

# WORTECS

**H2020-ICT-2016-2****RIA****Project-ID: 761329****WORTECS****Networking research beyond 5G****WP5 - D5.5 Dissemination: Plans and Update - Year 2**

<b>Contractual Date of Delivery:</b>	<b>2019, August 30<sup>th</sup></b>
<b>Actual Date of Delivery:</b>	<b>2019, August 30<sup>th</sup></b>
<b>Editor(s):</b>	<b>Dominic O'Brien (UOXF), Rafael Pérez (ULP)</b>
<b>Author(s):</b>	<b>Víctor Guerra (ULP), José Rabadán (ULP), Rafael Pérez (ULP), Olivier Bouchet (ORA)</b>
<b>Work package:</b>	<b>WP5 – D5.5</b>
<b>Security:</b>	<b>PU</b>
<b>Nature:</b>	<b>Deliverable</b>
<b>Version:</b>	<b>Version 1.6</b>
<b>Total number of pages:</b>	<b>23</b>

**Abstract**

*This report outlines the WP5 deliverable D5.5 and original tasks within this deliverable. A progress update on the tasks and new plans are detailed based on the periodic physical meetings. The action taken since the last review in November 2018 are presented along with the dissemination plan for the current review period (2018-2019). The contributions from the current period are detailed and a new plan for the third review period is presented.*

**Keyword list**

*Virtual Reality, High Quality / Low Latency, Wireless, OWC, radio transmission, Mac layer, HW implementation*

## List of Authors

First name	Last name	Beneficiary	Email address
Víctor	Guerra	ULP	victor.guerra@fpct.ulpgc.es
José	Rabadán	ULP	jose.rabadan@ulpgc.es
Rafael	Pérez	ULP	rafael.perez@ulpgc.es
Ravinder	Singh	UOXF	ravinder.singh@eng.ox.ac.uk
Vladica	Sark	IHP	sark@ihp-microelectronics.com
Bastien	Bechadergue	OLD	bastien.bechadergue@oledcomm.net
Guillaume	Vercasson	BCOM	guillaume.vercasson@b-com.com
Dominic	O'Brien	UOXF	dominic.obrien@eng.ox.ac.uk
Olivier	Bouchet	ORA	olivier.bouchet@orange.com
Tamas	Weszely	PLF	tamas.weszely@purelifi.com

## Document History

First name	Last name	Version	Comments
Víctor	Guerra	12 <sup>th</sup> Feb 2019	First version.
Ravinder	Singh	19 <sup>th</sup> Feb 2019	V1 revised. Main changes to the deliverable structure.
Ravinder	Singh	16 <sup>th</sup> May 2019	Updated "actions taken post 2017-2018 review" section. Structured the dissemination plan and contributions section for 2018-2019 period.
Víctor	Guerra	17 <sup>th</sup> August 2019	Added information about published papers
Ravinder	Singh	20 <sup>th</sup> August 2019	Added information on Open Event-1 plan and UOXF plan for dissemination in period 2019/2020.
Bastien	Bechadergue	24 <sup>th</sup> August 2019	Added OLD information
Víctor	Guerra	26 <sup>th</sup> August 2019	Added last information gathered from partners
Vladica	Sark	26 <sup>th</sup> August 2019	Added IHP information
Víctor	Guerra	27 <sup>th</sup> August 2019	Merged all remaining information
Dominic	O'Brien	29 <sup>th</sup> August 2019	WP5 work package leader review and edit

## List of Acronyms

Acronym	Meaning
BB	Base Band
DFE	Digital Front End
HMD	Head Mounted Display
OWC	Optical Wireless Communication
RF	Radio Frequency
VR	Virtual Reality
WORTECS	Wireless Optical/Radio TeraBite CommunicationS
LiFi	Light Fidelity
FWF	Fiber Wireless Fiber

