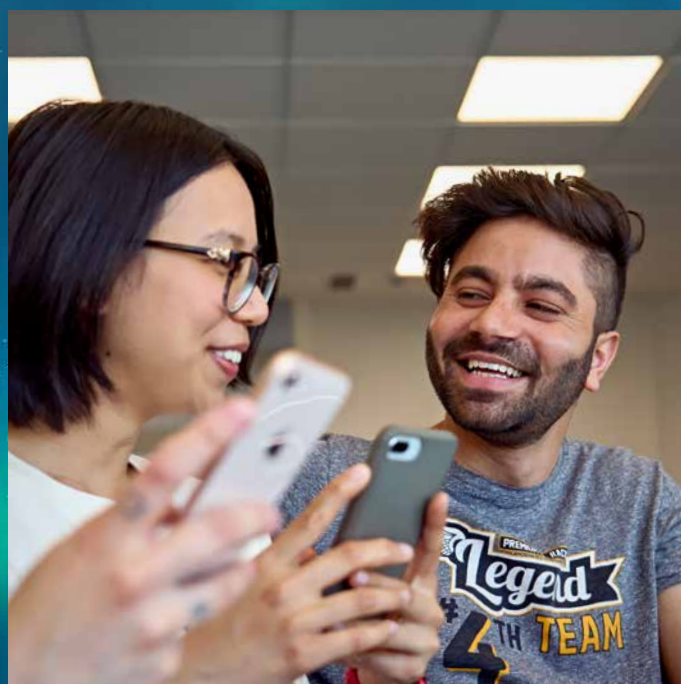
**Professor Mehdi Bennis,
Highly Cited Researcher for five consecutive years**



Compact City – World-class Research

The university is home to the world's first 6G research programme, 6G Flagship, where top innovators and leading experts work passionately to build a data-driven, sustainable future society.

Professor **Mehdi Bennis**, one of the world's most highly cited researchers and a Professor at 6G Flagship, summed Oulu's appeal to world-class researchers perfectly: "The big pro of Oulu is an optimal life-work balance, I think it's one of the best - better than Stockholm, better than Helsinki. Why? Life is so easy and simple. You don't have to commute. My gym, my supermarket, my house, my office are within half an hour's walk. I don't have to drive, I just bike to work. To me this is unbeatable."



Join the crew of trailblazers in 6G

6G Flagship is continually looking for new talents. We offer positions for doctoral and post-doctoral researchers in four research areas:

- **Wireless Connectivity**
- **Devices and Circuit Technology**
- **Distributed Intelligence**
- **Human-centric Wireless Services**

Are you the trailblazer we are looking for? Apply to one of our four research areas and help us shape the future of wireless communication!



Read more and apply:

6gflagship.com/careers

6G FLAGSHIP IN NUMBERS

MAY 2018 - OCTOBER 2024

Staff

577
experts in 2024

54
Nationalities

67% International



Company Collaboration

447
Company collaborators

47% International



Doctoral Degrees

141
Doctoral degrees

329 854
Doctoral thesis downloads*

Investments & Funding

498
Research projects (external funding)

124
Companies investing in research portfolio

Publications

3 601

Peer-reviewed publications /
Journal and conference articles

76,5 % Joint publications with collaborators



67% Joint international publications



12,1 % Joint publications with companies



6G White Papers

165 215

2019 White Paper downloads*

923 716

2020 White Papers downloads*

1 088 931

Total White Paper downloads*

6G Waves

337 204

Total downloads*

* Number of downloads in University of Oulu repositories jultika.oulu.fi and oulurepo.oulu.fi

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