TERAWAY PROJECT

Terahertz technology for ultra-broadband and ultra-wideband operation of backhaul and fronthaul links in systems with SDN management of network and radio resources

Maria Massaouti, PhD

Institute of Communication and Computer Systems (ICCS)

Topic: 5G Long Term Evolution
Call: H2020-ICT-2019-2
G.A No: 871668
Duration: 36 months
Start date: 01.11.2019

IEEE Wireless Communications and Networking Conference (Virtual)
25 May 2020 // AERCOMM Workshop

TERAWAY Vision

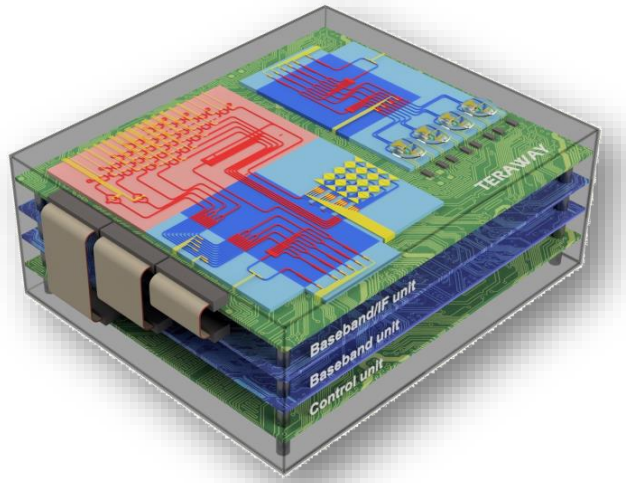
A new disruptive generation of photonic-enabled THz transceivers for high-capacity BH and FH links in 5G networks.

Vision - Concept

"*enabling industrialization of THz wireless communication technology*"

Development of photonic-enabled transceivers for wireless communication systems operating across the W- (92-114.5 GHz), D- (130-174.5 GHz) and THz (252 – 322 GHz) bands

- **Multi-channel, ultra-wide band transmitters**: Generation/emission of THz/W/D signals with selectable symbol rate, high bandwidth and of high transmission reach.
- **Multi-channel, ultra-wide band receivers**: Detection of THz/W/D band signals and their direct down-conversion to baseband.
- **Integration of the nodes inside a functional network system of high-flexibility and efficiency:** New network management platforms (based on SDN) and an extended control hierarchy to perform the management of the network and radio resources.

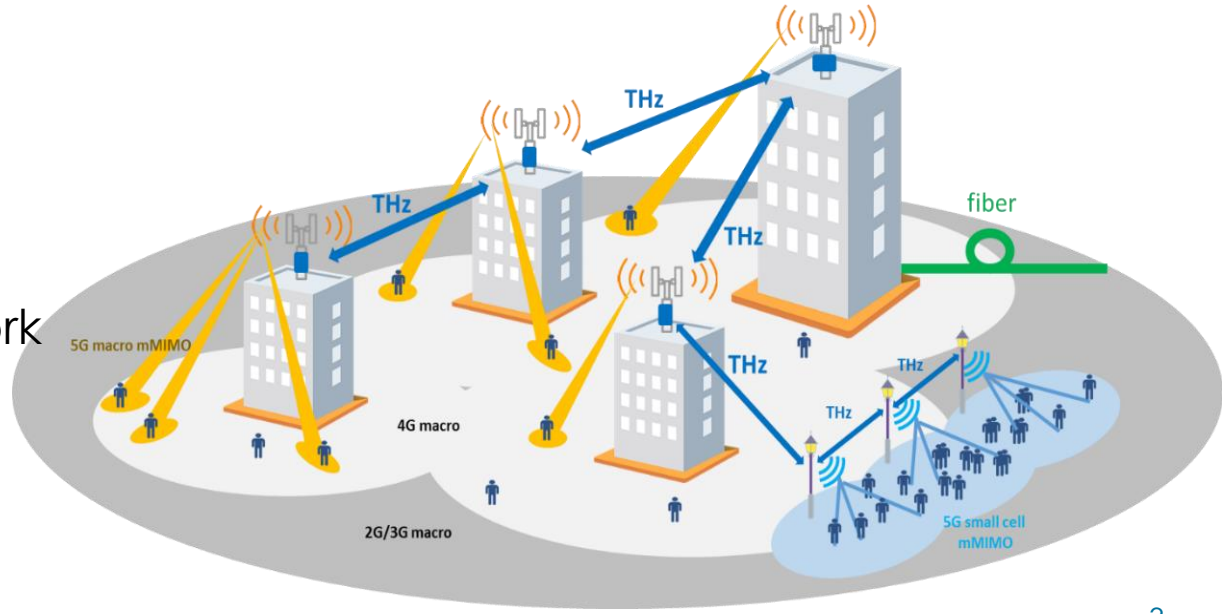


TERAWAY Use cases & Application scenarios (II)

Core Application BH/FH connectivity in support of ultra-high bandwidths, low latency communication requirements.

