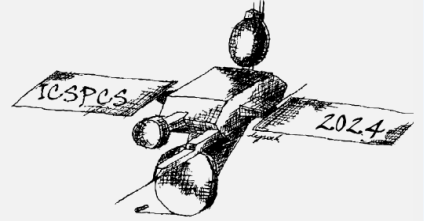


Standardization Steps for FAS in 6G Networks

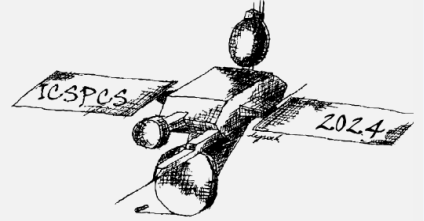
- Paulo R. de Moura, Anatel (Telecom Regulator in Brazil) and University of Brasília (PhD Student), Brazil
- Dr. Alexandre C. Moraes, Anatel (Telecom Regulator in Brazil), Brazil
- Prof. Hugerles S. Silva, Dept. Elect. Eng., University of Brasília, Brazil
- Prof. Ugo S. Dias, Dept. Elect. Eng., University of Brasília (UnB), Brazil
- Prof. Felipe A. P. de Figueiredo, National Institute of Telecommunications (Inatel), Brazil
- Prof. Rausley A. A. de Souza, National Institute of Telecommunications (Inatel), Brazil and University of Sydney, Australia



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... context of this paper



What makes a technology succeed ?

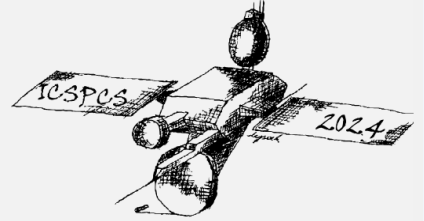
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- Technical quality of the technology
- Research effort
- Investments
- Benefits for users
- Standardization serves as the cohesive element that integrates all components.



Agenda

- A Brief Survey on FAS (Fluid Antenna System)
- Challenges for FAS Standardization
 - The Policy-Making Process
 - The Academic Rally and Steps for FAS Standardization
- Discussion
 - Benefits and Challenges of Fluid Antenna Systems for 6G Networks
 - The Role of Standardization in Accelerating FAS Deployment
 - Opportunities for FAS in Advanced 6G Use Cases
 - Encouraging Collaboration Between Industry and Standardization Bodies
- Conclusion



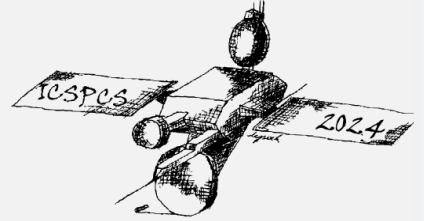
Brief Survey on FAS

- *“Fluid antenna may represent any antennas equipped with software-controllable fluidic structure, and which can alter their shape and position to reconfigure the polarisation, operating frequency, radiation pattern and other antenna and it may include designs involving no fluidic materials if they can mimic the agility performance metrics”*

K.-K. Wong, K.-F. Tong, Y. Zhang, and Z. Zhongbin, “Fluid antenna system for 6G: When Bruce Lee inspires wireless communications,” *Electron. Lett.*, vol. 56, no. 24, pp. 1288–1290, Nov. 2020.

- MIMO systems have the $\lambda/2$ physical space limitation due to correlation between two antennas which follows the Jake’s model, and hardware cost of RF chain for each antenna

