



# **ENLIGHT'EM**

## **European Training Network in Low-Energy Visible Light IoT Systems**

Innovative Training Networks (ITN)

H2020-MSCA-ITN-2018

### **Deliverable D4.4**

Final report on training activities, presentation of the results of past events and detailed planning of upcoming events



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## **Deliverable D4.4**

# **Final report on training activities, presentation of the results of past events and detailed planning of upcoming events**

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## **Abstract**

This document captures the fourth annual report on training activities, presentation of the results of past events and detailed planning of upcoming events of the ENLIGHT'EM project. The purpose of all these activities is the optimization of ESRs learning during their PhD programs, as well as the dissemination of knowledge in the project research field.

## **Revision History**

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0.1	Borja Genovés	23/12/2022	First version of deliverable.
0.2	Javier Hervás	09/10/2023	Update of last events
1.0	Domenico Giustiniano	11/10/2023	Revision and final version.





## **Executive summary**

This document captures the fourth annual report on training activities, presentation of the results of past events and detailed planning of upcoming events of the ENLIGHT'EM project. The purpose of all these activities is the optimization of ESRs learning during their PhD programs, as well as the dissemination of knowledge in the project research field.

Event 0, Training Events 1, 2, 3, 4, 5 and 6 took place within the first three years of the project, whose details were included in D4.1, D4.2 and D4.3, respectively. This document focuses on Training Event 7, 8, 9 and 10, which took place during the fourth (and last) year of the project.

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## List of Abbreviations

ENLIGHT'EM: European Training Network in Low-Energy Visible Light IoT Systems

ESR: Early-stage researcher

EWSN: International conference on embedded wireless systems and networks

IoL: Internet of Lights

MSCA: Marie Skłodowska-Curie Actions

R&D: Research and Development

# 1. Introduction

## 1.1. Scope and objectives

This document contains the fourth and final annual report on training activities and results of past events. Note that in this report we do not include a planning of upcoming events because of having concluded all the Training Events in the project. This constitutes the deliverable D4.4 of the H2020-MSCA-Innovative Training Network n° 814215 ENLIGHT'EM.

The purpose of this document is to report the training activities carried out in the project with the main objective of optimizing the training of the early-stage researchers (ESRs) that belong to the training network. Furthermore, a compendium of the results from the training events is detailed.

## 1.2. Document structure

The remainder of this document includes a description of the training activities in the fourth year of the project (M37-M55) in Section 2, the results of these training events together with important additional results in Section 3.

## 1.3. Project situation

The project has reacted promptly to minimize the effects of the critical situation that the COVID-19 pandemic created. As can be seen in this deliverable, after having established a normal situation, events have been organized in person and we have concluded with all the planned Training Events.

## 2. Training activities to date

This Section presents the training events that took place during year 4, providing details of the organization and description of the contents.

### 2.1. Training Event 7

The objective of Event 7, based on the Annex I of Grant Agreement, was as follows:

*Training on advanced research skills, tutorials at conference*

*The event will be co-located with the EWSN conference. The purpose of this event is two-fold: tutorial sessions will be organized to showcase the results of the ESRs to a broad global audience (activity led by UEDIN); and ESRs will be trained on advanced transferable skills (activity led by TUD). The training will include modules on thesis completion (effective writing, preparing for the thesis defense); continuing education and career development (career planning, skill development and professional development planning, CV writing, applications and interviews in the academic and non-academic domains); impact (advanced presentation skills, advanced communication skills, knowledge transfer).*

However, due to COVID-19 restrictions the conference to which we aimed to co-locate the event (2022 International Conference on Embedded Wireless Systems and Networks (EWSN)) was postponed till October 2022. We decided to postpone Training Event 7 too for the sake of the ESRs training, as we strongly think that it would be more fruitful for ESRs to attend a flagship conference in person, and because we thought it was beneficial to wait until the conference was held such that the results of ESRs were more mature.

The tutorial proposal was submitted, successfully accepted, and then the Training Event 7 took place together with EWSN 2022 conference in Austria on the dates 3<sup>rd</sup> – 5<sup>th</sup> October 2022.

Due to the proximity in dates, the originally planned Project Meeting 7 was merged with Project Meeting 8, and it took place virtually (to guarantee the maximum number of supervisors attending) on September 27<sup>th</sup>, 2022.

The details of the Training Event 7 are reported below. The tutorial was given by the ESRs to the audience of EWSN during the morning of October 3<sup>rd</sup>, 2022, and belong to part of the EWSN 2022. During the afternoon, the ESRs received a training on career paths, consisting on a panel

discussion formed by distinguished senior researchers (Kay Roemer (Tu Graz), Thiemo Voigt (University of Uppsala) Anna Förster (University of Bremen)). The two subsequent days, the ESRs enjoyed the EWSN conference talks. Besides, on October 4rd, 2022, the ESRs made a visit tour on the labs of the Institute of Experimental Physics of Johannes Kepler Universität Linz (JKU), which fabricates solar cells and they are of much importance to several ENLIGHT'EM ESRs that use solar cells for both receiving LiFi data and harvesting energy.

The details of the tutorial are as follows:

\*\*

**Title of the Tutorial:**

Fundamentals of LiFi Design and Applications

**Abstract:**

Wireless connectivity has instigated phenomenal advancements in our society with monumental socio-economic benefits. From commerce to healthcare and emerging paradigms such as internet of things (IoT), smart home/city, industry 4.0 and many more, wireless connectivity continues to enable new services, applications, products and developments.

To meet our ever-increasing demand for ubiquitous wireless connectivity and sustain future socio-economic growth, communication technology is rapidly advancing with wireless connectivity with lightwave. This idea of wireless connectivity with light is termed LiFi (it is a networked version of the optical wireless communication technology). The LiFi technology will undoubtedly play an increasingly significant role in the global communication network and infrastructure. This has already been happening in space with the use of laser beams to deliver unprecedented amount of data exchange between satellites and to ground stations.

