Ref. Ares(2020)898845 - 12/02/2020

Horizon 2020 Grant Agreement no: 814523

Tera**h**ertz end-to-end wireless systems supp**o**rting ultra-high data **R**ate applications

ThoR

D7.5
18M Dissemination and exploitation activity report

Coordinator (EU): Thomas Kürner
Organisation: Technische Universität Braunschweig

Coordinator (Japan): Tetsuya Kawansihi
Organisation: Waseda University

Start date of project: 01-Jul-2018

Date of issue: 31-Jan-2020
Due date: 31-Dec-2019
Ref: ThoR_VIV_200128_A_WP7

Leader in charge of deliverable: Bruce Napier
Vivid Components

Project co-funded by the European Commission within the Horizon 2020 programme and the National Institute of Information and Communications Technology in Japan (NICT)		
Dissemination level		
PU	**Public**	**X**
PP	**Restricted to other programme participants (including the Commission Services)**	
RE	**Restricted to a group specified by the consortium (including the Commission Services)**	
CO	**Confidential, only for members of the consortium (including the Commission Services)**	

© All rights reserved.

Contents

1. STATEMENT OF INDEPENDENCE 2
2. EXECUTIVE SUMMARY 3
3. DISSEMINATION ACTIVITIES AT 18M 4
3.1. ThoR website 4
3.2. ThoR events 4
3.2.1. Conference presentations 4
3.2.2. ThoR Japan workshop 7
3.2.3. Trade shows and exhibitions 8
3.2.4. Other events 8
3.3. Journal publications 9
3.4. Other ThoR dissemination activity 10
3.4.1. Newsletters 10
3.4.2. ThoR video 11
3.4.3. Dissemination material 11
3.5. Beyond 5G Cluster 13

Change register

Version	Date	Author	Organisation	Changes
A_DRAFT	29-Jan-2020	Bruce Napier	Vivid Components	Initial
A	31-Jan-2020	Bruce Napier	Vivid Components	Minor additions following review; typos & formatting

Reviewed by Prof. Thomas Kürner TU Braunschweig A_DRAFT 29-Jan-2020

1. Statement of independence

The work described in this document is genuinely a result of efforts pertaining to the ThoR project. Any external source is properly referenced.

Confirmation by Authors: Bruce Napier Vivid Components

© All rights reserved.

2. Executive summary

This document summarises the dissemination activities performed in ThoR in the first half of the project (*i.e.* M1 to M18). This activity has been broad and varied and is outlined in detail in this document.

More info is available from the project website www.thorproject.eu

The headline items are as follows:

- The website has been established and maintained including an RSS news feed
- The project has been widely represented at international conferences
    - Fourteen presentations at major events (with DOI proceedings)
    - ThoR workshop held 20-Sep-2019 at Waseda University
    - Representation at several trade shows and exhibitions
    - Seventeen presentations at other meetings and workshops
    - *The standards work has been highly influential and will be described elsewhere: see D7.4.*
- A refereed journal paper was published in this period and several new papers are in preparation
- A range of dissemination resources have been prepared:
    - Three newsletters issued
    - Video on DEMO-1 filmed at Lille with several EU and Japanese partners
    - An array of information on the project for public use (business cards, posters, presentation *etc.*) and merchandise for distribution at exhibitions (post-it notes and coasters)
- ThoR has joined the B5G Cluster which has been very active
    - Booth at European Microwave Week (Sep-2018)
    - Workshop on THz Communications held in Brussels (Mar-2019)
    - Booth and Special Session at EUCNC 2019 (Jun-2019)
    - Workshop at IEEE World Forum 2019 (Sep-2019)
    - Several events are already planned for the final Period.

© All rights reserved.

