



# Enabling TSN and Industrial Traffic with OpenAirInterface

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[airpuls.de](https://airpuls.de)

# about airpuls

- German **system integrator** for **O-RAN** and **Open-Source** private 5G networks
- **Tailor-made** 5G campus networks
  - Fixed scalable indoor and outdoors campus networks
  - Temporary deployments
  - All-in-one highly portable 5G systems
- **Extensive support** for customization and own developments

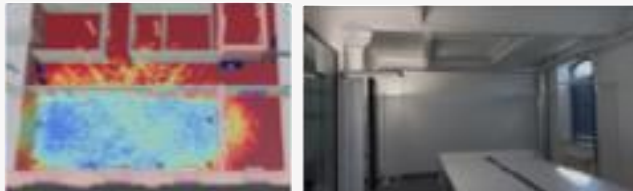


# Customized O-RAN networks (OAI-based): Examples



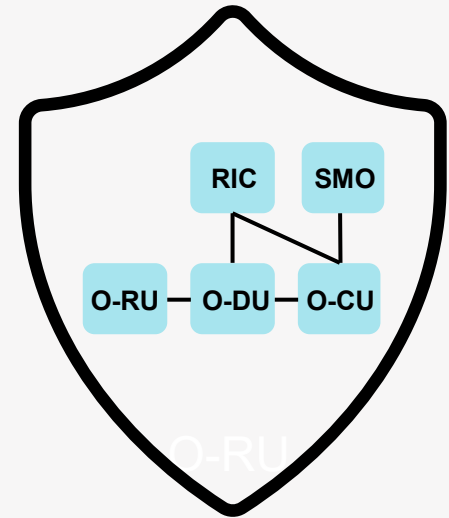
Nomadic outdoor networks for temporary deployments

- **Example:** 3-cell network for agriculture in Koblenz
- Cell-radius 500m – 1000m



Campus networks for 5G-positioning and sensing

- **Example:** 3-cell network (w. distributed antennas) for indoor positioning testing in Hamburg



Campus networks for p5G / O-RAN security analysis

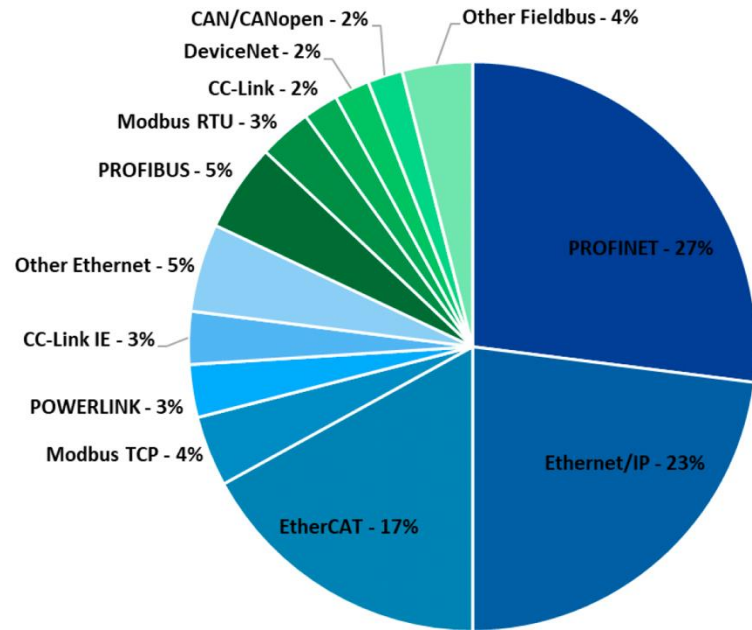
- **Example:** Two independent 2-cell networks with roaming at BSI
- Including SMO, RIC

