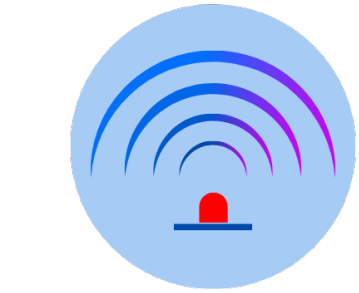
Horizon Europe Framework Programme



OPTI-6G

OPTICAL 6G CELL-FREE NETWORKS

D5.2 – Report on dissemination and liaisons with regulatory, industry associations and standardisation bodies activities

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ABSTRACT

This second deliverable reports on the dissemination, communication and liaison activities undertaken by the OPTI-6G project during its first reporting period. Building on the strategic foundations laid in deliverable D5.1, the project significantly expanded its online presence, intensified engagement through social media, and actively participated in high-profile conferences and workshops to enhance visibility and stakeholder outreach.

It also contributed to discussions on industry associations and standardisation in the domain of optical wireless communication (OWC). These activities support the broader mission of integrating OPTI-6G innovations into the emerging 6G ecosystem and ensuring alignment with key regulatory and industry developments.

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Executive summary

This deliverable outlines the dissemination and impact-generation actions undertaken by the OPTI-6G project from 20 June 2024 to 20 May 2025. During this period, the project consolidated its digital and social media strategies, expanded its visibility through major scientific and industrial events, and began engaging in pre-standardisation monitoring. The OPTI-6G website continued to act as a central information portal, with substantial increases in page views and user interaction.

The OPTI-6G project also intensified its presence on LinkedIn and YouTube, strategically aligning content to inform, engage, and expand its audience. Active participation in global events such as the IEEE Future Networks World Forum and the EUCNC & 6G Summit enabled the dissemination of key technical outcomes and strengthened inter-project collaboration. Although direct regulatory actions remain limited, monitoring and strategic positioning continue in relevant forums.

The project's future tentative presence again at key industry events such as IEEE, EuCNC, MWC, 6G Berlin, and the HomeGrid Forum reflects a growing emphasis on the practical integration of optical wireless communication within the broader 6G framework. Future plans include ongoing dissemination at major conferences, social media campaigns, and technical contributions to standardisation efforts.

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Abbreviations and Acronyms

3GPP	3rd Generation Partnership Project
6G IA	6G Infrastructure Association
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
AoA	Angle of Arrival
AP	Access Point
AR	Augmented Reality
CAGR	Compound Annual Growth Rate
CFN	Cell-Free Network
DOI	Digital Object Identifier
EM	Electromagnetic
EuCNC	European Conference on Networks and Communications
FoV	Field-of-View
IoT	Internet of Things
IR	Infrared
ICAS	Integrated Communication and Sensing
ISAC	Integrated Sensing and Communication
ITU	International Telecommunications Union
IPR	Intellectual Property Rights
JU	Joint Undertaking
LoS	Line of Sight
MIMO	Multiple-Input Multiple-Output
ML	Machine Learning
mMIMO	Massive Multiple-Input Multiple-Output
mmWave	Millimeter Wave
MWC	Mobile World Congress
O-RAN	Open-Radio Access Network
OFE	Optical Front End
OWC	Optical Wireless Communication
PLC	Programmable Logic Controller

RF	Radio Frequency
RSS	Received Signal Strength
SNS	Smart Networks and Services
TDoA	Time Difference of Arrival
ToA	Time of Arrival
UE	User Equipment
VLC	Visible Light Communication
VR	Virtual Reality
WP	Work Package
XR	Extended Reality

1 Introduction and Objectives

This document reports on the dissemination and other impact creation and exploitation activities of OPTI-6G concerning the first reporting period, and measures the accomplishments against the project targets.

This deliverable is developed as part of the OPTI-6G project Work Package 5 (Impact Creation from Exploitation, Dissemination and Standardisation).

The report is structured as follows:

- **Section 2** shows how, during this mature stage of the first reporting period, OPTI-6G strengthened its dissemination activities by expanding its digital presence and actively participating in major international conferences and workshops.
- **Section 3** discusses regulatory aspects, highlighting experimental 5G licences and the benefits of licence-free OWC, with ongoing monitoring of spectrum policies.
- **Section 4** highlights OPTI-6G's contributions to industry associations, especially under the SNS Joint Undertaking (SNS JU), but also outside the community in advanced Optical Wireless Communication (OWC) through its leadership in the HomeGrid Forum's LiFi Task Force, which promotes interoperability via the ITU-T G.hn standard.
- **Section 5** explains how OPTI-6G actively monitors key pre-standardisation efforts, particularly in IEEE and ITU. Focus areas include OWC developments.
- **Section 6** outlines the wider impacts of the OPTI-6G project, including patent activities, emerging services, and improved infrastructure.
- **Section 7** summarises how partners continue to advance their exploitation plans, focusing on improving and demonstrating innovative optical wireless positioning and integrated sensing-communication technologies.

2 Report on dissemination achievements

This part of the deliverable covers the results of the mature stage of the first perioding report (20 June 2024 and 20 May 2025), comparing it to its initial stage (22 February 2024 to 20 June 2024) described in the previous deliverable D5.1 Techno-economic analysis and exploitation plans, which highlighted the strategy the project wanted to undertake to a successful dissemination start.

Project dissemination and communication activities carried out between 20 June 2024 and 20 May 2025, are measures to show how, in this mature stage of the first perioding report, we have built upon the foundational branding and strategy efforts established during the initial phase of the project.

2.1 Statistics on online presence

The OPTI-6G project website (https://opti-6g.sns-ju.eu/) was officially launched on 22 February 2024, one month after the project's start. Developed and hosted by Eurescom GmbH, with collaborative input from all consortium members, the website serves as the central information hub for the project. It provides public access to an overview of the OPTI-6G concept, its timeline, consortium partners, publications, deliverables, news, and dissemination materials. The platform is regularly updated and will remain accessible for at least two years after the project concludes, with long-term publication archiving ensured through the open-access repository ZENODO.

All website statistics were collected using the Matomo Analytics tool, ethically hosted on Eurescom's local server in full compliance with the EU's General Data Protection Regulation (GDPR), avoiding reliance on third-party platforms like Google Analytics.

2.1.1 Website

This mature stage of the first reporting period (20 June 2024 – 20 May 2025), which spans nearly twice the duration of the initial phase, reflects the growing maturity of the website's role in OPTI-6G's dissemination strategy. The number of visits more than doubled to 557, and page views increased to 1,100, with 899 unique page views. While the average session duration moved to 2 minutes and 25 seconds, which is still a very good average time compared to the nearly 5 minutes in the first 6 months, still underlying genius interest for the project. The bounce rate slightly rose to 59%, which reflects the increase in first-time or new visitors through broader visibility. Actions per visit are nearly 2.2 per visitor, and the maximum actions per session is around 36, indicating a shift in user behaviour—possibly due to more targeted, quicker access to specific content as users became more familiar with the site structure.

Notably, this mature phase also introduced downloads, 14 total for 13 unique, and saw a substantial increase in outlinks (128 total, 121 unique), showing clear signs of growing engagement with external resources and interest in OPTI-6G materials.

Figure 1: OPTI-6G Overview of visits over time from 20/06/2024 to 20/05/2025

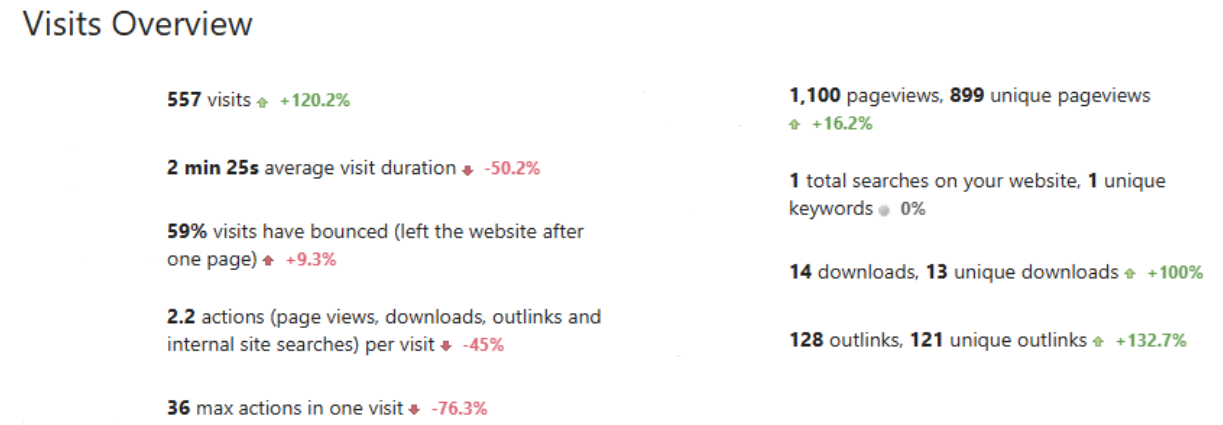


Figure 2: OPTI-6G Overview of total visits from 20/06/2024 to 20/05/2025

PAGE TITLE	▼ PAGEVIEWS	UNIQUE PAGEVIEWS	BOUNCE RATE	AVG. TIME ON PAGE	EXIT RATE	AVG. PAGE LOAD TIME
OPTI-6G	386	313	55%	00:00:57	65%	7.79s
Project overview – OPTI-6G	64	53	53%	00:01:04	43%	3.41s
Publications – OPTI-6G	61	43	78%	00:01:28	51%	3.1s
Consortium – OPTI-6G	59	46	50%	00:02:00	43%	2.88s
Public deliverables – OPTI-6G	59	44	17%	00:01:32	66%	2.78s
News – OPTI-6G	55	44	50%	00:01:05	48%	4.77s
The 2025 IEEE Radar Conference in Krakow, Poland...	52	47	64%	00:00:45	89%	6.17s
Berlin 6G Conference 2025 – The Annual Networki...	45	43	61%	00:00:42	91%	6.36s
Contact us – OPTI-6G	22	16	50%	00:00:57	69%	5.48s
OPTI-6G Project Presented at IEEE Future Network...	22	14	44%	00:01:24	43%	3.27s
Join founders and presidents at MWC25 Barcelona...	21	19	73%	00:00:56	84%	4.03s
Use Cases & Results – OPTI-6G	20	18	50%	00:00:32	33%	3.05s
EuCNC & 6G SUMMIT 2025 in Poznan, Poland – 3 t...	16	16	92%	00:00:04	88%	4.14s
IEEE Wireless Communications and Networking Co...	16	14	75%	00:00:11	93%	2.98s
IEEE International Conference on Communications:...	14	13	82%	00:03:24	92%	6.13s

Figure 3: OPTI-6G Most visited pages from 20/06/2024 to 20/05/2025

The most visited pages on the OPTI-6G website include the homepage, project overview, publications, consortium, and public deliverables. Visitors also showed interest in recent and upcoming event posts, such as major 6G conferences across Europe and beyond, including the 2025 IEEE Radar Conference and the Berlin 6G Conference, where both OPTI-6G applied to join the discussion and present the project through papers and contributions.

While engagement varied, content related to project outcomes and key dissemination activities attracted longer visits and lower exit rates, indicating sustained user interest. Technical pages and deliverables generally performed better in keeping users engaged compared to news announcements and event pages.

