FirstTo6G

Introduction and general overview

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FirstTo6G

Abstract

- **Focus**: Fourier-Domain Transceiver (TRx) solutions for 6G wireless communication.
- **Main Objective**: Enable widespread realization of 6G by improving radio hardware.
- **DAC/ADC Technologies**: A novel DAC and ADC technologies for enhanced performance.
- **RF Frontend**: Advancements in RF frontend technologies, essential for 6G communication, particularly for frequencies above 100 GHz.
- **Key Goals and Strategies**:
  - **Bandwidth and Efficiency**: Higher modulation bandwidths and improved energy efficiency.
  - **Form Factor and Cost**: Ensure suitable form factors for mobile and base station applications and maintain affordability.
  - **Technology Integration**: Integrate data converters and frontend technologies on a single chip for the V-band solution; for the D-band solution, integration involves multiple chips.

FirstTo6G – Partners

sivers SEMICONDUCTORS	ARGO SEMI	INCIRT	RWTH AACHEN UNIVERSITY HFE	YEDİTEPE ÜNİVERSİTESİ	SCIPROM Science, Management & Communication
• SME in Sweden • Extensive experience in RFIC design • Offers a product range of mmWave RFICs and BFICs for Licensed and Unlicensed 5G, RF Modules and Evaluation Kits (EVK) • **Role in FirstTo6G**: mm-wave frontends	• SME in Greece • Strong background in microelectronic engineering. • **Role in FirstTo6G**: Plays a key role in developing wideband mm-wave frontends	• SME in Germany • **Coordinator of FirstTo6G**: Manages strategic and operational aspects of the project. • Extensive experience in RFIC design • Innovative data converter approach • Specializes in 6G communications and related fields.	• University in Germany • Expertise in high-frequency circuit design and technology • Novel design algorithms for HF-amplifier and circuit design. • **Role in FirstTo6G Project**: D-Band components.	• University in Turkey • Expertise and resources for development of 6G technologies • Expertise in high-frequency circuit design and technology • **Role in FirstTo6G Project**: D-Band components.	• Project management company based in Switzerland • **Role in FirstTo6G Project**: Associated partner, Project management, communication and dissemination.

Background and motivation

- Rapid data growth
  - Mobile data usage at 12 GB, growing >20% annually.
- Enhancing Data Rates
  - Wide bandwidth spectrum use.
- Challenge: Limited spectrum availability below 57 GHz;
  - D-band (110-170 GHz) and V-band (40-75 GHz) identified as key candidates for 6G.
- 6G Hardware does not exist
  - Current technologies fall short in meeting 6G requirements due to limitations in signal quality, power consumption, and form factors.
- FirstTo6G Goals: Develop innovative DAC/ADC and RF frontend technologies to address these challenges.