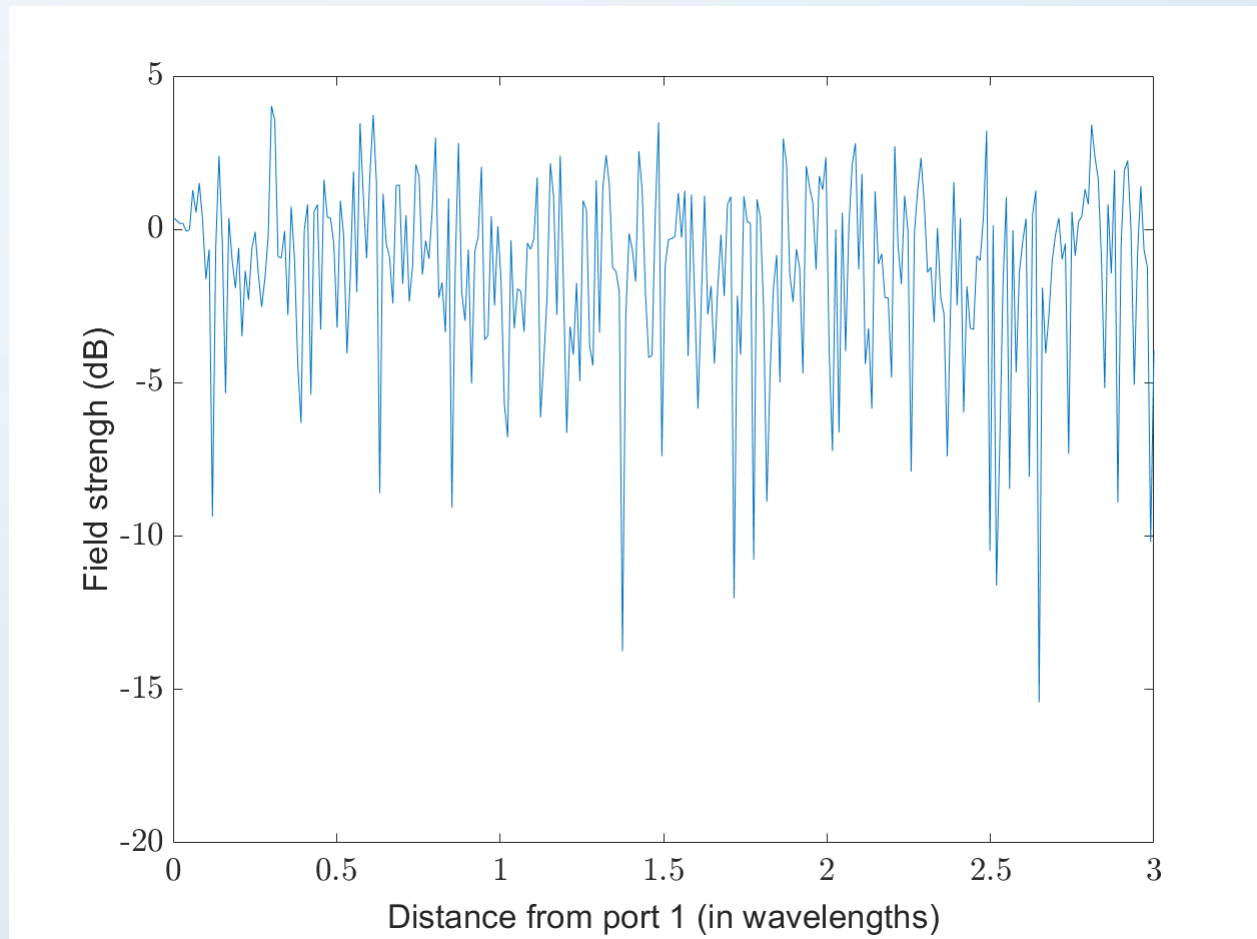
K.-K. Wong, A. Shojaeifard, K.-F. Tong, and Y. Zhang, “Fluid antenna systems,” *IEEE Trans. Wireless Commun.*, vol. 20, no. 3, pp. 1950–1962, Mar. 2021