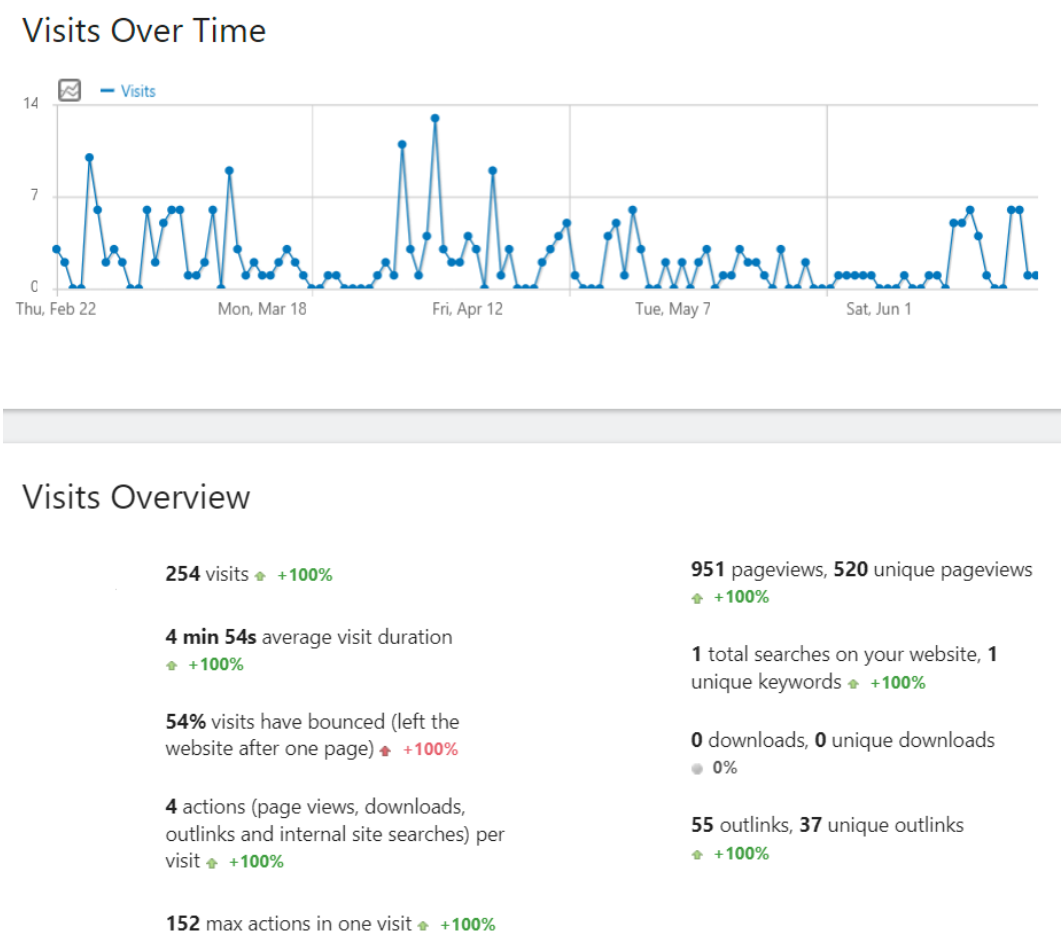


Figure 4: For comparison, OPTI-6G website initial phase of the first period overview visitors from 22/02/2024 to 20/06/2024

In comparison with the initial phase (22 February 2024 – 20 June 2024), covering the website's initial launch and outreach efforts, lasting approximately five months. During this early phase, the site recorded 254 visits, an average visit duration of nearly 5 minutes, and a relatively high engagement rate. A total of 951 pageviews were recorded, alongside 55 outlinks and no downloads, as the content was still under development.

This progression in website performance reflects both the expanding visibility of OPTI-6G and the increased availability of valuable content during this period. It will serve as a key benchmark for future analysis as the project continues to evolve and broaden its outreach efforts.

Two categories of data can now be analysed in this mature stage, the downloads and the outlinks, illustrating where the interest of the visitors is tending while browsing the OPTI-6G website and when leaving it.

DOWNLOAD URL	UNIQUE DOWNLOADS	DOWNLOADS
opti-6g.sns-ju.eu	11	11
/wp-content/uploads/2024/07/opti-6g-flyer-v5.1-a4-landscape.pdf	9	9
/wp-content/uploads/2024/10/img_20241015_172238_resized_20241025_122153295.jpg	1	1
/wp-content/uploads/2024/11/img-20241127-wa0011.jpg	1	1
ezywureyi7i.exactdn.com	1	1
smart-networks.europa.eu	1	2
/wp-content/uploads/2024/03/12-opti-6g-technical-overview-final-v2-0.pdf	1	2

Figure 5: OPTI-6G Downloads from 20/06/2024 to 20/05/2025

CLICKED OUTLINK	UNIQUE CLICKS	CLICKS
www.linkedin.com	18.2% 22	19.5% 25
zenodo.org	14.9% 18	14.1% 18
www.6g-plattform.de	13.2% 16	12.5% 16
radarconf2025.org	9.1% 11	8.6% 11
fnwf2024.ieee.org	5.8% 7	5.5% 7
www.youtube.com	5.8% 7	5.5% 7
pimrc2025.ieee-pimrc.org	4.1% 5	3.9% 5
icc2025.ieee-icc.org	3.3% 4	4.7% 6
www.runel.net	3.3% 4	3.9% 5
cordis.europa.eu	2.5% 3	2.3% 3

Figure 6: OPTI-6G Outlinks from 20/06/2024 to 20/05/2025

The OPTI-6G website's user activity reflects growing engagement both within and beyond the site. The majority of downloads focused on the project flyer and a few pictures; the main documents are present for download directly on the website. Outlinks show that users were also engaged with external platforms, especially our OPTI-6G LinkedIn and Zenodo, followed by the German 6G initiative, as well as featured events and our consortium partner websites.

This indicates successful redirection of traffic toward key dissemination channels and collaborative networks.

2.1.2 Social Media

Since the project's start, LinkedIn (OPTI-6G LinkedIn) and YouTube (OPTI-6G YouTube) have been selected as the primary social media platforms for disseminating project updates and deliverables.

LinkedIn is actively used to share concise updates and progress highlights, including milestone achievements, announcements of upcoming events, and summaries of past activities. Content is typically shared one to two times per week, aimed at both informing and engaging the project's growing community. In addition to regular updates, the platform is also leveraged to distribute thought leadership materials such as white papers, analytical summaries, and project reports.

On the OPTI-6G YouTube channel, audiovisual content such as webinar recordings has been published. Additional content—such as demonstrations of project applications and footage from workshops—is planned for the near future to expand the channel's impact.

To maximise the reach and impact of our communication efforts, social media posts often link to more comprehensive articles hosted on the project website. Our dissemination strategy includes tagging peer projects and referencing the Smart Networks and Services Joint Undertaking (SNS JU). We also actively contribute to and benefit from the SNS CO-OP communication strategy, including participation in its dedicated LinkedIn group and communication task force.

This approach has primarily enabled OPTI-6G to engage a technical audience within the SNS community. As of 16th of June, 2025, the project's LinkedIn page has organically grown to 98 followers, reflecting steady and sustainable engagement. Within this period of the project, the LinkedIn content generated approximately 5,272 impressions.[1] and 213 reactions[2]:

[1] An impression on LinkedIn refers to the number of times a post is shown to users.

[2] A reaction represents an interaction in which a user clicks on one of LinkedIn's engagement icons (e.g., Like, Celebrate, Insightful, etc.).

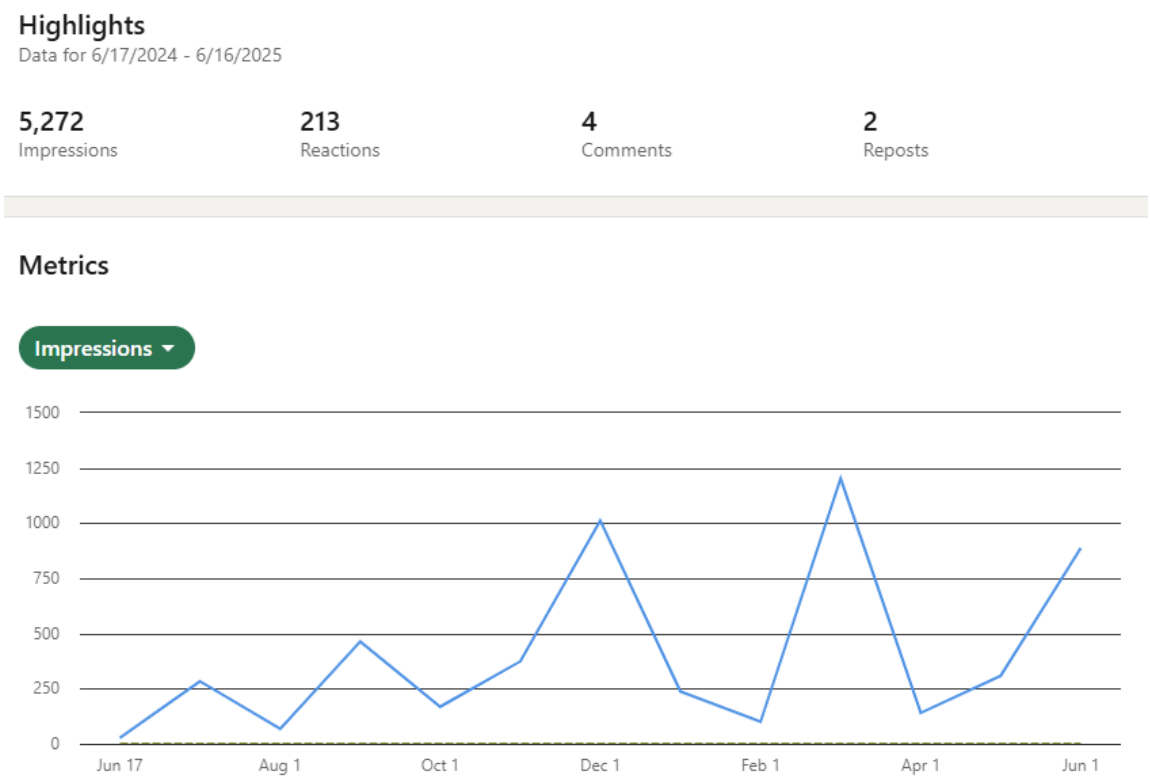


Figure 7: OPTI-6G LinkedIn Analytics Highlights and Impressions from 17/06/2024 to 16/06/2025

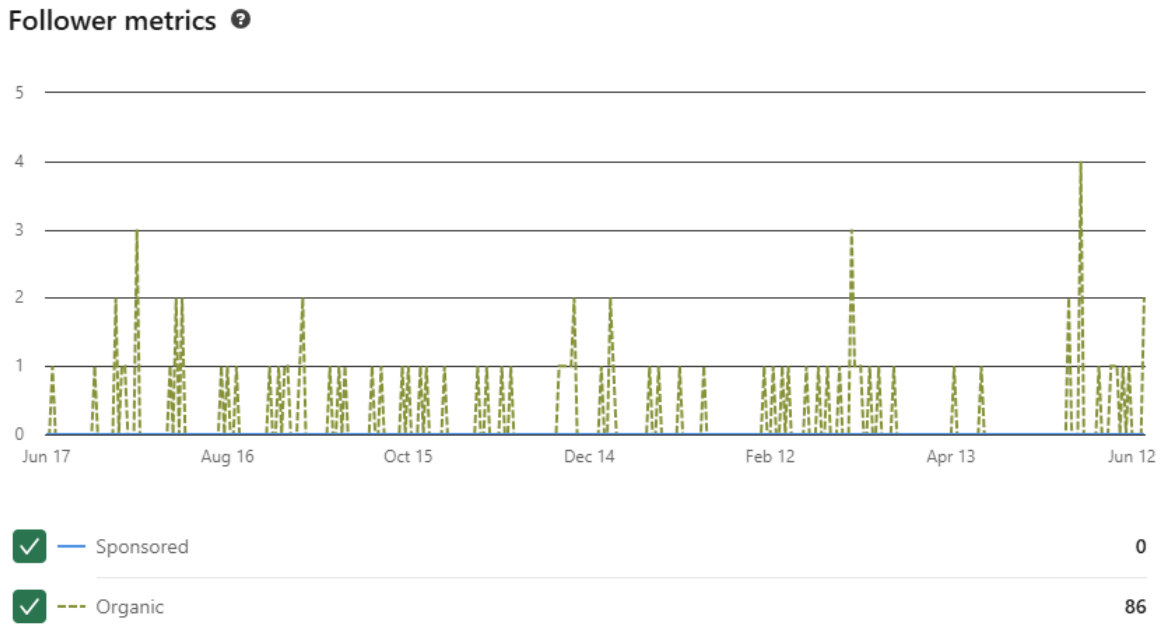


Figure 8: OPTI-6G LinkedIn Analytics - Followers metrics from 17/06/2024 to 16/06/2025

Importantly, this growth has been achieved entirely through organic (non-paid) activity.

The impact of our YouTube presence remains more limited at this stage, primarily due to the relatively small volume of published content. However, as more webinars and in-person events take place, content generation will increase in alignment with our communication objectives.