Backhaul & Fronthaul network connectivity cases

- **Capacity or coverage expansion:** BH/FH high capacity point to point links to add new sites for coverage gaps. Typical rooftop to rooftop.
- **Network densification and hotspot coverage:** Backhaul point to point links to add new sites for hotspot coverage.
- **Enterprise and industrial 5G**: High capacity point to point links as part of the aggregation network of Private 5G networks
- **Indoor point to point high speed links:** High capacity point to point links for enterprise and personal network applications like WPANs, etc.



TERAWAY Use cases & Application scenarios (II)

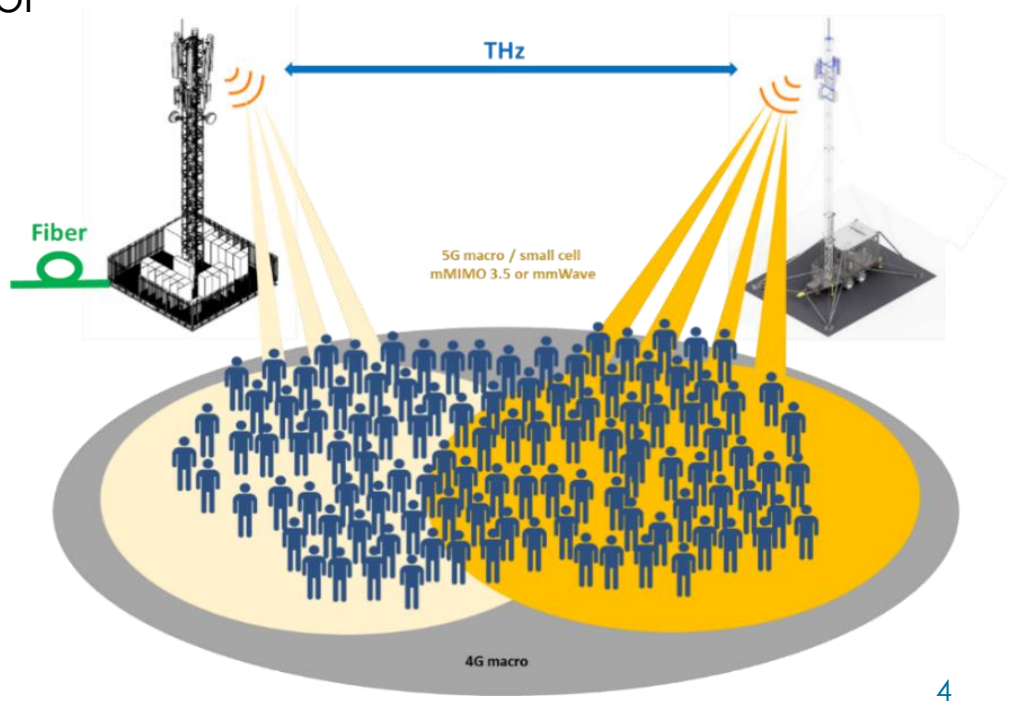
Core Application

BH/FH connectivity in support of ultra-high bandwidths, low latency communication requirements.

Backhaul or Fronthaul connectivity to support aerial mobile coverage for:

- **Special events**: 5G mobile coverage and surveillance from moving objects (UAV) enabled by high capacity links. Temporal point to point fixed links between temporal, semi-permanent or permanent infrastructure

- **Emergencies, natural disasters and network failures** scenarios: 5G mobile coverage and surveillance from moving objects (UAV),linking a drone providing the 5G coverage with a fixed node aggregating traffic from other fixed or moving nodes

