Introduction to the 6G Research @ Essex

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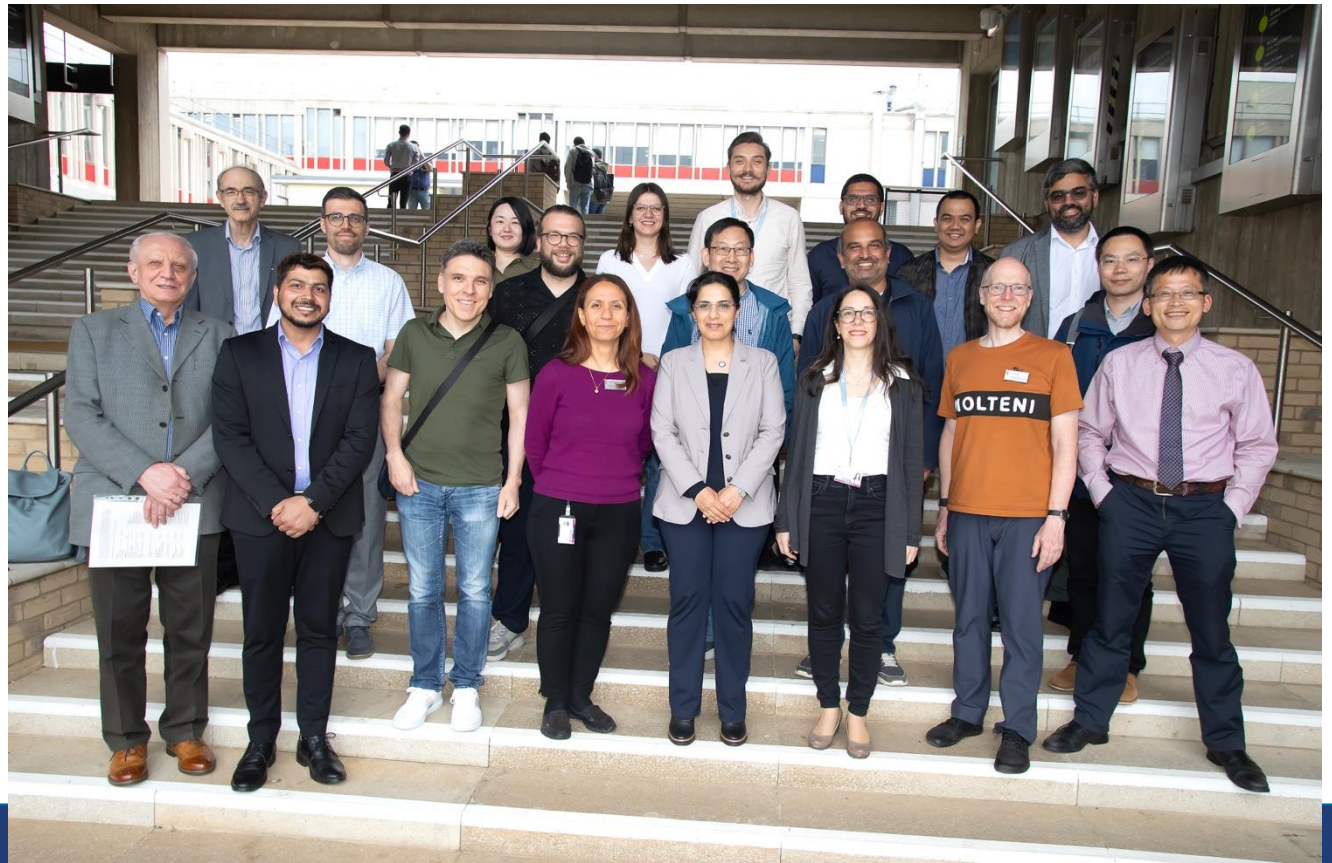
Comm Group at a Glance

