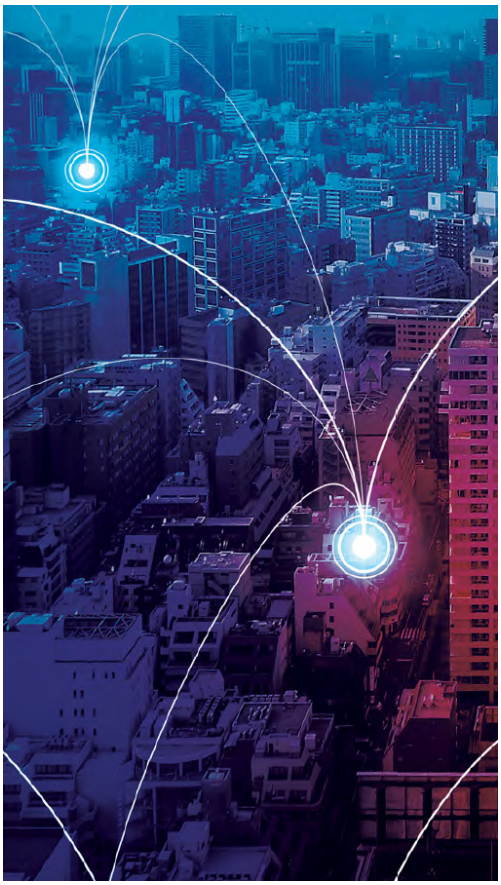
TERAPOD is a research project supported by the European Commission through Horizon 2020 under Grant Agreement 761579.

TERAPOD project newsletter #1

May 2018

Welcome to the first TERAPOD project newsletter!



TERAPOD is a Horizon 2020 project funded by the EC. The project aims to investigate and demonstrate the feasibility of ultra-high bandwidth wireless access networks operating in the terahertz (THz) band. The proposed TERAPOD THz communication system will be developed, driven by "beyond 5G" (B5G) usage scenario requirements, will be demonstrated in a "first adopter" operational setting (a data centre) and will significantly progress innovations across the whole communications protocol stack. There will be two newsletters per year: this first newsletter includes the following items:

- *An overview of the project objectives*
- *An introduction to the ICT-09-2017 cluster of related H2020 projects*
- *Some recent TERAPOD events*
- *A summary of the TERAPOD usage scenarios*
- *Notice of some upcoming TERAPOD activities*

More info is available on the website (www.terapod-project.eu)

TERAPOD video online!!

A short intro video outlining the objectives and concepts of the TERAPOD project is now online on the website. It includes some comments on the project vision from Dr. Alan Davy (WIT) and other researchers, and details of the technical challenges which will need to be overcome.

Coordinator Alan Davy adavy@tssg.org
Admin Bruce Napier bruce@vividcomponents.co.uk

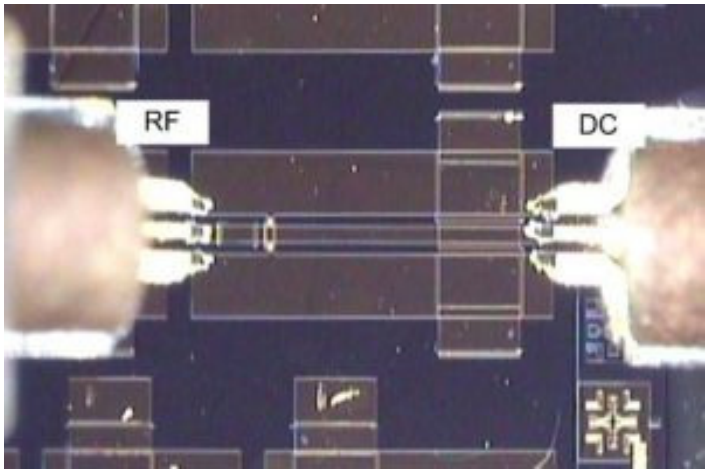
TERAPOD project summary

TERAPOD vision

TERAPOD pursues the ambitious vision of the short range Tbps wireless connectivity paradigm, by exploiting three of the most promising emerging THz device technologies:

- *Resonant tunnelling diodes (RTDs)*
- *Uni-travelling carrier photodiodes (UTC-PDs)*
- *Schottky barrier diodes (SBDs)*

These advances will enable the development and integration of the building blocks required for ultra-broadband communications in the THz spectrum. TERAPOD employs an holistic approach in which multiple technologies are explored simultaneously. The vision of the TERAPOD project is to push the boundaries of THz communications through this combination and integration of technologies to pave the way for future Tbps wireless communications.



A microscope image of an RTD.
[Image courtesy of University of Glasgow.]