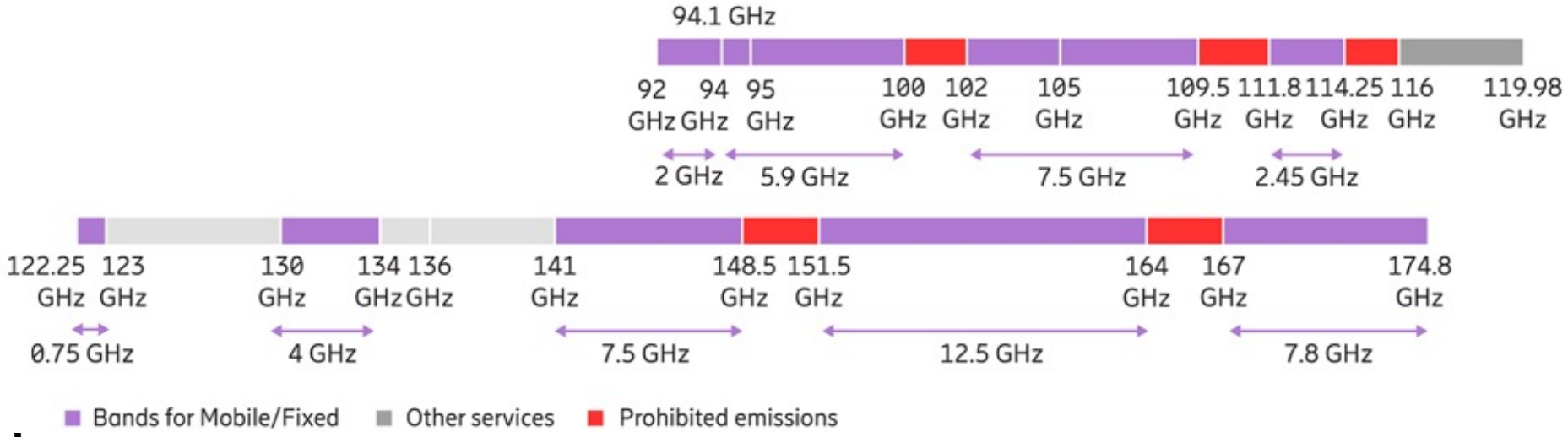


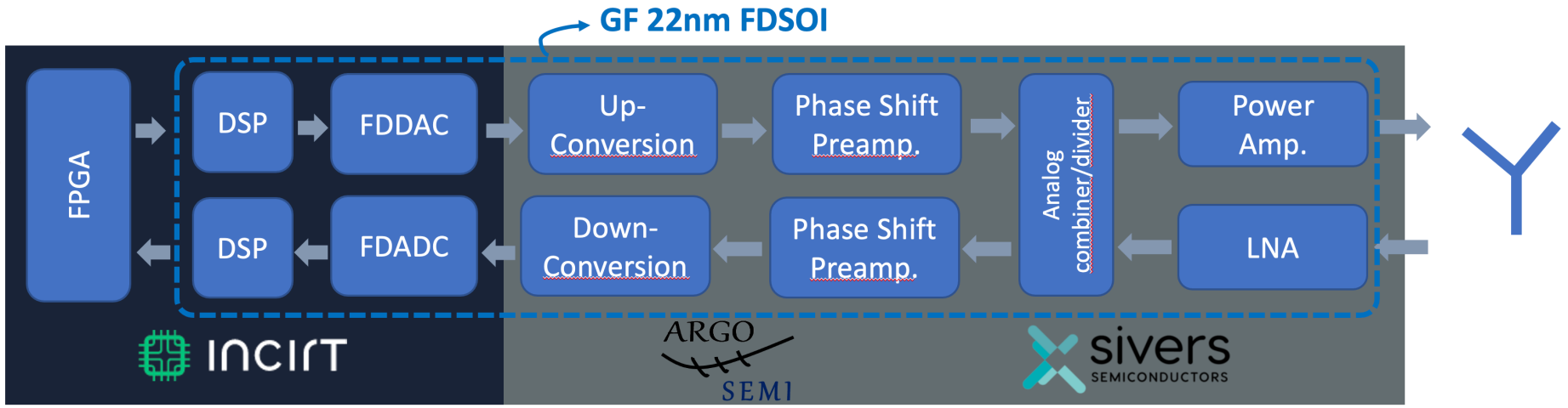
Figure 1. Frequency bands which are currently discussed for wide bandwidth 6G mobile communication (Source: https://www.ericsson.com/en/blog/2022/6/6g-spectrum-why-its-fundamental)

6G frequencies and hardware requirements

- **Spectrum Utilization:**
  - **D-band (110-170 GHz):** For high-rate data communication.
  - **V-band (40-75 GHz):** For range and capacity.
- **Hardware Innovation Needs:**
  - Wide modulation bandwidth for data rates.
  - Energy-efficient designs for sustainability.
  - Compact form factor for integration into devices.
  - Cost-effective production for market viability.
  - Secure communication for user trust.
- **FirstTo6G's Ambition:**
- Develop ground-breaking DAC/ADC & RF frontend technologies.
- Address current technology limitations in signal quality and power usage.
- Aim for 6G technology development with interdisciplinary collaboration.