3. Dissemination activities at 18M

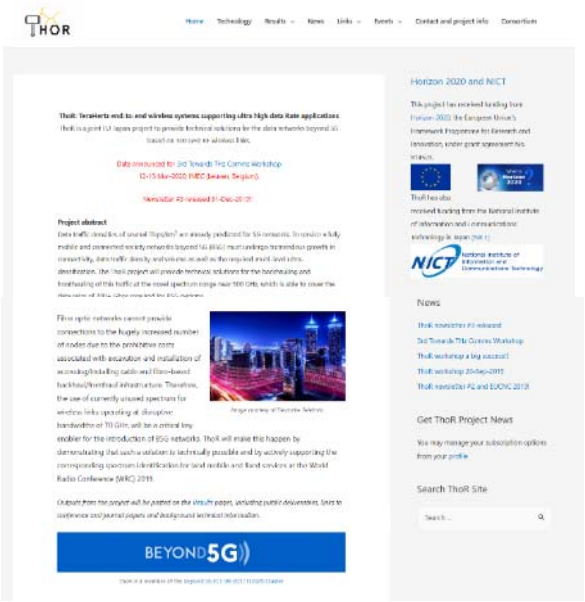
ThoR has been very active in its dissemination activity. A range of dissemination material is available, and ThoR has been a key participant in many events relating to THz communications and B5G.

3.1. ThoR website

A website has been established at https://thorproject.eu

This includes all public ThoR documents, and is frequently updated with events, conference and journal papers as well as all the public deliverables. An RSS news feed is used to update on project progress and for announcements relating to ThoR activities. The page structure was updated during the period to improve the presentation of the project results, and is currently as follows:

- Home
- Technology
- Results
  - Newsletters
  - Journal papers
  - Conference papers
  - Standards
  - Press coverage
  - Deliverables
- News
- Links
  - B5G Cluster
- Events
  - 3rd Towards THz Comms Workshop 12-13 Mar-2020
  - ThoR Workshop 20-Sep-2019
- Contact and project info
- Consortium



3.2. ThoR events

3.2.1. Conference presentations

To M18 in the project there have been 15 major conference papers which have subsequently been published in proceedings with DOI references. (In addition, there have been a number of presentations at smaller and less formal events: see §3.2.4.) These conferences are listed below in reverse chronological order. These papers are green or gold access: see ThoR website for details.

© All rights reserved.

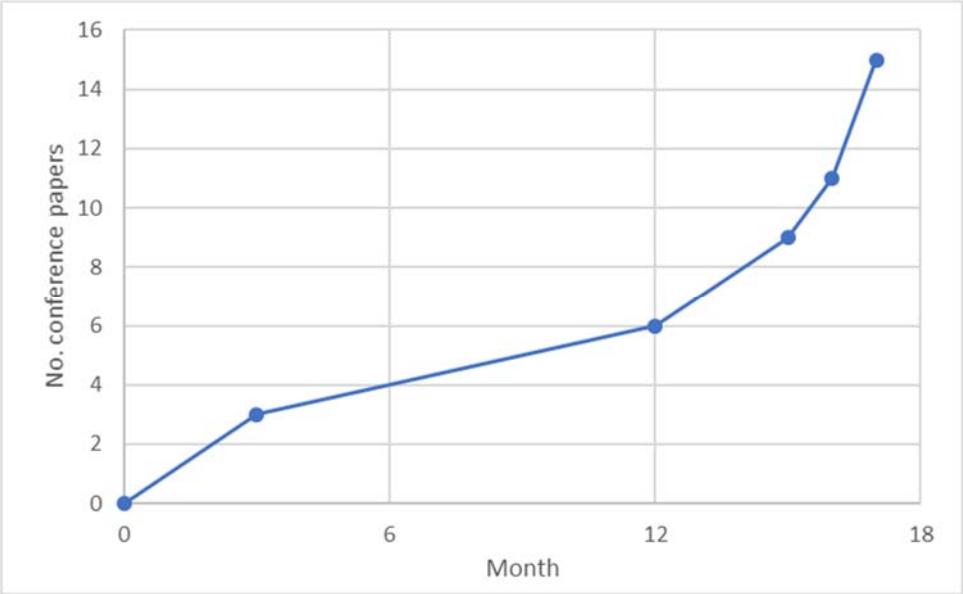


Figure 1: *Graph showing Period 1 ThoR conference papers (with DOI)*

WPMC 2019
Int. Symposium on Wireless Personal Multimedia Communications
25-27 November 2019, Lisbon Portugal