## Table of contents

<b>List of Authors .....</b>	<b>2</b>
<b>Document History .....</b>	<b>2</b>
<b>List of Acronyms.....</b>	<b>3</b>
<b>Table of contents .....</b>	<b>4</b>
<b><i>I. Contributions in 2017-18 period (Year 1).....</i></b>	<b><i>5</i></b>
<b><i>II. Table 1 – Contributions in 2017-2018 period (Year 1)Actions taken post 2017-18 (Year 1) review (UOXF/OR A).....</i></b>	<b><i>5</i></b>
<b><i>III. Dissemination plan for 2018-19 period (Year 2).....</i></b>	<b><i>7</i></b>
Scientific publications .....	7
Open Events .....	7
<b><i>IV. Contributions in 2018-19 period (Year 2) .....</i></b>	<b><i>8</i></b>
Cluster Activities.....	8
Invited talks and conference contributions.....	9
Open Event-1 Organization.....	12
Contributions to journals by partner.....	15
Patents by partner .....	15
Theses by partner .....	16
<b><i>V. Dissemination plan for 2019-20 period (Year 3).....</i></b>	<b><i>17</i></b>

## I. Contributions in 2017-18 period (Year 1)

Dissemination in Period 1 from the project was as shown in the table below. More details can be found in D5.1.

Title	Authors	conference/ magazine/ journal	Related WP
<b>Terabit per Second Optical Wireless Links for Virtual Reality Technology</b>	Olivier Bouchet, Marc Lanoiselée, Dominic O'Brien, Ravinder Singh, Mir Ghoraiishi, Rafael Perez, Víctor Guerra, Suat Topsis, and Jorge Garcia-Marquez	SPIE Optics and Photonics Conference 2018	WP3/ WP4
<b>Spatial Interpolation of Optical Wireless Impulse Responses</b>	Victor Guerra, Julio Rufo, Jose Rabadan, and Rafael Perez-Jimenez	CSNDSP Conference 2018	WP3/ WP4
<b>Wideband 240 GHz Transmitter and Receiver in BiCMOS Technology with 25 Gbit/s Data Rate</b>	M. H. Eissa, A. Malignaggi, R.Wang, M. Elkhoully, K. Schmalz, A. C. Ulusoy and D. Kissinger	Journal of solid state circuits (JSSC)	WP3/ WP4
<b>Noise Performance of Orthogonal RF Beamforming for Millimetre Wave Massive MIMO Communication Systems</b>	Krishna Tiwari, John Thompson and Eckhard Grass	WCSP Conference 2018	WP3/ WP4

Table 1 – Contributions in 2017-2018 period (Year 1)

## II. Actions taken post 2017-18 (Year 1) review (UOXF/ORR)

Taking the feedback from the Year-1 review into account, in Year-2, the project partners have taken some actions to improve the project website,

- making publications open access
- making dissemination more specific with appropriate definition of success criteria.

The latter can be seen in Section III, the dissemination plan for Year-2 (2018-19). More details on the specific changes to the project website and open access procedures are provided below:

1. **Project Website.** The project website has moved to <http://wortecs.eurestools.eu>. A snapshot can be observed in the following figure. The deliverables and dissemination section outlines the journal and conference publications to date and a link for open-access is also provided.

The screenshot shows the WORTECS website interface. At the top, there is a navigation bar with 'Log in', 'Home', 'Deliverables & Dissemination', 'Modélisation', and work packages WP1 through WP5. Below this, the 'DELIVERABLES & DISSEMINATION' section is active, displaying 'Deliverable D3.2: Common Analog and Digital Baseband Design for Flexible Radio and Optical Transceiver'. The abstract discusses the mutualization of radio and optical transmitter architectures. A list of specifications and performance evaluations is provided. To the right, the 'EVENTS, CONFERENCES AND PRESENTATIONS' section lists several publications with their titles, authors, and related work packages. Below that, 'COLLABORATION ACTIVITIES & OTHER DISSEMINATION ACTIONS' lists projects like DREAM, TERRANOVA, EPIC, and ULTRAWAVE.