Thus, this tutorial is pertinent and it is designed to educate and introduce the fundamentals of LiFi technology through lively discussions. Attendees will learn what designing a LiFi system entails. The tutorial promises to stimulate ideas for future application of LiFi beyond those currently envisaged.

Our approach in this tutorial will be a mix of discussions and presentation of LiFi to a much broader audience beyond those researching it. The tutorial is organised by the EU funded

project ENLIGHTEM (<https://enlightem.eu/>) – a training network dedicated to low power LiFi technology for IoT applications.

### **Co-Chairs**

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IMDEA Networks Institute

Madrid, Spain

### **Description of the topics that the tutorial addresses, emphasizing their timeliness:**

Progress in LiFi research has accelerated considerably in the past decade resulting in several high profile demonstrations, patents and numerous scholarly publications. The field has now progressed to the stage where professional and international bodies (particularly IEEE and ITU) are currently intensifying efforts to develop industry standards for it. This is in readiness for mass-market penetration.



Furthermore, several companies across the globe including, Signify (formerly Philips lighting) in the Netherlands, PureLiFi in the UK, Lightbee in Spain, Oledcomm in France, and many more now have early products in the market.

The foregoing buttresses the timeliness of this tutorial that aims to illuminate this nascent field of light-based wireless connectivity.

Finally, as part of our commitment to the development of future researchers, we will have a training session for early career researchers on career options. The entire tutorial is open to the general audience attending EWSN conference and not restricted to only ENLIGHT'EM members.

The topics that will be covered are as follows:

- LiFi Physical Layer Design
- Network Design in LiFi
- LiFi System Design
- LiFi Applications
- Training event for early career researchers.

**Agenda of the tutorial on Fundamentals of LiFi Design and Applications:**

	<b>Time</b>	<b>Activity</b>	
	08:45 - 09:00	Welcome and opening remark	Dr Marco Zuniga
Session 1	09:00 – 10:00	<b>LiFi Physical Layer Design</b>  Speakers: <ul style="list-style-type: none"><li>• Tilahun Gutema</li><li>• Janis Sperga</li><li>• Talia Xu</li><li>• Dayrene Frómeta (open VLC Framework)</li></ul>	Chair: Dr Marco Zuniga

Break 1	10:00 – 10:30	Coffee/Tea Break	
Session 2	10:30 – 12:00	<p><b>LiFi Network and System Design</b></p> <p>Speakers:</p> <ul style="list-style-type: none"> <li>• Burak Özyurt</li> <li>• Gianluca Martena</li> <li>• Kien Ngo</li> <li>• Sarmad Mir</li> <li>• Damon Ye</li> </ul>	Chair: Dr Qing Wang
Break 2	12:00 – 13:00	Lunch	
Session 3	13:00 – 14:30	<p><b>LiFi Applications</b></p> <p>Speakers:</p> <ul style="list-style-type: none"> <li>• Ömer Dalgic (Human-computer interaction)</li> <li>• Jagdeep Singh (Positioning)</li> <li>• Behnaz Majleseini (Underwater)</li> <li>• Khadijeh Ali Mahmoodi (Underwater)</li> <li>• Nasir Ashfaq (V2V)</li> <li>• Daniel Tettey (V2V)</li> </ul>	Chair: Dr Borja Genoves
Break 3	14:30 – 15:00	Coffee/Tea Break	
Career Talk	15:00 – 17:00	<p><b>Panel Discussion</b></p> <p>Topic: Career Paths/Options for Early Career Researchers</p> <p>Three speakers:</p>	Chair: Dr Marco Zuniga

		<ul style="list-style-type: none"><li>• Prof. Thiemo Voigt (Uppsala University): "Research institute vs. University positions"</li><li>• Prof. Kay Roemer (TU Graz): "How to choose the right research problem"</li><li>• Prof. Anna Foerster (University of Bremen): "The importance of networking for a scientific career"</li></ul> Open discussion.	
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**Description of talks:**

**Session 1: LiFi Physical Layer Design**

**Tilahun Gutema** ("High-Speed Visible Light Communication with Probabilistic Shaping"):

The University of Edinburgh, United Kingdom

Visible light communication is an emerging optical wireless communication technology based on light-emitting diodes (LEDs). Despite LEDs being energy-efficient, low cost and widely available, they have relatively low modulation bandwidth. Thus, for high-speed VLC systems, this usually requires transmitting well beyond the  $-3$  dB modulation bandwidth. Probabilistic shaping (PS) provides continuous entropy loading that makes efficient use of the limited bandwidth and enhances the VLC system capacity.

**Janis Sperga** ("Flexible LED Index Keying for LiFi")

pureLiFi, United Kingdom

Energy efficiency for high data throughput is an increasingly important benchmark for LiFi implementation. To achieve high data throughput, typically, LiFi systems utilize a family of O-OFDM schemes with adaptive bit loading. However, the drawback of solutions based on O-OFDM is high power consumption. An alternative to achieve high enough spectral efficiency is to use spatial modulation schemes. Here information is not only encoded in the signal but also in the spatial domain (i.e. in the positions of multiple transmitter elements). In this tutorial, we will describe a novel spatial modulation scheme called Flexible LED index keying and present the simulation results of the achievable data throughput of such a modulation scheme in a hemispherical transceiver system.

**Talia Xu** ("Using Ambient Light for Simultaneous Energy Harvesting and Communication"):

TU Delft, Netherlands

Ambient light communication allows us to take advantage of a free spectrum without modifications of existing lighting infrastructure. To use ambient light for communication, external optical surfaces, such as liquid crystal cells (LCs), are electrically controlled to modulate information. Most existing ambient light communication systems rely on a single type of optical receiver: photodiodes (PDs). PDs are ideal receivers in indoor applications. However, They require non-trivial amounts of power and can easily saturate under strong ambient light conditions. These limitations make it difficult to adapt PDs in an outdoor communication link.