THz Communications – A Candidate for a 6G Radio? (Invited)
Thomas Kürner
(DOI not issued at time of writing)

PEM 2019
3rd International Workshop on Photonics applied to Electromagnetic Measurement
18-19 Nov-2019; Ise, Mie, Japan

Evaluation of antenna radiation characteristics at terahertz frequency band based on an electrooptic near-field measurement
Yusuke Tanaka, Shintaro Hisatake
(DOI not issued at time of writing)

Characterisation of Terahertz Antenna for beyond 5G Systems
Akihiko Hirata, Katsumi Fujii, N. Sekine, I. Watanabe, A. Kasamatsu
(DOI not issued at time of writing)

Short-Focus Lens Design for Terahertz Ray
Keita Miyazawa, Atsushi Kanno, Shingo Saito, Keizo Inagaki and Tetsuya Kawanishi
(DOI not issued at time of writing)

ISAP 2019
International Symposium on Antennas and Propagation
27-30 Oct-2019; Xi'an, China

Measurement of Reflection and Transmission Characteristics of Glasses at 300 GHz
A. Hirata, N. Sekine, I. Watanabe, A. Kasamatsu
(DOI not issued at time of writing)

© All rights reserved.

ICRAMET 2019
International Conference on Radar, Antenna, Materials, Electronics and Telecoms
23-24 Oct-2019; Tangerang, Indonesia

Near-field visualization of millimeter-wave and THz wave based on photonics: principle and applications [Invited]
Shintaro Hisatake
(DOI not issued at time of writing)

EuMW 2019
European Microwave Week 2019
29-Sep to 04-Oct-2019; Paris, France

A Superheterodyne >300 GHz Wireless Link for Ultra-Fast Terahertz Communication System
Iulia Dan, Guillaume Ducournau, Shintaro Hisatake, Pascal Szriftgiser, Ralf-Peter Braun, Ingmar Kallfass
https://doi.org/10.23919/EuMC.2019.8910935

IRmmW-THz 2019
44th International Conference on Infrared, Millimeter, and Terahertz Waves
01-06 Sep-2019; Paris, France

Simulation and Automatic Planning of 300 GHz Backhaul Links [Keynote]
Bo Kum Jung, Nils Dreyer, Johannes M. Eckhardt and Thomas Kürner
https://doi.org/10.24355/dbbs.084-201908211532-0

Towards super-heterodyne THz links pumped by photonic local oscillators
Iulia Dan; Shintaro Hisatake; Pascal Szriftgiser; Ralf-Peter Braun; Ingmar Kallfass; Guillaume Ducournau
https://doi.org/10.1109/IRMMW-THz.2019.8873762

EUCNC 2019
European Conference on Networks and Communications
18-21 Jun-2019; Valencia, Spain

ICT Beyond 5G Cluster: Seven H2020 for Future 5G
Paoloni, Claudio; Alexiou, Angeliki; Bouchet, Oliver; Davy, Alan; Ermolov, Vladimir; Kürner, Thomas; Napier, Bruce; Sahin, Onur
https://doi.org/10.24355/dbbs.084-201908211514-0

Regulatory Aspects of THz Communications and Related Activities Towards WRC 2019
Thomas Kuerner
https://doi.org/10.24355/dbbs.084-201908211524-0

IMS 2019
International Microwave Symposium
02-07 Jun-2019; Boston, USA

300 GHz broadband power amplifier with 508 GHz gain-bandwidth product and 8 dBm output power
Benjamin Schoch, Axel Tessmann, Arnulf Leuther, Sandrine Wagner, Ingmar Kallfass
https://doi.org/10.1109/MWSYM.2019.8700754

© All rights reserved.