Moving forward, our strategy remains focused on leveraging the unique strengths of each platform to continue building awareness, engagement, and support for the OPTI-6G project.

2.2 Events participation and publications

During the second reporting period, OPTI-6G actively participated in several high-profile international conferences and workshops to disseminate its research outcomes and foster collaboration.

At the ***IEEE Future Networks World Forum 2024*** in Dubai, the project was featured prominently in the Symposium on Optical-Wireless Convergence, where a dedicated presentation highlighted OPTI-6G's advancements in cell-free optical 6G networks. Two peer-reviewed workshop papers were also presented in the technical tracks.

The project continued its visibility at the ***IEEE Wireless Communications and Networking Conference (WCNC)*** during the 6GArch Workshop, where Prof. John Cosmas and Dr. Kareem Ali presented work on scalable reinforcement learning agents for autonomous radio link control.

In 2025, OPTI-6G took a leading role in organising Workshop 13 at ***EUCNC & 6G Summit***, gathering 10 SNS JU projects to explore the future of integrated optical-wireless 6G networks. The workshop, chaired by Prof. Cosmas, technical manager of OPTI-6G, featured presentations from ten Horizon Europe projects and was promoted on LinkedIn, highlighting the consortium's commitment to sustainability, innovation, and inter-project collaboration.

2.2.1 IEEE Future Networks World Forum, Dubai 2024

At the IEEE Future Networks World Forum 2024, the OPTI-6G project featured in a dedicated symposium and two technical tracks.

A key highlight was its participation in the Symposium on Optical-Wireless Convergence: Beyond Xhaul, Enabling the Communications-Computing Continuum, which took place on Thursday, 17 October 2024, from 11:00 to 17:30 (UAE local time).

During this session, Professor John Cosmas from Brunel University London, UK & OPTI-6G Technical Manager, presented the talk "OPTI-6G: Optical 6G Cell-Free Networks". This

presentation was part of a session focused on EU-funded 6G SNS projects, alongside presentations from ECO-ENET, 6G-EWOC, and PROTEUS-6G.

A supporting paper was prepared and distributed to conference delegates as part of the symposium proceedings [C1].

Additionally, OPTI-6G was represented in two technical tracks through peer-reviewed papers:

- On Tuesday, 15 October, during Technical Track 3: 5G and Future Network Trials, Experimental Results, Deployment Scenarios, Hardware and Test/Measurements, a workshop paper related to the project was presented and published in IEEE Xplore [C2].
- On Wednesday, 16 October, in Technical Track 4: 5G and Future Network Special Verticals, a second peer-reviewed paper was presented and also made available through IEEE Xplore [C3].

Figure 9: Prof. John Cosmas in Technical Track Session

2.2.2 IEEE Wireless Communications and Networking Conference

The 3rd Workshop on 6G Architecture (6GArch3) was held on Sunday, April 21 and chaired by Marco Gramaglia. The event featured multiple sessions covering various aspects of 6G

architecture, including roadmaps, architectural building blocks, and wireless technologies.

A key presentation during the 6GArch3 session focused on *"Design of Scalable Population of Reinforcement Learning Agents for Autonomous 5G Radio Link Control"* by Prof. John Cosmas and Dr. Kareem Ali, both from Brunel University London. This work addressed advanced machine learning techniques applied to autonomous control of 5G radio links, highlighting scalable agent-based approaches for improving network performance and adaptability.

Other notable presentations in this session included spectral efficiency analysis for cell-free radio access networks, nonlinearity-aware learning for wireless backhaul, carrier phase-based localisation methods, federated beamforming for non-terrestrial networks, and TSN support in 3GPP networks.

The workshop provided a comprehensive platform for discussing the evolution of 6G architecture, emphasising the integration of AI and machine learning in future wireless systems.

Figure 10: Prof. John Cosmas and Dr. Kareem Ali in Workshop Session

2.2.3 Presence at EuCNC & 6G Summit 2025

The OPTI-6G project marked a strong presence at the EuCNC & 6G Summit 2025, contributing to three high-impact workshops and a well-received poster session that showcased the project's cutting-edge innovations in optical wireless communications and localisation.

Organisation of the Workshop 13 on Optics and Photonics Innovations:

A EuCNC & 6G Summit 2025 workshop was organised and moderated by OPTI-6G project to bring together Communication Research labs from all over the world, who are now engaged in research and development of Optics and Photonics to realize Integrated Optical Wireless Communications Network by the year 2030, to disseminate their research amongst themselves to create research collaborations between institutions for future potential research projects.

The organisation and leadership of Workshop 13, titled "*Optics and Photonics Innovations for Integrated Optical Wireless Communications Networks*". More details can be found here.

This workshop, chaired by Prof. John Cosmas (Brunel University London), Technical Manager of OPTI-6G, brought together 10 Horizon Europe SNS JU projects engaged in cutting-edge research in optics and photonics for 6G.

The workshop was structured into two sessions, featuring contributions from projects such as SEASON, FLEX-SCALE, SUPERIOT, 6G-MUSICAL, 6G-XCEL, ECO-eNET, 6G-EWOC, PROTEUS-6G, TERA6G, and OPTI-6G itself. In Session 2, Prof. Cosmas presented OPTI-6G's latest work on "Towards Optical 6G Cell Free Beamsteered Networks with Localisation", showcasing the project's role in shaping future integrated wireless-optical networks. Additionally, OPTI-6G was featured in the poster exhibition, with Prof. Cosmas presenting both a dedicated project poster and another on RFID performance.

The project's activities were also promoted via social media, celebrating the workshop as a major success and a catalyst for future 6G research collaboration. The workshop emphasised sustainability, efficiency, and innovation—key pillars of the SNS JU programme and OPTI-6G's mission.

Figure 11: Workshop 13 "Optics and Photonics Innovations for Integrated Optical Wireless Communications Networks" Session 2 speakers and participants.

Participation in Workshop 10 on Integrated Sensing and Communications (ISAC):

The OPTI-6G project was pleased to have been represented by Israel Koffman, co-founder of RunEL, Israel, at Workshop 10 on Integrated Sensing and Communications (ISAC) during the EuCNC & 6G Summit 2025. The workshop took place on Tuesday, June 3rd and featured a strong lineup of presentations and discussions with broad participation from across Europe's 6G innovation landscape.

Held under the umbrella of the European Union's Horizon Europe Smart Networks and Services Joint Undertaking (SNS JU), the workshop was part of a larger effort to accelerate research and collaboration in key 6G technologies. With ISAC set to play a defining role in next-generation networks, the session provided valuable insights into cutting-edge research, deployment scenarios, and ongoing standardisation efforts across the continent.

Figure 12: Israel Koffman (RunEL) presenting the OPTI-6G project at the Workshop 10 "Integrated Sensing and Communications (ISAC)".

Israel Koffman participated in Panel 2: System Level Improvements, where he highlighted OPTI-6G's contributions to advancing system architecture and performance through ISAC technologies. His presentation demonstrated the project's impactful work and reinforced OPTI-6G's central role in pushing forward innovation in 6G system integration.

The workshop was co-organised by leading academic and industrial partners, including the University Carlos III of Madrid, Chalmers University of Technology, the University of Málaga, and others. It successfully served as a coordination platform for ISAC-related activities across multiple Horizon Europe projects, promoting dialogue on current challenges and opportunities, and supporting collaboration for future research.

Presentation of OPTI-6G in SME Working Group Convened Session "Presentation in SME Working Group ":

During the convened session titled "SMEs in the Spotlight: Driving Innovation in the Next Generation of Communication Networks," held on 5 June at the EuCNC & 6G Summit 2025, Israel Koffman, representing RunEL, presented significant innovations developed under the OPTI-6G and TRIALS-NET projects. His intervention focused on the application of 5G technologies to Real Time Location Systems (RTLS), with a particular emphasis on achieving ultra-accurate positioning capabilities.

He demonstrated how 5G-enabled RTLS can deliver centimetre-level accuracy, representing a two orders of magnitude improvement over existing cellular-based location technologies. The presentation outlined the technical advantages of 5G in this context, including its ability to provide both indoor and outdoor coverage, support for low-latency operations essential for tracking fast-moving assets such as autonomous vehicles, and scalability to accommodate thousands of devices per cell. Furthermore, he emphasised that 5G RTLS does not require the use of special tracking devices, as all 5G user equipment (UE) can be located directly. When the positions of base stations are known, absolute three-dimensional UE positioning is also achievable.

Figure 13: Israel Koffman (RunEL) representing the OPTI-6G project at SME Working Group Convened Session "Presentation in SME Working Group".

This presentation underscored the strategic role that SMEs such as RunEL play in advancing the capabilities of next-generation communication networks and in driving forward the European agenda for digital innovation and technological leadership.

EuCNC & 6G Summit 2025 Posters session:

Additionally, OPTI-6G was featured in the poster exhibition, with Prof. Cosmas presenting both a dedicated OPTI-6G project poster and another on RFID performance.

The project's activities were also promoted via social media, celebrating the workshop as a major success and a catalyst for future 6G research collaboration.

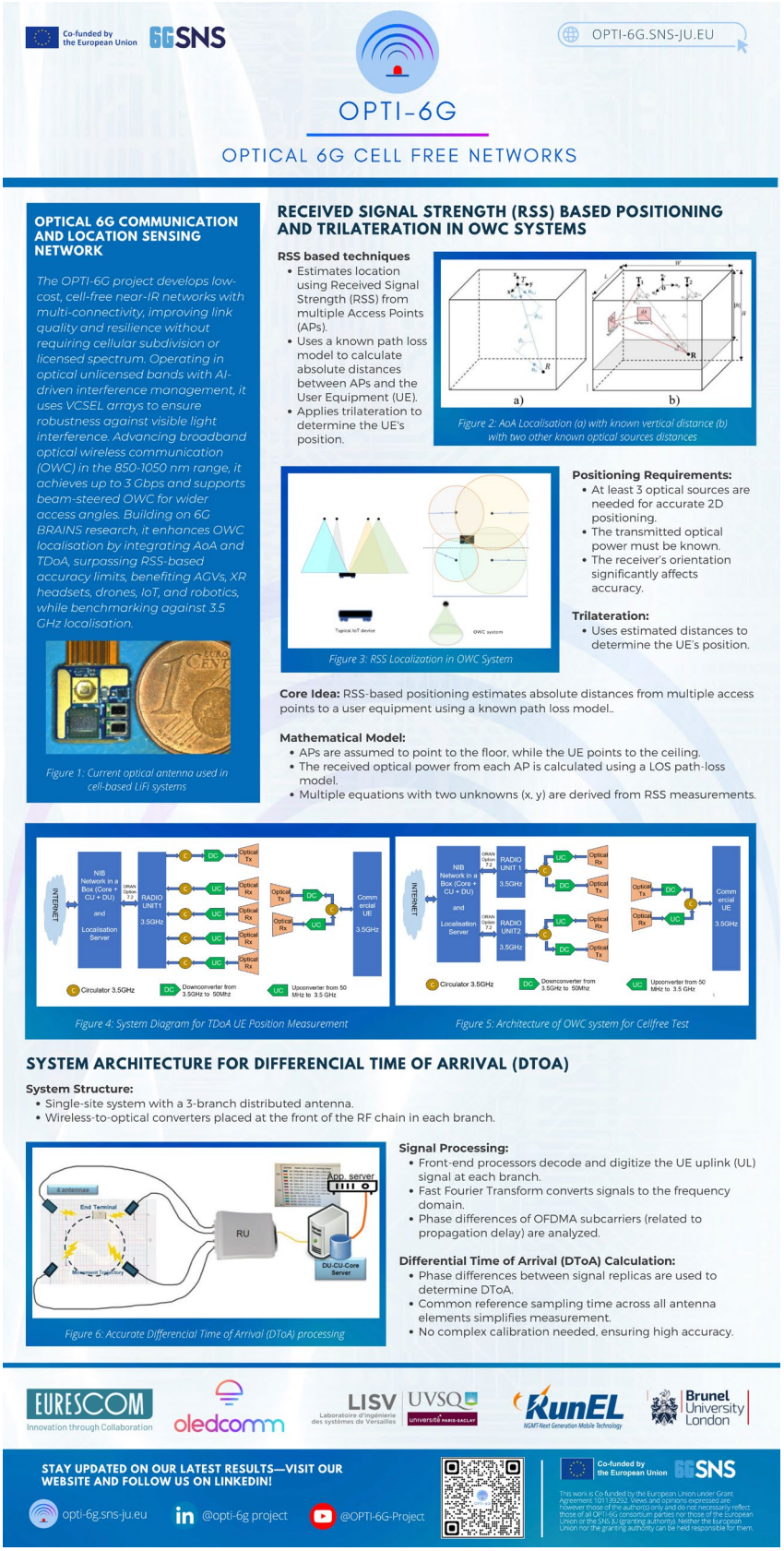
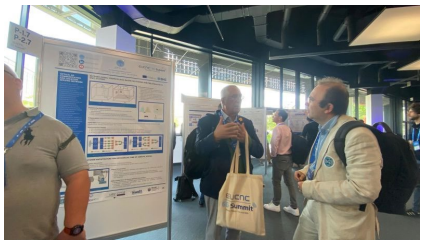
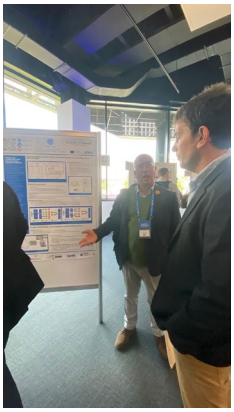
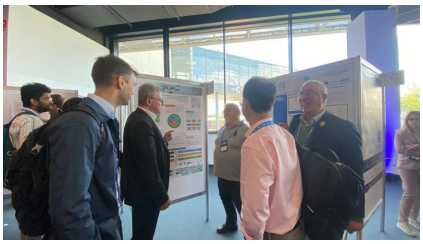