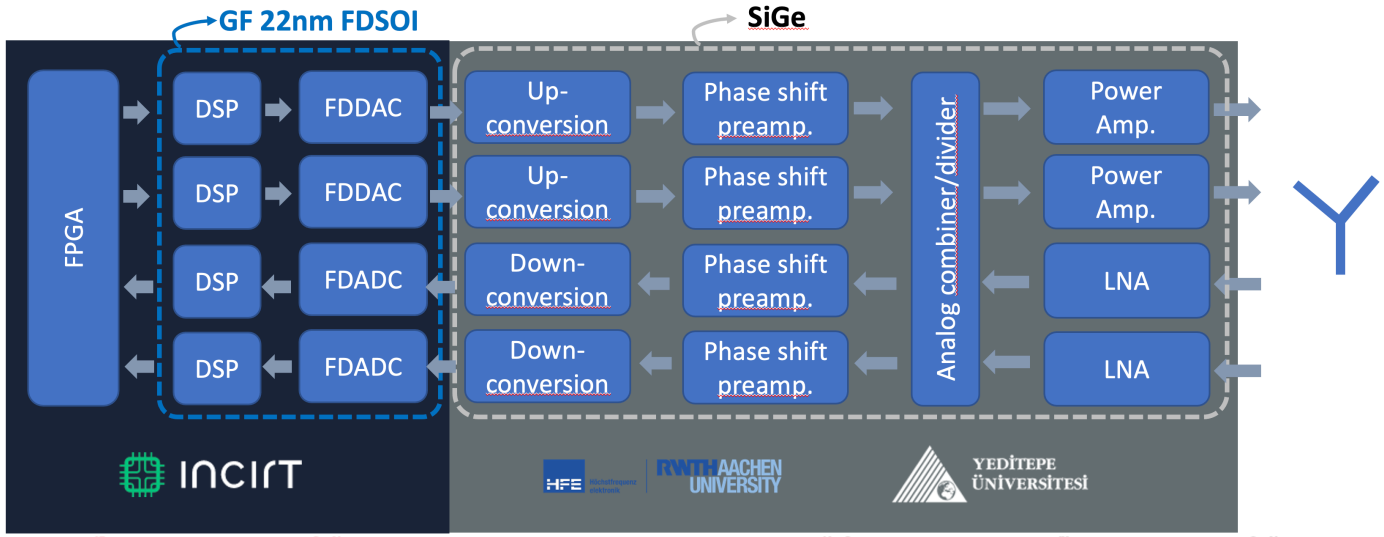
Below 100 Ghz Solution

- **Frequency:** V-band (ISM band for indoor and point-to-point 57-71 GHz communication)
- **Integrated TRx:** Combines DAC/ADC with RF frontend on one chip
- **Advantages:**
  - **Enhanced Range:** Optimal for urban deployment with fewer base stations
  - **Energy Efficiency:** Lower power design increases device longevity
  - **Affordability:** Cost-effective production with established 22FDX tech
  - **Seamless Integration:** Compatible with current standards, ensuring a smooth transition to 6G



Above 100 Ghz Solution

- **Frequency:** D-band (110-170 GHz)
- **High-Performance TRx:** Advanced DAC/ADC with novel RF frontend for maximum data rate.
- **Advantages:**
  - **Ultra-High Data Rates:** Suitable for extremely high-speed applications.
  - **Advanced Signal Quality:** Enables higher modulation orders for efficient data transmission.
  - **Innovative Integration:** Utilizes cutting-edge SiGe technology for enhanced RF performance.
  - **Optimized for Future Needs:** Designed for scalability and next-gen communication standards.