TERAPOD concept

The saturation of wireless spectrum access is leading to innovations in areas such as spectrum resource usage. However, it is widely thought that the low hanging fruits of innovation for wireless communication are all but exploited, with only marginal further gains possible. For a real step change towards the coveted 1 Tbps wireless transmission regime, new areas of the spectrum must be utilised. Recent breakthroughs in terahertz systems are overturning the “terahertz gap” stigma associated with this difficult to access spectral region. With the recent emergence of viable THz communications systems on the horizon, it is crucial to develop a technology roadmap for THz communication for beyond the 5G timeframe.

TERAPOD objectives

There are four key TERAPOD objectives which underpin the project workplan:

1) Advance the Technology Readiness Level (TRL) of THz communication devices and systems from the laboratory towards industrial and SME uptake, within the context of B5G usage scenario requirements.
2) Demonstrate the feasibility of THz communication systems in B5G scenarios through a fully integrated “first adopter” data centre demonstrator.
3) Address the non-technical barriers to adoption of THz communication in the areas of regulation and standardisation.
4) Promote scientific research and innovation of THz communications systems in Europe.

ICT-09-2017 cluster

TERAPOD was funded alongside several other projects in the H2020 call ICT-09-2017 "Networking research beyond 5G." These projects are working together to share and disseminate information among themselves and to a wider audience. There will also be a range of events including workshops and conferences (see pg. 7). The other five cluster members are:

DREAM www.h2020-dream.eu

D-band Radio solution Enabling up to 100 Gbps reconfigurable Approach for Meshed beyond 5G networks

Through the exploitation of the radio spectrum in D-band (130-174.4 GHz) with beam steering functionality, DREAM will enable wireless links with data rates exceeding current V-band and E-band wireless backhaul solutions by at least a factor of ten and thus, it will bring wireless systems to the speed of optical systems. The DREAM project vision and objectives rely on a power efficient and silicon based BiCMOS transceiver analog front end, operating in D-band and enabling cost efficient deployment of meshed networks with seamless fiber performance. A beam steering integrated antenna array using an intelligent low-cost packaging technology prototype will be developed for the implementation of the B5G network proof of concept in a realistic environment.

EPIC www.epic-h2020.eu

Enabling Practical Wireless Tbps Communications with Next Generation Channel Coding

EPIC aims to develop a new generation of Forward Error Correction (FEC) codes in a manner that will serve as a fundamental enabler of practicable B5G wireless Tbps solutions. The project also aims to develop and utilise a disruptive FEC design allowing to advance state-of-the-art FEC schemes and to obtain the principal channel codes for B5G use cases. The design framework developed within the project will offer new ways to conduct research and development and has the potential to affect the development of all future B5G communication systems.

TERRANOVA www.ict-terranova.eu

Terabit/s Wireless Connectivity by TeraHertz innovative technologies to deliver Optical Network Quality of Experience in Systems beyond 5G

TERRANOVA envisions to extend the fibre-optic systems' Quality of Experience to wireless links by exploiting frequencies above 275 GHz. This means reliable connectivity at extremely high data rates in the Tbp/s regime and almost 'zero-latency' for networks B5G. The consortium will employ breakthrough technology concepts, namely: the design of baseband signal processing for the complete optical and wireless link and the development of THz wireless frontends and their integration with photonic components. A network information theory framework, caching techniques, channel and interference models, all tailored to the particularities of the THz regime and extremely large bandwidths will achieve the successful co-design of components and network solutions.

ULTRAWAVE www.ultrawave2020.eu

Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes

The ULTRAWAVE project is aimed at developing a high capacity backhaul that enables 5G cell densification by exploiting bands beyond 100 GHz. New travelling wave tubes delivering high power will allow the creation of an ultra capacity layer providing more than 100 Gbps per kilometer square in point-to-multi-point at D-band (141-174.8 GHz) fed by novel G-band (300 GHz) point-to-point high capacity links. The ULTRAWAVE system is empowered by the convergence of three main technologies: vacuum electronics, solid-state electronics and photonics. This ULTRAWAVE layer will enable backhaul of hundreds of small and pico cells, no matter the density, opening scenarios for new network paradigms aiming at a full 5G implementation.

WORTECS www.wortecs.cms.orange-labs.fr

Wireless Optical/Radio TErabit CommunicationS

WORTECS will explore the Tbps capability of the spectrum above 90 GHz, combining radio and optical wireless technologies. The primary challenge of WORTECS is to propose scientific and technology advances for novel use of the spectrum, de-risking technological building blocks at frequencies above 90 GHz up to THz communications backed by innovative usage scenarios, for instance, virtual reality. It will also address visible light communications and develop radically new approaches for spectrum efficiency. WORTECS aims to offer: optical wireless communication and radio over 90 GHz proof of concept with several Gbps throughput: innovation on antennas, coding and heterogeneous wireless network studies with new architectures and protocols for routing, latency and caching.