Figure 14: OPTI-6G poster on "Cellfree Optical Wireless Integrated Sensing and Communication System Design and Test Plan" presented at the EuCNC & 6G Summit 2025

The following shows Prof. John Cosmas presenting a poster on the OPTI-6G project to interested visitors:

The following shows Prof. John Cosmas presenting a poster on RFID performance to interested visitors:



Conference papers:

[C1] J. Cosmas, K. Ali, A. Mahbas, P. K. Boakye, J. Miguel, V. Gabillon, A. Kazmierowski, and L. Sear, "Design of Scalable Population of Reinforcement Learning Agents for Autonomous 5G Radio Link Control," 2024 IEEE Wireless Communications and Networking Conference (WCNC), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C2] J. Cosmas, K. Ali, I. Koffman, Z. Hadad, A. Karamani, A. Salomon, B. Globen, "Accuracy and Repeatability Results of a 5G Sub 6GHz Time of Arrival Distance Measurement Campaign," 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C3] A. Mahbas, J. Cosmas, K. Ali, "Environment Sensing and Landmarks Detection for Accurate Self-Localisation," 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C4] J. Cosmas, K. Ali, H. Malki, A. Kapovits, I. Koffman, B. Azoulay, C. Lartigue, E. Plascencia, B. Béchadergue, B. Cagneau, L. Chassagne, and A. Gavras, "Optical 6G Cell Free Networks for High Performance Communications and Sensing in Industry 4.0," 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C5] K. Acuna-Condori, H. Guan, B. Béchadergue, and L. Chassagne, "Robust Visible Light Positioning: A Comparative Study of Machine Learning Estimators in Spatial Segmentation and Transmitter Failure Scenarios", 2025 IEEE International Conference on Communications (ICC), Montreal, Canada, 2025.

[C6] Yanan Xin, Qilie Liu, John Cosmas "Real-Valued Genetic Algorithm-Based Hybrid Beamforming Optimisation in Multi-IRSs-Aided mmWave MIMO-OFDM Systems" EuCNC & 6G Summit 2025, June 2nd - 6th, Poznan, Poland

[C7] John Cosmas, Kareem Ali, Adam Kapovits, Audrey Bienvenu, Anastasius Scencia, Bastien Béchadergue, Barthélemy Cagneau, Luc Chassagne "Cellfree Optical Wireless Integrated Sensing and Communication System Design and Test Plan" EuCNC & 6G Summit 2025, June 2nd - 6th, Poznan, Poland

Journal papers:

[J1] A. Mahbas, J. Cosmas, S. Mueen, and J. Wang, "LOS Analysis for Localization in High Frequency Systems," IEEE Transactions on Wireless Communications, vol. 23, no. 6, pp. 6425-6437, June 2024.

[J2] L. Shi, Z. Liu, B. Béchadergue, H. Guan, L. Chassagne and X. Zhang, "Experimental Demonstration of Integrated Optical Wireless Sensing and Communication," Journal of Lightwave Technology, vol. 42, no. 20, pp. 7070-7084, Oct. 2024.

[J3] L. Chassagne, B. Béchadergue, O. Barrois, B. Cagneau, H. AL Satai and P. Ruaux, "Optical wireless positioning by modulation of the optical source orientation," Optics Express, Vol. 33, no. 6, pp. 13161-13183, March 2025.

Submitted papers:

[S1] J. Cosmas, K. Ali, A. Kapovits, A. Gavras, I. Koffman, B. Azoulay, C. Lartigue, E. Plascencia, K. Acuna-Condori, B. Béchadergue, B. Cagneau, L. Chassagne, C. Tsokos, E. Andrianopoulos, C. Kouloumentas, M. Milosevic, F. Caetano, C. Roeloffzen, and P. van Dijk, "Towards a Steerable Optical Wireless Integrated Sensing and Communication System," submitted to 2025 IEEE Radar Conference (IEEE RadarConf 2025).

[S2] H. AL Satai, B. Béchadergue, L. Chassagne, K. Acuna-Condori, B. Cagneau, and P. Ruaux, "Beamsteering-Enabled Optical Wireless Integrated Sensing and Communication," submitted to 2025 Global Communications Conference (GLOBECOM).

[S3] H. AL Satai, B. Béchadergue, and L. Chassagne, "Beamsteering-Driven Coverage Improvement and Misalignment Effect in indoor Optical Wireless Communications," submitted to IEEE Open Journal of the Communications Society, June 2025.

2.3 Dissemination strategy for the upcoming period

For the upcoming dissemination period, the OPTI-6G project will continue to strengthen its online presence by maintaining active engagement across social media platforms and producing targeted promotional materials for key events. Building on the successful use of LinkedIn and other channels during previous reporting phases, the team plans to enhance content outreach with regular updates, event highlights, and interactive posts to broaden the project's visibility and stakeholder engagement.

OPTI-6G co-ordinator Adam Kapovits was amongst the initiators of a special session on ICAS at IEEE RadarConf 2025 in Krakow, where we expect a number of SNS JU projects to feature.

OPTI-6G offered to contribute to the full-day Symposium on Optical/wireless convergence at IEEE Future Networks World Forum (FNWF) 10–12 November 2025, Bangalore, India.

OPTI-6G also anticipates participation in Mobile World Congress 2026 (via the presence of OPTI-6G partner RunEL) and EuCNC & 6G Summit 2026 in Malaga, Spain, continuing its presence at high-profile venues to disseminate results, attract potential collaborators, and reinforce its leadership in optical 6G.

These in-person activities will be complemented by workshops and networking sessions aimed at facilitating collaboration and promoting the integration of OPTI-6G innovations into broader 6G efforts and among the SNS community.

3 Report on activities regarding regulatory aspects

Project partners, most notably Brunel University, obtained experimental licences to operate a 5G campus network. The requirement for experimental 5G campus network licences highlights the importance of OWC, which does not require additional licences.

In the coming period, OPTI-6G will continue monitoring how the regulatory landscape evolves and seek to support initiatives for using unlicensed spectrum.

4 Report on liaisons and contributions to industry associations

The OPTI-6G project actively contributed to industry initiatives in the area. Notably, it contributed to several working groups of the 6G Smart Networks and Services Joint Undertaking (SNS JU).

Among others, OPTI-6G provided input to the Architecture Working Group's white paper "Towards 6G Architecture", specifically to Section 6.3 on "Optical Wireless Communication-based ISAC" [WP1], helping to position Optical Wireless Communication (OWC) as a key enabler in future integrated sensing and communication frameworks.

In addition, OPTI-6G contributed to key SNS-JU publications, including the SNS Journal 2024, SNS Journal 2025, and the Key Achievements 2025 report, reinforcing the project's role in shaping the technical narrative and strategic direction of 6G research in Europe.

Advancing Interoperability in OWC Systems: The Role of the LiFi Task Force within the HomeGrid Forum:

The establishment of the LiFi Task Force within the HomeGrid Forum marks a significant milestone in the global effort to achieve interoperability across Optical Wireless Communication (OWC) systems. Oriented specifically toward harmonising the fragmented OWC landscape, the task force is driving the development of common frameworks, specifications, and certification programs that allow LiFi technologies from different manufacturers to operate cohesively within the same network environment. This is a foundational step in ensuring that LiFi—a key modality within the broader OWC domain—can transition from isolated deployments to large-scale, standardised implementations.

At the core of the task force's mission is the integration of LiFi with the G.hn standard, a mature, ITU-T approved technology known for enabling high-speed, robust data transmission over various physical media, including powerline, coaxial cable, and now, light. By extending G.hn to the optical domain, the task force is effectively bridging the gap between wired and wireless domains, positioning LiFi as a complementary solution

that enhances network flexibility, security, and performance. This standards-driven orientation is crucial not only for achieving technical compatibility but also for fostering a vibrant, multi-vendor ecosystem where innovation and scalability can thrive.

The task force also plays an essential role in identifying and promoting use cases where OWC systems provide clear advantages over traditional RF-based communications. These include environments where electromagnetic interference is a concern—such as in hospitals, industrial facilities, and aerospace applications—as well as scenarios demanding ultra-secure, localised connectivity. Through ongoing collaboration with technology providers, research institutions, and end-users, the task force is helping to build the technical and commercial foundations needed for OWC systems to succeed in these domains.

Under the leadership of Benjamin Azoulay, CEO of Oledcomm, the LiFi Task Force continues to expand its influence, supporting the design, testing, and validation of interoperable LiFi solutions. Its work represents a forward-looking commitment to the principles of open standards and cross-industry collaboration—key enablers of a truly interconnected and future-proof digital infrastructure. As OWC technologies gain traction worldwide, the LiFi Task Force stands as a central, interoperability-oriented pillar in the drive to ensure these innovations can seamlessly integrate with existing and next-generation communication networks.

Role and Contributions of the Light Communications Alliance: Driving market adoption of OWC:

The Light Communications Alliance (LCA) is a global industry consortium committed to fostering the development, standardisation, and widespread adoption of Light Communication (LC) technologies. These include Light Fidelity (LiFi), Optical Camera Communication (OCC), and other forms of wireless optical data transmission. Founded in 2019, the LCA brings together a multidisciplinary group of stakeholders—including telecommunications providers, lighting manufacturers, component suppliers, research institutions, and technology integrators—with the shared objective of establishing a coherent and interoperable LC ecosystem.

The LCA serves as a key platform for coordinating industry efforts to define technical standards, promote interoperability, and align Light Communication technologies with existing communication infrastructures such as Wi-Fi and 5G. Its activities include contributions to international standardisation processes, technical working groups, policy engagement, and strategic communication to ensure consistent messaging and market education. By addressing the fragmentation that has historically characterised the LC landscape, the LCA plays a pivotal role in facilitating market readiness and accelerating commercial deployment.

A notable contributor to the Alliance's mission is Oledcomm. As a founding member of the LCA, Oledcomm has made significant technical and strategic contributions to both the development of interoperable LiFi solutions and the broader promotion of LC technologies. Among its most prominent achievements is the development of the first LiFi G.hn solution launched into space, deployed aboard a SpaceX Falcon 9 rocket in April 2023. This project served as a high-profile demonstration of the technology's robustness, security, and adaptability to extreme environments.

In addition to its technological leadership, Oledcomm has actively supported the miniaturisation of LiFi components for integration into consumer electronics and mobile platforms, a critical step toward mainstream adoption.

Through its involvement in the LCA, Oledcomm exemplifies the strategic and technical leadership required to bridge the gap between research and deployment. The Alliance, supported by such leading industry actors, continues to provide an essential foundation for the coordinated advancement of Light Communication technologies, ensuring their compatibility, scalability, and long-term viability within the global communications landscape.

