Project: IEEE P802.15 Working Group for Wireless Speciality Networks (WSN)

Submission Title: Overview on the Horizon Europe 6G SNS Project TERRAMETA

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Abstract: This document provides information on the Horizon Europe 6G SNS Project TERRAMETA (TERahertz ReconfigurAble METAsurfaces for ultra-high rate wireless communications)

Purpose: Information of IEEE 802.15 SC THz

TERRAMETA
TERahertz ReconfigurAble METAsurfaces for ultra-high rate wireless communications

Project Overview

Presented to IEEE 802.15 SC THz

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6GSNS

Funded by the European Union

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Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union, 6G SNS or UKRI. The European Union, 6G SNS or UKRI cannot be held responsible for them.

Funding Framework

- A total of 35 Research and Innovation (R&I) projects have been selected following the evaluation of proposals submitted under the first call of the EU's Smart Networks and Services Joint Undertaking (SNS JU).
- TERRAMETA is one of those funded projects in Stream-B, see https://smart-networks.europa.eu/stream-b-research-for-revolutionary-technology-advancement-towards-6g/
- Project run-time: 1 January 2023 – 31 December 2025

TERRAMETA's Consortium

Sectorechnische	Partner	Expertise	Role inTERRAMETA
Research Center	INESC TEC	THz antennas; switch modelling; IC design.	**Project coordinator**, Task leader
University	University of Athens (NKUA)	Signal processing; multi-element transceiver hardware architectures; reconfigurable metasurfaces.	**Technical coordinator**, WP leader
University	University of Hertfordshire	Reflectarrays and transmitarrays; beam-forming algorithms; localization and sensing.	Task leader
University	University of Oulu	THz antennas and measurement; micro-fluidics.	Task leader
Research Center	Instituto de Telecomunicações	Reflectarrays and transmitarrays; antenna characterization.	WP leader
Large Industrial	Intracom	Baseband unit; signal processing.	Task leader
Research Center	CEA-Leti	Reflectarrays and transmitarrays; array and metasurface modelling, design and characterization; IC design.	WP leader
University	University of Luxembourg	Network design and optimization; metasurfaces.	Task leader
Large Industrial	Dell EMC Research	Industrial operations and management.	WP leader
University	Technische Universität Braunschweig	THz characterization and propagation modelling; standardization.	WP leader
SME	ACST GMBH	THz transmitter and receiver.	Task leader
University	NOVA.ID.FCT	Memristor design and fabrication.	Task leader
Large Industrial	British Telecom	System architecture; Exploitation of application scenarios.	WP leader

TERRAMETA in a nutshell

- Investigation of ground-breaking technologies for 6G, demonstrating the feasibility of ultra-high data rate wireless communications leveraging THz metasurfaces (140 GHz and 300 GHz).
  - Novel high-performance THz hardware will be developed, including low-power consumption wideband switches, RISs, and TXs/RXs.
  - Using the designed THz components, advanced network analysis/optimization techniques will be investigated.
- Developments driven by 6G usage scenario requirements.
- Indoor, outdoor, and indoor-to-outdoor scenarios will be demonstrated in a real factory setting and a telecom testing field.

Objective 1

- **Novel hardware development for 6G THz wireless communications and its integration:**
  - At switch level, novel reconfigurable approaches based on **memristors and microfluidics** will be addressed for the first time in THz, as well as the performance of lower risk approaches, namely **CMOS-based switches**, will be advanced.
  - **TXs and RXs** capable of handling **high-power modulated THz signals** will be developed and optimized for the considered applications of RIS-enabled THz networks.
  - **Multi-functional RISs - T-RIS, R-RIS, hybrid RISs with sensing capability -** integrating different switch technologies will be designed and experimentally tested.