Figure 1- Snapshots of the current WORTECS’ website

- Open Access.** All the recent scientific contributions from project WORTECS have now been stored in open access repositories. In addition to this the partners have updated the publications information on OpenAir ([https://explore.openaire.eu/search/project?projectId=corda\\_h2020::c966dab4a83dcbd73bb2375c6aa68737](https://explore.openaire.eu/search/project?projectId=corda_h2020::c966dab4a83dcbd73bb2375c6aa68737)), where you can find all the scientific publications by project WORTECS.

# WORTECS

Wireless Optical/Radio TErabit Communications (761329)

PROJECT EC OPEN ACCESS MANDATE FOR PUBLICATIONS

Funding: H2020 | RIA

Start Date: 2017-09-01

End Date: 2020-08-31

Open Access mandate for Research Data: no

Organization: ORANGE | ULPGC | B-COM | OLEDCOMM | UOXF | pureLiFi | IHP

Detailed project information (CORDIS) →

Publications (3)

Figure 2 – WORTECS entry on Openaire

### III. Dissemination plan for 2018-19 period (Year 2)

This section describes the planning of dissemination in year 2. The contributions and implementation are described in section IV.

The WORTECS schedule is planned in three phases. The first phase, corresponding to Year 1, was focused on determining the requirements of all the parts involved into the two high-speed demonstrators. Year 2's aim is to implement all the designs proposed during Year 1. Finally, Year 3 will plan to refine the results of Year 2.

There are three elements to dissemination in Year 2

- Dissemination of results in Journals and Conferences
- Joint dissemination activities within the Beyond 5G (B5G) cluster
- A first WORTECS 'open event' in M26

Regarding dissemination, Year 2 will be focused on publishing the results from Year 1 and also those obtained during the same year. This part of the project is critical and is oriented to the fabrication of functional demonstrators. Once the results are obtained and the systems assessed, these will be properly advertised using other channels (social media, webpage, local press, etcetera) in addition to scientific fora, in order to reach also a broad non-scientific audience.

#### Scientific publications

This section describes the individual partner's plans for scientific publication, including journals and conferences for year 2.

Partner	Journal/Congress	Motivation
ORA	International Congress in Asia	To increase the dissemination level on Asia area with WORTECS project presentation
IHP	European Microwave Week	WORTECS workshop – IHP would give a presentation on data communications in the bands above 200 GHz and about Heterogeneous networks.
	Conference	Paper about beam steering chip with integrated on-chip antenna in the 240 GHz band
	Conference	Paper for RF based positioning in VR scenarios
OLED	High impact Journal	Disruptive lens-design mathematical modelling has been developed.
ULP	Congress	Disseminate WORTECS in a forum in which other VLC/OWC European key players are present.

**Table 2 – Dissemination plan for Year 2**

The contributions of partners are detailed in section IV.

#### Open Events

WP5 has two open-event deliverables. The partners aim to use these events as a platform to explain the purpose of this research and present the findings to general public and research community. The open event-1 is due on M26.

The plan for the workshop within open event-1 is described below.

### Open event-1 initial plan (M26)

This will focus on tutorial presentations of the project and the need for Tbit/s data rates for VR and other applications. Technical progress will be reported.

### Timetable

1. Project overview – ORA
2. Gbit/s VLC (OWC) – OLED/PLF
3. Tbit/s FWF – UOXF
4. Tbit/s RF - IHP
5. HetNet - IHP
6. Tutorial – ULPGC

### Invitations

Academia, Industry

### Venue

If possible, this will be Co-located with a larger workshop to ensure good audience attendance- Possibilities are EUCNC (June 2019), and European Microwave Week (September 2019). In addition, some elements of this might be presented at the EC THz workshop (March 2019) if this is feasible.