5 Report on standardisation relevant activities

Although not directly involved, the OPTI-6G consortium closely follows the evolution of OWC standards developed within the IEEE, especially within its 802.15 working group, dedicated to specialised wireless networks, and in parallel within its IEEE 802.11 working group dedicated to wireless local area networks (e.g. WiFi networks). In total, three main standards have been published since 2011, and improvements are currently being discussed on one of them.

IEEE 802.15.7 family of standards:

The first standardisation efforts from the IEEE were concentrated within the 802.15 working group from 2009 onwards, through the task group (TG) 7. A first standard named IEEE 802.15.7-2011 and inspired by ZigBee (i.e. IEEE 802.15.4) was published in 2011 but was followed by industrials. TG7, therefore, started in 2015 a revision which led in 2018 to a new mount (IEEE 802.15.7-2018) mainly dedicated to optical camera communications (OCC), i.e. OWCs using cameras as light receivers rather than non-imaging detectors like photodiodes.

In 2020, this work was reopened, with the stated ambition of improving data rates up to 100 Mbps and communication ranges up to 200 m, even in the case of high mobility (speeds up to 350 km/h), notably for vehicle-to-everything (V2X) use cases. This work led to the approval in December 2024 and publication in February 2025 of a new version of the standard, named IEEE 802.15.7a-2024. Note that this standardisation effort was led in particular by South Korean organisations, and especially by Yeong Min Jang (Kookmin University, Chair), Sangsung Choi (Kookmin University, Vice-Chair), Sang-Kyu Lim (ETRI, Vice-Chair), Huy Nguyen (Kookmin University, Technical Editor) and Md. Faisal (Kookmin University, Secretary).

IEEE 802.15.13 standard:

In parallel, TG13 was created in 2017 within the IEEE 802.15 working group as it became clear that IEEE 802.15.7 alone could not encompass OCC and OWC-based networking (e.g. LiFi). The stated aim was to enable data rates of up to 10 Gbps over 200 m in point-to-point and point-to-multipoint configurations at wavelengths ranging from 10,000 nm to 190 nm, with a view to complementing existing wired and radio-frequency solutions, especially in industrial environments under the Industry 4.0 paradigm, where real-time constraints may be stringent. Eventually published in August 2023, the IEEE 802.15.13 standard thus defines a network topology, a physical (PHY) layer and a medium access control (MAC) layer adapted to these time-sensitive networking (TSN) environments.

The IEEE 802.15.13 network is built around a star topology, consisting of a central coordinator and multiple member devices, connected through optical frontends (OFEs).

The system supports multiple-input multiple-output (MIMO) configurations using distributed OFEs, enabling spatial diversity and extended coverage.

Two complementary PHY layers are then specified, namely the pulsed modulation PHY (PM-PHY) and the high-bandwidth PHY (HB-PHY), which both use a frame-based format with preambles and headers for synchronisation and adaptive demodulation:

- On the one hand, the PM-PHY is based on on-off keying (OOK) and Reed-Solomon forward error correction (FEC) and optimised for energy efficiency and low SNR environments, so that it is particularly suited to uplink from mobile/battery-powered devices.
- On the other hand, the HB-PHY uses direct current-biased optical orthogonal frequency division multiplexing (DCO-OFDM) with low-density parity check (LDPC) FEC coding and adaptive bit-power-loading (derived from ITU-T G.9961 recommendations). It is designed to optimise the link spectral efficiency and performance despite channel variations, and enables in practice data rates up to around 2.2 Gbps.

From the MAC perspective, IEEE 802.15.13 networks use centrally coordinated medium access for all data transmissions, where the central coordinator employs a dynamic time division multiple access (TDMA) scheme, i.e. allocates time slots dynamically for scheduled data transmissions. These time slots are either guaranteed time slices (GTS) for deterministic communication or random time slices (RTS) for unscheduled access based on the ALOHA scheme. This design allows low jitter and latency, which are essential in industrial automation, by avoiding the delay issues of carrier sensing approaches, nevertheless, at the cost of transmitter synchronisation. In parallel, a standout feature of IEEE 802.15.13 is distributed MIMO. Periodic pilot signals and channel state feedback allow the central coordinator to dynamically choose the optimal set of OFEs for each device, which facilitates seamless mobility, robust signal quality in the presence of obstructions, and efficient spatial multiplexing.

Finally, in order to meet TSN constraints, IEEE 802.15.13 has been designed to interoperate with IEEE 802.1 local area networks (LANs), supporting TSN standards such as IEEE 802.1AS (time synchronisation) and IEEE 802.1Qbv (scheduled traffic). While the current standard provides basic TSN compatibility, future amendments may expand on this to fully integrate advanced TSN features.

In practice, this standardisation effort has been mainly led by Volker Jungnickel (Fraunhofer HHI, Chair), Nikola Serafimovski (pureLiFi during TG13 work, Vice-Chair), Sang-Kyu Lim (ETRI, Vice-Chair), Kai Lennert Bober (Fraunhofer HHI, Technical Editor) and Tuncer Baykas (Istanbul Medipol University, then Kadir Has University, Secretary).

IEEE 802.11bb and TGbr:

Soon after its creation, TG13 identified during discussions on the MAC layer that the IEEE 802.11 layers could also be used. It was then preferred to bring this proposal directly into the 802.11 working group, which finally led to the official launch of the TGbb in May 2018. This TG was focused on introducing necessary changes to the base IEEE 802.11 standard to enable light communications (LC) in the 800-1000 nm band at speeds ranging from 10 Mbps and 9.6 Gbps while meeting the needs of the mass-market (high performance at low cost, low power consumption, small form factor and high volume in particular).

Based on a common 802.11 network topology, the IEEE 802.11bb standard, finally published in November 2023, proposes a PHY layer mainly inspired by existing 802.11 OFDM-based PHY in order to facilitate chipset re-use (11a, 11n, 11ac, 11ax). Therefore, the 802.11a PHY was used as a basis for a common mode, and more advanced PHYs are then detailed to reach improved performance. The maximum data rate per wavelength can be 2.5 Gbps using 2 x 160 MHz channels, so that a data rate of up to 10 Gbps may be reached using wavelength division multiplexing (WDM).

In parallel, IEEE 802.11bb specifies a single MAC layer, which is kept as close as possible to that of the WiFi standards in order to ease interoperability between technologies. Therefore, TGbb introduced changes to the IEEE 802.11MAC limited to the hybrid coordination function (HCF) channel access, the overlapping basic service set (OBSS) detection and co-existence, and the existing power management modes of operation (excluding new modes).

Eventually published in November 2023, this standard was led by Nikola Serafimovski (pureLiFi during TGbb work, Chair), Tuncer Baykas (Istanbul Mediopol University, then Kadir Has University, Vice-Chair), Volker Jungnickel (Fraunhofer HHI, Technical Editor - PHY layer) and Harry Bims (Bims Laboratories, Technical Editor - MAC layer). However, although it was imagined for the enterprise/home market (i.e., low cost and high volume), and thus to enable the design of minimum-viable products reusing existing 802.11n/ac/ax chipsets, the IEEE 802.11bb standard has been more successful in the military and security markets (i.e., high cost and small volume markets). In September 2024, a new study group called enhanced LC (ELC) was created to consider the levers that could enable more mass adoption and market diversification of LCs. In March 2025, these discussions led to the creation of a fully-fledged task group, the TGbr, whose objectives are to modify the IEEE 802.11 MAC to support the ELC PHY and multi-link operation; to introduce an ELC PHY through the modification of IEEE 802.11 sub-7.25 GHz PHYs that are limited to specifying:

- Operations in new optical bands in the range of 400 nm to 600 nm and 1200 nm to 1600 nm (hence enabling support of underwater use cases where the 400-600 nm range is preferred),
- New channelisation (from 320 to 640 MHz channels using IEEE 802.11bn),

- The use of WDM,
- Simpler integration of the IEEE 802.11 baseband with optical frontends (enabling simple up/down conversion),
- PHY support for existing ranging techniques (e.g. fine time measurements as in IEEE 802.11az or IEEE 802.11bk),
- Methods to reduce the peak-to-average-power ratio (with minor changes in OFDM PHYs to enable OOK with frequency domain equalisation and space shift keying).

The stated stakeholders include chipset manufacturers to deliver PHY and MAC sub-systems, system integrators and lighting companies, telecom operators, Internet Service Providers (ISPs), emerging IoT companies, large industrial manufacturers, aviation and transportation industries. In practice, this TG is led by Nikola Serafimovski (now University of Cambridge, Chair), Volker Jungnickel (Fraunhofer HHI, Vice-Chair), Stefan Videv (Kyocera, Vice-Chair) and Mohamed Islim (pureLiFi, Vice-Chair).

ITU-T G.9991 standard:

ITU-T Recommendation G.hn is a comprehensive international standard designed for high-speed, home-networking over existing wired infrastructures. It enables gigabit-per-second data rates over multiple types of legacy wiring, including power lines (PLCs), coaxial cables, telephone lines (twisted pair), and plastic optical fibre. The standard specifies the physical (PHY) and medium access control (MAC) layers to provide a unified networking protocol that supports multiple media types within a single, interoperable framework.

G.hn incorporates several advanced technical features to optimise performance across diverse and often noisy wired channels:

- Multi-carrier modulation (OFDM): Utilises Orthogonal Frequency-Division Multiplexing to achieve high spectral efficiency and resilience against channel impairments.
- Dynamic spectrum management: Allocates frequency bands adaptively to minimise interference and optimise throughput.
- Robust error correction and retransmission mechanisms: Employs Forward Error Correction (FEC) and Automatic Repeat reQuest (ARQ) to maintain data integrity.
- Quality of Service (QoS): Supports traffic prioritisation, critical for latency-sensitive applications such as voice, video streaming, and industrial control.
- Security: Implements AES-based encryption and authentication to ensure data confidentiality and network integrity.

Because it is a derivative from ITU-T G9961 standard, G.hn technology has found application across residential, commercial, and industrial domains:

- Home Networking: Facilitates high-speed connectivity for multimedia streaming, gaming, and smart home devices over existing in-home wiring without additional cables.
- Smart Grid and Energy Management: Enables secure and reliable communication over power lines for smart metering and grid automation.
- Industrial Automation: Supports real-time control and monitoring systems requiring low latency and robust data transmission.
- Broadband Access: Used in G.fast deployments and hybrid fibre-coaxial (HFC) networks to extend broadband coverage efficiently.

While IEEE 802.11bb is an emerging wireless standard for optical communication (LiFi) utilising visible and infrared light to provide high-speed wireless local area networking, ITU G.hn offers several distinct advantages that position it as a complementary or preferred solution in many scenarios:

- Wired Infrastructure Utilisation: G.hn leverages existing physical wiring, eliminating the need for new cabling and enabling stable, interference-resilient connections not subject to optical line-of-sight constraints inherent in IEEE 802.11bb.
- Robustness and Reliability: G.hn's wired medium ensures consistent throughput and reduced susceptibility to environmental factors such as shadowing, ambient light interference, or mobility limitations that challenge optical wireless links.
- Broader Application Scope: While IEEE 802.11bb targets wireless indoor local area networking, G.hn supports a wider variety of applications, including industrial automation and smart grid communications, where wireless optical communication may be impractical or less reliable.
- Security and QoS: G.hn integrates mature encryption and traffic prioritisation techniques optimised for wired networks, enabling secure and deterministic data delivery essential for mission-critical applications.
- Maturity and Ecosystem: With over a decade of development, a broad ecosystem of interoperable devices, and active certification processes via the HomeGrid Forum, G.hn is more established for immediate commercial deployment compared to the still maturing IEEE 802.11bb standard.

6 Report on further impacts created

In addition to the general dissemination, liaisons with and contributions to industry associations, standardisation and regulation treated earlier in our report, here, in this section we focus on tangible exploitation measures taken and achievements reached by the OPTI-6G partners improving their market and business position.

6.1 Patents and other IPR protection measures taken

As reported in D5.1, UVSQ filed in June 2024 a patent application for a "*System for determining the position of a receiver moving in a plane from a signal transmitted by direction modulation by a directional transmitter*" (translated) [P1]. However, after receiving the review report from the French patent office, it was decided to withdraw this application.