IRmmW-THz 2018
43rd International Conference on Infrared, mm-wave and THz waves
09-14 Sep-2018; Nagoya, Japan

Compact Antennas Pattern Measurement Setup at 240 GHz
C. Belem Goncalves ; E. Lacombe ; Carlos del Rio ; F. Gianesello ; C. Luxey ; G. Ducournau
http://doi.org/10.1109/IRMMW-THz.2018.8509996

Considerations on Local Oscillator Isolation in a Terahertz Wireless Link Used for Future Communication Systems
Iulia Dan ; Christopher M. Grotsch ; Shoichi Shiba ; Ingmar Kallfass
http://doi.org/10.1109/IRMMW-THz.2018.8510497

[Keynote] Turning THz Communications into Reality: Status on Technology, Standardization and Regulation
Thomas Kuerner
http://doi.org/10.1109/IRMMW-THz.2018.8510153

3.2.2.ThoR Japan workshop

The first ThoR workshop was organised and hosted by Waseda University on FRI 20-Sep-2019. The workshop included three invited keynotes, presentations from the ThoR partners and a poster session. In addition, there was a small exhibition during the lunch and coffee breaks. Over seventy attendees were present, and the event was very well received. Based on this success, a follow-up event in Japan is under discussion in addition to the EU workshop planned at the end of the project.

Further details have already been published in *D7.6 Mid-term ThoR Workshop (Japan)* and on the project website: https://thorproject.eu/events/thor-workshop-sep-2019

Figure 2: *Attendees of the first ThoR workshop at Waseda University Sep-2019*

© All rights reserved.

3.2.3. Trade shows and exhibitions

ThoR has participated in several trade shows and exhibition, including:

- ThoR Workshop exhibition
  - The first ThoR workshop included a small 12 booth exhibition (see D7.6 and §3.2.2)
  - Waseda University
  - FRI 20-Sep-2019
- IRmmW-THz conference and exhibition
  - 44th International Conference on Infrared, Millimeter, and Terahertz Waves
  - Booth 31 (PSL-University of Paris) showed ThoR merchandise
  - 02-Sep-2019; Paris, France
  - Guillaume Ducournau (Lille)
- B5G Cluster booth at EUCNC 2019: see §3.5.

3.2.4. Other events

ThoR researchers have presented on the project at (at least) seventeen other conferences, meetings and workshops. These are listed below in chronological order:

- Invited lecture on ThoR
  - 12-Oct-2018; Aalto University, Espoo, Finland
  - Thomas Kürner, TUBS
- Tutorial at IEEE 802.15 meeting
  - *THz Communications: An overview and options for IEEE 802 standardisation*
  - 12-Nov-2018; Bangkok, Thailand
  - Thomas Kürner, TUBS
- Presentation at IEEE 802.15 THz Interest Group
  - *Introduction to the H2020 EU-Japan project ThoR*
  - 14-Nov-2018; Bangkok, Thailand
  - Thomas Kuerner (TUBS) & Tetsuya Kawanashi (WUT)
- 8th EU-Japan Digital Strategies workshop
  - Presentation on ThoR
  - 04-Dec-2018; Vienna, Austria
  - Thomas Kürner, TUBS
- IEEE 802.15 THZ IG
  - *ThoR: Initial Results on Sharing Studies*
  - 11-Mar-2019; Vancouver, Canada
  - Thomas Kürner, TUBS
- Meeting of German National Preparatory Group for WRC 19
  - Presentation of initial results on sharing studies
  - 13-Mar-2019; Mainz, Germany
  - Sebastian Rey (TUBS)
- Terahertz System Application Promotion Council Meeting
  - H2020 ThoR Initial results on sharing studies
  - 25-Mar-2019; online
  - Thomas Kürner (TUBS)
- INFOCOM THz Workshop
  - Keynote address including ThoR
  - 29-Apr-2019; Paris, France
  - Thomas Kürner (TUBS)

© All rights reserved.