In this talk, we will discuss a system using solar cells as receivers and liquid crystals as transmitters to attain an eco-friendly communication system where ambient light is used for both energy harvesting and communication. First, we look at the behavior of solar cells in different configurations under a range of different ambient light intensities. We will show how a reconfigurable receiver is necessary to achieve energy-positive communication in an outdoor environment. In addition, based on the solar cell characteristics, we discuss the challenges in an energy-positive outdoor link and look at how a dynamic reconfiguration scheme can allow the receiver to harvest enough energy to support its operation, while simultaneously achieving good communication.

**Dayrene Frómata** (“Programming the LiFi Physical layer with OpenVLC”):

IMDEA Networks, Spain

The talk will focus on the programming aspects of OpenVLC. It will give more details about the software and firmware design of OpenVLC, focusing on implementation details and how it can be modified to implement new modulation schemes or to integrate more hardware components (i.e., sensors, additional LEDs, etc.). It will present the firmware and software of OpenVLC in a modular way, showing its main files and the main functionalities implemented on each. Finally, a specific case of firmware modification will be analyzed, showing the steps that must be followed and some useful tips and good practices when programming with the PRUs of the BBB.

## **Session 2: LiFi Network and System Design**

**Burak Özyurt, Gianluca Martena and Kien Ngo** (“Network Design and Mobility Management in LiFi”)

The University of Edinburgh, United Kingdom; pureLiFi, United Kingdom; Università degli Studi di Palermo, Italy

In this tutorial, the speakers will present the LiFi reference scenarios and topologies, resource allocation for data rate maximisation, and a demonstration of handover in LiFi networks. First, a few different indoor LiFi reference scenarios, which are suggested in the IEEE 802.11bb Task Group on Light Communications, will be shared for understanding the main models and limitations. Then, the nodes distribution modelling will be analysed together. In the second part, wavelength division for LiFi and associated challenges will be presented, along with techniques for efficient resource allocation. As a last, a demonstration will take place for understanding the characteristics of handover and mobility management in LiFi networks.

**Sarmad Mir** (“LiFi for Low-Power and Long Range RF Backscatter”):

IMDEA Networks, Spain

In this talk, Sarmad will introduce PassiveLiFi, a battery-free system that uses LiFi to transmit RF backscatter at a meagre power budget. Sarmad will present several challenges in the system design of the LiFi transmitter, the tag and the RF receiver followed by his design approach to implement a chirp spread spectrum (CSS) using the visible light spectrum. He will also present experimental results to show that we can generate RF backscatter with a range of 80.3 meters/ $\mu W$  consumed in the tag.

**Damon Ye** (“Through-Screen LiFi”):

TU Delft, Netherlands

The trend of adopting full-screen on commodity devices is bringing new challenges to the deployment of LiFi systems. In this talk, Damon will elaborate on the impact of high-brightness and full-screen on LiFi links, when the visible light receiver is placed under the transparent region of the full-screen. To tackle these challenges, Damon will introduce how to design and implement a through-screen LiFi system that can be deployed on commodity devices.

**Session 3: LiFi Applications**

**Ömer Dalgic** (“Potential of LEDs for interaction with smartphone users”):

SUPSI, Switzerland

Almost all light sources in our environment are based on LEDs. They are commonly used in homes, vehicles, and streetlights. There are also tiny lights in toys, sensors, and devices. In addition to their lighting function, LEDs also have great potential for providing information. LEDs can be turned on and off quickly, which the human eye cannot detect, but sensors (photodiode,

camera, etc.) can detect this change. LEDs appear to be fully on to the human eye with no loss of quality, but only sensors can understand this small change in illumination. Sensors convert this small change into digital information. With the help of this property, LEDs emit information from everyday objects. Smartphone users can retrieve this information from the LEDs with the help of their cameras. This enables interaction between everyday objects and smartphone users. Our goal is to show processes of information transfer for communication between LEDs and smartphone cameras and to demonstrate possible applications.

**Jagdeep Singh** ("Passive Positioning with White LEDs"):

Toshiba Research Europe Ltd., United Kingdom

Localization is a killer application of visible light communication, which could provide centimetre-level positioning. In this tutorial, Jagdeep will talk about passive Visible Light Positioning (VLP), a technique that does not require the modulation of LEDs. He will introduce a method to perform passive VLP by exploring the hue spectrum of unmodulated and unmodified white LEDs. It can be used in potential applications such as providing location-based services for Automated Guided Vehicles.

**Behnaz Majlesein** ("Solar cell-camera underwater optical wireless optical communication"):

LightBee, Spain

Presentation on using a solar cell and camera as a receiver in underwater wireless optical communication (UWOC). Behnaz will describe simultaneous lightwave information and power transfer (SLIPT) and its three possible approaches. In addition, a brief explanation of optical camera communication technology in UWOC will be given.

**Khadijeh Ali Mahmoodi** ("Optical Communication in Underwater Sensor Networks"):

Ozyegin University, Turkey

Underwater sensor networks (USNs) have been increasingly deployed in various maritime applications including pollution monitoring, tsunami warnings, underwater oil field detection, and valuable minerals explorations among others. Underwater sensor nodes are usually distributed in a large-scale marine environment. The sensor data can be collected manually or might be transferred via cable or wireless means to a gateway node (e.g., a buoy) which then communicates with a land station, support vessel or satellite. Another option for data collection is to use autonomous underwater vehicle (AUV) as "data mules" to retrieve data from sensor nodes via a wireless link. For underwater wireless transmission, acoustic signalling is commonly

used and particularly appealing with its long range in the order of kilometres. However, acoustic communication suffers from low data rates (in the order of tens of kb/s) and low propagation speed (1500 m/s). An alternative underwater wireless connectivity solution is visible light communication (VLC) offering low latency and high data rates in the order of Gb/s, albeit at relatively shorter distances (in the order of tens of meters). VLC is particularly suitable for “data mule” AUVs since communications is enabled only when the sensor node and mule AUV are in close proximity. Transmitting data over these shorter distances further reduces the power consumption on each sensor.