### Success criteria

Workshop accepted within an event where there is a large potential audience, with industry, trade and academic attendees. High number of attendees with good number of follow-up enquiries, and interest in attending open event No 2.

WORTECS was or will be represented at all the venues listed, as detailed in section IV. ORA presented at the EC THz workshop EUCNC via the Beyond 5G cluster (see below) and a successful workshop proposal was submitted to the European Microwave Week (see section IV). The Open event deliverable is the European Microwave Workshop.

## IV. Contributions in 2018-19 period (Year 2)

In this section activities within the cluster, invited and conference presentations, open event 1 and other contributions during year 2 of the project are detailed.

### Cluster Activities

WORTECS monitors the ICT-09-2017 cluster calls to ensure dissemination within the cluster of projects.

The Beyond 5G cluster had a booth at the EUCNC 2019 conference exhibition. The WORTECS project took part in the activities for presenting the cluster as well as the WORTECS project. IHP, on behalf of all project partners was representing the project at the booth. The WORTECS project also presented a demo for high precision indoor ranging and positioning, which should be used later for positioning users in VR scenario, as envisioned in the WORTECS project. Figure 3 and Figure 4 show the booth and the WORTECS demonstration undertaken by IHP.

The projects that were present at the booth were:

- **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
- **ULTRAWAVE** – Ultra capacity wireless layer beyond 100 GHz based on millimeter wave Traveling Wave Tubes



- **WORTECS** – Wireless Optical/Radio TErabit CommunicationS
- **THOR** – TeraHertz end-to-end wireless systems supporting ultra high data Rate applications



**Figure 3 - Beyond 5G cluster booth**



**Figure 4 - WORTECS demo at the Beyond 5G cluster booth presented by IHP**

### **Invited talks and conference contributions**

ORA participated to the round Table “Lifi beyond 5G – High speed connectivity”, organized at the Global LiFi Congress, 12th & 13th of June, 2019, Salons Hoche, Paris.

The Global LiFi Congress® is the 1st international event dedicated to LiFi (Light Fidelity). This event was its second edition, in which both LiFi-involved scientific and professional sectors gather together in order to share ideas, so as to pave the way for the future of the technology.

## Objectives:

- To demonstrate both academic and industrial overview of LiFi, so as to open an exchange of ideas, as it pertains to the core challenges LiFi may face, as well as its future evolutionary potential.
- To enable industrial and scientific leaders to share their visions, as it pertains to the innovation, as well as the application, of LiFi related technologies.



**Figure 7 – Round table during Global LiFi congress 2019**

IHP and ORA have written an invited paper for ISWCS 2019, Oulu, Finland. The paper title is “Wireless Communication Systems in the 240 GHz Band: Applications, Feasibility, and Challenges” and the authors are Nebojsa Maletic, Vladica Sark, Mohamed Eissa, Jesus Gutierrez, Eckhard Grass, Olivier Bouchet. The paper is peer reviewed and got excellent feedback from the reviewers. This paper gives an overview of the approach for terahertz communications as envisioned in the WORTECS project.

### Report on individual conferences

**ICISPC 2019.** Singapore, Singapore. The conference was small in size. About fifty presentations and there were three conferences in parallel. After the presentation of the WORTECS project, people did not expect the WORTECS throughput, so they were very impressed. We offered the flyers to the participants and on the reception. The majority of people were curious about the project and they were pleasantly surprised to see the flyer in Chinese. A person in charge of the organizing committee has noted our coordinates because she wishes to invite us for the next edition.



**Figure 5 – WORTECS presentation during ICISPC 2019.**

**ConTEL 2019.** Graz, Austria. This conference was co-organized with H2020 MCSA VISION project's 1<sup>st</sup> workshop. ULP is also part of this project, in which several VLC/OWC European key players are present. The paper presented in this conference, which had a notable audience, was focused on the impact of the receiver's orientation on the OWC link performance. The presentation introduced also WORTECS' aims and scope, and generated an interesting debate. The assistants were pretty interested on WORTECS' upcoming results and provided their contact information.



