

Editor's Note

Welcome to the second newsletter from the COST Action OPTICWISE. Inside this very Action, everything is about Optical Wireless Communications (OWC). Let it be indoor, outdoor, let the channel be space or atmosphere, short range or long range, the technology becomes more and more mature and it is only a matter of time till all invested research efforts will pay out in a new generation of high-speed data communication systems.

Since publishing the last newsletter, we held our first OPTICWISE Training School and Annual Workshop. Much interaction was also possible during our 3rd and 4th Management Committee meetings which were held, respectively, at Pisa and Prague. The Short Term Scientific Missions also provided unique opportunities for collaboration among the Action participants. Further details on all these can be found in this issue.

Florian Moll
Editor of the Newsletter

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been also instrumental in igniting collaboration among the participants. We expect to see further increase in the number of joint works in parallel to the increasing number of Short Term Scientific Missions (STSMs) in the next year.

The Special Interest Group (SIG) on "Techno-Economics, Industrial Standards and Future Trends in OWC (TESEO)" was exclusively formed to influence decision makers at all levels of the OWC market chain. It became particularly instrumental in establishing relationships with the major standardization bodies and global forums such as ITU, URSI, IrDA, Li-Fi. Furthermore, we are in an effort to increase the participation from industry. We have also established contacts with a number of other COST Actions and FP7 projects and plan to further increase these interactions.

OPTICWISE Highlights

OPTICWISE is the very first COST Action dedicated solely to the field of OWC. The launch of this Action has brought together key European researchers in this field. The Action has also attracted attention from non-COST countries and currently has six partner institutions from Australia, China, Pakistan, Taiwan and Republic of Korea. The Action is expected to further grow with more international participants and become an actual global platform for synergizing research activities in the OWC field.

To ensure inter-disciplinary activities within the Action and maximize the impact, a mixed structure of "horizontal" and "vertical" organization was adopted through the introduction of topic-focused Working Groups (WGs) and application-focused Special Interest Groups (SIGs). We have already seen early positive outputs of this strategy in terms of increased collaboration among Action participants. During the first year of the Action, the participants have produced a total of 207 publications, 29 of which as a result of COST networking through the Action. The launch of the researcher information database on the Action website has

Meetings

3rd MC Meeting

The Action's 3rd Management Committee (MC) meeting was held at Scuola Superiore Sant'Anna, Pisa, Italy on October 22-24, 2012. During the event, ten input documents were presented covering a wide range of topics spanning from experimental channel modeling to circuit engineering. These documents can be found on the website <http://opticwise.uop.gr>. Invited speaker Professor Jean Armstrong of Monash University gave a talk on the use of OFDM for OWC systems. Professor Dominic O'Brien of Oxford University followed this with a talk overviewing his research program on various aspects of

indoor and outdoor OWC systems. Another invited speaker was Dr. Hubertus Haan from Cassidian who provided an industrial perspective emphasizing the current challenges that OWC technology encounters in market penetration.



Opening speech was made by the meeting host Professor Ernesto Ciaramella.

4th MC Meeting

The fourth MC meeting was in April 25-26, 2013 and held at the Institute of Atmospheric Physics in Prag, Czech Republic. Annual progress reports were presented by the WG and SIG Chairs summarizing the major achievements in their groups. Some STSM holders presented their research results during their visits (See third page of this newsletter for more information).



Dr Giorgio Corbellini during his invited speech.

Invited speakers of this meeting were Dr Peter Shardlow (Southampton University, UK), Dr Ciprian Gavrincea (CTTC, Spain) and Dr Giorgio Corbellini (Disney Research Zurich, Switzerland). Dr. Shardlow made a presentation on the ongoing FP7 project ISLA which aims to develop integrated disruptive components for 2 μm fiber lasers. Potential deployment of this optical wavelength for OWC systems is an open research problem and it was decided that OPTICWISE and ISLA can collaborate on this. Dr. Ciprian presented a prototype developed for the IEEE 802.15.7 VLC (visible light communication) standart. The use of VLC for toy-to-toy communication was discussed by the other invited speaker Dr Corbellini.

1st Annual Workshop

OPTICWISE organized the **First Annual International Workshop on Optical Wireless Communications (IWOW)** on October 22, 2012. It was held at Scuola Superiore Sant'Anna, Pisa, Italy co-located with the 3rd MC meeting. The workshop attracted submissions worldwide and, after a rigorous review process, 21 papers were accepted for presentation. IWOW is technically sponsored by the IEEE and the workshop papers can be accessed through [IEEEExplore](#).