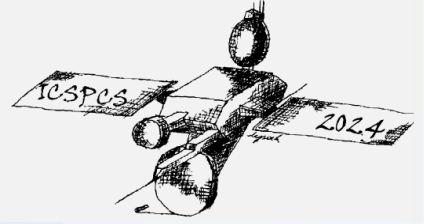


Envelop of a typical received signal in a multipath fading environment

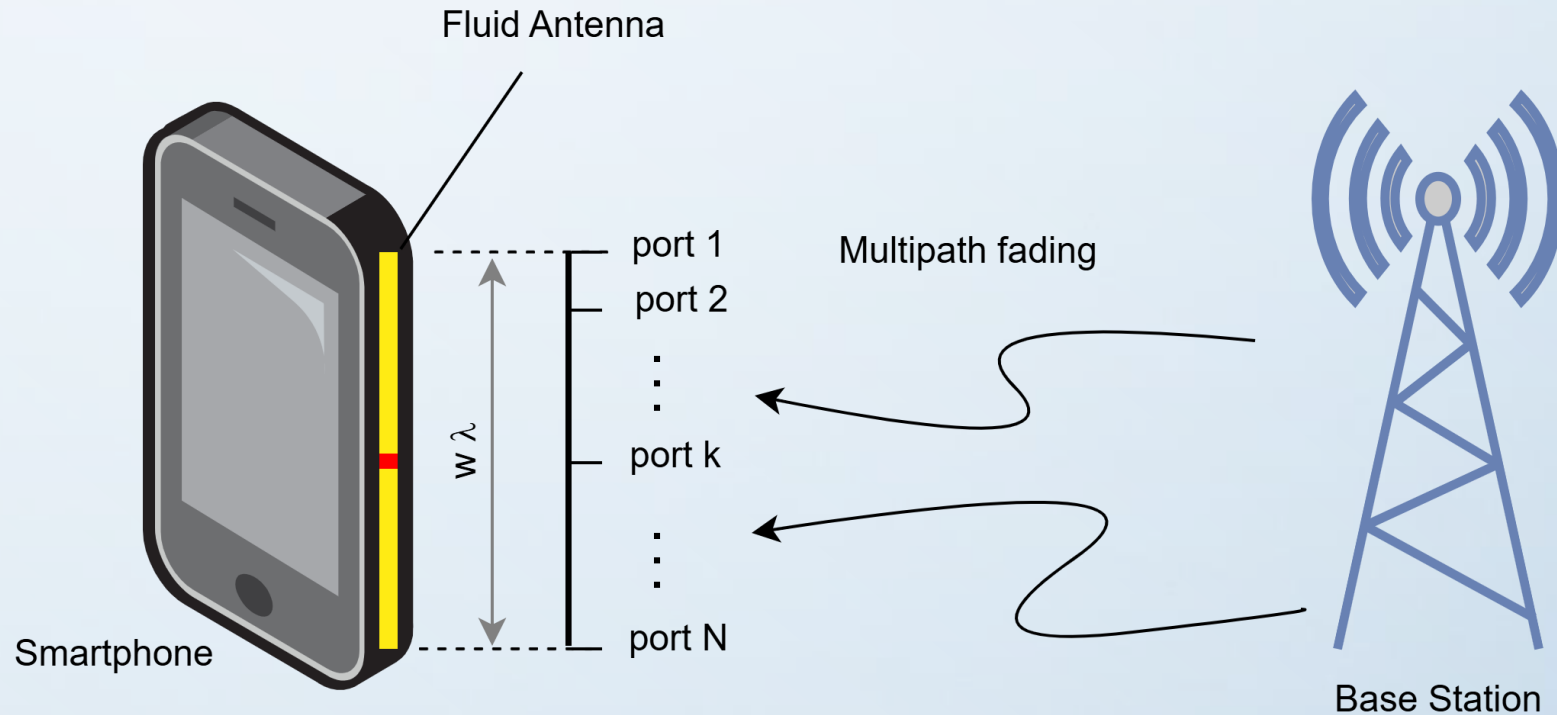
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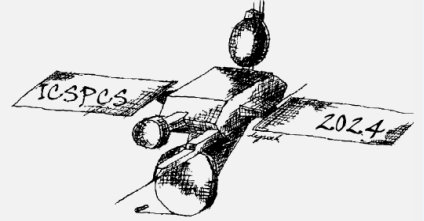
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Fluid Antenna System (FAS)