**Nasir Ashfaq** (“Vehicular LED Selection and Characterization for Opto-electronic Front-End Design of Vehicular VLC Systems”):

FORD OTOSAN, Turkey

One of the key issues in applying VLC to vehicular scenario is the ability to drive high power vehicular LEDs using various types of modulation schemes and at a sufficiently high bandwidth to achieve desired data rates. For this purpose, it is important to determine the COTS vehicular LED’s inherent bandwidth as well as linear region of operation, so that appropriate vehicular LED driver may be designed and implemented.

Based on the above description, in this tutorial, we explain the experimental setup and share measurement results for some of the experiments we performed to characterize COTS vehicular LEDs. These experiments include:

- Vehicular LED Bandwidth Measurement
- Vehicular LED Optical Output vs. Input Voltage and Current Response Measurement

The results of these experiments help select appropriate COTS vehicular LEDs for V2V VLC applications, and also provide useful insights to design vehicular LED driver with required specifications.

**Daniel Tettey** (“ V2V testbed using software defined radio (SDR): from choosing SDR hardware to a working prototype ”):

FORD OTOSAN, Turkey

In this tutorial, the audience will be taken through the implementation of an SDR-based vehicle-to-vehicle (V2V) testbed. In the first part of the tutorial, we will look at process of choosing the right testbed sub-system components (SDR hardware, software, LEDs, photodetectors etc.).

The second part of the tutorial will take the audience through the implementation of OOK transceiver V2V testbed. Due to time constraints, only key details of the transmitter and receiver

system will be covered in this section. The tutorial will be concluded by playing a pre-recorded demo video of the testbed.

\*\*

In Fig. 1 we show a picture during the tutorial session at EWSN, and Fig. 2 represents part of the afternoon training session.



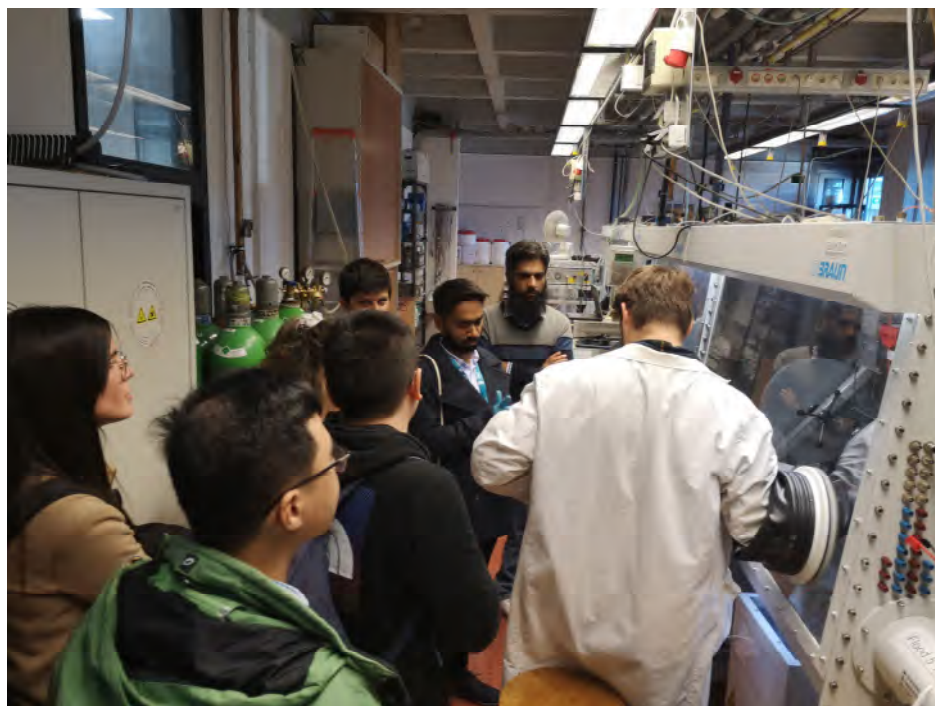
**Figure 1: Tutorial given by ESRs during Training Event 7**





**Figure 2: Training on career paths (panel session) of Training Event 7**

Finally, as said before, the ESRs were shown the solar cells labs of JKU, and it is shown in Fig. 3.



**Figure 3: Tour visit of ESRs to the Institute of Experimental Physics of Johannes Kepler Universität Linz (JKU)**

## **2.2. Training Event 8**

The objective of Event 8, based on the Annex I of Grant Agreement, was as follows:

Training Event 8 (*Industry day*): *In this training event, all industrial beneficiaries and partners will form a panel to provide substantial insight and feedback on potential applications and use cases for the ESR's work and on optical technologies in general. The event will feature demonstrations and poster sessions to showcase the project technologies.*

It was finally be taken at FORD facilities (Istanbul, Turkey) on the 26<sup>th</sup>-27<sup>th</sup> July, 2022. Note that the date is earlier than the one of Training Event 7. The reason is because Training Event 7 was co-located with EWSN 2022 conference, which was postponed to October 2022. The agenda of Training Event 8 is shown in the following:

\*\*

### **Agenda:**

**DAY 1 (July 26, 2022):** Presentations on Automotive E/E Systems, and Autonomous Truck Applications

*Time slots below are Istanbul Time (Central European Time + 1hour)*

Time	Topic	Title	Speaker
10:00 – 10:30	Gathering & Warm-Up at Ford Otosan Café Nero		
10:30 – 11:45	Ford Otosan Introduction (Sercan Karaağaç)		
11:45 – 12:00	Coffee Break		
12:00 – 13:30	Vehicle E/E Design	Electrical Electronics Systems on Modern Vehicles	Sercan Karaağaç
13:30 – 14:30	Lunch		
14:30 – 15:15	Autonomous Vehicles	Autonomous Truck Projects (Remote Driving, Driver Monitoring System)	Tahir Sarı, Duygu Serbes
15:15 – 15:30	Coffee Break with Open Discussion		
15:30 – 16:30	VLC Demonstration	Demonstration of ESR 3.4 & 3.5 presenting current state of work	Daniel Tettey, Nasir Ashfaq
16:30 – 17:30	Industrial Presentation	Consider IP within daily business	Alexander Barth from Tridonic
19:30 – 22:30	Dinner	Social Event	