- Next Generation Mobile Networks (NGMN) Forum
  - Presentation on ThoR
  - 14-May-2019; Berlin, Germany
  - Thomas Kürner (TUBS)
- 42nd Meeting of the Wireless World Research Forum
  - Presentation on ThoR
  - 16-May-2019; Tokyo, Japan
  - Tetsuya Kawanashi (WUT)
- Compound Semiconductor Week 2019
  - *THz Frequency HEMTs: Future Trends and Applications [WeE2-1 Invited]*
  - 19-May-2019; Nara, Japan
  - Arnulf Leuther (IAF)
- Wireless Technology Park 2019 (exhibition)
  - Presentation on ThoR (in Japanese)
  - 29-May-2019; Tokyo, Japan
  - Tetsuya Kawanashi (WUT)
- Asian Wireless Group (AWG) meeting
  - Liaison from ITU-R antenna measurements
  - 01-Jul-2019; Tangerang, Indonesia
  - Tetsuya Kawanashi (WUT)
- IEEE 802.15 THZ IG
  - *Simulation and Automatic Planning of 300 GHz Backhaul Links -First Results from H2020-ThoR*
  - 16-Jul-2019; Vienna, Austria
  - Bo Kum Yung (TUBS)
- OSA Advanced Photonics Congress
  - Symposium: A Light in Digital Darkness: Optical Wireless Communications to Connect the Unconnected
  - *THz and Photonic Seamless Networks for Easy-deployable High-speed Access*
  - 30-Jul-2019; San Francisco, USA
  - Tetsuya Kawanashi (WUT)
- Terahertz Systems Application Symposium (IEICE)
  - *Photonics for millimeter/THz-wave networks*
  - 06-Aug-2019; Osaka, Japan
  - Tetsuya Kawanashi (WUT)
- Workshop WS-13 THz Communications
  - Part of Globecom 2019
  - *Terahertz and photonics seamless networks 1570573789*
  - 09-Dec-2019; Puako, Hawaii, USA
  - Tetsuya Kawanashi (WUT)
- IET Antennas and Propagation Conference
  - Invited Keynote at IET Antennas and Propation Conference
  - *THz Communications – A Candidate for a 6G Radio?*
  - 18- Nov-19, Birmingham, United Kingdom
  - Thomas Kürner (TUBS)

3.3. Journal publications

At the time of writing there has only been one journal paper printed on the ThoR results. (Several other papers are currently under review or in preparation.)

A Terahertz Wireless Communication Link Using a Superheterodyne Approach

© All rights reserved.

Iulia Dan; Guillaume Ducournau; Shintaro Hisatake; Pascal Szriftgiser; Ralf-Peter Braun; Ingmar Kallfass
IEEE Transactions on Terahertz Science and Technology **10**, p. 32-43 (2019).
https://doi.org/10.1109/TTHZ.2019.2953647

3.4. Other ThoR dissemination activity

3.4.1. Newsletters

Three ThoR newsletters have been released and are available to download from the project website: https://thorproject.eu/results/newsletters/

Figure 3: *Examples of the ThoR newsletter*

The main topics are as follows:

- **ThoR newsletter #3 Dec-2019**
- ThoR workshop in Japan (20-Sep-2019; University of Waseda)
- Save the date! 3rd Towards THz Comms Workshop 12-13 Mar-2020 at IMEC
- Overview of 5G/beyond 5G requirements wireless transport links from Deutsche Telekom
- Review of the ThoR parallelisation of 70/80 GHz transceiver modules from Siklu
- An update on measurement of 300 GHz band high-gain antennas at CIT.

- **ThoR newsletter #2 Jun-2019**
- Near-field measurements and antenna characterisation at 300 GHz by Gifu University
- 300 GHz front end development by Fraunhofer IAF and Univ. Stuttgart
- ThoR DEMO-1 and circuit design by the project team
- Development of a high power TWTA at 300 GHz band by NEC.