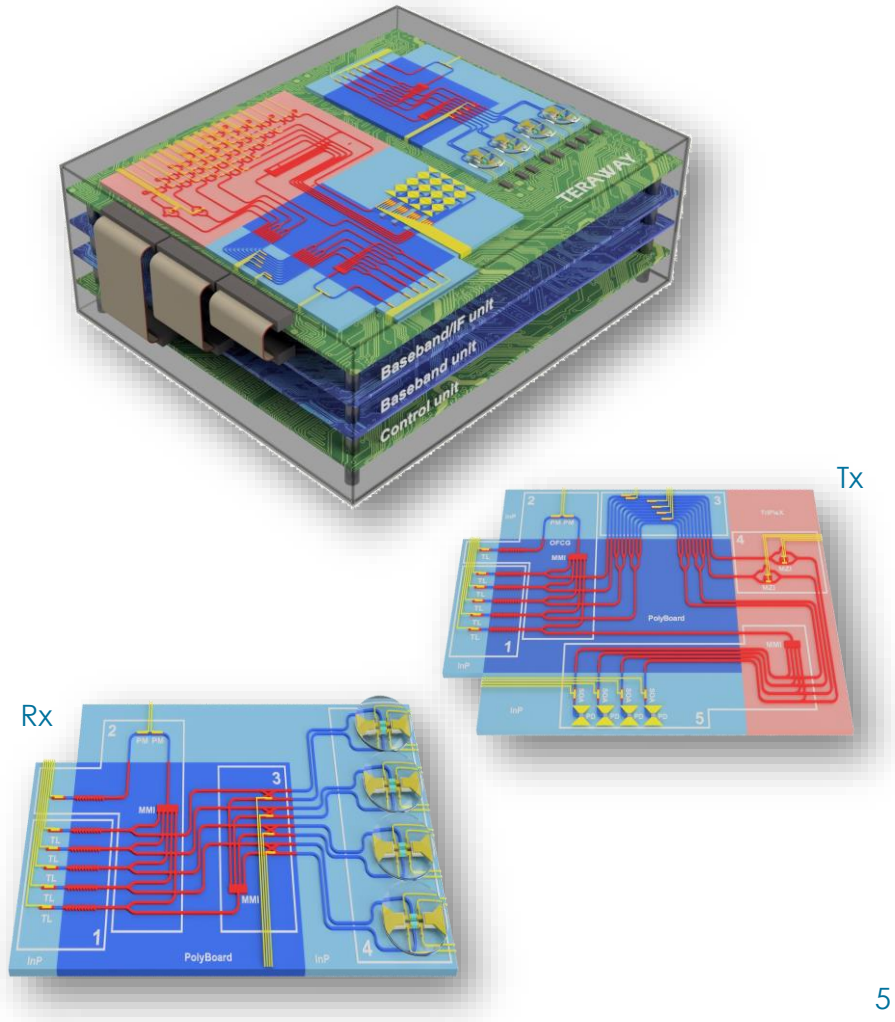


TERAWAY Innovations

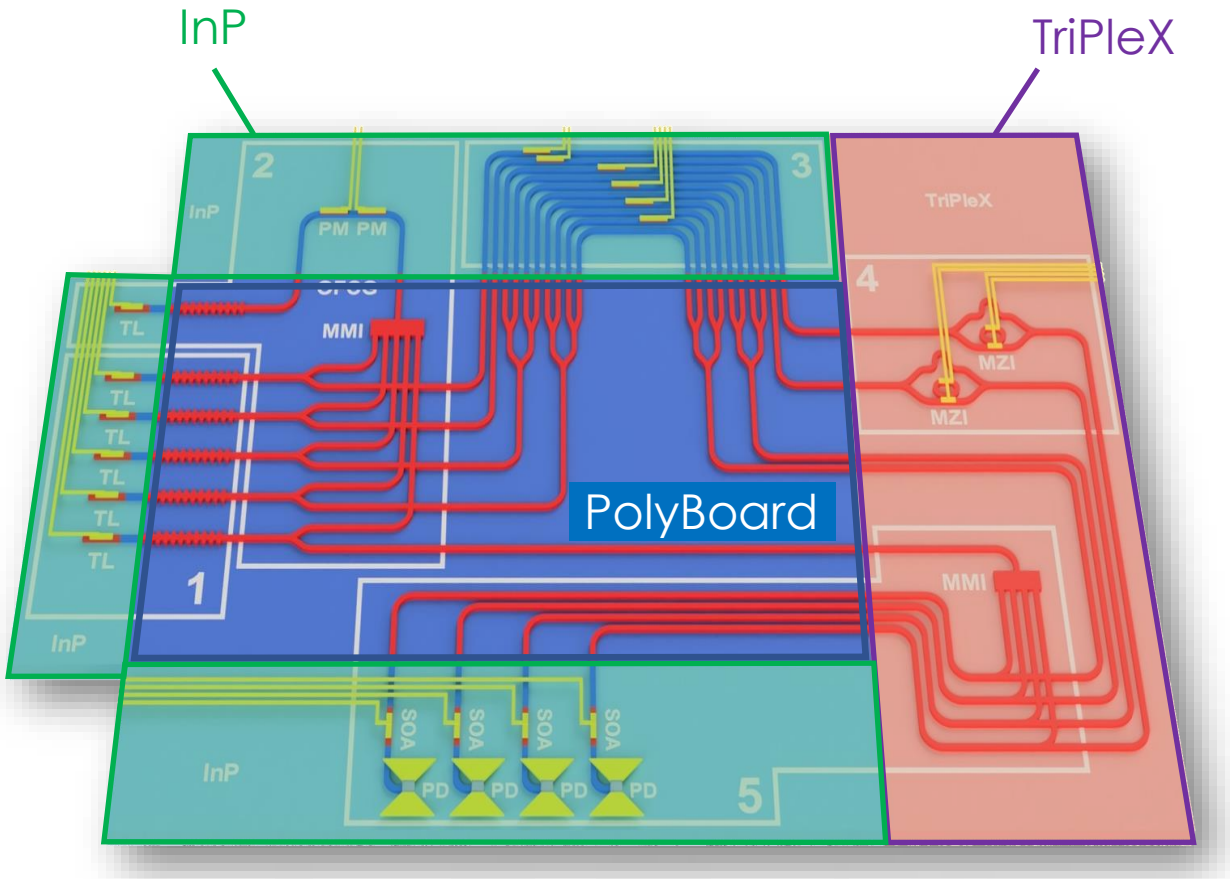
Development of a common technology base for the generation, emission and detection of wireless signals in the THz (252–322 GHz) and W/D bands