**DAY 2 (July 27, 2022): Industrial Partner Presentations**

Time	Topic	Title	Speaker
09:00 – 09:40	Gathering & Warm-Up at Ford Otosan Café Nero		

09:40 – 10:25	Industrial Presentation	Technology- and Innovation Management @ Tridonic/Zumtobel Group	Klaus Vamberszky from Tridonic
10:25 – 10:30	Short Break		
10:30 – 11:20	Industrial Presentation	Career path models for Technicians in a new work reality - A discontinued model or new opportunities?	Sabine Huber-Wynnyczenko from Tridonic
11:20 – 11:30	Coffee Break		
11:30 – 12:20	Industrial Presentation	UMBRELLA IoT testbed journey from use-cases to deployment	TREL
12:20 – 13:00	Lunch Break		
13:00 – 13:50	Industrial Presentation	LightKey. An example of VLC- IoT product	Lightbee
13:50 – 14:40	Industrial Presentation	Consider IP within daily business	Alexander Barth from Tridonic
14:40 – 14:50	Coffee Break		
14:50 – 15:40	Industrial Presentation	Connect everything and everyone with LiFi	PureLifi
15:40 – 16:30	Industrial Presentation	Lab to Market	Velmenni

\*\*

Note that every industrial partner involved in the project contributed to the organization of this event. In the following, we show images of a talk and all ESRs in the event:



**Figure 4: Talk during Training Event 8**



**Figure 5: ENLIGHT'EM researchers during Training Event 8 at FORD Otosan (Istanbul, Turkey)**

## 2.3. Training Event 9

On the 12-13 of December event 9, organized by University of Palermo took place.

The objective of Event 8, based on the Annex I of Grant Agreement, was as follows:

*A workshop on the topics of ENLIGHT'EM will be organized as a co-located event of the EWSN 2023 conference, presenting the main innovation of projects led by ESRs when approaching the completion of their programs.*

However, during one of the Supervisory board meetings, it has been decided to revise the objectives of the Event, following the feedback of ESRs that additional training was desired on additional *soft-skills and best practices for the career path after the PhD*. Furthermore, it was also agreed that the original plan was in part redundant with the event 7 co-located with EWSN 2022. Therefore, we have leveraged Event 9 as a new opportunity for the network to get together and keep improving the ESR's skills in different topics like entrepreneurship, PhD defense, CV preparation, all very useful for their career after the PhD defense.

\*\*

### **Agenda:**

#### **DAY 1 (Dec 12, 2022):**

<b>Time</b>	<b>Topic</b>	<b>Title</b>	<b>Speaker</b>
9.30		Introduction and Welcome	D. Giustiniano, I. Tinnirello
10.00	PhD & Startup	From Research to an Innovative Company: the case of Prysmian Electronics	A. Di Stefano, PhD (Prysmian Electronics), Prof. Costantino Giaconia (Università degli Studi di Palermo)
11.30	Coffee break		
12.00	PhD & Large Companies	After a PhD: Opportunities and perspectives in a large company	Iolanda Incontrera, PhD (Head of Global Market Analyses for



		(Assessment criteria, international dimension, strategic foresight)	Strategic Development, Enel Global Trading)
13.15	Lunch break		
14.15	PhD & Large Companies	Interactive discussion and presentation of testimonials	Iolanda Incontrera, PhD (Enel)
15.30	Coffee Break		
16.00	CV Preparation	CV Preparation	D. Giustiniano (IMDEA Networks)
17.00	End of the day		

**19.30 - Social Event**

**DAY 2 (Dec 13, 2022):**

Time	Topic	Title	Speaker
9.00		Introduction of the day	I. Tinnirello
9.30	PhD and Entrepreneurship	Young Entrepreneurship after a PhD: case studies	Prof. Giovanni Perrone (Università degli Studi di Palermo)
11.30	Coffee Break		
11.45	Roadmap to PhD graduation		ESR Representatives. Shape of this slot is to be defined by ESRs.
12.15	Updates on ESR Projects/ Brief Project Meeting	Presentations from ESRs (3' + 2 Q&A). Same template as in Training Event 6: <ul style="list-style-type: none"> <li>• 1<sup>st</sup> slide (objectives + current status)</li> <li>• 2<sup>nd</sup> slide (new results)</li> </ul>	

		<ul style="list-style-type: none"><li>• 3<sup>rd</sup> slide (next steps)</li></ul>	
13.30	Lunch Break		
14.30	Updates on ESR Projects (cont.)		
15.30	Lab visit		
16.00	End of the day		

\*\*

In the following we provide a picture of ESRs during the Extra Training Event:



Figure 6: Talk during Training Event at UNIPA

## 2.4. Training Event 10

Event 10 in our project marks the final training event of the project where we assessed the degree of achievement of our objectives. The objective of Event 10, based on the Annex I of Grant Agreement, was as follows: *Invited talks from VLC experts, research talks and practical*



*demonstration of ENLIGHT'EM will be blended together into the final open day of ENLIGHT'EM . The event will be organized at IMDEA premises. The event will be advertised in order to reach out to a wide spectrum of audience, with technology demonstrations for practitioners, industry and government representative, as well as more engaging technology displays for the general public. The final project meeting will be held alongside this event.*

During of the SB meetings, we have revised the original plan. In fact, it was agreed that a standalone event at IMDEA premises could not reach the desired impact, but it was rather more convenient to co-locate the final event with a large conference. In this direction, we have leveraged the fact that Project coordinator (Dr. Giustiniano) was General Vice Chair of ACM Mobicom, the flagship conference in Communication Systems and Mobile Computing, physically located in Madrid. A total of almost 400 people attended the event, both from academia and industry, providing the desired wide spectrum of audience.