Objective 2

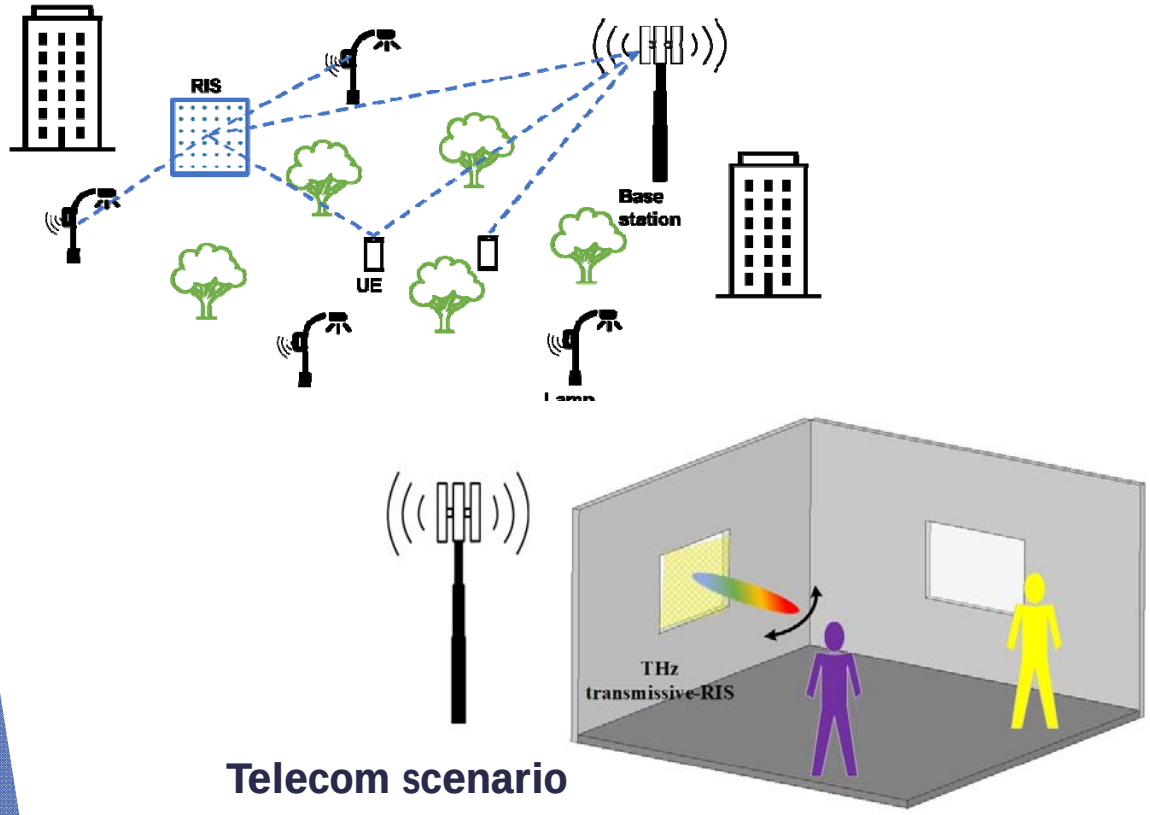
- **Development of THz-tailored network architectures based on realistic models:**
  - THz network design **based on the hardware developments** of the project.
  - Assessment of **Large active antenna arrays** (massive/ultra-massive MIMO) under
    - **power-limited and low-resolution hardware**
    - **accurate THz channel models**,
    - **centralized** and **cell-free** network architectures.
  - The **placement of RISs will be optimized** to provide extra degree of freedoms and enhance the network coverage, connectivity, and rate performance.
  - The **sharing of RISs between different nodes** and the effects of wideband processing on the network performance will be studied as well.
  - The obtained theoretical and simulation-based results will be further tested through lab emulations to demonstrate the performance of realistic THz networks.