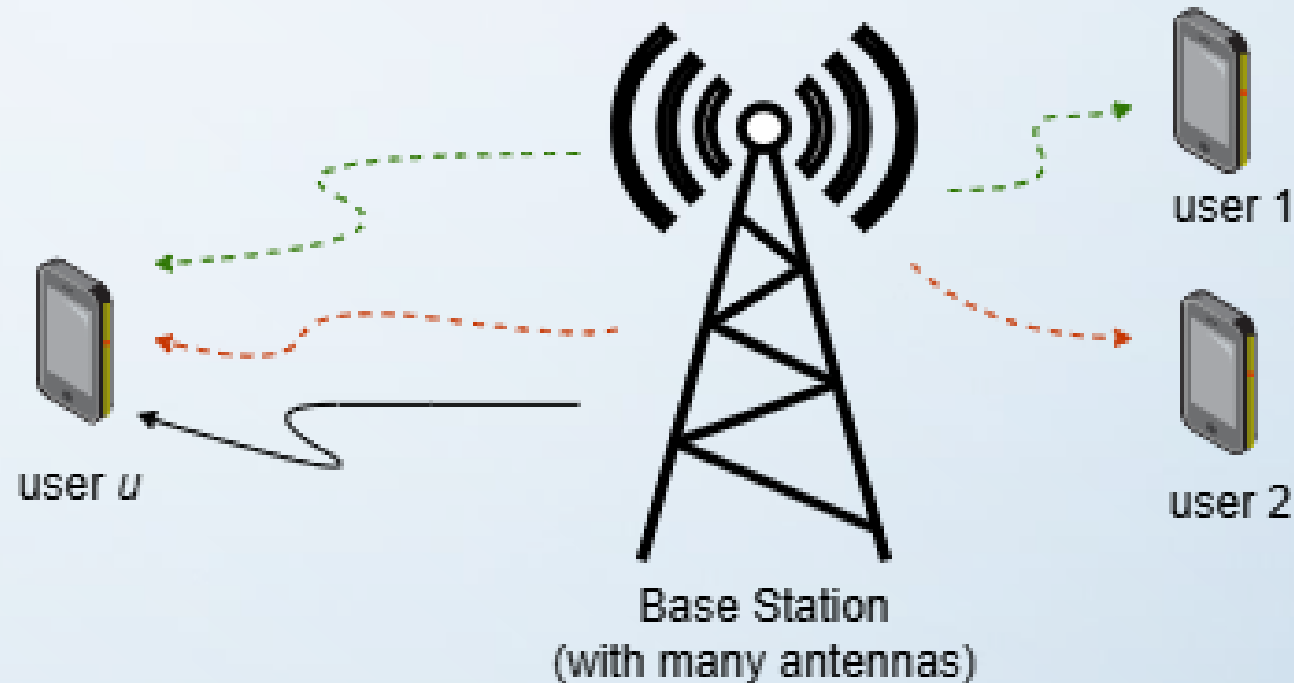
Fluid Antenna Multiple Access (FAMA)

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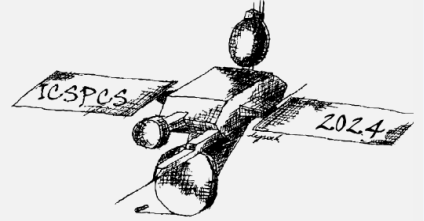
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- signal to user u
- - - signal to user 1, interference to user u
- - - signal to user 2, interference to user u

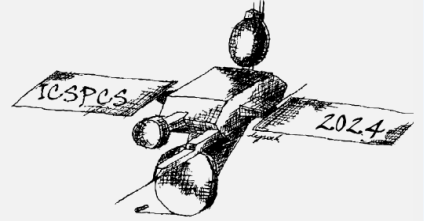


Many articles in the literature

Some references

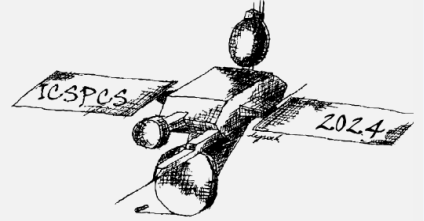
- (...)
- W. K. New et al., "A Tutorial on Fluid Antenna System for 6G Networks: Encompassing Communication Theory, Optimization Methods and Hardware Designs," arXiv preprint n° 2407.03449, July 2024.
- W. K. New et al., "A Tutorial on Fluid Antenna System for 6G Networks: Encompassing Communication Theory, Optimization Methods and Hardware Designs," IEEE Communications Surveys & Tutorials (Early Access), Nov. 2024.

Academy has been making a great effort to understand the behavior of FAS.