- **ThoR newsletter #1 Dec-2018**
- A brief overview of the project and its objectives
- An outline of the ICT-09-2017 Cluster of related projects
- Information on an EC THz communications workshop on 07-Mar-2019
- Results from spectrum sharing studies relevant to WRC 2019

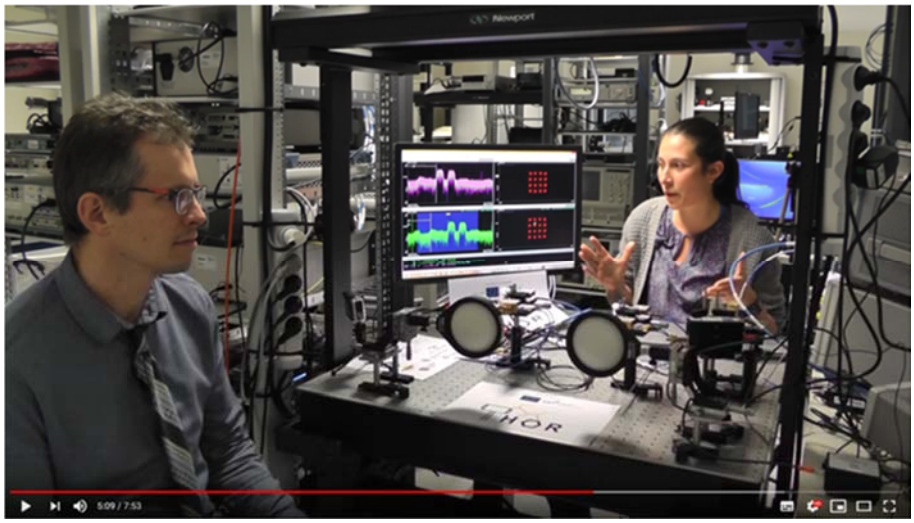
© All rights reserved.

- World first experimental demonstration of a superheterodyne 300 GHz wireless link!

Further newsletters will be produced approximately every six months, and the topics will be summarised in D7.10 (Summary of newsletters).

3.4.2. ThoR video

The first video (*c.* 8 min) of the ThoR DEMO-1 was recorded on 28-Nov-2018 at University of Lille/ IEMN CNRS (France). The experimental work was performed by University of Lille, University of Stuttgart, Gifu University and Deutsche Telekom. The video was recorded and edited by Vivid and has been approved for release by the ThoR consortium. This represents the first ever superheterodyne wireless link at 300 GHz, and demonstrates the proof-of-principle for the project.



The journal publication was in progress at the time of writing (see §3.3), so no details were provided, but the video gives an overview of the laboratory set-up, and was put on the project website on 21-Dec-2018: https://thorproject.eu/results

The video is also available directly from YouTube: https://www.youtube.com/watch?v=U1zatU6Gfbk

3.4.3. Dissemination material

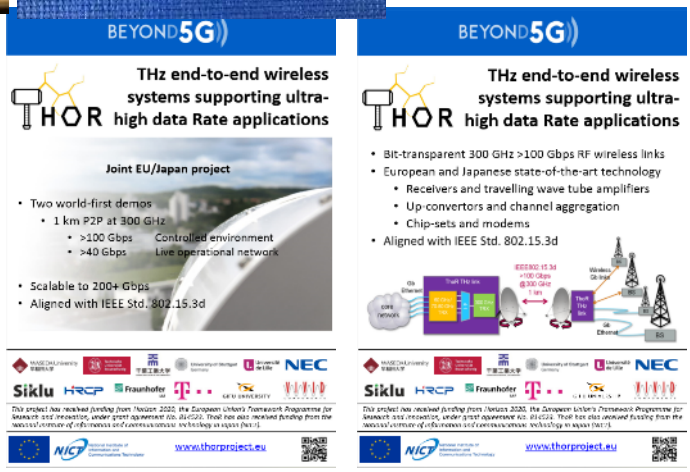
- Business cards
  - Business cards were produced with the project contact info
  - These are very useful for passing on info to contacts at *e.g.* exhibitions, conferences *etc.*
- Save the date cards (EC THz Communications Workshop (07-Mar-2019)
  - These were sent to all B5G Cluster project Coordinators and all ThoR partners
  - These proved very useful for promoting the event at *e.g.* EuMW 2018 *etc.*

- Merchandise
  - Coasters (*i.e.* drinks mats) and post-it notes
  - For promotion at exhibitions, *e.g.* EUCNC 2019.