Key Technological Innovations

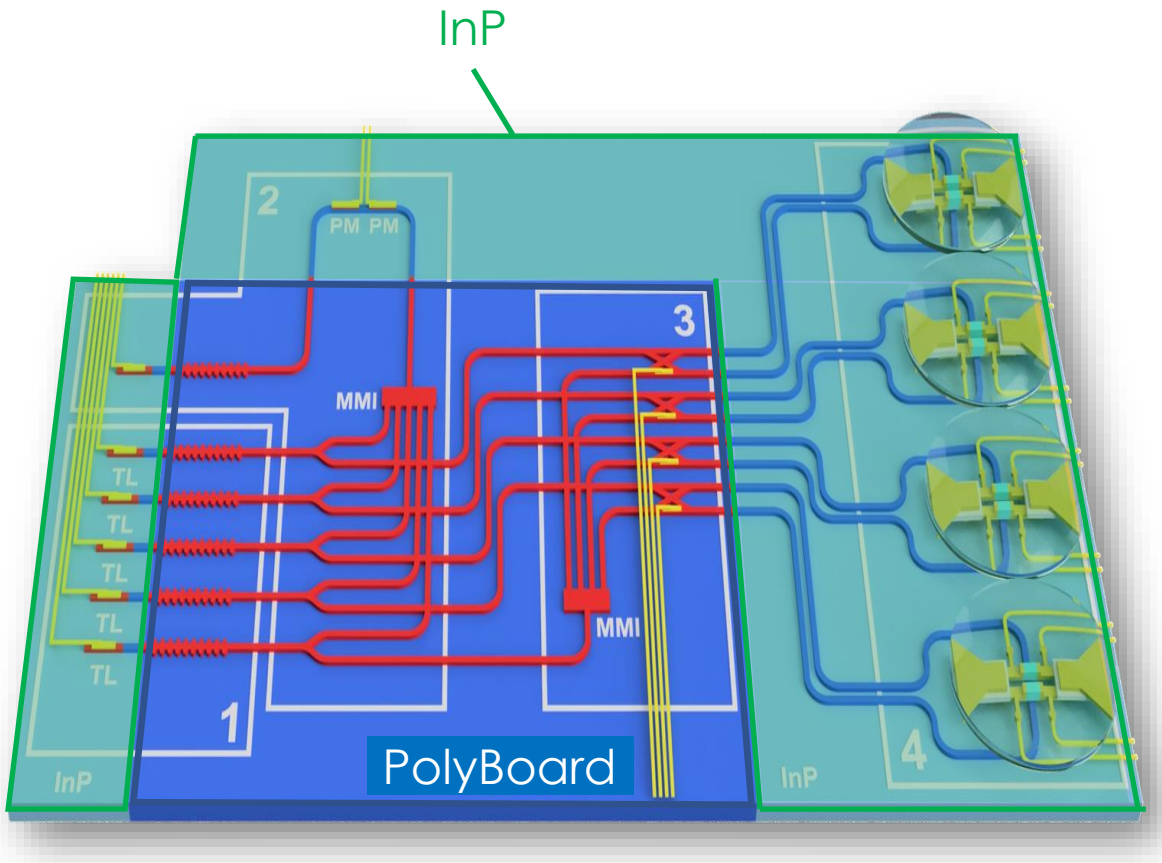
- Hybrid photonic platform for ultra-wideband wireless Tx
- Optical multi-beam beamforming platform
- Hybrid photonic platform for ultra-wideband wireless Rx
- Tools for network management, resource allocation and service provision



TERAWAY: Artistic layout of transceivers (Tx & Rx)