**Figure 6 – Presentation of ULP's paper during ConTEL 2019.**

## Open Event-1 Organization

The open event-1 has been arranged as a half day workshop at EuMW 2019, Paris. EuMW was chosen as it is a large event (4000 key attendees and 1,500-1,700 conference delegates according to the website), and it allows WORTECS to address the major relevant RF wireless community. The abstract and presentations are shown below.

### Workshop Abstract:

Exponential growth in demand for wireless data services has led to a 'spectrum crunch' in the lower frequency unlicensed spectrum bands, leading to interest in THz and Optical frequency bands. While 5G technologies will use sub 100 GHz millimetre bands, the use of THz and Optical regions of the spectrum will likely be required for wireless beyond 100Gbit/s. The abundant spectrum and consequent high capacity available in these bands comes at the cost of very limited coverage, with narrow beam transmission between terminals, and the need to implement tracking to maintain such links. Link margins are limited, and atmospheric absorption can add additional impairments. Line-of-sight transmission is normally required, especially to achieve the highest data rates. In many cases there is a limited set of experimental transmitter and receiver components available, with much development required for full commercialisation. This workshop will bring RF and optical experts together to discuss the challenges faced and possible solutions in the design of THz and optical wireless communication components, systems and networks for beyond 5G applications. The key aim is to discuss and provide the audience a vision of the system and network designs which will enable joint use of the RF and optical spectrum. The workshop will conclude by a panel session with the plenary speakers to summarise the ideas and directions for future research opportunities. Speakers and talks can be observed in the following tables.

<b>1. Speaker's Name:</b> Olivier Bouchet	
<b>Affiliation:</b> Orange Labs, France	
<b>Presentation Title:</b> Nanometric band, the new wireless Eldorado	
<b>Abstract:</b>	
We are witnessing an exponential growth in the demand for wireless communications. In addition to the availability of different spectral bands, it is also necessary to cope with increased customer's sensitivity to radiometric waves. In this context, there is increasing interest in exploring other spectral bands, particularly in the nanometric band. This presentation offers an overview of this domain with use cases, currently mainly oriented in professional area.	

<b>2. Speaker's Name:</b> Dr. Marcin Brzozowski	
<b>Affiliation:</b> IHP, Frankfurt (Oder), Germany	
<b>Presentation Title:</b> Facing the Challenges in Aggregation of Terabit Wireless Links	



**Abstract:**

In the last decade advances in the communication technologies, both in the Internet and in home networks, revolutionized the way we use these networks today. To fully benefit from these new technologies both researchers and industrial partners worked on solutions to integrate them into a single network. It led to several research activities and also to global standards, such as IEEE 1905.1 for home, heterogeneous networks.

Nowadays, researchers keep working on newer technologies aiming at Tbps. We envision that also these emerging technologies will benefit from synergy effects when working together. In this talk, we share our experience from the last decade in the integration of heterogeneous networking technologies, mainly for home networks. Further, we show also the challenges we are facing to integrate upcoming ultra high-speed wireless technologies.

**3. Speaker's Name:** Prof Cyril Renaud

**Affiliation:** Professor of Photonics, University College London

**Presentation Title:** Photonically enabled THz wireless communication

**Abstract:**

We are witnessing an exponential growth in the demand for wireless communications. In addition to the availability of different spectral bands, it is also necessary to cope with increased customer's sensitivity to radiometric waves. In this context, there is increasing interest in exploring other spectral bands, particularly in the nanometric band. This presentation offers an overview of this domain with use cases, currently mainly oriented in professional area.