**Figure 7: Project coordinator and General Vice-Chair of the conference presenting the Awarding Ceremony and highlighting the high attendance**

This event consisted of two main activities:

#### Activity 1: Last Project Meeting (September 27)

The first activity of Event 10 involved the celebration of our last project meeting. On this occasion, each ESR had the opportunity to present a summary of the status of their research from the beginning of the project up to the current date. Additionally, they shared their plans for defending their doctoral theses and their perspectives on how to continue their professional careers after the project concludes.

Due to the tight schedule of ACM Mobicom, where the meeting was initially planned, we had to advance it by one week and hold it virtually. This allowed students to effectively share their progress and promote interaction and feedback among team members. Each presentation demonstrated the commitment and dedication of our ESRs to their respective research, as well as their determination to achieve success in their future academic and professional challenges.

#### Activity 2: Participation in the ACM Mobicom Conference (October 2 to 6)

The second activity of ENLIGHTEM Event 10 was the participation of our ESRs in the prestigious ACM Mobicom Conference, held in Madrid from October 2 to 6, 2023. In this conference, our students had the opportunity to showcase their research by presenting papers, posters and demonstrations of their projects. *For the occasion, IMDEA designed special t-shirts with ENLIGHT'EM logo and name and number of all ESRs to provide a sense of community and increasing team building among ESRs.*

As a result of our participation, we presented:

1 paper in the main conference:

- *“Screen Perturbation: Adversarial Attack and Defense on Under-Screen Camera”*, **Hanting Ye**, Guohao Lan, Jinyuan Jia, Qing Wang.



Figure 8: Hanting Ye – Paper presentation in ACM Mobicom 2023

5 posters:

- “A Novel Intelligent Management System Architecture for Hybrid VLC/RF Systems in Smart Retail Environment” **Kien Trung Ngo**, Stefano Mangione, Ilenia Tinnirello. **Best Poster Award.**
- “When BLE Meets Light: Multi-modal Fusion for Enhanced Indoor Localization”, **Jagdeep Singh**, Tim Farnham, Qing Wang.
- “Experimental Study of Wavy Surface Effects on Uplink Water-Air Optical Camera Communication”, **Behnaz Majleseini**, Callum T. Geldard, Victor Guerra, J.M. Luna-Rivera, Julio Rufo, Wasiu O. Popoola, Jose Rabadan.
- “Experimental Investigation of Angle Diversity Receiver for Vehicular VLC”, **Daniel K. Tettey**, Mohammed Elamassie, Murat Uysal.

- “*Vehicular Visible Light Communications with A Solar Panel Receiver*”, **Daniel K. Tettey, Khadijeh Ali Mahmoodi, Roozbeh Bonakdar, and Murat Uysal.**



**Figure 9: Kien Ngo – Best Poster Award in ACM Mobicom 2023**

1 Demo:

- “*Demo: Rethinking LiFi for Low-Power and Long Range RF Backscatter*”, **Dayrene Frometa, Sarmad Mir, Borja Genovés, Ambuj Varshney, Domenico Giustiniano.**

This conference not only served as a valuable platform for our research but also provided an opportunity for the team to come together in support of our ESRs during their presentations. The presence and support of our colleagues and peers at this international event reinforced the sense of community and collaboration that characterizes our project.

In summary, Event 10 was a moment of celebration and recognition of the achievements reached by ENLIGHT’EM.. The ESR’s presentations at the last project meeting demonstrated their commitment and progress, while their participation in the ACM Mobicom Conference strengthened our presence in the international academic community.

A teaser video has been published in our YouTube channel here: [ENLIGHTEM in Mobicom 2023 - Teaser Video](#)



### 3. Results of past events

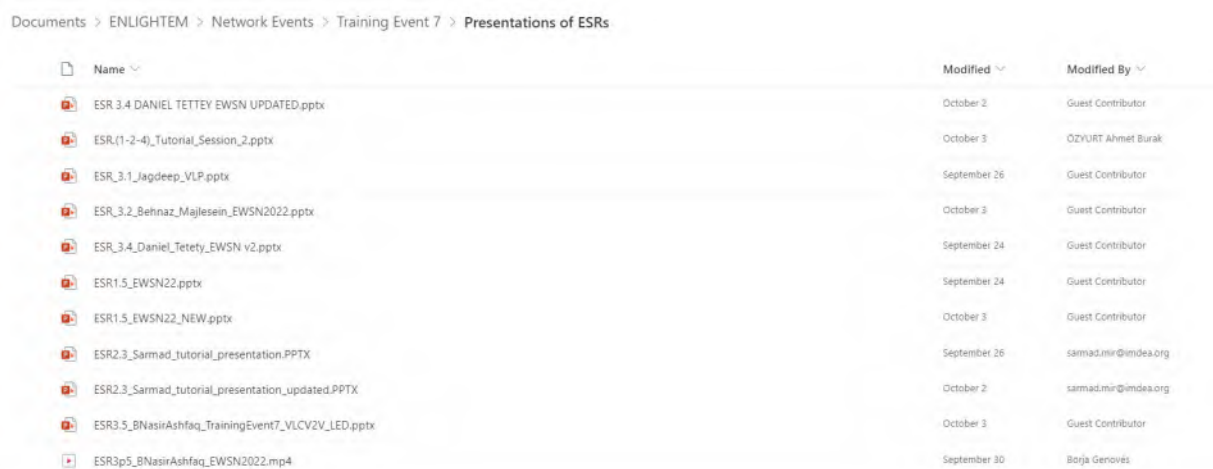
This section presents the results obtained from the events that took place during the fourth year of the project, in the form of slides, videos, etc.

#### 3.1. Training Event 7

The material created for the Training Event 7 that can be re-used in the future within the project lifetime and beyond, are: slides from the ESRs about the tutorial given at EWSN 2022, and some other outcomes for the sake of ESRs learning such as networking.

##### 3.1.1. Slides

The slides created by the speakers of the training are uploaded to the SharePoint repository of the project, where only people involved in the project can access them. It can be seen in the following image.