Transmitter

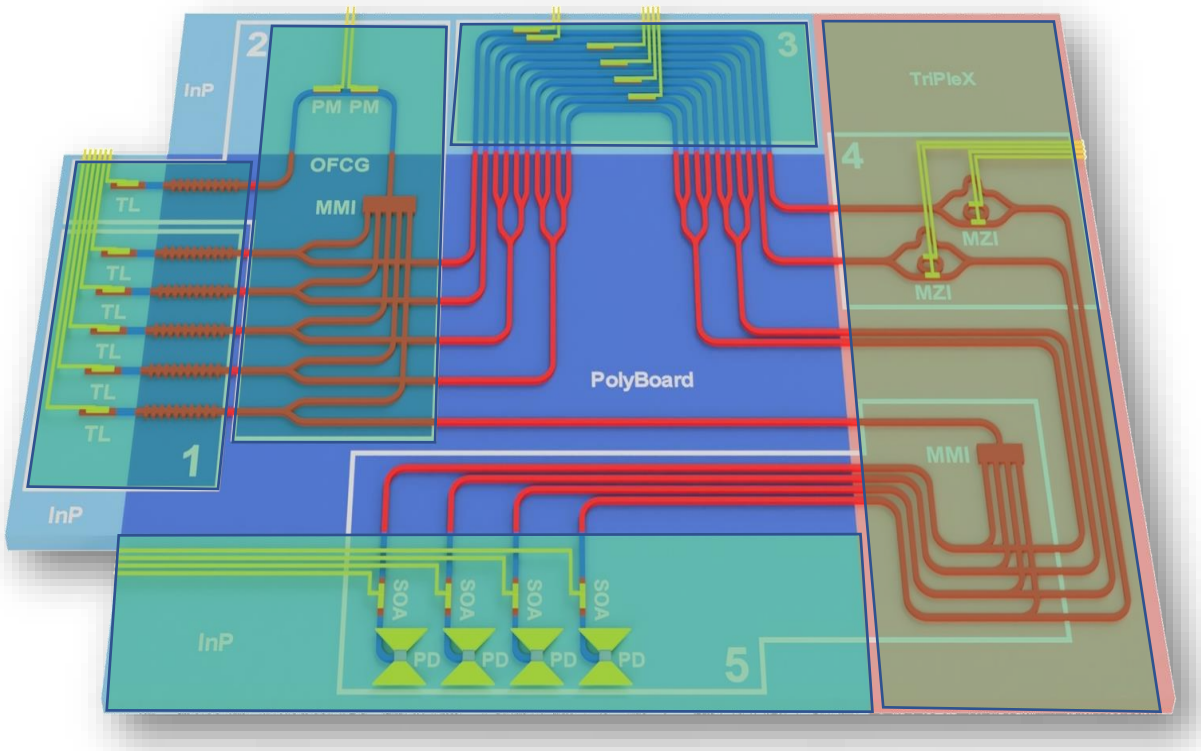


Receiver

TERAWAY Transmitter (Tx): Main units

Hybrid photonics-based platform for ultra-wideband signal generation and emission

Transmitter



1. Optical carrier generation unit
Tunable Lasers (TLs): Free selection of the emission wavelength over a range of more than 10 nm

2. Optical phase locking unit
Optical Frequency comb generator (OFCG) + optical circuit: low phase noise

3. Optical modulation unit
Phase Modulators for • low-capacity links and • IQ Modulators for high-capacity links

4. Optical multi-beamforming unit
Independent steering of the transmitted wireless beam

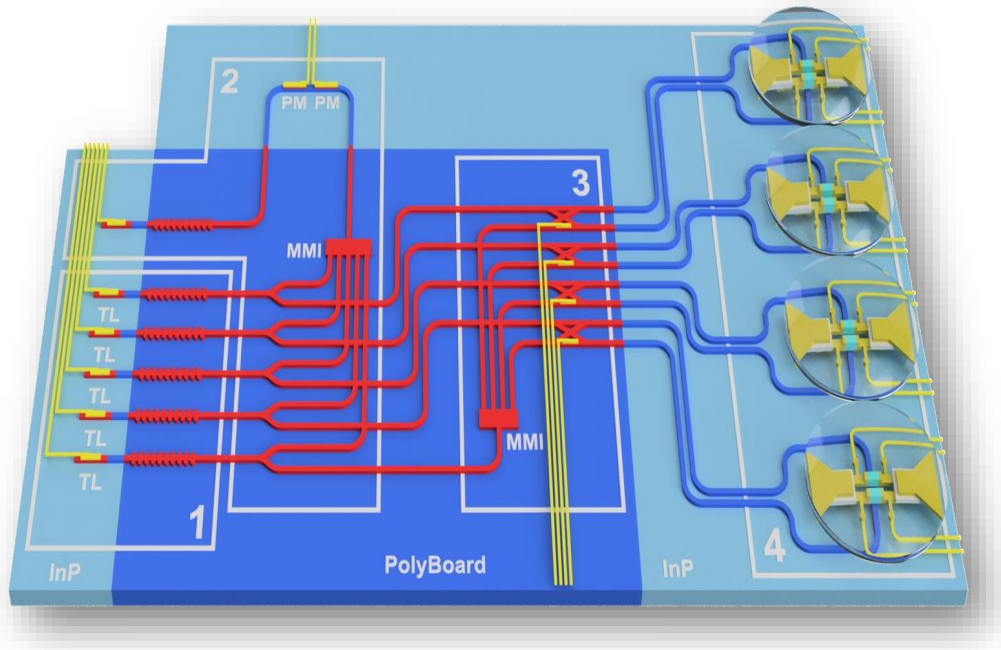
5. Optical amplification, frequency up-conversion and wireless emission unit
Use of semiconductor optical amplifiers, PIN- photodiodes as photonic mixer and bow-ties antennas