**4. Speaker's Name:** Dr. Vladica Sark

**Affiliation:** IHP, Frankfurt (Oder), Germany

**Presentation Title:** Next generation terabit wireless communications in the 200 GHz band

**Abstract:**

The demand for higher data rates in future wireless networks is hardly achievable in the currently used spectrum. New unallocated frequency bands for short and medium range high data rate wireless systems are being considered. Among those, bands above 200 GHz are interesting candidates due to the large available bandwidth. Nevertheless, obtaining a significant link budget at these frequencies is challenging due to their inherent high free space path loss and limited output power of the integrated analog RF frontends. In addition, design of a baseband and MAC processors capable of processing terabit throughputs is of paramount importance. The latest CMOS integrated technologies can be used, but at the cost of increased chip size and increased power consumption.

To address these challenges, we are developing modular, fully integrated analog RF frontends. The modular design enables the use of on chip phased antenna arrays with arbitrary number of elements. A similar approach is used in the baseband design where multiple baseband processors are combined to achieve the required throughputs.

Initial tests were performed and throughputs of up to 25 Gbps were achieved for short distances and BPSK modulation. Further work is focused on increasing the output power of the transmitter and on integrating phase shifters for the antenna elements to enable beamforming. The baseband processor

will be further optimized to match the channel characteristics at frequencies above 200 GHz.

**Contributions summary-contributions to conferences, journals, theses and patents by partner.**

**Tables 3,4,5,6 show contributions from each partner during year 2.**

Partner	Title	Authors	Congress	Related to
ULP	Suitability of Optical Wireless Communication receivers for Virtual Reality Applications	Victor Guerra, Jose Rabadan and Rafael Perez-Jimenes	ConTEL 2019. Graz, Austria	WP3
ORA	European H2020 Project WORTECS Wireless Mixed Reality Prototyping	Olivier Bouchet, Dominic O'Brien, Ravinder Singh, Grahame Faulkner, Mir Ghoraiishi, Jorge Garcia-Marquez, Guillaume Vercasson, Marcin Brzozowski and Vladica Sark	ICISPC 2019. Singapore, Singapore.	WP5
	WORTECS Proof of Concept presentation	Olivier Bouchet	Second Towards TeraHertz Communications Workshop, Brussels, Belgium	WP5
IHP	Wireless Communication Systems in the 240 GHz Band: Applications, Feasibility, and Challenges in the WORTECS Project	Nebojsa Maletic, Vladica Sark, Mohamed Eissa, Jesus Gutierrez, Eckhard Grass, Olivier Bouchet	ISWCS 2019. Oulu, Finland.  Invited paper	WP3/4
	A 13.5dBm Fully Integrated 200-to-255GHz Power Amplifier with a 4-Way Power Combiner in SiGe:C BiCMOS	M.H. Eissa and D. Kissinger	ISSCC 2019, San Francisco, California, United States	
	Achieving Millimeter Precision Distance Estimation using Two-Way Ranging in the 60 GHz Band	Vladica Sark, Nebojsa Maletic, Marcus Ehrig, Jesus Gutierrez and Eckhard Grass	EuCNC 2019. Valencia, Spain	
	Monopulse-based THz Beam Tracking for Indoor Virtual Reality Applications	Krishan Kumar Tiwari, Vladica Sark, Eckhard Grass and Rolf Kraemer	Proc. 24. ITG Fachtagung Mobilkommunikation - Technologien und Anwendungen (2019), Osnabrueck, Germany	
	Noise Performance of Orthogonal RF Beamforming for THz Radio Communications	Krishan Tiwari, Eckhard Grass, Rolf Kraemer	CCWC 2019. Nevada, USA	