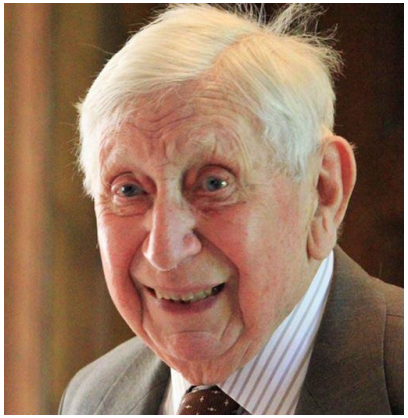
- Our vision: **Connecting a Sustainable Future**
- Group's identity & history
  - One of the oldest groups in the CSEE back to 1970s;
  - Our group **covers expertise on all** communications layers, from Physical Layer to Application Layer. 22 Academics including 5 female;
  - 1 IEEE Fellow, 2 IEEE Life Fellows, 5 IET Fellows.
  - Group Lead: Prof Leila Musavian



Some Past Key Members

Prof. Mohammad Ghanbari – IEEE Life fellow; **Layered Video coding** used in all standard video codecs; A.H. Reeves prize; Rayleigh prize;

Prof. Brian Ridley – Fellow of the Royal Society; Recipient of **Dirac Medal**; Author of the Ridley-Watkins-Hilsum Effect.

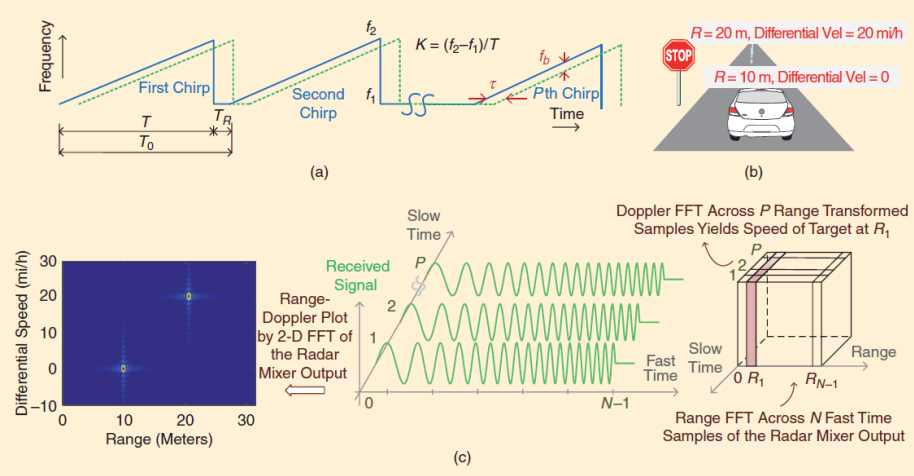


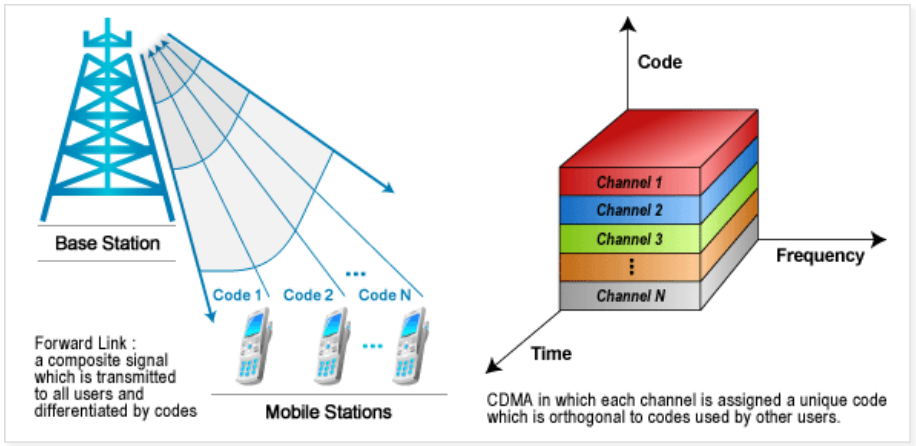
Professor Ken Cattermole – Founding Chair in Telecommunications
Recipient of IET **JJ Thompson Medal**