Targetted system specs

	V-band Solution	D-band Solution
DAC / ADC		
Mod. Bandwidth	8 GHz	16 GHz
Power Consumption	1.0 W	2 W
Modulation	Up to 128QAM	Up to 128QAM
Data Rate	56 Gbit/s	112 Gbit/s
Nyquist Filtering	Yes	Yes
On-Chip DSP	Yes	Yes
Technology	GF 22FDX	GF 22FDX
Chip area	8 mm^2	16 mm^2
Frontend		
RF bandwidth	14 GHz (57-71 GHz)	45 GHz (130-175 GHz)
Noise Figure	5 dB incl TDD switch	<6 dB
Output power	10 dBm/ant. path @ -27dB EVM	>0 dBm
Power consumption	100 mW/Tx ant. path in a multi-antenna config, 300 mW & 200 mW for up- and down-converters, respectively	<300 mW
Supported modulation bandwidth	8 GHz	>16 GHz
Technology	GF 22FDX	IHP SiGe G3
Overall system		
Mod. Bandwidth	8 GHz	16 GHz
Frequency Range	57-71 GHz	130-175 GHz
Data rate	56 Gbit/s	112 Gbit/s
Energy Efficiency	26 pJ/bit	20 pJ/bit
Total power Consumption	<1.5 W	<2.5 W
Integration	Single Chip (GF 22FDX)	Multiple Chips

Workpackages - Organisation

WP1: System Modeling,
- Foundations for all technical WPs
- Defines use cases, system architecture

WP2: Data Converters Development
- Builds upon WP1's requirements
- Focus on DAC/ADC technologies

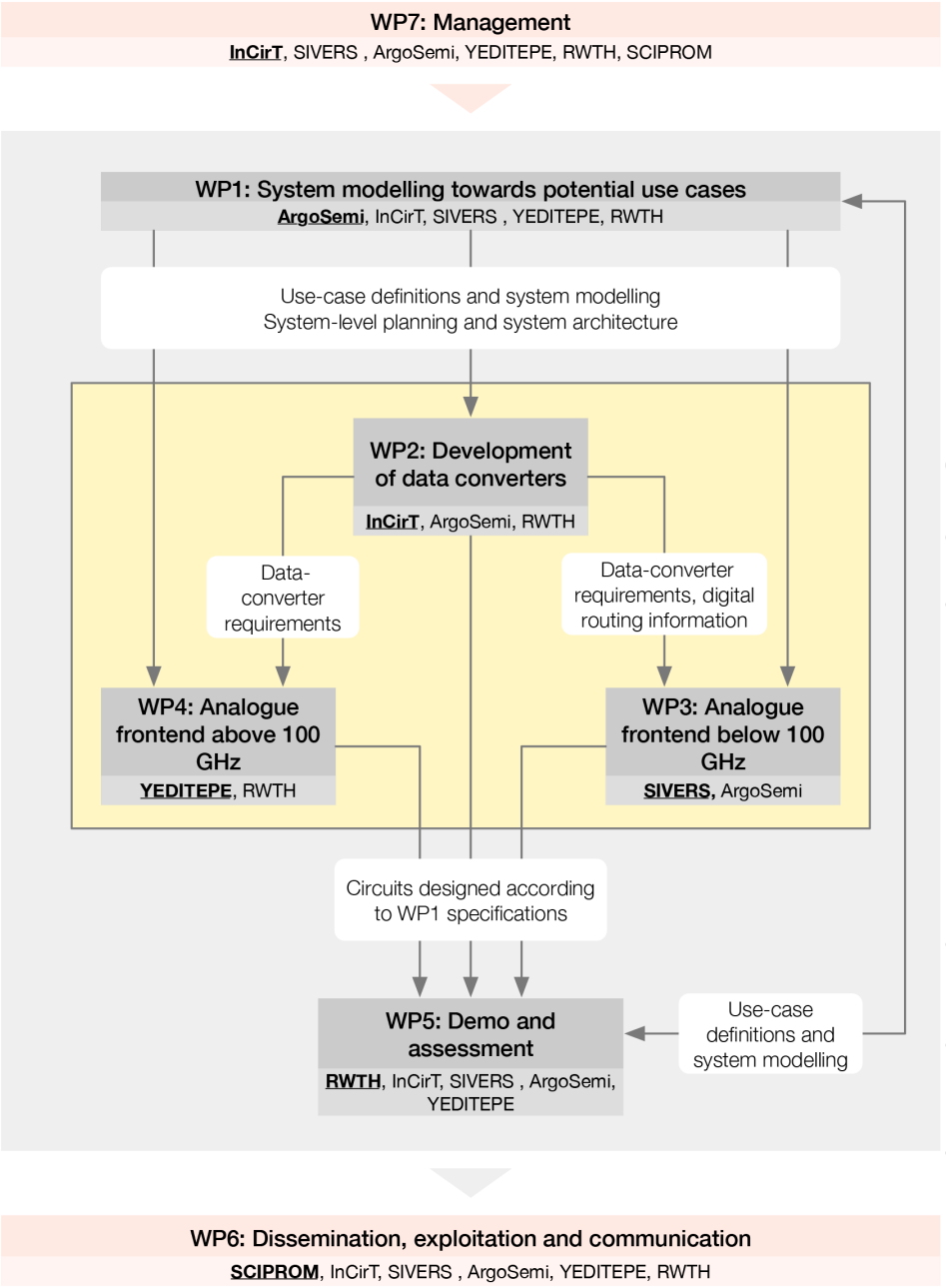
WP3: Sub-100 GHz Analogue Frontend
- Utilizes data from WP2
- Develops frontend solutions for below 100 GHz