1st Training School

OPTICWISE organized its **First Training School** at the Northumbria University, Newcastle upon Tyne, UK. This training school, held on February 25-26, 2013, included lecturers given by colleagues from France, Greece, and UK, supported by hands-on practical sessions about free space optical communication, visible light communication and radio-over-fiber systems.

Achievements of Working Groups

In this Section, the major achievements of each Working Group during the first year of the Action are summarized. All relevant publications can be found on the website <http://opticwise.uop.gr>.

The objective of **WG1 (Propagation Modeling and Channel Characterization)** is to develop, evaluate and validate statistical and empirical channel models for indoor and outdoor OWC applications. During the first year, WG1 has devoted large efforts on the microphysical and thermodynamic characterization of meteorological constituents (i.e., rain, snow, fog, haze, clouds etc). The development of advanced empirical channel models and tools to evaluate and predict the effect of such meteorological phenomena on the outdoor OWC links have been further addressed. In particular, priority has been given to the effect of fog, which is the most impairing meteorological condition for terrestrial OWC links. Accurate channel modeling is still an open issue and more work is envisaged in the next year. Some initial studies have been carried out also on the determination of the most appropriate optical wavelengths to be used for communication applications. Deployment of different laser beam shapes and types has been further explored.

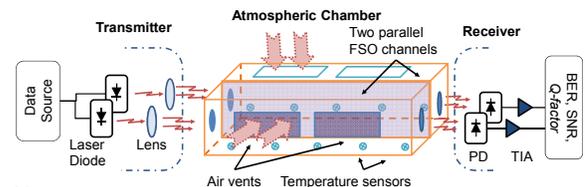
The **WG2 (Physical Layer Algorithm Design and Verification)** is involved with the development of efficient physical (PHY) layer solutions for OWC systems. The investigation of multiple input multiple output (MIMO) systems has been carried out by various Action participants for both indoor and outdoor OWC. MIMO systems involve the use of multiple transmitters and receivers and provide superior performance (in terms of reliability and throughput) over conventional single transmitter/receiver systems. Another promising solution to improve the link reliability particularly for outdoor OWC systems in the presence of atmospheric turbulence is relay-assisted (cooperative) transmission. Relay-assisted OWC systems have been investigated and shown to outperform conventional point-to-point transmission. A particular area which WG2 participants have devoted large efforts is hybrid RF/OWC outdoor systems in an effort to simultaneously leverage the media and spatial diversities for weather-robust performance. On the other hand, for high-rate indoor OWC, an active research topic has been the development of optical orthogonal frequency division multiplexing (OFDM) using visible light band. More research efforts are expected on this topic within next year as visible light communication (VLC) has been receiving a growing attention from both academia and industry.

While WG2 focuses on PHY layer for point-to-point transmission, **WG3 (Networking Protocols)** deals with upper layer protocol stacks as well as investigating co-existence and interoperability of OWC with other communication networks. Initial results have been obtained on the development of automatic repeat request (ARQ) protocols and joint topology control and routing algorithms for outdoor OWC systems. For indoor OWC systems, performance analysis and optimization of the link-layer protocols in Gb/s infrared links have been addressed.

The successful implementation of OWC systems and indeed the research activities highlighted in the previous WGs are premised on the availability of suitable and appropriate opto-electronic/optical front-end devices and components. These issues are addressed by the **WG4 (Advanced Photonic Components)**. Some specific objectives tackled by the WG4 during the first year include the investigation of optical wavelength selection with emphasis on the availability of relevant devices and components, the development of multi-array transmitters and receivers, the design and development of highly sensitive optical receiver with optical amplifiers, and the integration of the opto-electronic and electronics at substrate levels. Design and development of various OWC subsystem/system test-beds at visible, infrared and ultraviolet wavelengths for indoor and outdoor applications have been also carried out by various research groups within the Action.