TERAPOD events since the project start

ICUMT 2017

9th Int. Congress on Ultra Modern Telecommunications and Control Systems

06-08 Nov-2017; Munich, Germany

There were four TERAPOD papers at this major international annual congress:

Device characterization for THz wireless links
Mira Naftaly (NPL)

Building an End User focused THz based Ultra High Bandwidth Wireless Access Network: The TERAPOD Approach
Alan Davy (WIT); Luis Pessoa (INESC); Cyril Renaud (UCL); Edward Wasige (UGLA); Mira Naftaly (NPL); Thomas Kürner (TUBS); Glenn George (Bay P.); Oleg Cojocari (ACST); Niamh O' Mahony (Dell EMC) and Marco A. Porcel (VLC)

Channel Sounding Techniques for Applications in THz Communications
Sebastian Rey; Johannes M. Eckhardt; Bile Peng; Ke Guan and Thomas Kürner (TUBS)

THz Electronics for Data Centre Wireless Links - the TERAPOD Project
Abdullah Al-Khalidi; Khalid Alharbi; Jue Wang and Edward Wasige (UGLA).

Teranet Terahertz Communications

08-Jan-2018; London, UK

There were three invited TERAPOD papers at this workshop organised by the EPSRC project TERANET, led by University of Leeds:

Terahertz communications-introduction
Cyril Renaud (UCL)

Advanced methods for channel characterization in THz communication systems
Thomas Kürner (TU Braunschweig)

Building an end user focused THz based ultra high bandwidth wireless access network
Alan Davy (WIT)

Towards TeraHertz Communications Workshop

07-Mar-2018; Brussels, Belgium

This workshop aimed to bring together key actors currently working on, or having interest in THz communications in order to explore future R&I plans for the period beyond 2020. The main goal of the workshop was to get an overview of the current state-of-the-art of the research in this area, discuss the main challenges, highlight key research directions for future R&I actions and to share opinions on the foreseen frequency bands which could be good candidates to be supported by the EU in the global allocation exercise.

TERAPOD had a strong representation at the event, with presentations from Thomas Kürner (TU Braunschweig) on *IEEE 802.15.3d and other activities related to THz Communications. Where to go next?,* Mira Naftely (NPL) on *Standards and metrology for THz devices,* and Alan Davy both presented on *Data Centre Use Case for THz wireless links* and chaired the session on “Standardisation, Regulation and Metrology for THz Communication.”

6M plenary meeting

21-22 Mar-2018; Cork, Ireland

A two day plenary meeting was hosted by Dell EMC at its Cork (Ovens) site. Led by the project Coordinator (TSSG, Waterford Institute of Technology) the comprehensive agenda covered technical and dissemination aspects of the project. Progress in the first period has been good, and the use cases for the project have been established (see pg. 6).

iBROW workshop

23-24 Apr-2018; Glasgow, UK

The iBROW H2020 project held a THz Electronics Workshop in Glasgow on 23-24 Apr-2018. Abdullah Al-Khalidi (University of Glasgow) organised the event which was attended by almost 100 THz researchers, including some leading experts from across the world.

There were a number of contributions from TERAPOD partners: Dr. Abdullah Al-Khalidi himself on 300 GHz RTDs and their applications, Prof. Thomas Kürner (TU Braunschweig) presented on channel modelling, Dr. Mira Nartaly (NPL, UK) on THz metrology and Dr. Luis Pessoa (INESC) on RTD based microwave photonic links.

The workshop was such a success that there were already discussions about where the next event should be!