RunEL holds a Patent on "*System and method for accurate positioning of end terminal in a wireless network*" [P2] by the Israeli Patent Office since 2024. During this reporting period, RunEL issued a patent application (Patent Application number 18/631.254) to the United States Patent and Trademark Office (USPTO) as can be seen in the picture below taken from the results of a search on the Google Patents search website.

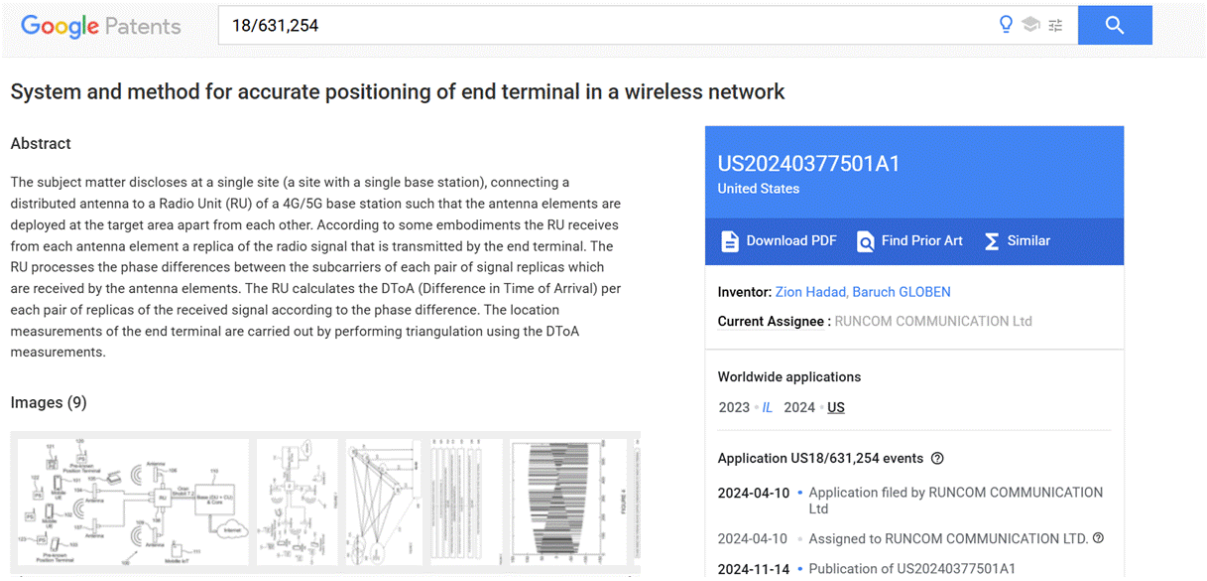


Figure 15: Screenshot of the "System and method for accurate positioning of end terminal in a wireless network" patent submitted to the USPTO and listed in Google Patents

Patents:

[P1] L. Chassagne, O. Barrois, B. Béchadergue, and B. Cagneau, "Système de détermination de la position d'un récepteur se déplaçant dans un plan à partir d'un signal émis par modulation de direction d'émission par un émetteur directif configuré pour émettre un signal respectant

un profil d'émission anisotrope connu." filed in June 13, 2024 to the Institut National de la Propriété Intellectuelle, withdrawn April 9, 2025- dépôt n°2406270.

[P2] Z. Hadad and B. Globen, "System and method for accurate positioning of end terminal in a wireless network", filed on April 10, 2024 to the United States Patent and Trademark Office (USPTO), application number US18/631,254, published as US20240377501A1 on November 14, 2024. Pending. Assignee: Runcom Communication Ltd. Available at: https://patents.google.com/patent/US20240377501A1/en.

6.2 New products and services created

During the current reporting period, partners of the OPTI-6G consortium made initial progress toward the development of exploitable outcomes.

RunEL introduced a new service derived from the successful implementation of its algorithm for accurately measuring the location of cellular end terminals. This service has been formally described in a white paper and accompanied by a press release, both of which are provided in Annexes A and B of this deliverable.

Brunel University London also advanced the development of a Received Signal Strength (RSS)-based Optical Wireless Communication (OWC) solution, with the potential for future integration into Oledcomm's product portfolio.

6.3 New workplaces created

Brunel University London reported progress in upgrading its existing 5G laboratory into a 6G lab by incorporating optical wireless communication technologies. This initiative is expected to support future research activities and potentially open new workplace opportunities as the lab evolves.

Eurescom, UVSQ, Oledcomm and RunEL do not report new workplaces created.

However, following the completion of the Opti 6G project, RunEL is planning to double the number of employees by the 2027 timeframe as a result of the project's expected results in accurate (cm-level) user equipment (UE) location measurements.

6.4 Spin-offs

No spin-offs have been created during the reporting period by any of the OPTI-6G partners.

6.5 Market position of consortium members

UVSQ: Not applicable

Oledcomm has observed growing interest in using location-awareness between transmitter and receiver to support auto-alignment functions within OWC systems.

RunEL is experiencing increased market interest for its ultra-accurate user equipment (UE) location measurement solution, which is gaining traction for integration into private and public cellular networks.

At Brunel University, interest has emerged around the potential of OWC-enabled IoT devices, positioning the institution for future collaborations and applied innovation.

Eurescom uses OPTI-6G results to reinforce its leading position both within SNS JU and ICAS in general regarding competences in the emerging field of ICAS.

7 Updates regarding exploitation plans going forward

Consortium members continue to pursue concrete exploitation strategies aligned with their technical developments.

During the first half of the OPTI-6G project, UVSQ was able to theoretically and experimentally develop its positioning technique based on optical beamsteering (cf [J3] and D4.1), demonstrating indoor positioning with an accuracy of the order of a few centimetres. The objective for the second half of the project will now be, on the one hand, to improve these performances using machine learning techniques. This work was initiated with the classical RSS positioning method [C5] and will be continued with the proposed beamsteering-based technique. On the other hand, future work will focus on combining beamsteering-based positioning and simultaneous data transmission, and thus on setting up an integrated sensing and communication (ISAC) framework adapted to the proposed positioning method. Work in this area has already begun (see [S4] and [S5]) and will be pursued further, both theoretically and experimentally. The ultimate aim is to produce a complete beamsteering-based OWC-ISAC demonstrator that will serve as a proof-of-concept for this new ISAC technique, which we will promote as much as possible through publications, but also through technology transfers to partners such as Oledcomm, for integration in future OWC products.

Oledcomm is actively working on integrating a self-alignment system into its medium- and long-range optical wireless communication products to enhance deployment efficiency and performance.

RunEL is developing a comprehensive marketing strategy to promote its Ultra Accurate UE Location measurement solution, targeting both private and public cellular network markets.

Brunel University is preparing two scientific papers on 3D localisation techniques—using both camera/LIDAR data and optical wireless RSS-based sensing—for presentation at the ICCVDM 2025 Conference:

- 3D Localisation from Camera and LIDAR images of environment – Lakshan Divakar, Hussein Malki, Ali Mahbas and John Cosmas
- 3D Localisation from Received Signal Strength of an Optical Wireless Integrated Sensing and Communication System – Ali Mahbas, John Cosmas

In parallel, Brunel is also involved in drafting a proposal for the upcoming SNS JU 2025 call under the STREAM-D-01: SNS Trials and Pilots with Verticals, reinforcing its role in ongoing 6G innovation efforts.

Eurescom will continue exploring possibilities of exploiting OPTI-6G results in various contexts, most notably within the SNS JU and ICAS in general, and strengthening its position and competence through the insight accumulated through OPTI-6G.

Conference papers and Journal Contributions:

[C5] K. Acuna-Condori, H. Guan, B. Béchadergue, and L. Chassagne, "Robust Visible Light Positioning: A Comparative Study of Machine Learning Estimators in Spatial Segmentation and Transmitter Failure Scenarios", 2025 IEEE International Conference on Communications (ICC), Montreal, Canada, 2025.

[J3] L. Chassagne, B. Béchadergue, O. Barrois, B. Cagneau, H. AL Satai and P. Ruaux, "Optical wireless positioning by modulation of the optical source orientation," Optics Express, Vol. 33, no. 6, pp. 13161-13183, March 2025.

Submitted papers:

[S4] H. AL Satai, B. Béchadergue, L. Chassagne, K. Acuna-Condori, B. Cagneau, and P. Ruaux, "Beamsteering-Enabled Optical Wireless Integrated Sensing and Communication," submitted to 2025 Global Communications Conference (GLOBECOM).

[S5] H. AL Satai, B. Béchadergue, and L. Chassagne, "Beamsteering-Driven Coverage Improvement and Misalignment Effect in indoor Optical Wireless Communications," submitted to IEEE Open Journal of the Communications Society, June 2025.

8 Summary and conclusions

During its first reporting period, the OPTI-6G project has made notable progress in amplifying its visibility, strengthening its dissemination framework, and aligning its technical direction with key industry and regulatory developments. Enhanced website metrics and a growing LinkedIn following underscore the project's increasing reach. Strategic participation in international events and workshops has not only promoted OPTI-6G's innovations but also facilitated collaborative exchanges within the SNS ecosystem. While regulatory engagement remains in the monitoring phase, substantive contributions to standardisation discussions and active roles in OWC-focused industry groups affirm the project's commitment to innovation and standard alignment. These cumulative efforts serve as a robust foundation for sustained impact in the final stages of the project.

References

Conference papers:

[C1] J. Cosmas, K. Ali, A. Mahbas, P. K. Boakye, J. Miguel, V. Gabillon, A. Kazmierowski, and L. Sear, “Design of Scalable Population of Reinforcement Learning Agents for Autonomous 5G Radio Link Control,” 2024 IEEE Wireless Communications and Networking Conference (WCNC), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C2] J. Cosmas, K. Ali, I. Koffman, Z. Hadad, A. Karamani, A. Salomon, B. Globen, “Accuracy and Repeatability Results of a 5G Sub 6GHz Time of Arrival Distance Measurement Campaign,” 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C3] A. Mahbas, J. Cosmas, K. Ali, “Environment Sensing and Landmarks Detection for Accurate Self-Localisation,” 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C4] J. Cosmas, K. Ali, H. Malki, A. Kapovits, I. Koffman, B. Azoulay, C. Lartigue, E. Plascencia, B. Béchadergue, B. Cagneau, L. Chassagne, and A. Gavras, “Optical 6G Cell Free Networks for High Performance Communications and Sensing in Industry 4.0,” 2024 IEEE Future Networks World Forum (FNWF), Dubai, United Arab Emirates, 2024, pp. 1-6.

[C5] K. Acuna-Condori, H. Guan, B. Béchadergue, and L. Chassagne, “Robust Visible Light Positioning: A Comparative Study of Machine Learning Estimators in Spatial Segmentation and Transmitter Failure Scenarios”, 2025 IEEE International Conference on Communications (ICC), Montreal, Canada, 2025.

[C6] Yanan Xin, Qilie Liu, John Cosmas “Real-Valued Genetic Algorithm-Based Hybrid Beamforming Optimization in Multi-IRSs-Aided mmWave MIMO-OFDM Systems” EuCNC & 6G Summit 2025, June 2nd - 6th, Poznan, Poland

[C7] John Cosmas, Kareem Ali, Adam Kapovits, Audrey Bienvenu, Anastasius Scencia, Bastien Béchadergue, Barthélemy Cagneau, Luc Chassagne "Cellfree Optical Wireless Integrated Sensing and Communication System Design and Test Plan" EuCNC & 6G Summit 2025, June 2nd - 6th Poznan, Poland

Journal papers:

[J1] A. Mahbas, J. Cosmas, S. Mueen, and J. Wang, “LOS Analysis for Localization in High Frequency Systems,” IEEE Transactions on Wireless Communications, vol. 23, no. 6, pp. 6425-6437, June 2024.

[J2] L. Shi, Z. Liu, B. Béchadergue, H. Guan, L. Chassagne and X. Zhang, "Experimental Demonstration of Integrated Optical Wireless Sensing and Communication," Journal of Lightwave Technology, vol. 42, no. 20, pp. 7070-7084, Oct. 2024.

[J3] L. Chassagne, B. Béchadergue, O. Barrois, B. Cagneau, H. AL Satai and P. Ruaux, "Optical wireless positioning by modulation of the optical source orientation," Optics Express, Vol. 33, no. 6, pp. 13161-13183, March 2025.