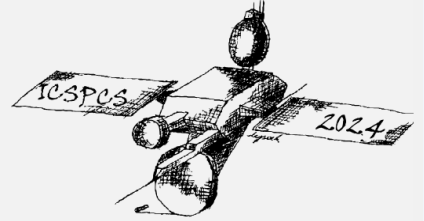
Policy-Making Process

- It is a good momentum to start a discussion on FAS in international SDOs (standards development organizations)
- Main actors: ITU, 3GPP, ETSI, IEEE SA, Open RAN Alliance
- ITU (International Telecommunication Union)
 - Advantages: global recognition, inclusivity, political neutrality, integration into national regulations, legal standing in many countries
 - Drawbacks: slow process, bureaucratic delays, focus on governmental interests, geopolitical influence
- Techno-diplomacy



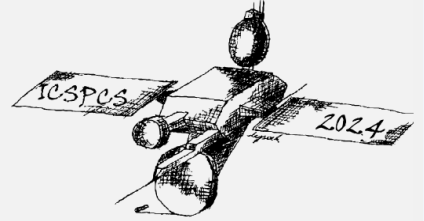
Policy-Making Process

- ITU divisions:
 - General Secretariat
 - Radiocommunication Sector (ITU-R)
 - Telecommunication Standardization Sector (ITU-T)
 - Telecommunication Development Sector (ITU-D)
- ITU has study cycles of 4 years between main conferences
 - Plenipotentiary Conference (PP)
 - World Radiocommunication Conference (WRC)
 - World Telecommunication Standardization Assembly (WTSA)
 - World Telecommunication Development Conference (WTDC)



Policy-Making Process

- ITU's work on International Mobile Telecommunications (IMT)
 - Study Group 5 — Terrestrial Services (SG 5)
 - Working Party 5D (WP 5D)
 - spectrum allocation to the mobile service (MS), with the possibility of identifying specific bands for the IMT application,
 - evaluation of candidate technologies to a given IMT standard, and
 - definition of the expected characteristics of any given IMT generation.
- Report ITU-R M.2516-0 *Future technology trends of terrestrial International Mobile Telecommunications systems towards 2030 and beyond*, Nov. 2022.
 - Fluid Antenna System (FAS) was not mentioned in the report



The Academic Rally and Steps for FAS Standardization

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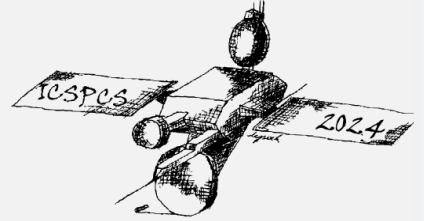
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- When a technology is “ahead of its time,” it can be expedited through appropriate standardization.

IEEE Future Networks Technical Community (FNTC), “Standardization Building Blocks,” in *IEEE International Network Generations Roadmap (INGR)*, New York, NY, USA, 2023.

- FAS is highly disruptive, but It is not on the radar of SDOs
- It is a long road to standardization for a given technology
- The first step: include FAS as a study item on an SDO agenda
 - ITU WP 5D: evaluate FAS as a possible IMT-2030 candidate
 - 3GPP: consider FAS in preparatory work



The Academic Rally and Steps for FAS Standardization

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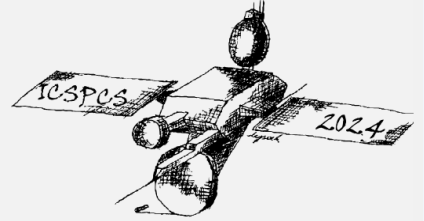
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- Short path: consider FAS in UE (user equipment) rather BS (base station)
- FAS synergy with other technologies: artificial intelligence (AI), full-duplex (FD) communications, green communications, integrated sensing and communications (ISAC), next generation multiple access (NGMA), non-terrestrial networks (NTN), physical layer security (PLS), RIS, terahertz (THz) communications and extremely large-scale (XL)-MIMO or continuous aperture (CAP)-MIMO.