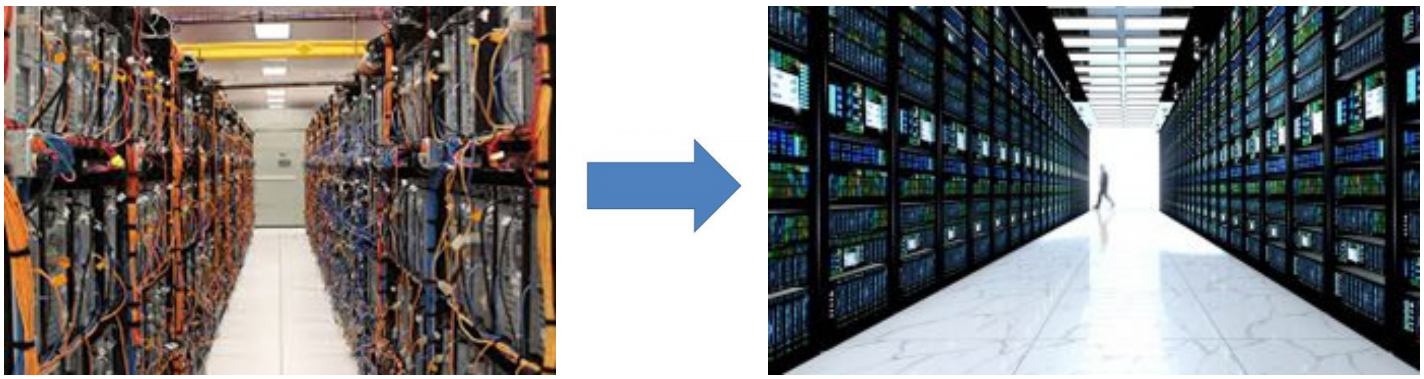
IEEE 802 Wireless Interim Session

06-11 May-2018; Warsaw, Poland

Thomas Kürner (TU Braunschweig) leads the Terahertz Interest Group in this key standards forum and introduced TERAPOD and the ICT-09-2017 Cluster to the group. There were also presentations from both EPIC and TERRANOVA.

TERAPOD usage scenarios

A data centre has been selected for the demonstration because it is a likely “first adopter” of the technology. Data centres represent very well controlled environments in which ultra-high bandwidth is vital. Current systems are linked using thousands of cables to connect the server ports. Although this offers extremely high performance in terms of data volume, it restricts capacity flexibility, manageability, scalability and performance for dynamic work loads. Replacing these physical connections with wireless THz links will offer a step change in all these aspects, as well as improving energy efficiency.



TERAPOD has defined four use cases, each of which was derived from early engagement with potential end users of TERAPOD technologies. These four use cases are:

- Commercial Feasibility of THz DC Wireless Networks
- Static (Layer-1) THz Wireless Data Links
- Dynamic (Multi-Layer) THz Wireless Data Link Integration
- Wireless Data Centre Auto-Configuration

These use cases, and their detailed requirements, will underpin the technology development efforts for the TERAPOD project. Each use case will continue to be refined and revised throughout the lifetime of the project, in order to ensure that the project produces technology for which deployment within a data centre environment is both technically viable and commercially feasible.

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For more info contact Fiach O'Donnell (DELL EMC): Fiach.ODonnell@Dell.com

Upcoming TERAPOD events

THz Communications Beyond 5G Workshop

1st Int. Workshop on THz Communication Technologies for Systems B5G (In conjunction with 2018 IEEE VTC2018-Spring)

03-06 Jun-2018; Porto, Portugal

Motivated by the potential of THz technologies to transform the future of ICT, this workshop aspires to reveal and discuss the critical technology gaps as well as the appropriate enablers, in terms of baseband processing RF frontend, channel models and waveforms, signals and coding, beam-patterns and medium access schemes. This event is also a Cluster activity: Angeliki Alexiou (University of Piraeus) from TERRANOVA will chair the session and there will be presentations from TERAPOD members UGLA (on RTD oscillators) and TU Braunschweig (on human blockage of mm-waves).

EuCNC 2018

European Conference on Networks and Communications 2018

18-21 Jun-2018; Ljubljana, Slovenia

EuCNC 2018 is the 27th edition of a successful series of technical conferences in the field of telecommunications, sponsored by IEEE ComSoc and EURASIP, and financially supported by the European Commission, focusing on communication networks and systems, and reaching services and applications. As another Cluster event, there will be a Special Session at the conference entitled “Terabit Wireless Transport for Networks Beyond 5G” led by Claudio Paoloni (ULTRAWAVE) with presentations from EPIC, TERRANOVA and TERAPOD.

NanoCom 2018

5th ACM/IEEE Int. Conf. on Nanoscale Computing and Communication

05-07 Sep-2018; Reykjavik, Iceland

The main goals of ACM/IEEE NanoCom 2018 are to increase the visibility of this growing research area to the wider computing and communication research communities as well as bring together researchers from diverse disciplines that can foster and develop new paradigms for nanoscale devices. Alan Davy (TSSG, WIT) will present an invited paper on TERAPOD at this event.

EuMW 2018

European Microwave Week 2018

23-28 Sep-2018; Madrid, Spain

The ICT-09-2017 Cluster will have a booth at the European Microwave Exhibition which is the largest trade show dedicated to Microwaves and RF in Europe. There are expected to be a number of papers from TERAPOD and the other Cluster members at the European Microwave (EuMC) and Microwave Integrated Circuits Conferences (EuMIC).