Houlin Zhao - MSc in Telematics, 1985, **Secretary-General** of the ITU from 2015 to 2022

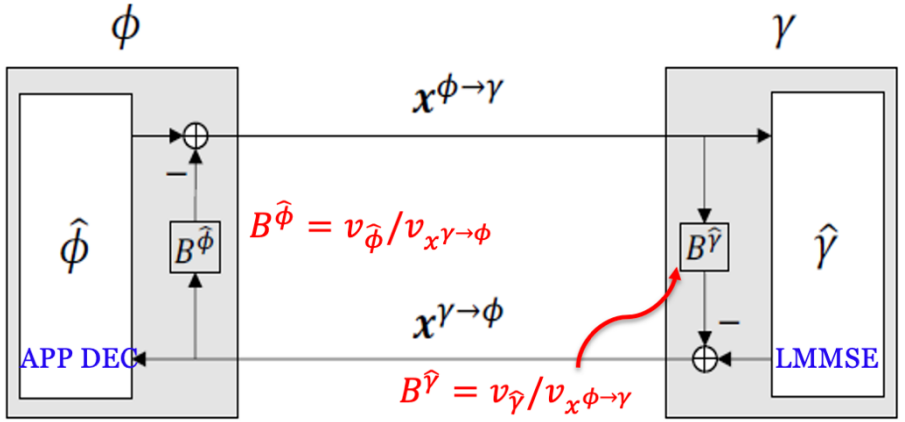
Research Focus (1/2): Air Interface for 6G

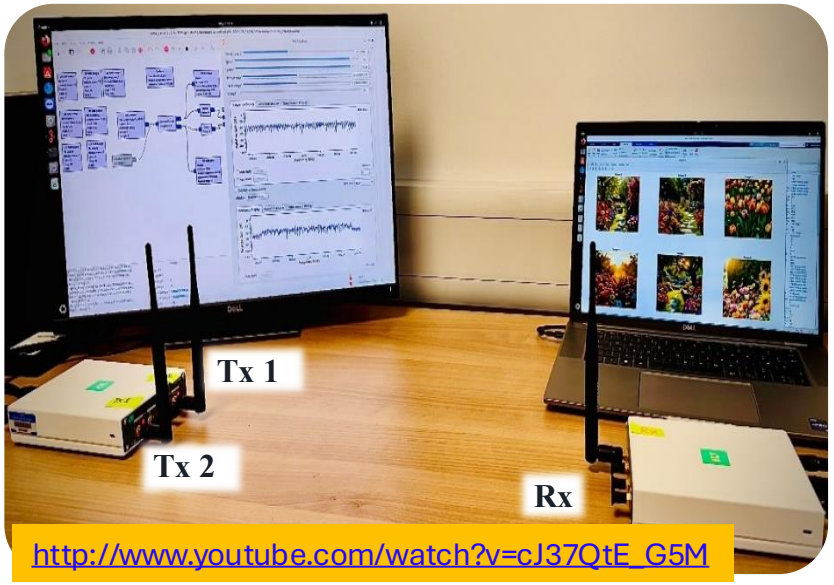
Comm/Radar Signal Design (e,g, sequences, waveforms, codebooks, channel codes)





Efficient/reliable Receiver Processing Algorithms





http://www.youtube.com/watch?v=cJ37QtE_G5M

Multiple Access Techniques (e.g., CD-NOMA & RSMA)