# Enabling Wireless Industrial Connectivity

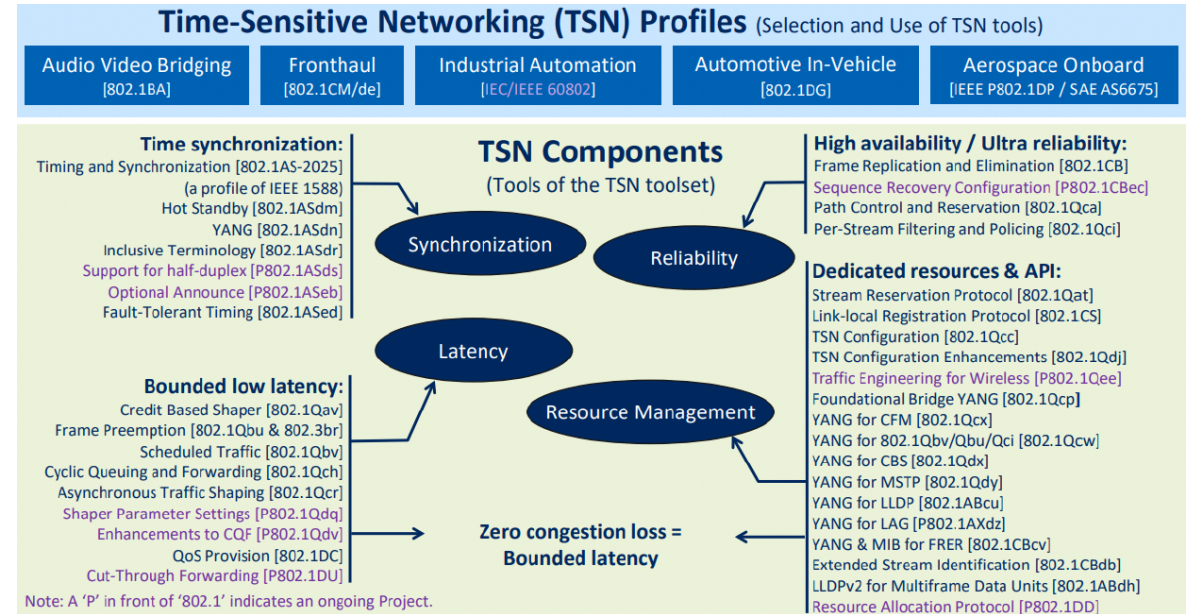


- Deterministic communication (bounded latency, low jitter) is needed for many industrial applications
- Wireless connectivity (e.g., 5G) is increasingly required to increase flexibility, ease of installation and to cover larger areas
- Examples:
  - Cable replacement, closed loop control (flexible production lines etc)
  - Coordinating / cooperating robots, AGVs
  - Safety functions
  - Real-time vision

# Time Sensitive Networking (TSN)



Industrial applications talk industrial protocols. Source: hms-networks.com/news/news-details/27-05-2025-hmg-networks-report-industrial-trends-2025



Source: <https://1.ieee802.org/tsn>

- Current state: Mix of industrial protocols - attempt to unify/converge: TSN
  - Several protocols providing synchronization, reliability, latency, and resource management
- Strict requirements when transmitting over wireless links

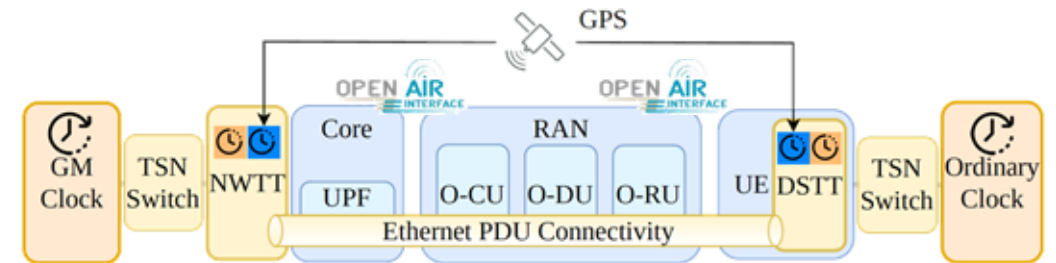


# Ethernet PDU-Sessions (“5G LAN”)

- Many factory networks rely on L2-protocols => PDU session of type 'Ethernet required'
- Transports Ethernet frames natively (preserving MAC addresses, VLAN tags, and TSN-specific fields, priority tagging)
- Bridge TSN frames into/from 5GS tunnels (TSN bridges use specific 802.1Q VLAN tags and PCP priority bits)
- **Eth. PDU sessions allow the 5GS to appear as a transparent TSN bridge** carrying streams between TSN nodes without protocol translation.