W. K. New et al., "A Tutorial on Fluid Antenna System for 6G Networks: Encompassing Communication Theory, Optimization Methods and Hardware Designs"

- 3GPP Working Plan: Release 20 will address 6G, first Technical Specification Group (TSG)-wide 6G workshop planned for March 2025
- **FAS is not a spectrum-demanding technology**



The Academic Rally and Steps for FAS Standardization

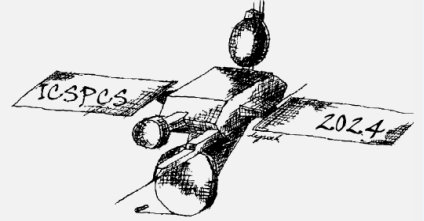
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- Possible drawback: security of the liquid, in the case of fluid leakage
- Academics can contribute to FAS development by participating in their countries' standardization processes
- If discussions about FAS start soon in the ITU, the time needed to make FAS a standard could be reduced



Benefits and Challenges of FAS for 6G Networks

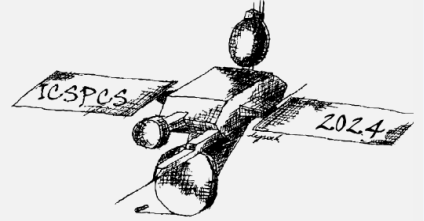
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- Benefits: adaptability to dynamic wireless conditions
- Challenges
 - Need of advanced materials
 - Mutual coupling for FAS based on pixels
 - Switching time
 - Safety for users, in case fluid leakage

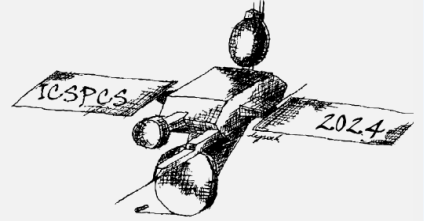


The Role of Standardization in Accelerating FAS Deployment

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- Standardization could streamline the integration of FAS in commercial 6G devices
- Common guidelines would facilitate the regulatory approvals required for FAS-enabled devices in different countries.
- Drive innovation by encouraging industry wide collaboration, leading to improvements in fluid antenna designs, materials, and associated algorithms



Opportunities for FAS in Advanced 6G Use Cases

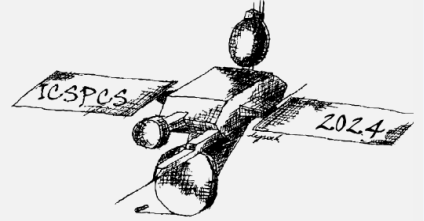
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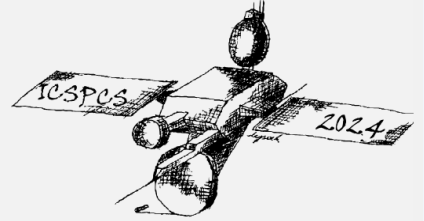
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- Usage scenarios for 6G, Recommendation ITU-R M.2160-0:
 - Immersive communication;
 - Hyper reliable, low-latency communication (HRLLC);
 - Massive communication;
 - Artificial intelligence (AI) and communication;
 - Ubiquitous connectivity;
 - Integrated sensing and communication (ISAC).
- FAS can help support these use cases, but require close collaboration between industry, academia, and standards bodies to refine and validate FAS technology for each application context.



Encouraging Collaboration between Industry and Standardization Bodies

- Collaborative initiatives involving academia, industry and SDOs are essential.
- Specialized working groups on FAS in ITU and 3GPP. Focused discussions on FAS requirements, technical challenges, and performance metrics.
- Workshops and research programs
- Standards could reduce risk investments for manufacturers and network providers, enabling faster and broader deployment.



Conclusion

- FAS technology is in the early stages, but it is a good momentum to start discussing it in international SDOs
- It can be treated as a separate technology or take a “ride” with other antenna technologies, such as MIMO, or new materials for telecommunications, such as RIS.
- The academic community should actively participate in standardization study groups to achieve this goal, especially in ITU and 3GPP.

“A small article by a research team marks a significant step for a FAS standard”

17th International Conference on Signal Processing and Communication Systems – ICSPCS 2024

16-18 December 2024, Surfers Paradise, Gold Coast, Australia

Enjoy your stay in Gold Coast!