© All rights reserved.

Figure 4: *ThoR promotional coasters and post-it notes*

- Posters and pop-ups
  - Poster version with common format and Beyond 5G logo produced and used
  - E.*g.* at EUCNC 2019 (Valencia, Jun-2019)



- Project presentation
  - Available online
  - Used as basic structure for many ThoR external presentations (see §3.2.4)

© All rights reserved.

3.5. Beyond 5G Cluster

The ICT-09-2017 Cluster was initiated by the TERAPOD project to gather the resources of the six projects funded in the H2020 call ICT-09-2017 “Networking research beyond 5G.” Following discussions within the group, the ThoR project was allowed to join the Cluster in Q3 2018. The Cluster agreed on a more succinct name, the Beyond 5G Cluster, and a common logo which is used to improve the visibility of the group in the various dissemination activities. Thus, the current B5G Cluster membership is as follows:

DREAM	*D-band Radio solution Enabling up to 100 Gbps reconfigurable Approach for Meshed beyond 5G networks*	
EPIC	*Enabling Practical Wireless Tb/s Communications with Next Generation Channel Coding*	
TERAPOD	*Terahertz-based ultra-high bandwidth wireless access networks*	
TERRANOVA	*Terabit/s Wireless Connectivity by TeraHertz innovative technologies to deliver Optical Network Quality of Experience in Systems beyond 5G*	
THOR	*TeraHertz end-to-end wireless systems supporting ultra high data Rate applications*	
ULTRAWAVE	*Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes*	
WORTECS	*Wireless Optical/Radio TErabit CommunicationS*	

© All rights reserved.

B5G Cluster activities (since ThoR membership)

- Second Towards Terahertz Communications Workshop (07-Mar-2019; Brussels)
  - Held in the EC facilities at Albert Borschette Congress Centre (CCAB)
  - EC, B5G and high profile international invited speakers, including:
    - Prof. Tadao Nagatsuma; Osaka University, Japan
    - Prof. Daniel Mittleman; Brown University, USA
    - Dr. Wolfgang Templ; Nokia Bell Labs, German

  - Full agenda and public presentations available from the TERAPOD website (hosted on behalf of the Cluster
    - https://terapod-project.eu/events/ec-thz-workshop

- European Conference on Networks and Communications (18-21 Jun-2019; Valencia, Spain); EUCNC 2019
  - Cluster booth #60
  - This is a major EU event (750 attendees) co-financed by the EC
  - The Cluster also held a Special Session
    - Special Session #2: Advanced THz technologies towards terabit/s wireless communications
    - https://www.eucnc.eu/special-sessions/special-session-2

- IEEE World Forum 2019 (30-Sep-2019; Dresden, Germany)
  - The B5G Cluster organised a workshop entitled: From Evolution to Revolution, a Roadmap for Beyond 5G
  - The workshop included several presentations and a panel discussion session
  - Further info from a webpage produced by the ULTRAWAVE partner University of Lancaster: http://wp.lancs.ac.uk/wf5gworkshopb5g/

- Cluster calls: A number of calls were held to plan these events and coordinate activities:
  - Conference call (05-Oct-2018)
  - Conference call (25-Oct-2018)
  - Conference call (11-Jan-2019)
  - Conference call (08-Feb-2019)
  - Conference call (22-May-2019)
  - Conference call (03-Sep-2019)
  - Conference call (26-Nov-2019)
  - Conference call (12-Dec-2019)
- Minutes were taken and circulated by Vivid
- A Cluster actions register is kept and maintained by Vivid

© All rights reserved.