Documents > ENLIGHTEM > Network Events > Training Event 7 > Presentations of ESRs

Name	Modified	Modified By
ESR 3.4 DANIEL TETTEY EWSN UPDATED.pptx	October 2	Guest Contributor
ESR(1-2-4)_Tutorial_Session_2.pptx	October 3	OZYURT Ahmet Burak
ESR_3.1_Jagdeep_VLP.pptx	September 26	Guest Contributor
ESR_3.2_Behnaz_Majlesein_EWSN2022.pptx	October 3	Guest Contributor
ESR_3.4_Daniel_Tetety_EWSN v2.pptx	September 24	Guest Contributor
ESR1.5_EWSN22.pptx	September 24	Guest Contributor
ESR1.5_EWSN22_NEW.pptx	October 3	Guest Contributor
ESR2.3_Sarmad_tutorial_presentation.PPTX	September 26	sarmad.mir@imdea.org
ESR2.3_Sarmad_tutorial_presentation_updated.PPTX	October 2	sarmad.mir@imdea.org
ESR3.5_BNasirAshfaq_TrainingEvent7_VLCV2V_LED.pptx	October 3	Guest Contributor
ESR3p5_BNasirAshfaq_EWSN2022.mp4	September 30	Borja Genovés

**Figure 10: SharePoint repository of ENLIGHT'EM where the slides of tutorial belonging to Training Event 7 are uploaded**

Note that slides are private because companies and universities had some reservations about the potential replication of the slides' content without their consent.

### 3.1.2. Other results

On Tuesday September 27<sup>th</sup>, 2022 the Project meeting #7 and 8 took place together. It was a virtual meeting organized via Zoom application. It was used to discuss the ESRs projects progress, deliverables, next Training Events, etc.

To summarize the issues addressed in Project meeting #7 and 8, its minutes/agenda is included in the following:

\*\*

### Project Meeting 7 & 8

Time: Sep 27, 2022 10:00 AM CEST

Join Zoom Meeting

Agenda:

1. Update on secondments (to be concluded by Feb 2023 at the latest)

**ESRs and supervisors updated with current secondment status.**

2. Report after secondment

**Borja reminded about the need for reporting the secondment activities once secondment has finished. Template and folder can be found in GitLab of the project.**

3. Lack of communication activities.

**ESRs and supervisors updated their involvement in communication activities:**

	open electronic media	formal press	public events
IMDEA	X	X	X (SiW '20, Research Night '20, Week Science '20, Researchers Night '21, EIMundo newspaper,

			Madrid is Science Fair 2022, press article at ABC)
TUD			x Damon: “LiFi applications” poster in <a href="https://www.researchersnight.eu/can-leds-talk">https://www.researchersnight.eu/can-leds-talk</a>
SUPSI			x “LiFi applications” poster in <a href="https://www.researchersnight.eu/can-leds-talk">https://www.researchersnight.eu/can-leds-talk</a>
LBEE			X Canary Island Science Fair 2022. “Mujer y Niña en la Ciencia: Conoce a nuestras científicas y tecnólogas”. 6th May 2022.  “LiFi applications” poster in <a href="https://www.researchersnight.eu/can-leds-talk">https://www.researchersnight.eu/can-leds-talk</a>
UEDIN			X (SiW '20)
PLF			X (SiW '20)
OZU			X (Researchers Night '21)
UNIPA			X (Research Night '20 + Sharper Night 2021)
TREL			X “LiFi applications” poster in <a href="https://www.researchersnight.eu/can-leds-talk">https://www.researchersnight.eu/can-leds-talk</a>
FORD			X (Researchers Night '21)

#### 4. Next deliverables/Milestones

**Borja briefly summarized the remaining deliverables:**



WP No	Del Rel. No	Del No	Title	Description	Lead Beneficiary	Nature	Est. Del. Date (annex I)
WP1	D1.3	D3	Final research progress reports on Low-energy Technologies; final work, tools developed, software and results available.	Final research progress reports on Low-energy Technologies; final work, tools developed, software and results available.	PLF	Report	30 Sep 2023
WP2	D2.3	D6	Final research progress reports on Intelligent Algorithms and RF Integration; final work, tools developed, software and results available.	Final research progress reports on Intelligent Algorithms and RF Integration; final work, tools developed, software and results available.	UEDIN	Report	30 Sep 2023
WP3	D3.3	D9	Final research progress reports on Applications and Services; final work, tools developed, software and results available.	Final research progress reports on Applications and Services; final work, tools developed, software and results available.	TU Delft	Report	30 Sep 2023
WP4	D4.4	D13	Final report on training activities, presentation of the results of past events and detailed planning of upcoming events	Fourth report on training activities, presentation of the results of past events and detailed planning of upcoming events	IMDEA NETWORKS	Other	30 Sep 2023

WP4	D4.6	D15	Annual report on secondments, description of the research conducted, Second report on tie-ins with the secondments and research direction of description of the ESRs at the hosting institution	IMDEA NETWORKS	Other	31 Mar 2023
WP4	D4.10	D19	Final report on the ESR career development plans (CDPs)	IMDEA NETWORKS	Other	30 Sep 2023
WP5	D5.5	D24	Final report on dissemination and exploitation results	FORD	Other	31 Dec 2023
WP5	D5.6	D25	Roadmap for exploitation and impact	FORD	Other	31 Dec 2023
WP6	D6.5	D31	PhD Theses report of the 15 Early Stage Researchers	IMDEA NETWORKS	Other	31 Dec 2023
WP6	D6.6	D32	Potential inputs for policy feedback (if applicable)	IMDEA NETWORKS	Other	31 Dec 2023

- Next SB Meeting and Project Meeting. For event 9, we said to have it co-located with a conference. But it's also true that the event in Austria is about ESR presenting their projects and findings. So, there is some overlap there, and we could propose to change event 9 to the one in Palermo.