Submitted papers:

[S1] J. Cosmas, K. Ali, A. Kapovits, A. Gavras, I. Koffman, B. Azoulay, C. Lartigue, E. Plascencia, K. Acuna-Condori, B. Béchadergue, B. Cagneau, L. Chassagne, C. Tsokos, E. Andrianopoulos, C. Kouloumentas, M. Milosevic, F. Caetano, C. Roeloffzen, and P. van Dijk, "Towards a Steerable Optical Wireless Integrated Sensing and Communication System," submitted to 2025 IEEE Radar Conference (RadarConf).

[S2] H. AL Satai, B. Béchadergue, L. Chassagne, K. Acuna-Condori, B. Cagneau, and P. Ruaux, "Beamsteering-Enabled Optical Wireless Integrated Sensing and Communication," submitted to 2025 Global Communications Conference (GLOBECOM).

[S3] H. AL Satai, B. Béchadergue, and L. Chassagne, "Beamsteering-Driven Coverage Improvement and Misalignment Effect in indoor Optical Wireless Communications," submitted to IEEE Open Journal of the Communications Society, June 2025.

[S4] H. AL Satai, B. Béchadergue, L. Chassagne, K. Acuna-Condori, B. Cagneau, and P. Ruaux, "Beamsteering-Enabled Optical Wireless Integrated Sensing and Communication," submitted to 2025 Global Communications Conference (GLOBECOM).

[S5] H. AL Satai, B. Béchadergue, and L. Chassagne, "Beamsteering-Driven Coverage Improvement and Misalignment Effect in indoor Optical Wireless Communications," submitted to IEEE Open Journal of the Communications Society, June 2025.

Workshop participations:

[WP1] Marco Gramaglia, Ömer Bulakci, Xi Li, Anastasius Gavras et. al. "TOWARDS 6G ARCHITECTURE: Key Concepts, Challenges, and Building Blocks" DOI: 10.5281/zenodo.15001377, URL: https://doi.org/10.5281/zenodo.15001377

Conference contributions:

[C1] K. Acuna-Condori, H. Guan, B. Béchadergue, and L. Chassagne, "Robust Visible Light Positioning: A Comparative Study of Machine Learning Estimators in Spatial

Segmentation and Transmitter Failure Scenarios", 2025 IEEE International Conference on Communications (ICC), Montreal, Canada, 2025.

Patents:

[P1] L. Chassagne, O. Barrois, B. Béchadergue, and B. Cagneau, "Système de détermination de la position d'un récepteur se déplaçant dans un plan à partir d'un signal émis par modulation de direction d'émission par un émetteur directif configuré pour émettre un signal respectant un profil d'émission anisotrope connu." filed in June 13, 2024 to the Institut National de la Propriété Intellectuelle, withdrawn April 9, 2025- dépôt n°2406270.

[P2] Z. Hadad and B. Globen, "System and method for accurate positioning of end terminal in a wireless network", filed on April 10, 2024 to the United States Patent and Trademark Office (USPTO), application number US18/631,254, published as US20240377501A1 on November 14, 2024. Pending. Assignee: Runcom Communication Ltd. Available at: https://patents.google.com/patent/US20240377501A1/en.

Annex A

Apr. 2025

5G End-Terminal Positioning - Test at PT Stadium

RunEL NGMT developed an accurate positioning technique for accurate online measuring the location of 5G end-terminals. Centimeter range accuracy is achieved by this innovative technique.

The implications of this advancement are disruptive, paving the way for a multitude of innovative applications across various industries, including:

- **Factory 4.0:** Optimizing smart manufacturing processes with real-time, pinpointed asset tracking.
- **Robotics:** Facilitating accurate movement and operations in dynamic settings.
- **Autonomous Warehouses:** Enhancing the efficiency and safety of automated inventory management systems.
- **Drone Deliveries:** Enabling precise navigation and drop-off in densely populated urban environments.
- **Remote Healthcare:** Enabling precise monitoring and interaction with medical devices in patient care
- **Online Gaming:** Providing immersive experiences through exact player positioning in augmented reality environments.

Herein we present the tests report to demonstrate and verify RunEL positioning technique in a real-life stadium. This test was carried out by RunEL team at Moshava stadium in Petach-Tikva Israel.

Test Date: March 25th, 2025
Location: Petach-Tikva Moshava Stadium, Israel

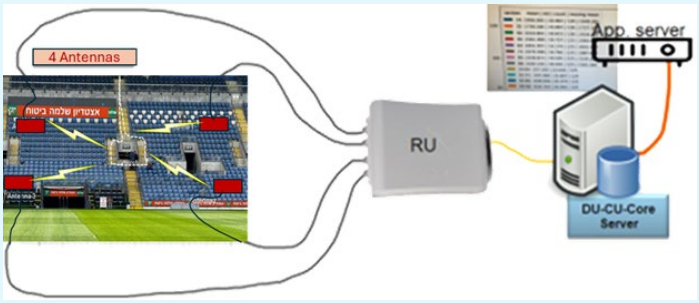
Conducted by - The test was conducted by RunEL's R&D engineers

1. Introduction

This document describes the tests and results of the accurate positioning test conducted using a 5G system provided by RunEL. The main objective was to demonstrate and verify precisely the performance of RunEL positioning technique in an authentic stadium environment.

2. Test Setup

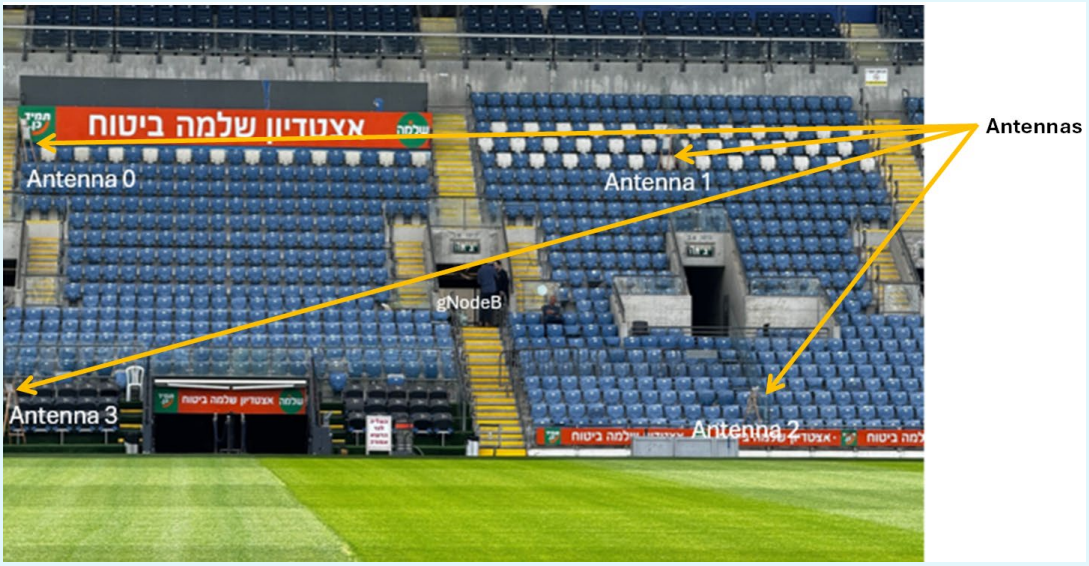
The test setup is presented in the following drawing.



Tests Configuration

The system under test included a 5G system including RunEL RU, a Server running DU, CU and 5G Core packages supplemented by an application server running the Positioning App.

The RU was connected to 4 antennas deployed at the stadium's main tribune as depicted in the next image. The four antennas configure a near 20m x 20m rectangular.



RU Antennas Deployment

On the Move Test - A UE (DUT) was moved manually at this tribune as depicted in the next image.

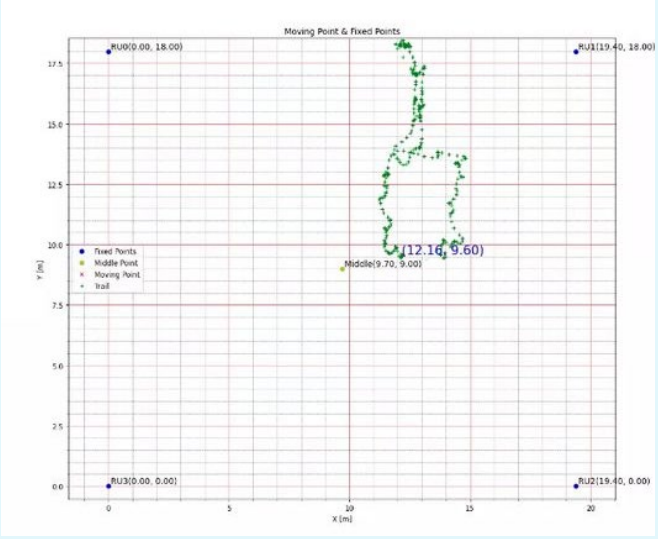
Left picture: UE Movement Trajectory *(in white);* Right pictures: Spectator Moving with Tracked Phone

The 4 antennas were located at four corners as follows: antenna 0 at (0.0, 18.0); antenna 1 at (19.40, 18.00); antenna 2 at (19.40, 0.00) and antenna 3 at (0.00, 0.00).

The above coordinates dimensions are in meters, the lower left antenna is at (0.0, 0.0)).

The UE was an off-the-shelf Telit990A28 5G end terminal.

The measured trajectory is depicted in the next diagram.



Measured Trajectory

In the corners of the diagram depicted are the antennas, including Front End, all connected to the same RU. The point in the middle is a reference point (for calibration).

Fixed UE Test - To demonstrate the measurements stability the UE was left at a point with no movement. The measured location is depicted in the following figure.

Fixed Seat Test

This test was accomplished by repeating the measurement at every 20miliseconds for 25times. Antennae 0, 2 and 3 were preferred for these measurements' scenario.

It can be observed from the measurements results file that the location coordinates change at both axis (x and y) was up to 1 centimeter.

(array ([5.15, 9.92]), array ([0, 2, 3]))

(array ([5.15, 9.92]), array ([0, 2, 3]))

(array ([5.15, 9.92]), array ([0, 2, 3]))

(array ([5.14, 9.92]), array ([0, 2, 3]))

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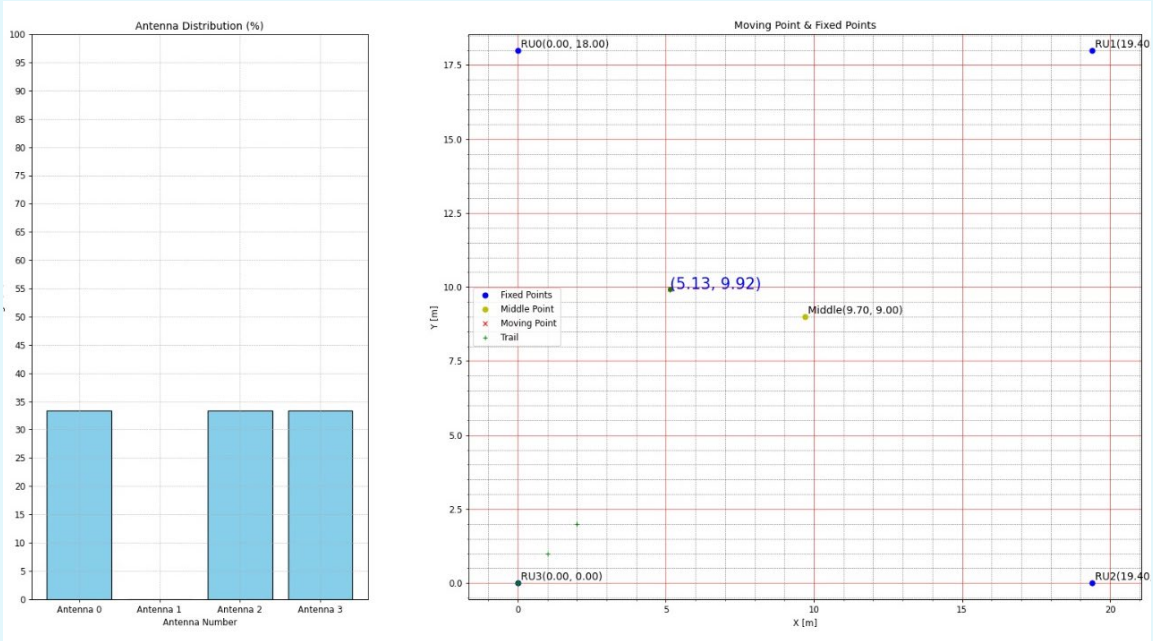
(array ([5.14, 9.92]), array ([0, 2, 3]))

(array ([5.14, 9.92]), array ([0, 2, 3]))

(array ([5.13, 9.92]), array ([0, 2, 3]))

(array ([5.13, 9.92]), array ([0, 2, 3]))

The above measurement trajectory is depicted in the next diagram.