Report from STSMs

A Short Term Scientific Mission (STSM) was carried out by Dr Stanislav Zvanovec from **Czech Technical University in Prague (CTU)** in laboratories of **Northumbria University**, Newcastle upon Tyne, UK (hosted by Prof. Zabih Ghassemlooy) from 17th September to 11th October 2012. This STSM was related to channel characterization of diversity free-space optical (FSO) links intersecting different turbulent areas. The main aim was to confront results obtained from outdoor measurement campaign to new laboratory experiments and to investigate and validate influences of turbulence and network configurations under precise laboratory-set conditions. Joint research has led to some corrections/modifications of conventionally used methodologies and extended research towards more complex network schemes. Apart publishing results in conferences and submission of two journal papers, a new modular concept of turbulence chamber has been developed through this collaboration.



(a) The experimental set-up to research route diversity for FSO links within turbulent scenarios

The **Istituto de Telecomunicacoes de Aveiro** and the **Communication Department of the Italian Ministry of Economic Development** performed in February 2013 several experiments on FSO transmission as a part of STSM. The tests took place in Aveiro, a small town close to the Portuguese Atlantic ocean coast. A Wavelength Division Multiplexed signal, formed by 16 optical carriers 100 GHz spaced, DQPSK modulated and polarization multiplexed up to 100Gbit/s, has been used to connect two different buildings located inside the university campus covering a total length of around 80m. The quality of the 16x100Gbps transmission, the highest-ever capacity for a building-to-building OWC link has been verified in terms of bit error rate and error vector magnitude and error free conditions are achieved.

Prof. Teixeira and Dr. Tosi Belleffi commented: "This experiment demonstrates that optical wireless technology



can represent a key actor in the today convergent access telecommunication scenario". Experiments are still on the way, and opened to everyone, on the Aveiro trial.

Member Profiles



Eszter Udvarý, PhD
Chair of WG4

Eszter Udvarý received Ph.D. degree in electrical engineering from Budapest University of Technology and Economics (BME), Budapest, Hungary, in 2009. She is currently an associate professor at BME, Department of Broadband Infocommunications and Electromagnetic Theory where she leads the Optical and Microwave Telecommunication Lab. Dr. Udvarý's research interests are in the broad areas of optical communications, including optical and microwave communication systems, radio over fiber systems, optical and microwave interactions and applications of special electro-optical devices. Her special research focuses on multifunctional semiconductor optical amplifier application techniques and visible light communications.



Prof. Anthony C. Boucouvalas
Chair of WG3

Anthony C. Boucouvalas received the B.Sc. degree in Electrical and Electronic Engineering from Newcastle upon Tyne University, U.K., in 1978. He received his MSc and D.I.C. degrees in Communications Engineering from Imperial College, University of London, U.K., in 1979, and the PhD degree in fiber optics from Imperial College, in 1982. He is now Head of the Telecommunication Sciences and Technology Department at the University of Peloponnese in Greece. His research interests lie in optical wireless communications, optical fiber communications, HCI communications, and human-computer interfaces. He has published over 280 papers on related topics.



Giorgio Tosi Beleffi, PhD
Chair of SIG TESEO

Dr. Tosi Beleffi graduated in 2000 at the University of Roma Tre and got the PhD in 2006 at the University of Roma Tor Vergata with a work on "All Optical Signal Regeneration Based on Non Linear Optical Effects". He is specialized in broadband telecommunications, green networks, signal processing and telecommunications standards. He is a Senior Member of IEEE and a co-author of more than 120 publications on international journals and conferences proceedings, four books and one patent.

Upcoming Events

- Special Session on Optical Wireless Communication, IEEE PIMRC, London, UK, 8-11 September 2013
- **OPTICWISE EVENT** | 2nd International Workshop on Optical Wireless Communications 2013 (IWOW), 21 October, 2013, Newcastle, UK.
- **OPTICWISE EVENT** | IWOW 2013 Training School, 21-23 October, 2013, Newcastle, UK.
- OSA Topical Meeting, Application of Lasers for Sensing & Free Space Communication, 27 October - 1 November, Paris, France.
- IEEE GLOBECOM 2013, Workshop on Optical Wireless Communication, 9 December 2013, Atlanta
- SPIE Photonics West 2014, Free-Space Laser Communications and Atmospheric Propagation, 1-6 February, 2014, San Francisco, USA
- International Conference on Space Optical Systems and Applications (ICSOS), 7-9 May, 2014, Kobe, Japan.
- SPIE Optics + Photonics 2014, Optical Engineering + Applications, 17-21 August, 2014, San Diego, USA.

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Website of the Action

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