WP4: Above 100 GHz Analogue Frontend
- Parallel to WP3, informed by WP1 & WP2
- Targets frontend solutions for above 100 GHz

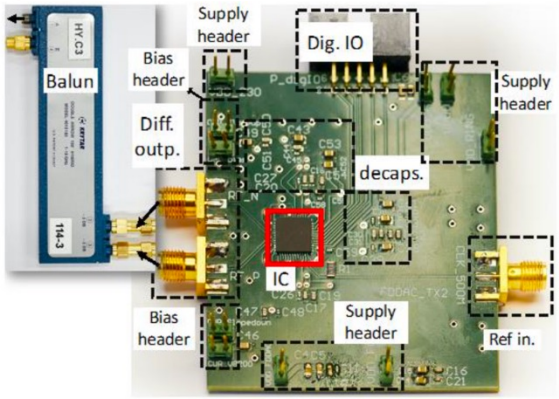
WP5: Demonstration and Assessment
- Integration of WP2, WP3, and WP4 outputs
- System-level testing and validation

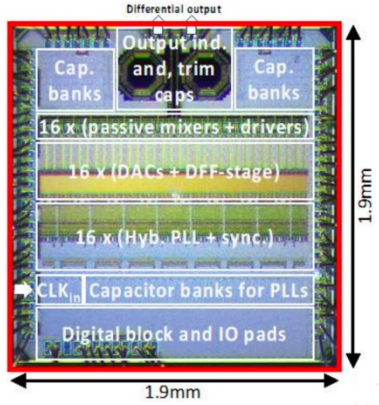
WP6: Dissemination and Communication
- Leverages results from all WPs
- Shares knowledge, ensuring project impact

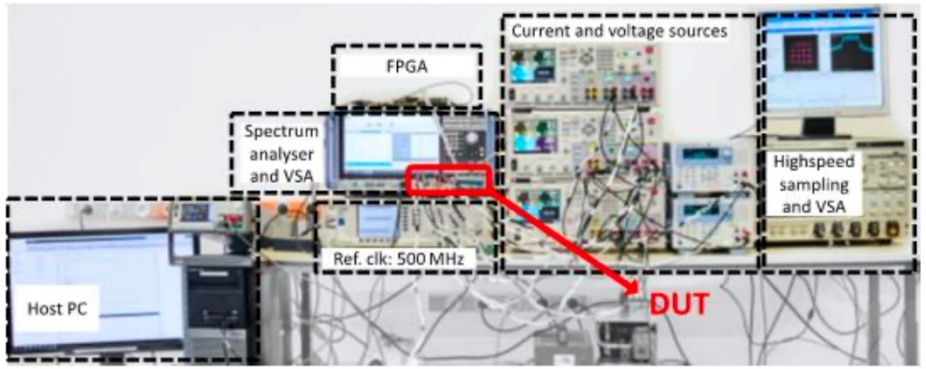
WP7: Management
- Overarching coordination of all WPs
- Ensures alignment and project cohesion