Measurements of a UE at a Fixed Location

Handheld UE Test - At another location a similar measurement was repeated while the user was talking with the UE under test. At this case the UE was slightly moving while the user is seated.

The measurements and related trajectory are presented in the following figures.

(array([7.9 , 9.81]), array([0, 2, 3]))	7.9	9.81
(array([7.89, 9.79]), array([0, 2, 3]))	7.89	9.79
(array([7.89, 9.78]), array([0, 2, 3]))	7.89	9.78
(array([7.88, 9.76]), array([0, 2, 3]))	7.88	9.76
(array([7.88, 9.75]), array([0, 2, 3]))	7.88	9.75
(array([7.88, 9.74]), array([0, 2, 3]))	7.88	9.74
(array([7.88, 9.73]), array([0, 2, 3]))	7.88	9.73
(array([7.88, 9.73]), array([0, 2, 3]))	7.88	9.73
(array([7.87, 9.7]), array([0, 2, 3]))	7.87	9.7
(array([7.86, 9.67]), array([0, 2, 3]))	7.86	9.67
(array([7.85, 9.65]), array([0, 2, 3]))	7.85	9.65
(array([7.85, 9.64]), array([0, 2, 3]))	7.85	9.64
(array([7.85, 9.63]), array([0, 2, 3]))	7.85	9.63
(array([7.84, 9.62]), array([0, 2, 3]))	7.84	9.62
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(array([7.72, 9.55]), array([0, 2, 3]))	7.72	9.55
(array([7.72, 9.61]), array([0, 2, 3]))	7.72	9.61
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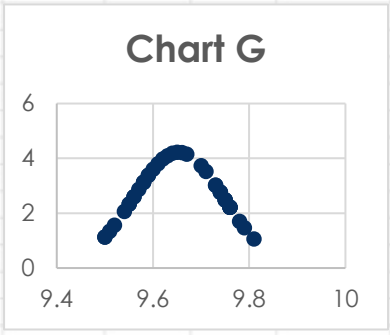
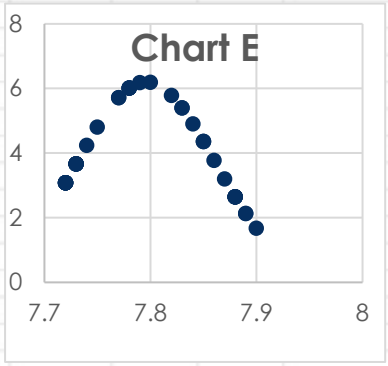
(array([7.73, 9.71]), array([0, 2, 3]))	7.73	9.71
(array([7.73, 9.74]), array([0, 2, 3]))	7.73	9.74
(array([7.73, 9.76]), array([0, 2, 3]))	7.73	9.76
(array([7.73, 9.76]), array([0, 2, 3]))	7.73	9.76
(array([7.72, 9.76]), array([0, 2, 3]))	7.72	9.76
(array([7.72, 9.75]), array([0, 2, 3]))	7.72	9.75
(array([7.73, 9.75]), array([0, 2, 3]))	7.73	9.75
(array([7.74, 9.74]), array([0, 2, 3]))	7.74	9.74

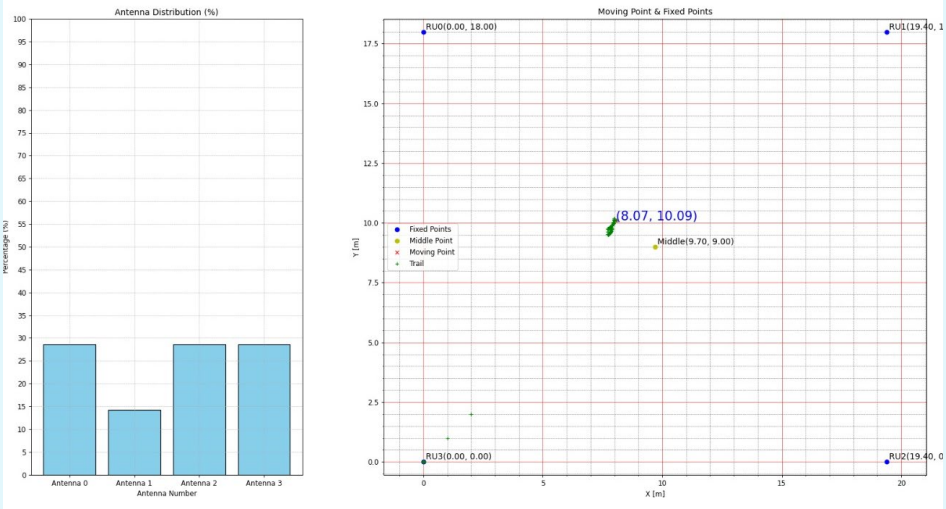


Average (x)	7.796	Std. Dev(x)	0.064283
Average (y)	9.645263	Std. Dev(y)	0.094386



Seated User Measurements and Std. Deviation Charts

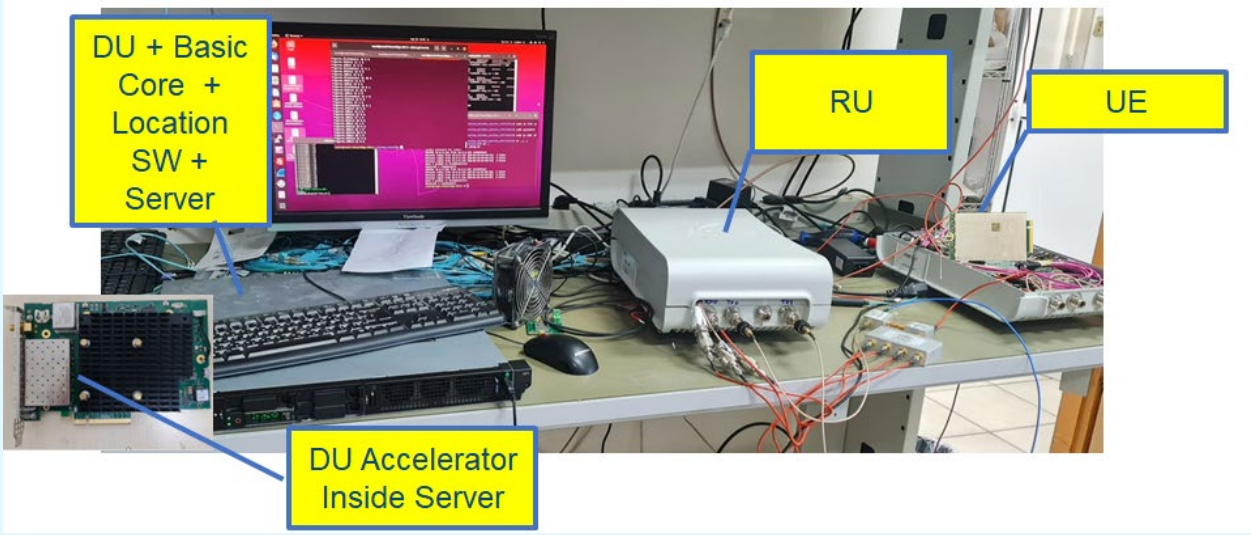
These UE measurements related to the movement of the phone while the person was using the phone are shown in the next drawing.



Seated Spectator talking with the phone (UE) location measurements

It can be observed (calculated and specified at the right side) that the standard deviation for this case is less than 10cm which enables accurately to isolate the user's seat in less than a second)

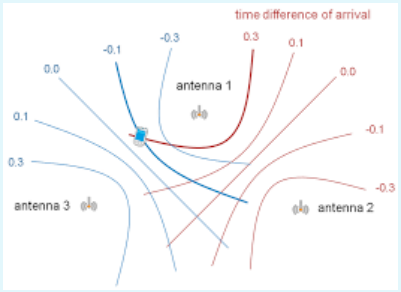
A photo of the test's setup in RunEL's lab is presented below.



Tests Setup

Test Method

- Up Link (UL) transmissions from the end Terminal are received by 4 antennas connected to the 5G RU.
- The Time of Arrival Difference is measured for each couple of antennas. DToA measurements are accomplished in picoseconds accuracy using RunEL patented technique.
- Based on Hyperbolic Trilateration the UE position is calculated after measurements calibration.
- Measurements calibration is carried out by using a pre-known location UE.



Demonstration Tests Configuration

Physical layer adheres 3GPP Release 16 for Stand Alone.

- ✓ Duplexing Mode: TDD
- ✓ Sub Carrier Spacing 30, KHz
- ✓ Channel BW: Up to 100MHz
- ✓ Antenna Gain- BS – 10 dB /each
- ✓ Frequency: 3.3-3.8 GHz (Band N78)
- ✓ P_{out}: 21dBm
- ✓ Modulation: QPSK REFERENCE SIGNAL
- ✓ Beam width of BS Antennas – 45^0, 45^0 Average +/- 5 deg
- ✓ TTI spacing – 500 µsec
- ✓ Support for CSI-RS, PTRS, DMRS
- ✓ Synchronization: GPS, Local clock, external input clock

Test Results and Conclusions

- The system operates perfectly in a real-life football stadium environment.
- UE measured location accuracy was better than 10 centimeters.

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Annex B

Monday, 3 March 2025

FOR IMMEDIATE RELEASE

RunEL NGMT and 1st tier company achieve a Breakthrough in 5G Positioning Accuracy

Rishon Lezion, Israel – February 27, 2025 – RunEL Next Generation Mobile Technologies, led by CEO Dr. Zion Hadad, in collaboration with a 1st tier Israeli company proudly announce the successful completion of an outdoor field test demonstrating a groundbreaking 5G positioning algorithm. This proprietary algorithm, patented by RunEL, has achieved unprecedented location accuracy for commercial 5G User Equipment (UE), pinpointing positions within 5 to 7 centimeters range.

This signifies an improvement of two orders of magnitude over current state-of-the-art wireless positioning technologies.

Notably, the measurement was accomplished solely through 5G signals, eliminating the need for supplementary geopositioning equipment such as GPS.

The implications of this advancement are vast, paving the way for a multitude of innovative applications across various industries, including:

- **Factory 4.0:** Optimizing smart manufacturing processes with real-time, pinpointed asset tracking.
- **Robotics:** Facilitating accurate movement and operations in dynamic settings.
- **Autonomous Warehouses:** Enhancing the efficiency and safety of automated inventory management systems.
- **Drone Deliveries:** Enabling precise navigation and drop-off in densely populated urban environments.
- **Remote Healthcare:** Allowing for precise monitoring and interaction with medical devices in patient care
- **Online Gaming:** Providing immersive experiences through exact player positioning in augmented reality environments.

RunEL is exhibiting this solution at its stand at MWC25 Barcelona as depicted below:

Dr. Zion Hadad, CEO of RunEL, stated, "This achievement underscores our commitment to pushing the boundaries of 5G technology. The collaboration has been instrumental in realizing a solution that not only meets but exceeds current market demands for precision and reliability."

Monday, 3 March 2025

RunEL's Sparq-2020 System on Chip (SoC), optimized for Ultra-Reliable Low Latency Communication (URLLC) applications, played a pivotal role in this development. The Sparq-2020 is 5G 3GPP standard compliant (Release-15) and is designed to deliver latency below 250 microseconds, making it ideal for applications requiring real-time awareness.

This collaboration exemplifies the potential of synergistic partnerships in advancing technology to create new opportunities across diverse sectors.

About RunEL Next Generation Mobile Technologies:

RunEL NGMT Ltd. specializes in developing cutting-edge 5G infrastructure solutions. Their flagship product, the Sparq-2020 SoC, is tailored for URLLC applications, including V2X, connected cars, drone communication, and remote surgery. RunEL is committed to delivering innovative technologies that drive the future of mobile communications.

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