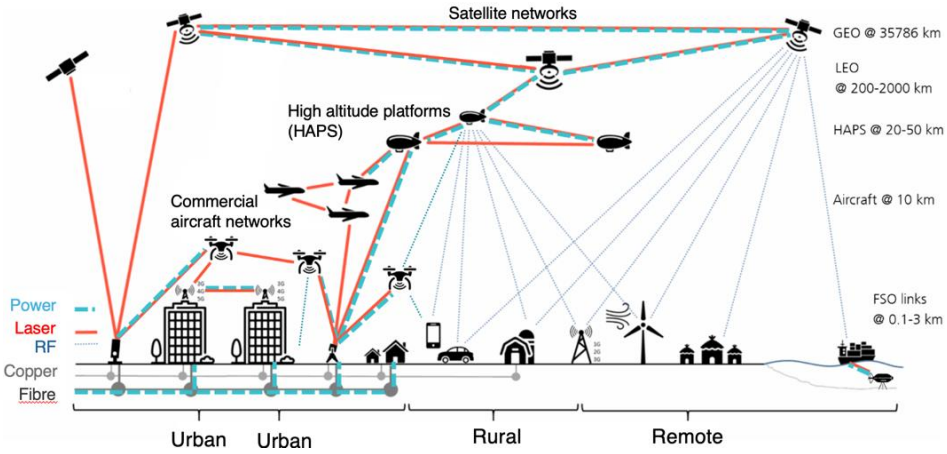
Proof-of-Concept Hardware Prototyping

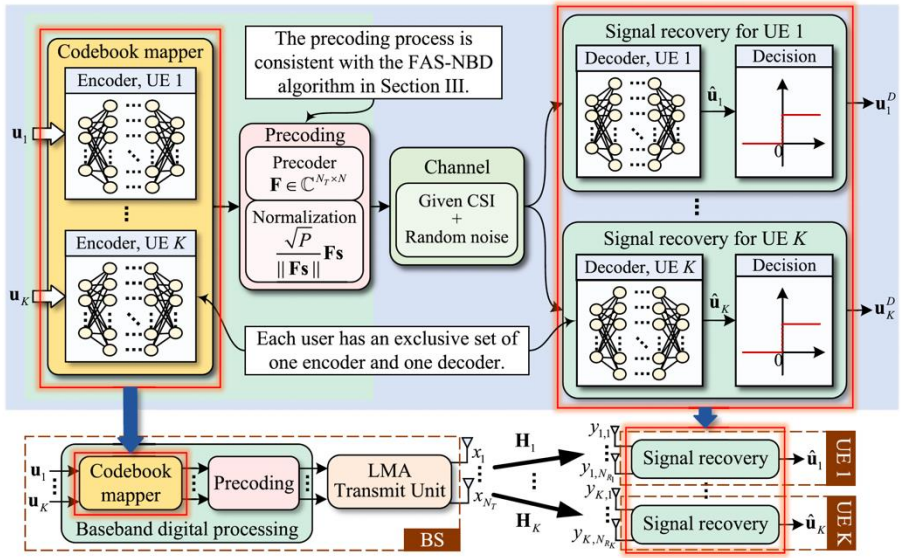
Research Focus (2/2): Air Interface for 6G

Integrated Communication, Sensing and Localization

Mission Critical Communication (i.e., URLLC)

Non-Terrestrial Networks (NTN)





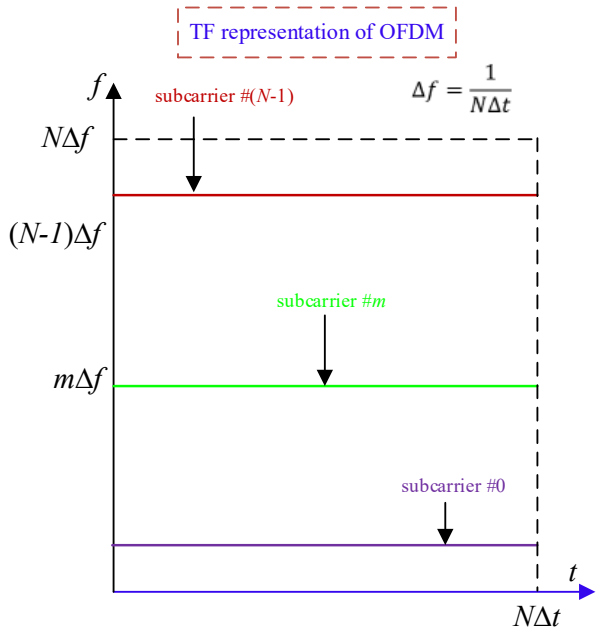
Machine Learning for Comm. & Signal Processing

