Verifying Key Performance Indicators Across Multiple 6G-EWOC Demonstrations

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***Abstract*— Testing, measuring, and validating Key Performance Indicators (KPIs) are crucial tasks across SNS-JU projects. These activities foster collaboration at the TMV Working Group, enabling the sharing of methods, definitions, target values, and best practices within the 6G vision. Thanks to collaboration of multiple agents, objectives can be different although the main goal of the WG is to develop and mature 6G technology. The 6G-EWOC project aims to describe how KPIs will be verified in different categories through multiple demonstrations. These categories include data rate and capacity in several technologies, sensing, positioning and localization, and energy efficiency. By addressing these different KPIs, the 6G-EWOC project ensures comprehensive evaluation and validation, contributing to the progress of the 6G vision.**

Keywords*— *Key Performance Indicators (KPI), 6G vision, TMV Working Group, Data Rate, Capacity, Sensing, Positioning, Localization, Energy Efficiency.

I. INTRODUCTION

Autonomous Vehicles (AVs) offer significant benefits for road safety and traffic management, addressing concerns such as the more than 1 million deaths per year [1] and the economic impacts of traffic incidents. AVs can enhance road safety, optimize traffic flow, reduce CO_2 emissions, and improve accessibility [2]. They promise to transform transportation systems, increase efficiency, well-being, and provide mobility for those who do not drive. AVs will also stimulate growth in sectors like software engineering, cybersecurity, vehicle maintenance, and fleet management. Self-driving, ride-sharing, and delivery services can reduce transportation and logistics costs, benefiting consumers and businesses [3]. However, to achieve the full potential of AVs, especially at autonomy levels 4 and 5, key technological and regulatory challenges need to be overcome. The 6G-EWOC project aims to develop six main objectives to contribute to the development of future 6G-AI based networks by ending with TRL-4-level developments on critical technologies and devices to extend the reach of 6G, especially in high mobility scenarios:

- O1: OWC for V2V and high-rate (Gb/s) V2I applications, using chip-scale optical beamformers.
- O2: Connected laser/radio detection, ranging and communication (LiDAR/RaDAR) for Joint Communication And Sensing (JCAS) applications.
- O3: PIC and ASIC for tuneable transmitter and receiver concepts for fibre-based fronthaul supporting net, data rates of 50 Gbps and 100 Gbps per wavelength channel over dense wavelength division multiplexed (DWDM) fibre links.
- O4: SDN-enabled Photonic Switching.
- O5: AI-powered control and orchestration of resources for the 6G-EWOC network concept.
- O6: AI-based applications development for AVs.

II. KPI TO BE DEMONSTRATED

A set of 17 KPIs are proposed for validation to drive the 6 ambitious goals outlined for future 6G-AI based networks.

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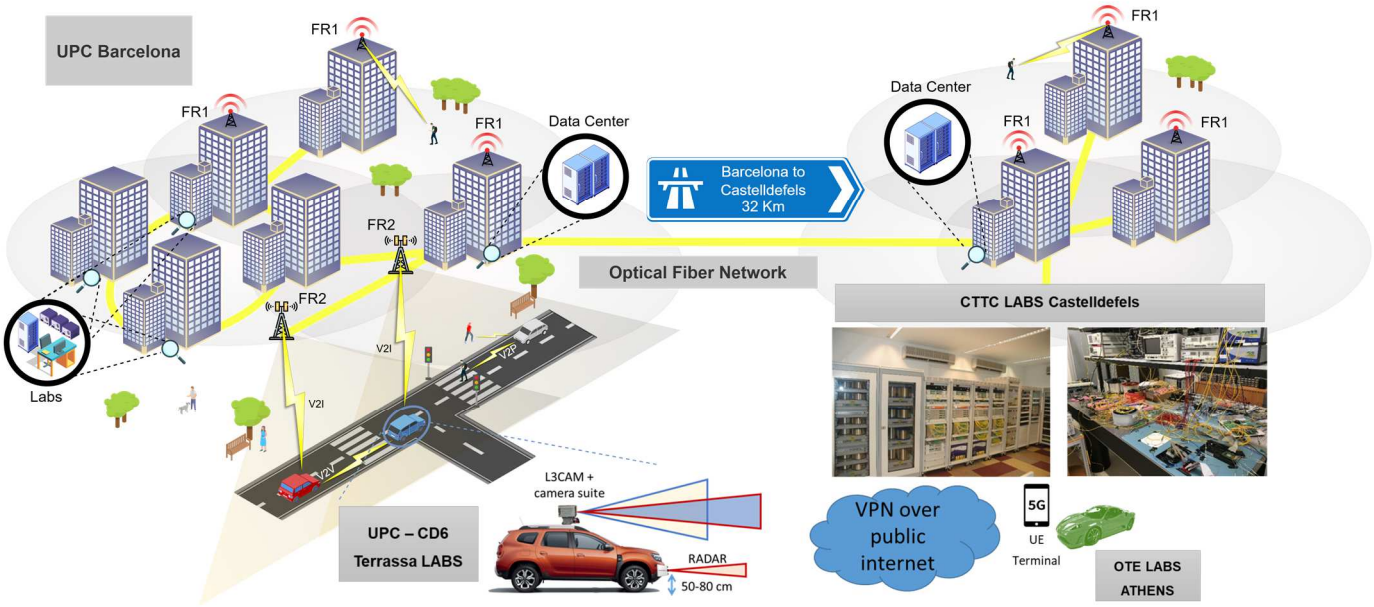