## Extra training Event: December 2022 in UNIPA

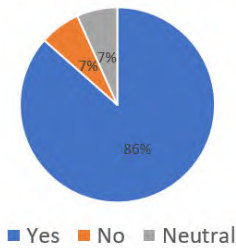
Training Event 9 and 10 will be discussed in next events.

### 6. Miscellaneous

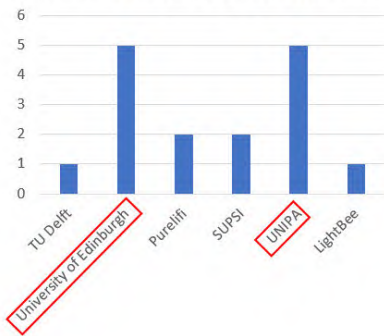
Nasir presented results of ESRs survey about their desire of having an extra event and potential topics to cover.

#### ➤ Extra event: Survey results

ESR's interest in an extra event



Suggested Universities/Partner institutions



Suggested dates



### Survey Results: Suggested Topics

- **ML applications in OWC** (2 ESRs)
- **CV and interview preparations** for standing out in selection process (2 ESRs)
- Learn more about **current LiFi implementations in the market**
- **Patenting vs. open-source** publishing (Pros and Cons)
- Future career in **academia vs. industry** (Pros and Cons), Is there a **third option?** How to target top universities and companies in the world?
- How to handle **paper rejections?** Tips on **reviewing papers...**
- **Interdisciplinary research** (guidelines on switching to other technologies)
- **Project management** (tools + experience sharing)

- Technical tutorial on **vehicular VLC frontend design**
- Tutorials on **Phy and MAC layer design** of LiFi systems
- How to prepare and find opportunities to deliver big platform talks (e.g., Ted Talks)

#### 7. Rehearsal of EWSN 2022 tutorial (Breakout rooms)

We will organize breakout rooms for each of the sessions to be given at EWSN tutorial. The chair of the session and additional supervisors will monitor the rehearsal and provide feedback.

Please, update your presentation in the following SharePoint folder by Friday 23<sup>rd</sup>, September. I suggest you follow up the timing (Time: 10'+5' (Q&A)) and format instructions (tutorial in nature) provided. For those we organized the talk in a group, consider that this time is for each person.

**The participants were divided in three breakout rooms to do a rehearsal of the Tutorial to be given in EWSN. ESRs received feedback from supervisors.**

\*\*

## 3.2. Training Event 8

The material created for the Training Event 8 that can be re-used in the future within the project lifetime and beyond, are: slides from the training speakers and some other outcomes for the sake of ESR learning such as networking.

### 3.2.1. Other results

The Project meeting #8 took place jointly with Project meeting #7. Its agenda and minutes was included in previous section.

### 3.3. Training Event 9

The material created for the Training Event 9 that can be re-used in the future within the project lifetime and beyond, are slides from the training speakers that are uploaded in the GitLab of the project. In the following image we show the corresponding folder of the Gitlab with the slides uploaded:

enlightem > Consortium

master consortium / Network Events / ExtraEvent / + History Find file Web IDE 42466a2c Clone

Upload New File  
Borja Genoves authored 1 week ago

Name	Last commit	Last update
..		
AllESRPresentations.pptx	Upload New File	1 week ago
CVs_for-scientists.pdf	Upload New File	1 week ago
Deep_Tech_Entrepreneurship.pdf	Upload New File	1 week ago
ENLIGHTEM-Palermo_CV.pptx	Upload New File	1 week ago
Electricity_Market_Evol_-_Opp_and_Prosp_fo...	Upload New File	1 week ago
From_Research_to_an_Innovative_Company....	Upload New File	1 week ago
LICENSE	Update Network Events/ExtraEvent/LICENSE	1 week ago
OrganizationTrainingEventExtra_ENLIGHTEM...	Upload New File	1 week ago

**Figure 11: Slides of Training Event 9 uploaded in the GitLab repository of ENLIGHT'EM**

### 3.4. Training Event 10

The material created as a result of the Training Event 10 is composed by slides of the presentations given by the ESRs in the Project Meeting and the Papers, Posters and Demos presented in ACM Mobicom 2023. We keep the presentations in the GitLab of the project and the material of Mobicom will be published in Zenodo as well.

master v consortium / Network Events / Event 10 / ESR Presentations / + v History Find file Web IDE ↓ Clone v

Name	Last commit	Last update
--		
.gitkeep	Add new directory	1 week ago
2023-09-27_ENLIGHTEM_Event10_Tilahun.pptx	Upload New File	4 days ago
ESR2.4_Kien_Ngo_Final_Meeting.pptx	Upload New File	1 week ago
ESR3.4DanielTetty.pdf	Upload New File	1 week ago
ESR_1.2_Janis_Report.pdf	Upload New File	1 week ago
ESR_1.2_Janis_Report.pptx	Upload New File	1 week ago
ESR_1.4_Project_Meeting_202309.pptx	Upload New File	3 days ago
ESR_2.1_Burak_Ozyurt_Project_Meeting_10.pptx	Upload New File	1 week ago
ESR_2.2_Report__Next_Steps.pdf	Upload New File	1 week ago
ESR_3.2_Behnaz.pdf	Upload New File	1 week ago
ESR_3.3_Jagdeep_Event10_Spain.pdf	Upload New File	1 week ago
ProjectMeeting10_Sep27_2023_ESR3.5_BNashfaq_uploaded.pptx	Upload New File	1 week ago
Report_ESR3_3_DamonYe_v2.pptx	Upload New File	2 days ago

Figure 12: Slides of Event 10 uploaded in the GitLab repository of ENLIGHT'EM

## 4. Conclusion

This document presented the training activities during the fourth year of the project, as well as the results obtained from those past events.

Although the project has been affected by COVID-19 outbreak, measures were taken to alleviate this situation. Furthermore, all ENLIGHT'EM members were committed to guarantee the highest impact and visibility to the training events, and we have uploaded the materials of the Events to the repositories of the project.