TERAWAY Receiver (Rx): Main units

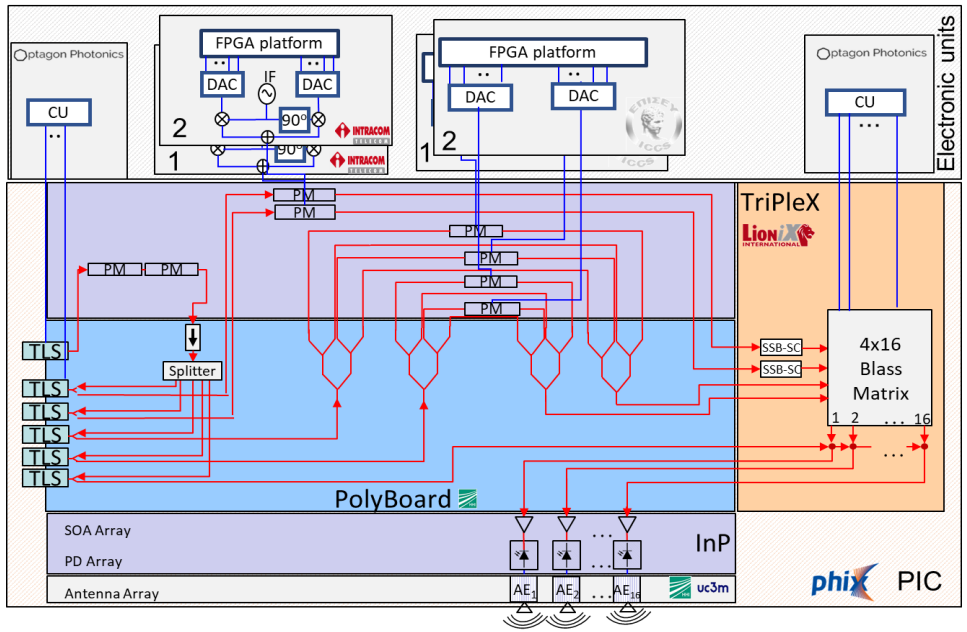
Hybrid photonics-based platform for ultra-wideband signal detection and reception

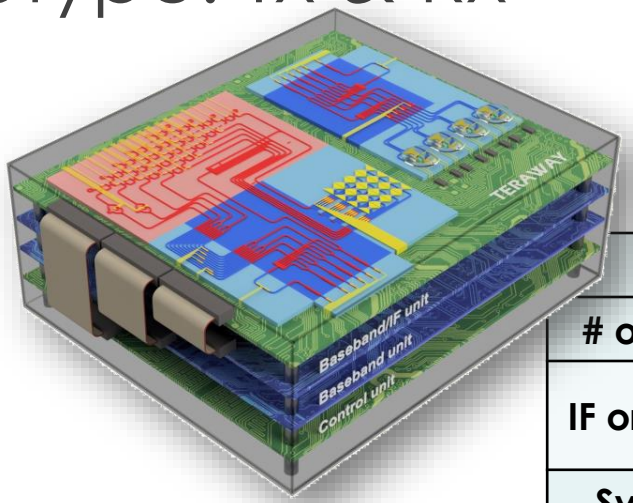
1. **Optical carrier generation unit**
   Same as transmitter
2. **Optical frequency comb generator unit**
   Same as transmitter
3. **Optical phase shift unit**
   Introduction of 90° phase difference between copies of the same optical carrier
4. **Wireless detection and IQ photonic mixing unit**
   Use of bow-tie antennas with silicon lenses and photoconductive elements for down-conversion to the baseband
   Development of low-noise and high bandwidth TIAs