	Experimental Evaluation of Round-Trip ToF-based Localization in the 60 GHz Band	Nebojsa Maletic, Vladica Sark, Marcus Ehrig, Jesús Gutiérrez and Eckhard Grass	IPIN 2019, Pisa, Italy	
	Beam Entropy of 5G Cellular Millimetre Wave Channels	Krishan K. Tiwari, Eckhard Grass, John S. Thompson and Rolf Kraemer	VTC 2019 Fall, Honolulu, USA	
PLF	The next generation of wireless internet	Dr. Harald Burchardt	Wired Score Launch Event, Birmingham, UK	Whole Project
	A LiFi World: A New Digital World Powered By Billions Of Connections Through Light	Dr. Harald Burchardt	Internet & Mobile World, Bucharest	Whole Project
	LiFi: How, What, Why	Dr. Mostafa Afgani	pureLiFi hosted Webinar	Whole Project
	A Light Connected World	Prof. Harald Haas	Institute of Physics LiFi Launch Event	Whole Project

**Table 3 – Contributions to congresses during Year 2**

**Contributions to journals by partner**

Partner	Title	Authors	Journal	Related to
OLD	Freeform geometrical optics I: Foundations	Juan Camilo Valencia-Estrada and Jorge Garcia-Marquez	Applied Optics (under review)	WP3/4
	Freeform geometrical optics II: From parametric representation to CAD/CAM	Thibault Grillon, Camilo Valencia-Estrada, Jorge Garcia-Marquez, Alejandro Espinoza-Garcia and Bastien Béchadergue	Applied Optics (under review)	WP3/4

**Table 4 – Contributions to journals during Year 2**

**Patents by partner**

Partner	Title	Authors	Patent	Related to
IHP	Memory-Assisted Radio Frequency Beam Training for MIMO Channels	K.K. Tiwari	submitted EP 19 170 298.4	WP3/4
PLF	Wireless Communication System and Method	Stephan Berner, Mir Ghoraiishi	Filed 03/09/2018 GB1814254.7	WP3/4
PLF	Signal retransmission System and Method	Stephan Berner, Mostafa Afgani, Nikola	Filed 11/10/2018	WP3/4

		Serafimovski	GB1816598.5	
PLF	Wireless Communication System and Method	Stephan Berner	Granted 18/06/2019 US10327050	WP3/4
PLF	Divisional based on US10327050	Stephan Berner	Filed 17/06/2019	WP3/4

**Table 5 – Patents submitted during Year 2**

### Theses by partner

Partner	Title	Authors	University	Related to
IHP	Fully Integrated 240 GHz Transmitter and Receiver for High Data Rate Communication	M. Eissa	TU Berlin, Germany	WP3/4

**Table 6 – Theses supervised during Year 2**



## V. Dissemination plan for 2019-20 period (Year 3)

The major dissemination event for year 3 is open event 2, planned between month 34 to 36. This will be a showcase of WORTECS technologies, and will take place in Rennes. The programme will include; technology demonstrations; presentations on the technology implementation, talks on state of the art wireless and VR, tutorial talks and a roundtable. A preliminary web site for the event has been developed.

In addition, each partner is planning the following dissemination activities.

Partner	Journal/Congress	Motivation
ORA	SPIE Optics + Photonics	The subject could be link to Optical Wireless Proof of Concept Version 2 proposal. This meeting proposes to hear and see advances in optical engineering and applications, nanotechnology, quantum science, organic photonics, and astronomical instrumentation. The date and place are: 23 - 27 August 2020, San Diego, California.in USA.
	Third Towards TeraHertz Communications Workshop, Brussels, Belgium	We plan for propose a publication about overall Proof of Concept V1 version achievement.
IHP	In the 2019-2020, IHP plans to finish the integration of the analog front-end as well as the new baseband for the 240 GHz band.	
	IEEE Transactions on Microwave Theory and Techniques (or similar)	Measures of the overall performances of the developed front-end
	Conference	A conference publication for a beam steering chip, working on 240 GHz is also planned. This chip should be measured and evaluated and the results should be published.
	PIMRC 2020 or IEEE Globecom 2020	The baseband for the 240 GHz system should be finalized in the third year and the achieved results should be published on a reputable conference.
	WPNC 2020 or IPIN 2020	It is also planned to publish a paper on radio indoor positioning for use in VR systems.
PLF	Mobile World Congress 2020	A presentation on the WORTECS project is planned, with focus on the OWC system.
	Planned patent filing	We are planning to file a patent, in the topic of OWC MIMO. The invention may be utilised in the WP3/4 work.
	Light Communication Alliance	We are planning to share outcomes and milestones with the alliance for consideration to be concluded in whitepapers and technology/market reports
	Company newsletters, social media posts	Key results, milestones and findings will be shared in periodic company newsletters and social media posts including LinkedIn, Facebook and Twitter
OLD	OLD plans to keep disseminating its work on freeform optics through the series of article named "Freeform geometrical optics". Two articles have already been submitted and are currently under review by the Applied Optics journal (see Section IV). Depending on the outcome of these reviews, these articles will be revised and	