Demonstration setup at IEEE WFCS 2026



Ethernet PDU Test Setup (TSN Time Synchronization)

## Status / Plans

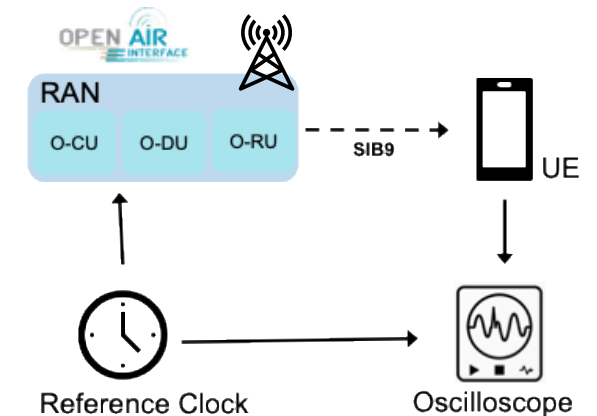
- Available and tested in OAI-core, Cumucore, amarisoft
- Limited choice of COTS-UEs - successfully tested with Quectel RM500-CN
- Available in OAI-UE

# Time Synchronization with SIB-9

- TSN requires network-wide clock synchronization (IEEE 802.1AS / gPTP).
- SIB9 allows the 5G to act as a Time-Aware System (without, UEs cannot participate in TSN time domains, making E2E deterministic scheduling impossible)
  - Broadcast message in 5G NR that carries current GPS/GNSS timing information to all UEs in a cell
  - gNB encodes absolute UTC time and transmits it periodically.
  - UEs decode SIB9 and synchronize their internal clock
- Allows the UE to synch to the cell with accuracies beyond regular 5G sync (sub-ms time alignment for TSN time-awareness)



Raspberry Pi-based UE with Telit Modem for SIB-9 Testing



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## Status / Plans

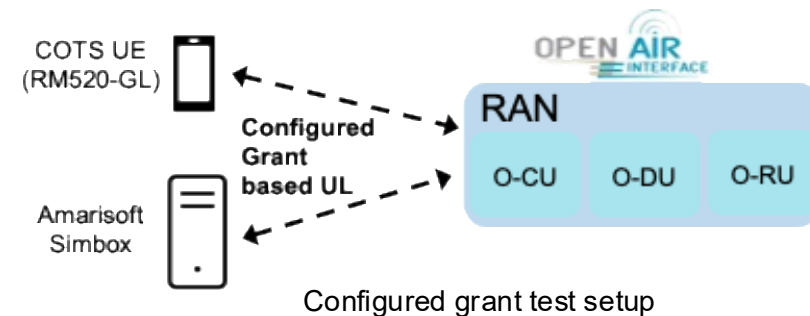
- SIB9 generation implemented in RAN (O-CU) based on the (time synched) cell time
- SIB9 transmission successfully tested with COTS-UE (Telit FN990)
- Hardware output required for accuracy testing and calibration

# Configured Grant

- Scheduling of UL grants to UEs creates significant latency -> pre-allocation of uplink resources
- gNB pre-configures periodic transmission slots for UEs (eliminating request-grant round-trip overhead)
  - Type 1 (fully RRC-configured)
  - Type 2 (RRC pre-configured + activated by DCI)
- UE transmits on predefined periodic slots (e.g., every 0.5 ms) without waiting for a scheduler grant achieving bounded latency and jitter.
- TSN traffic (e.g., PROFINET, EtherNet/IP) demands deterministic sub-ms delivery.
- Configured Grant guarantees periodic, low-latency uplink slots, enabling the 5G air interface to meet TSN flow requirements



Configured grant resource allocation, Source: IIS



## Status / Plans

- Implementation planned (starting with Type 1) as part of TSN-related funding project
- Testing with COTS UEs

# Summary

- Deterministic wireless communication remains challenging and will be a critical success factor for private cellular networks
- High need for testbed infrastructures that allow E2E TSN functionality
- Missing features are being developed step by step
- Let's collaborate to realize E2E testing and validation of these use cases



DEWICOMM Workshop 2026, Dresden, showing high interest in 5G-TSN technology from academia, industry



# Questions?

## Contact

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