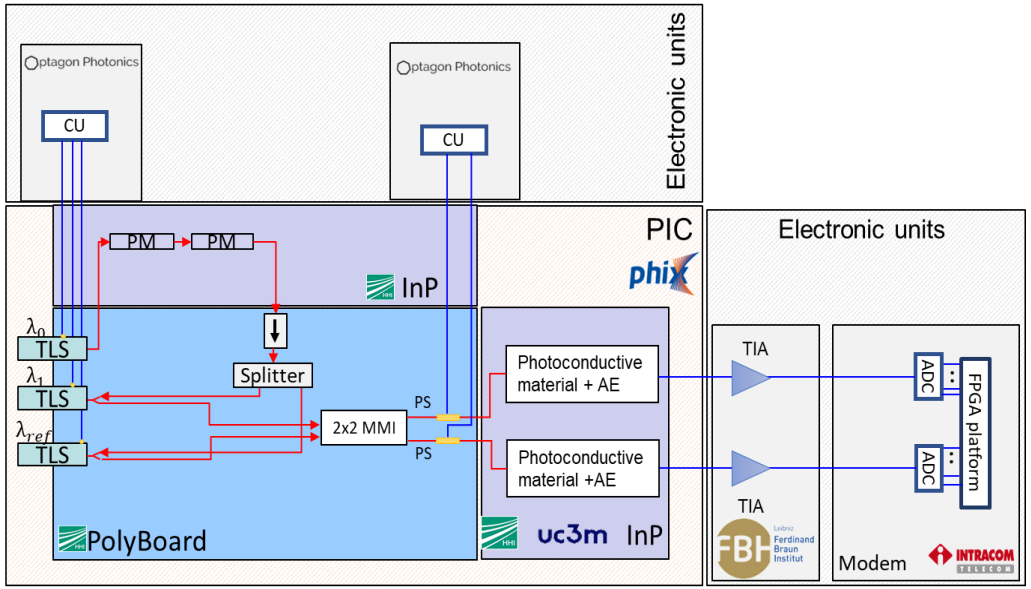
Receiver



Example of TERAWAY prototype: Tx & Rx





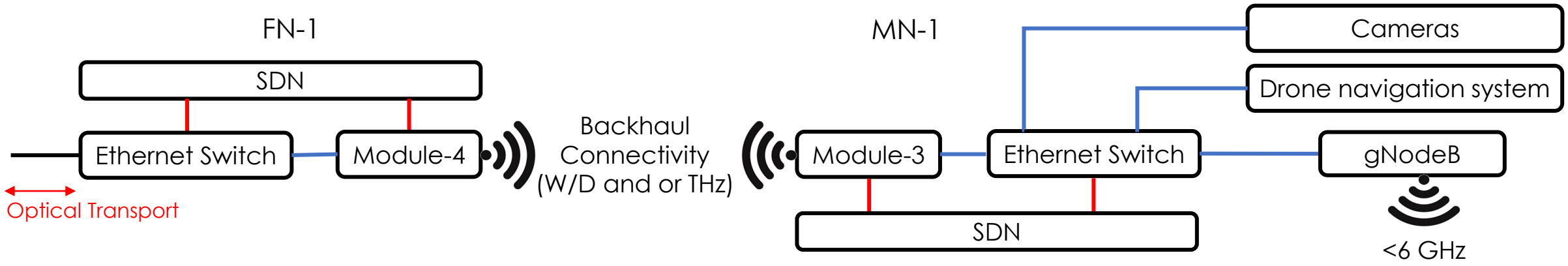


System specifications

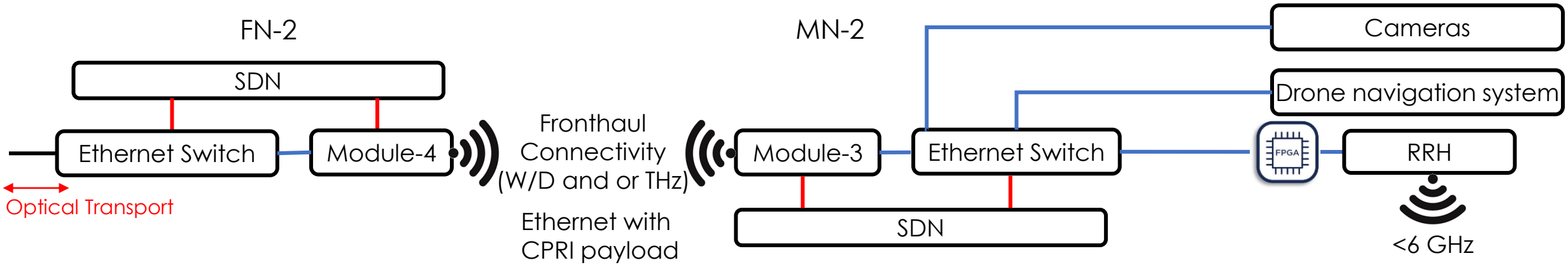
	Tx	Rx
# of channels	up to 4	
IF or baseband	2 IF / 2 Baseband	Baseband
Symbol rate (Gbaud)	1.5 / 18	1.5 / 18
Modulation format	256-QAM / 64-QAM	Up to 256-QAM
Total bit rate (Gb/s)	Up to 241	
OBFN	4x16 Blass matrix	-
Operation band	W/ D/ THz	

TERAWAY: Main demonstration scenarios

Scenario-1: Backhaul connectivity between Fixed Node-1 and Moving Node-1



Scenario-2: Fronthaul connectivity between Fixed Node-2 and Moving Node-2



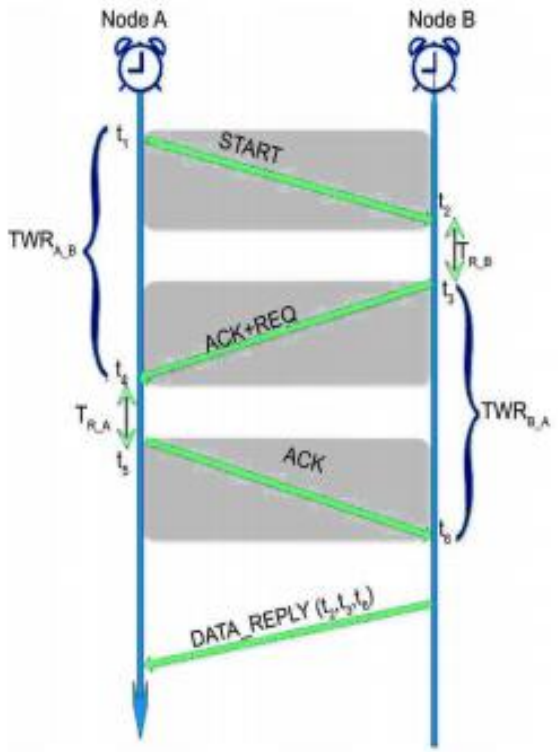
THz propagation model & localization techniques

Development of 3D path-loss map

- Development of a simulator for the generation of path-loss maps for THz signals inside realistic propagation environments
- Development of modeling tools for effects such as Doppler spread, shadowing effects and the interference effects from co-channels or adjacent channels
- Enable the optimization of the link geometries via the selection of the optimum positions of the moving nodes

Development localization algorithms

- Calculation of the distance between two nodes by combining the symmetrical double-sided two-way ranging method and the beam steering capabilities of the TERAWAY nodes



Network management and application tools

Optimum use of network and radio resources and accommodation of eMBB and URLLC services