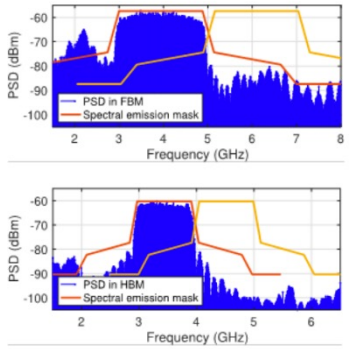


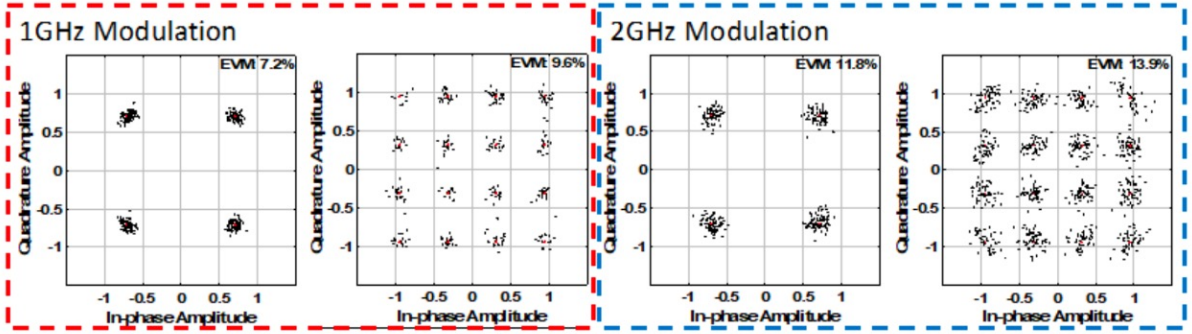
Previous work – FDDAC/ADC by InCirT

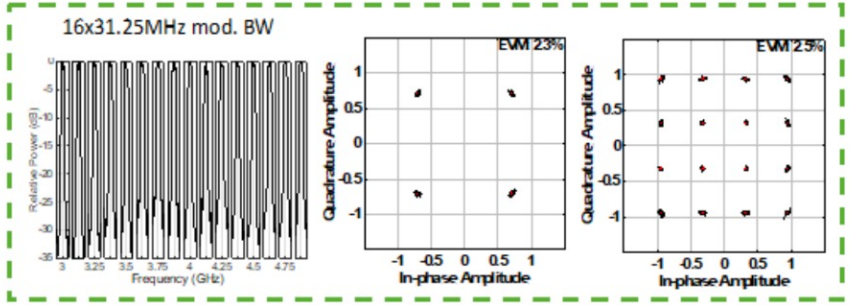












Anticipated Outcome

- **Advanced 6G TRx Solutions**: Develop transceivers suitable for 6G communications.
- **High Bandwidth DAC/ADC**: Achieve high modulation bandwidths in data converters.
- **Energy-Efficient Radio Hardware**: Focus on sustainability and economic viability in 6G hardware.
- **V-band and D-band Solutions**: Optimize technologies for specific frequency ranges: V-band (57-71 GHz) and D-band (130-175 GHz).
- **Single-Chip Integration for V-band**: Combine DAC/ADC and frontend on one chip, enhancing efficiency and security.
- **Enhanced D-band Performance**: Aim for maximum data rate and energy efficiency in D-band TRx.
- **Knowledge Dissemination**: Share project insights with industry and academia, promoting further research and education.
- **Influence 6G Standards**: Integrate findings into global 6G standardization efforts.
- **Post-Project Commercialization**: Enable the development of 6G-based commercial products.
- **Policy Guidance**: Provide technical insights for 6G policy and regulation framing.
- **New Communication Use Cases**: Support novel applications enabled by 6G technology.
- **Societal Advancement**: Contribute to societal development through improved 6G communication.

FirstTo6G

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6GSNS

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