Fig. 1. Planned 6G-EWOC Demo 3 network test-bed in Barcelona (UPC/CTTC) and Athens (OTE).

These KPIs are intended to contribute to key value indicators (KVIs) such as enhancing road safety, optimizing traffic flow, reducing CO2 emissions, and improving accessibility. They are:

- KPI O.1.1: V2V data rate of >100 Mb/s for short-range (>100 m) head/rear-lamp OWC channel.
- KPI O.1.2: User data rate of >1 Gb/s for long-range (>200 m) V2I OWC channel.
- KPI O.1.3: User data rate of 10+ Gb/s (better than long-term evolution for terrestrial 5G-NR radio, as motivated by the Networld2020 SRIA).
- KPI O.1.4: Transparency of Fi-Wi-Fi bridge through loss of <13dB for FPA-enabled medium-range (100 m) OWC channel.
- KPI O.2.1: Demonstration an improved pulsed MEMS-based LiDAR with sensing (high density point clouds within a camera-like FOV of 30ºx20º at 7 fps) and FSO communication capabilities up to 200 m and <500 kHz PRR (bitrate) for JCAS applications in autonomous navigation systems.
- KPI O.2.2: Demonstration of a connected RaDAR, including simultaneous detection and communication capabilities for a range of <200 m and between 0.5 and 1 Gb/s.
- KPI O.3.1: Demonstration of a 50 Gb/s PAM4 Quasi-Coherent ASIC with built-in dispersion compensation.
- KPI O.3.2: Demonstration of a 100 Gb/s PAM4 Quasi-Coherent ASIC with built-in dispersion compensation.
- KPI O.3.4: Demonstration of an integrated QC receiver photonic chip with 10mW on chip tunable LO and 100 GHz photoreceptor.
- KPI O.4.1: Demonstration of a 16x16 switch with 9 dB fiber-to-fiber loss and sub-microsecond reconfiguration time.
- KPI O.4.2: Time slotted operation with guaranteed operation (i.e. no out-of-order packets) for a min of 50µs slot duration.
- KPI O.5.1: Provisioning of traffic flows achieving 50% reduction in energy consumption.
- KPI O.5.2: Provisioning of traffic flows in < 60 sec, considering packet and optical layers.
- KPI O.5.3: AI-assisted energy-efficiency algorithm(s) and/or heuristics for multi-layer (packet/optical) networks.
- KPI O.6.1: Demonstration of a data fusion sensor suite with low parallax error based on connected LiDARs / RaDARs.
- KPI O.6.2: Incremental reconstruction of scenes from multiple ego-poses and discrimination of dynamic objects with range precision better than 0.5 m and accuracy >60%.

III. KPI VERIFICATION ACROSS THREE DEMONSTRATIONS

Three demonstrations are planned to validate the proposed KPIs. As will be further discussed at the workshop session, Demo 1: on OWC including connected LiDAR and RaDAR for JCAS, will focus on laboratory demonstration of KPI O.1.1 to KPI O.2.2, to demonstrate the highest, record values of the latest technologies developed at 6G-EWOC.

Similarly, Demo 2: on PIC and ASIC for tuneable TX and RX concepts for fibre-based fronthaul and WDM-SDM photonic switching, will verify KPI O.3.1 to KPI O.4.2, using leading edge laboratory equipment of the participating partners.

Once the ultimate technology's performances are verified, Fig. 1 shows a schematic of Demo 3: on AI-assisted control and orchestration of resources for the 6G-EWOC network concept and AI-based applications for AVs, focusing on the validation of KPI O.5.1 to KPI O.6.2, following proofs of concepts and related use cases as indicated in the 6G-SNS white paper [4].

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