SDN platform

- **Re-organization of the network traffic flows** based on the path-loss maps and the positions of the drones
- **Configuration of the system parameters** of the TERAWAY transceivers (e.g. frequency band, channel bandwidth, modulation format/rate)
- **Development of SBIs and NBIs**

Slicing manager

- Identification/ categorization of the network slices that will be created and allocation of the network and radio resources (**End-to-End slices**)

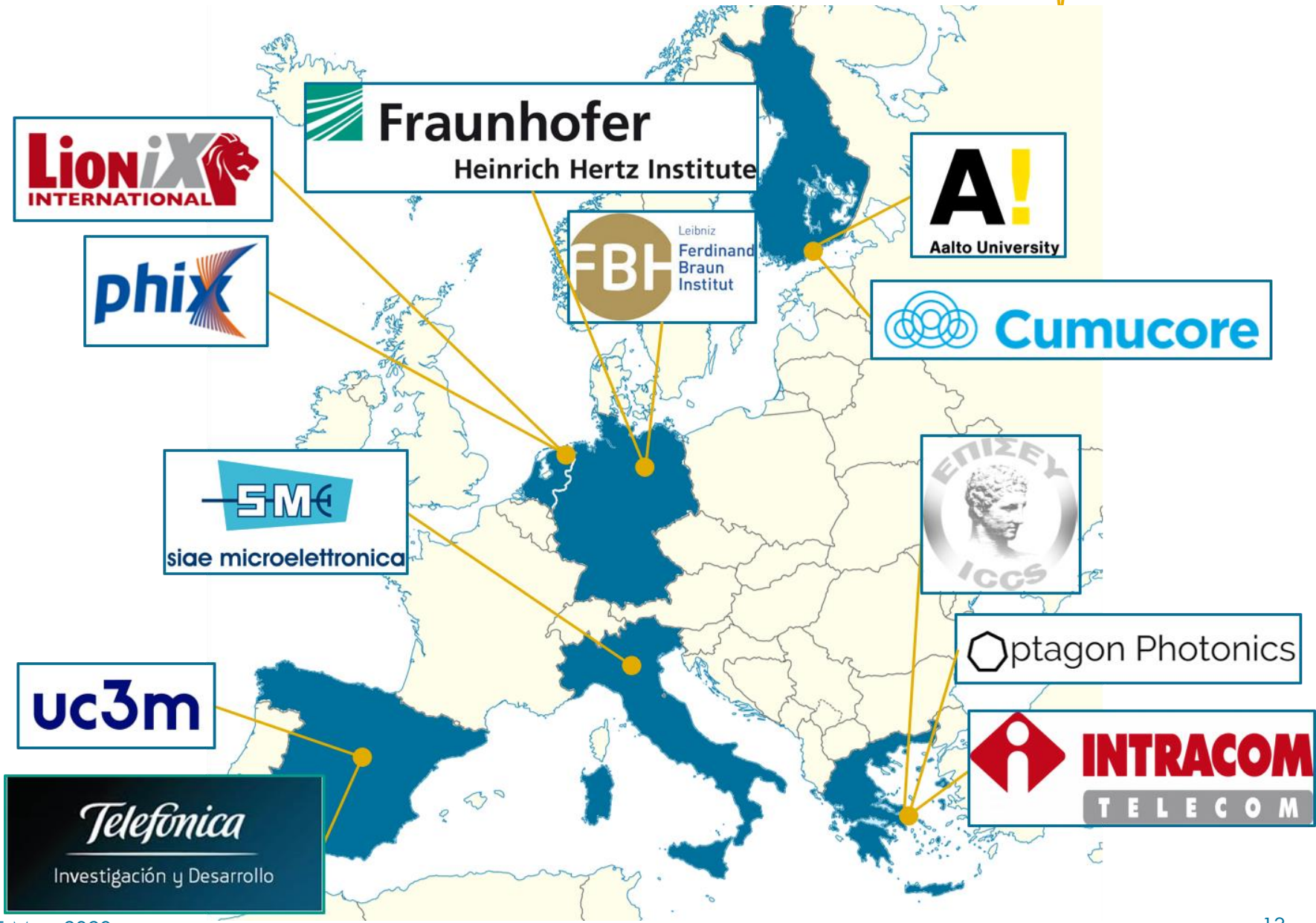
Platform for processing of surveillance data

- Local processing of the surveillance data at the edge of the network (**Critical latency reduction**)

TERAWAY Consortium

12 Partners
6 EU countries

- **1** Operator
- **2** Vendors
- **2** Industry-oriented Research Institutes
- **4** SMEs
- **3** Academic Organizations



Thank you!

For more info, visit TERAWAY website

https://ict-teraway.eu/

Project Coordination

Prof. Hercules Avramopoulos
E-mail: hav@mail.ntua.gr

Dr. Maria Massaouti
E-mail: mmas@mail.ntua.gr

Christos Tsokos
E-mail: ctso@mail.ntua.gr

Funded by the Horizon 2020 Framework Programme of the European Union under under G.A No 871668 and it is an initiative of the Photonics Public Private Partnership