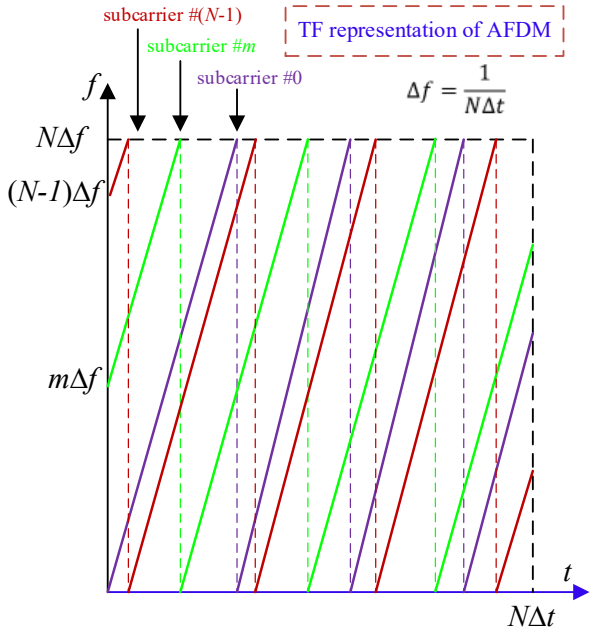
Ongoing EPSRC Projects: waveforms, sequences, and multiple access

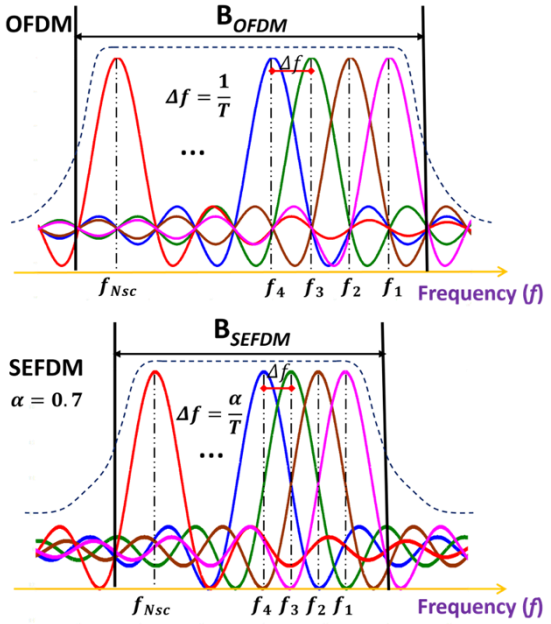
6G Lab Essex

1. **A Novel and Legacy Compatible Doppler Resilient Waveform Design for 6G (Legend6G) – EPSRC TITAN project**
2. **Integrating Rate-Splitting and SCMA for Efficient 6G Massive Access (RETHIN6G) – EPSRC HASC project with Imperial College**
3. **Affine Frequency Division Multiplexing for 6G Communications and Sensing (REVOL6G) – EPSRC TITAN project with Southampton and UCL**
   - **Doppler resilient multicarrier waveforms**
4. **New Signal Design and Processing for Future Vehicular Communications (DRIVE) – EPSRC New Investigator Award project**
   - **High mobility machine-type communications**
5. **Evolving Sequences for Beyond-5G Machine-Type Communications (SORT) – EPSRC International Collaboration project with NTU Singapore, U Bergen, and SWJTU**
   - **Doppler resilient Sequences for URLLC, ISAC and mMTC**
6. **Pervasive Wireless Intelligence Beyond the Generations (PerCom) – EPSRC Standard Grant with Southampton and Loughborough**
   - **Intelligent Integrated Satellite & Terrestrial Networks**

Doppler-Resilient 6G-NTN Waveforms (e.g., AFDM, OTFS)