Objective 3

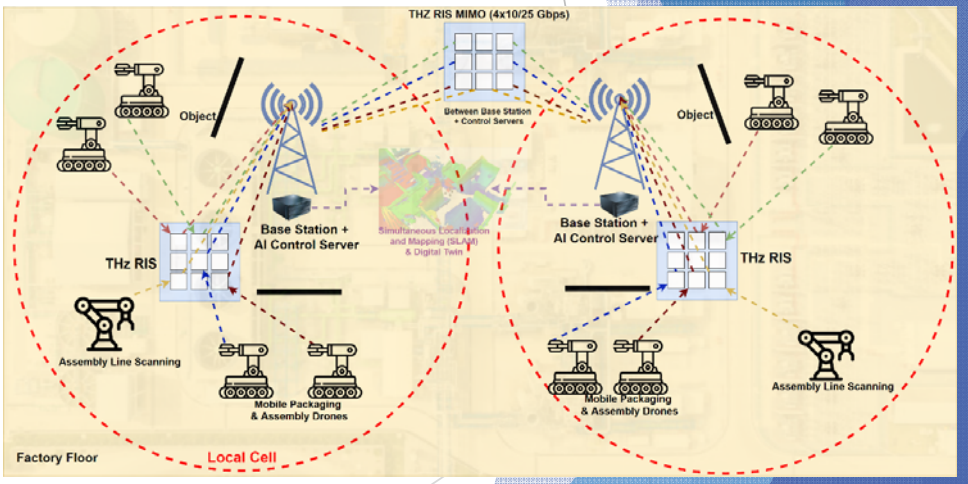
- **Development of signal processing techniques for THz communications, localization, and sensing with various forms of reconfigurable metasurfaces:**
  - **Signal processing algorithms and techniques** for ultra-massive THz systems, considering:
    - transceivers and wireless environment **equipped with RIS**
    - the **actual hardware specifications** and operational capabilities of metasurfaces.
  - **Development of THz channel models** profiting from a dedicated channel sounding activity.
  - The designed algorithms will focus on the selected use cases and target ultra-high data rate wireless communications, localization, and sensing.

Objective 4

- **Demonstrate the feasibility of applying THz RISs in an “Industrial Edge” environment and an outdoor Telecom scenario with real-world equipment**



Telecom scenario



Factory Floor - Industrial Edge environment

Objective 5

- **Actively influence 6G and THz communications standardization and regulation:**
  - Standardization process at various standards bodies (3GPP, ETSI, and IEEE 802).
    - RIS **hardware reconfigurability** methods
    - RIS based THz **channel models**
    - RIS based **network architectures**
  - The project will also work on proposals for interfacing RISs into THz communication systems.
  - Influence the preparation of the World Radio Conference (WRC) 2027, where the THz spectrum is likely to be on the agenda.

TERRAMETA's Focus (1/3)

- **Development of THz RIS technology (both transmissive and reflective use-cases):**
  - **Materials and electronics components** that can support the THz operation frequency with appropriate performance, cost-efficient fabrication and low power consumption will be investigated.
  - Two types of THz RIS, **reflective-RIS** and **transmissive-RIS**, will be developed by exploring multiple THz capable reconfigurable **micro-electronics technologies: memristors, BiCMOS/GaN and microfluidics**.
  - **Signal processing techniques** for THz RIS communications, **localisation**, and **sensing**, including **channel modelling**, **channel estimation**, **beam management**, **baseband processing** and THz-tailored network architectures including Ultra-Massive MIMO techniques will be developed.