	enhanced.	
	High Impact Journal	In parallel, a third article focused on the manufacturing and the evaluation of freeform optics is currently being written and will be completed with field tests results.
BCOM	IEEE Global Communications Conference 2020	High-Throughput on the fly LDPC decoder. Jean Dion and Guillaume Vercasson are preparing a submission for this internally-recognized congress. This target has been selected because of its high impact.
UOXF	We plan to disseminate the research work on the development of FWF demonstrators. The first version (V1) of the FWF demonstrator is ready, which is capable of nomadic tracking and localisation with a field-of-view (FoV) of $\pm 30^\circ$ and could potentially achieve 1 Tbit/s data transmission capacity through wavelength division multiplexing (WDM) around the 1500nm region.	
	IEEE Journal of Lightwave Technology. This journal is highly ranked (impact factor of 4.1) platform for dissemination of novel work in the field of optics, opto-electronics, optical fiber and optical wireless communications. We believe that our work on the compact nomadic terminals is sufficiently novel and relevant for an IEEE JLT publication.	Design and Characterisation of Compact Localisation Integrated Fiber-Wireless (FiWi) Terminals. The aim of this publication is to present the design and characterisation of our compact FWF-V1 demonstrator, which utilises cost effective board cameras to provide $\pm 30^\circ$ FoV tracking with an accuracy of $0.02^\circ$ and a tracking latency of few seconds.
	OSA Optics Express. Optics express is internationally known publication platform for research in the field of optical devices and optical communications. Demonstrating 1 Tbit/s tracked communication link with sufficiently broad indoor coverage will be a significant contribution to the field of optical communications and suitable for optics express publication.	Compact nomadic FWF terminals for data centre application. The aim here is to demonstrate 1 Tbit/s data transmission capability of the FWF terminals through the use of WDM and M-PAM modulation techniques.
	Notable OWC Letters TBD	The plans for the FWF-V2 are underway and the aim here is to address the mobility issue in the FWF systems, targeting 1m/s mobility by reducing the tracking latency to $\sim 1$ ms. We aim to publish this work in a notable optical /wireless communication technologies letters towards the end of 2020.
ULP	IEEE Photonics Technology Letters	During WORTECS, some complexity-reduction strategies have been analysed and tested on the developed Monte Carlo Ray Tracing algorithm. These modifications will be published on IEEE PTL.

	High-impact journal	The developed Monte Carlo Ray Tracing algorithm will be published using WORTECS’s manufactured optical frontend parameters (emission pattern and power, receiver noise, etcetera). This publication aims to join the work from Periods 1 and 2. This developed algorithm outputs a data warehouse of the optical wireless impulse response, including position and impact angle information (rank 6 tensor). In addition, it stores an encoded version of each light path, resulting in a “Ray Tracing footprint” which allows changing the scenario’s materials easily.
	International Congress	The channel model of WORTECS will be evaluated under mobility conditions using the feedback information gathered from the results of Demonstrator v1. ICC or GlobeCom are candidate conferences.

**Table 7 – Dissemination plan for Year 3**