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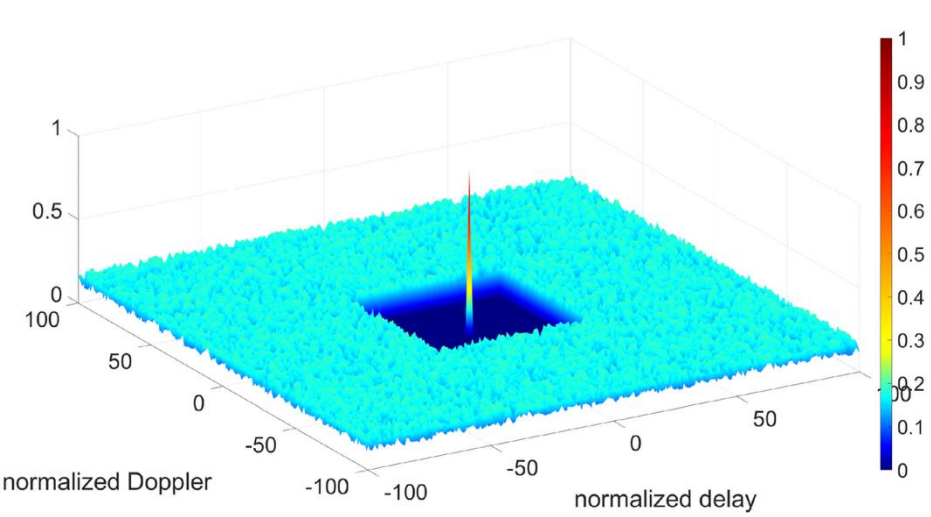
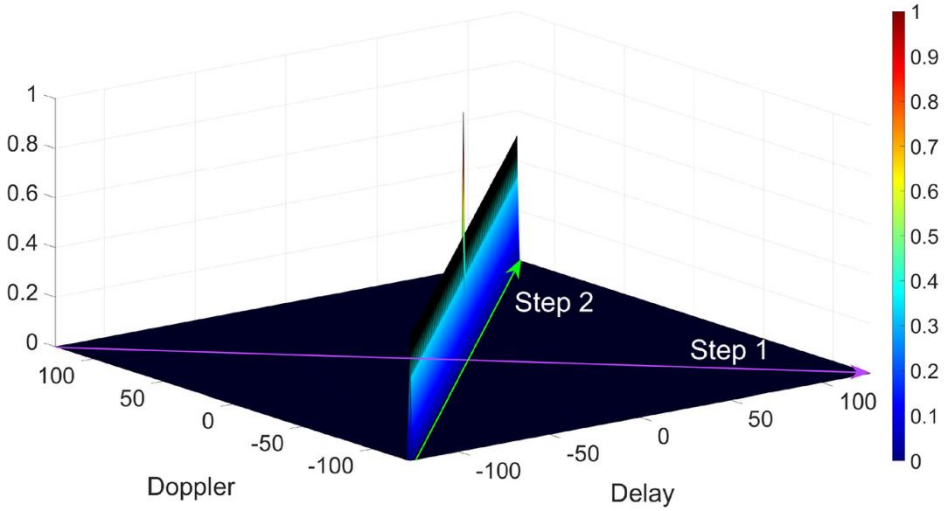
- Q. Luo, **Z. Liu**, et al, ``AFDM-SCMA: A promising waveform for massive connectivity over high mobility channels," ***IEEE TWC***, vol. 23, no. 10, pp. 14421-14436, Oct. 2024. [online]: https://arxiv.org/abs/2312.11302
- C. Bai, **Z. Liu**, et al, "Orthogonal Chirp Delay-Doppler Division Multiplexing Modulation," in ***IEEE VTC-Fall'2025***, 19-22 October 2025, Chengdu, China.
- Huang, **Liu**, et al, "Designing Low-PAPR Waveform for OFDM-based RadCom Systems," ***IEEE TWC***., Sep 2022. [online]: https://repository.essex.ac.uk/34563/.