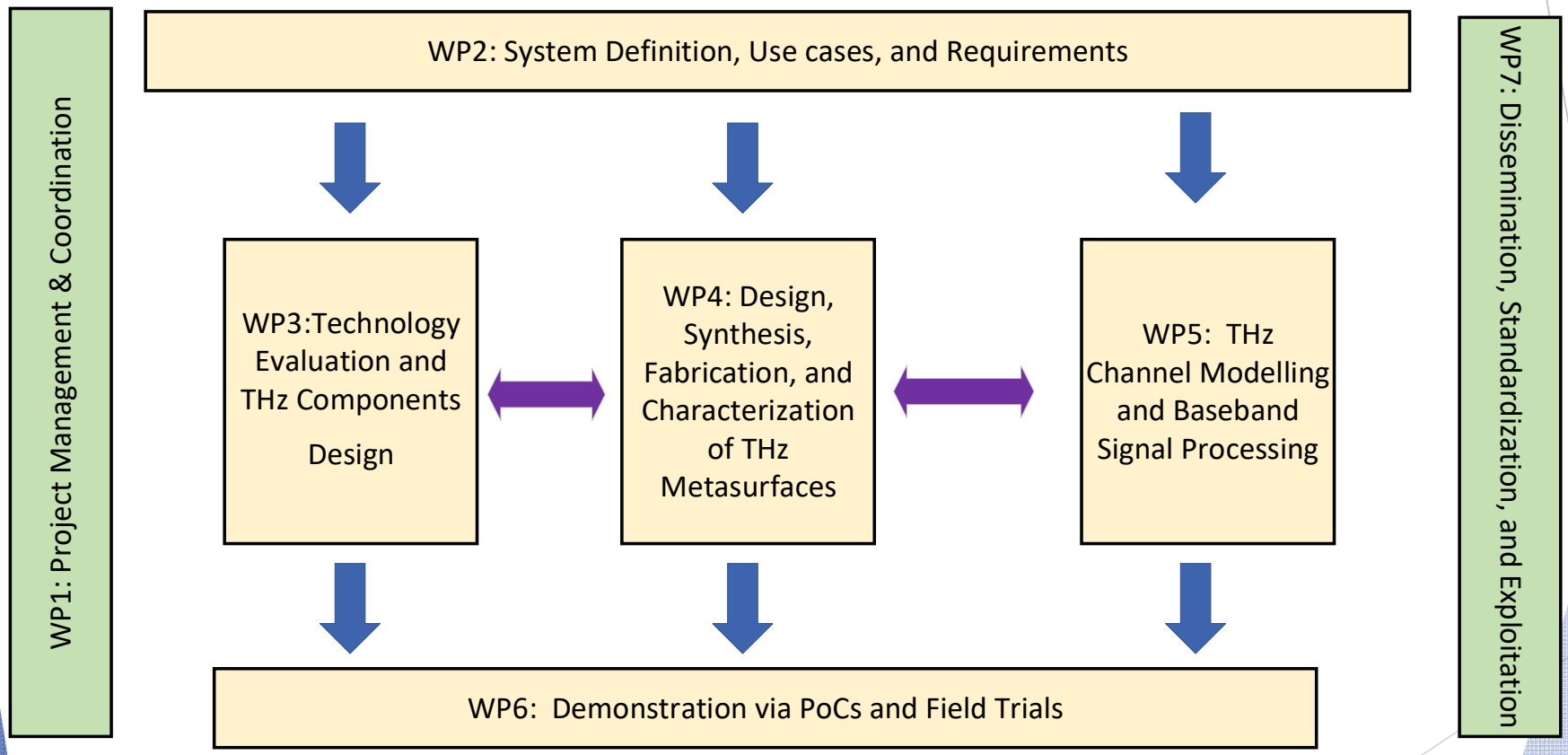
TERRAMETA's Focus (2/3)

- **Two frequency bands being currently under strong research focus at device level and expected to play a key role as part of 6G (enabling ultra-high data rates):**
  - **140GHz** (D-band: 110-170 GHz): around 30GHz spectrum available especially for backhaul/fronthaul applications
  - **300GHz** (253-322GHz band; IEEE 802.15.3d): almost 70GHz spectrum considered in IEEE 802 Std 15.3d-2017 with most of it allocated to fixed and mobile services.

TERRAMETA's Focus (3/3)

- **R-RIS design target:**
  - Different reconfiguration technologies: **memristor switches, BiCMOS/GaN switches, and microfluidic** with piezoelectric actuation, striving to improve technologies that have been shown to work at lower frequencies in order to demonstrate their viability in the 140 GHz band.
- **T-RIS design target:**
  - Demonstrate the first such device operating in the D-band and at 300GHz, using more advanced **RF-SOI-based CMOS processes**. The switch architecture will be co-designed with the RIS elements to achieve the best trade-off between Ron, Coff, power dissipation, insertion loss, and bandwidth.

Work Plan


WP1: Project Management & Coordination
WP2: System Definition, Use cases, and Requirements
WP3:Technology Evaluation and THz Components Design
WP4: Design, Synthesis, Fabrication, and Characterization of THz Metasurfaces
WP5: THz Channel Modelling and Baseband Signal Processing
WP6: Demonstration via PoCs and Field Trials
WP7: Dissemination, Standardization, and Exploitation

TERRAMETA‘s Standardisation Plans

- Standardization plans / objectives:
  - Standardization is seen as a means to dissemination the project’s results as pre-normative input to standardization.
- Project activities / technologies that may lead to standardization:
  - Definition of scenarios and use cases;
  - RIS based Hardware Reconfigurability Methods;
  - RIS based network architectures;
  - THz channel measurements and modelling in scenarios with RISs; and
  - RF impairment modeling of RISs.
- Potential targeted standardization bodies / groups:
  - IEEE 802 SC ;
  - ETSI ISG THz;
  - ETSI ISG RIS; and
  - ITU-R (Preparation of WRC 2027, ITU-R SG3).

Thank you for your attention!