Doppler-Resilient Sequences for 6G Comm and Sensing





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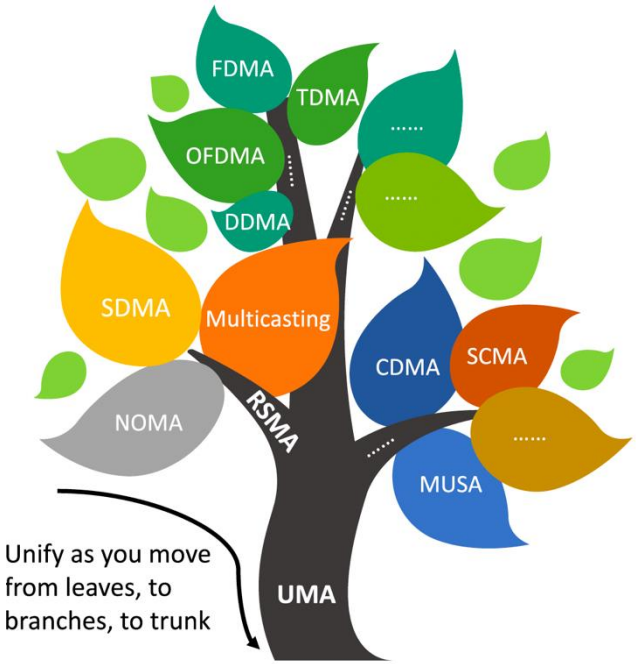
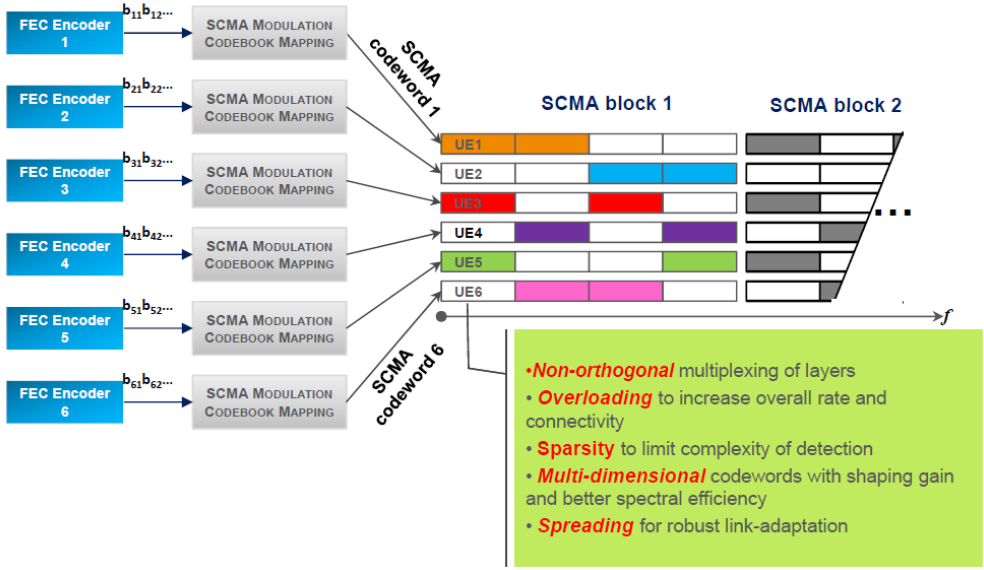
- L. Tian, **Z. Liu**, et al, "Asymptotically Optimal Sequence Sets with Low/Zero Ambiguity Zone Properties," ***IEEE Trans. Information Theory***, March 2025. [Online]: https://arxiv.org/abs/2401.00683.
- B. Zhou, **Z. Liu**, et al, "Doppler Resilient Complementary Sequences: Theoretical Bounds and Optimal Constructions," ***IEEE Trans. Information Theory***, May 2025.

Code-Domain NOMA for 6G Massive Access





- Luo, **Liu**, et al, "Enhancing signal space diversity for SCMA over Rayleigh fading channels," ***IEEE TWC***, 2023.
- Gui, **Liu**, et al, "Novel power-imbalanced dense codebooks for reliable multiplexing in Nakagami channels," ***IEEE WCL***, 2023. [online]: https://arxiv.org/abs/2309.03806
- Luo, **Liu**, et al, "A design of low-projection SCMA codebooks for ultra-low decoding complexity in downlink IoT networks," **IEEE TWC**, 2022. [online]: https://arxiv.org/abs/2208.03118
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Our Strong National Research Networks

6G Lab Essex

TITAN
NETWORK OF NETWORKS HUB
PLATFORM DRIVING THE ULTIMATE CONNECTIVITY

HASC
HUB IN ALL-SPECTRUM CONNECTIVITY

UK Hub on Network of Networks

JOINER

CHEDDAR

UCL

University of Southampton

IMPERIAL

UNIVERSITY OF SURREY

Our Strong Collaborations with the Industry

6G Lab Essex

https://isac.committes.comsoc.org

VIAVI Solutions

SAMSUNG

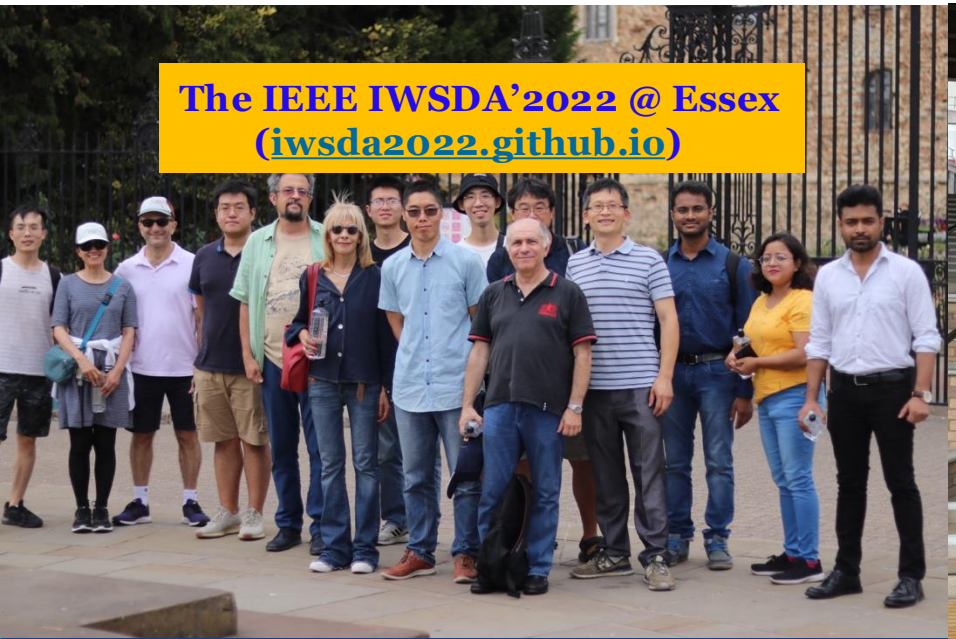
ACCELERCOMM
SUPERCHARGED WIRELESS

DLR

BT

Tyndall
National Institute
Institiúid Náisiúnta

Events that We Feel Proud



6G Technologies that Essex can offer

- **Next Generation Multiple Access**
  - SCMA, RSMA, IDMA, PDMA, Grant-free NOMA
- **Waveforms for 6G Networks**
  - AFDM, OCDM, OTFS, ODDM, OFDM
- **Integrated Satellite-Terrestrial Networks (Integration of TN and NTN)**
  - Resource allocation, interference management, waveforms, random access…
- **Integrated Sensing, Localization, and Communications**
  - Waveform assisted ISAC, PAPR reduction, ISAC sequences with good correlation and ambiguity properties.
- **Connected Autonomous Vehicles**
  - V2X networking, resource allocation, high mobility communications

University of Essex

Thank You!

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