# IEEE 802 LAN/MAN STANDARDS COMMITTEE (LMSC)

# CRITERIA FOR STANDARDS DEVELOPMENT (CSD)

Amendment: High Data Rate Optical Camera Communications (OCC)

# IEEE 802 criteria for standards development (CSD)

The CSD documents an agreement between the WG and the Sponsor that provides a description of the project and the Sponsor's requirements more detailed than required in the PAR. The CSD consists of the project process requirements, 1.1, and the 5C requirements, 1.2.

## Project process requirements

### Managed objects

Describe the plan for developing a definition of managed objects. The plan shall specify one of the following:

1. The definitions will be part of this project. Yes
2. The definitions will be part of a different project and provide the plan for that project or anticipated future project.
3. The definitions will not be developed and explain why such definitions are not needed.

### Coexistence

A WG proposing a wireless project shall demonstrate coexistence through the preparation of a Coexistence Assurance (CA) document unless it is not applicable.

1. Will the WG create a CA document as part of the WG balloting process as described in Clause 13? (yes/no) Yes
2. If not, explain why the CA document is not applicable.

## 5C requirements

### Broad market potential

Each proposed IEEE 802 LMSC standard shall have broad market potential. At a minimum, address the following areas:

1. Broad sets of applicability.

There is a growing need to increase the degree of connectivity of mobile devices, both new and existing, to support a growing set of applications requiring higher data rates without overloading existing radio frequency (RF) spectrum or requiring additional hardware. Adding Multiple-Input-Multiple-Output (MIMO) based high-speed Optical Camera Communication (OCC) to this standard addresses a significant additional opportunity, extending to billions of existing devices (e.g. Smartphone, CCTV, Mobile Robot, Blackbox, Webcam, Tablet, and etc.) to provide secure non RF based communications capability between industrial devices and/or between consumer devices and fixed infrastructure on either a one to one, or one to many or many to one basis. Currently, almost all types of smartphones have built-in cameras. The camera2 application programming interfaces (APIs) (greater than android version 4.4) has additional features, such as manually-controlled exposure, focus, raw capture, etc. And nowadays almost (more than 87% in 2018) every smartphone camera is built with camera2 API. These features help to build an OCC application on a smartphone. OCC programmable applications can be installed in the smartphones to use it as a receiver. Also, the LED flash light can transmit visible light or near infrared (NIR). OCC data can be integrated in them for the prospective uplink communication. CCTV cameras can be used as receivers. Here, the OCC data processing can be done in the processing unit (e.g., computer, tablet, etc) only without adding new hardware and software in the CCTV. Only the OCC-based software is needed to be installed in the processing unit. The LED headlights or taillights can be used as transmitters. Also, the camera installed in the car can be used as receivers. In particular, a switching device and a Micro-controller Unit (MCU) in the transmitter is used to implement the OCC system. Here, in the case of a low-speed OCC system, an Arduino Uno (that uses an ATmega328 microcontroller capable of running up to 20 MHz) and a general MOSFET (with 2.47 microseconds as max switching time) can be used. However, a semiconductor device that has a very high switching speed (more than 100 GHz) is required to implement the high-speed OCC system. Here, only few hardware modifications are needed to install OCC. ISO TC 204 Plenary Meeting approved OCC as one of International Standards in V2X applications in April, 2020. Similarly, OCC can be applied in tablet, mobile robot and other devices by adding few updates in the hardware and software regarding the transmitter, and few software in the device where the received signal will be processed. LinkRay, developed by Panasonic, delivers mobile contents by enabling smartphones to read IDs sent from LED transmitters. These transmitters include displays, signboards, and spotlights. Associated mobile contents will be connected as well. LinkRay delivers excellent end user experiences intuitively and securely. Picalico is an indoor positioning system that uses Casio's unique camera designed for visible light communications. The LED that represents the information in the color-change pattern is used as the transmitter. On the other hand, the camera is used as the receiver to collect the ID and position information. Currently, existing smart cameras such as Galaxy S20 has a frame rate of 960fps. So, we can achieve a date rate up to 32kbps. We also have 100kfps camera in real market. In this case, we can increase the data rate up to 3Mbps. OCC can support a data rate more than 1Mbps for Full Duplex operation using an LED array (in other words, using MIMO) in the transmitter side and existing cameras in the receiver side. Furthermore, we can achieve data rate up to 3.2Mbps using MIMO functionality in smart phone camera.

The hardware and software of the future cameras will be upgraded to increase the quality of images. In addition, the image sensor, GPU, and CPU will be upgraded and new AI algorithms will be utilized. Consequently, it will be more convenient to implement the OCC system in the future cameras. Therefore, OCC is not compatible only with the existing cameras, but also with the future cameras.

Using light frequencies rather than RF allows for significant additional unlicensed bandwidth without RF interference. The ability to use existing hardware for many applications substantially broadens the available market and contains the cost.

1. Multiple vendors and numerous users.

Applications include autonomous vehicles, advanced driver-assistance systems (ADAS), Intelligent Transportation Systems (ITS), high-speed railway (HSR) communications, drone-to-drone communications, marine communications, logistics automation, medical instruments, control of mobile robots in a manufacturing cell or assembly line, automated guided vehicular systems, small cell backhaul, patient monitoring in hospitals, security and processes monitoring in manufacturing factories, semiconductor fabrication plants, etc. ~~, petrochemical plants, chemical factories, nuclear facilities or semiconductor fabrication plants, secure and safety communications in nuclear facilities and hospitals, etc.~~ This translates to a large community of vendors and users especially with the ability to retrofit into existing applications. We are expecting more than 20 participations from more than 10 affiliations, which can collaborate to complete this standard.

### Compatibility

Each proposed IEEE 802 LMSC standard should be in conformance with IEEE Std 802, IEEE 802.1AC, and IEEE 802.1Q. If any variances in conformance emerge, they shall be thoroughly disclosed and reviewed with IEEE 802.1 WG prior to submitting a PAR to the Sponsor.

1. Will the proposed standard comply with IEEE Std 802, IEEE Std 802.1AC and IEEE Std 802.1Q?

To implement OCC, we don’t need to add any hardware or software in the camera. The existing cameras are used. However, we need to install new software in the processing unit. For example, in terms of CCTV, the camera and the processing unit are two separate parts, that can be connected via 802.3. Additionally, the processing unit can use the 802.1Q or the 802.1 TSN to connect with the server. In recapitulation, the amendment is compatible with 802.1, 802.1Q, and 802.3. Furthermore, the OCC technology can be implemented with full-duplex or Simplex communication mode. In recapitulation, the amendment is compatible with 802.1, 802.1Q, and 802.3.

1. If the answer to a) is no, supply the response from the IEEE 802.1 WG.

The review and response is not required if the proposed standard is an amendment or revision to an existing standard for which it has been previously determined that compliance with the above IEEE 802 standards is not possible. In this case, the CSD statement shall state that this is the case.

### Distinct Identity

Each proposed IEEE 802 LMSC standard shall provide evidence of a distinct identity. Identify standards and standards projects with similar scopes and for each one describe why the proposed project is substantially different.

This project focuses on high data rate, long range (up to 200m) OCC using both single carrier and multi-carrier modulations. This is unique in the 802 Optical Wireless Communication (OWC) activities. Additionally, the amendment includes adaptation to varying channel conditions and maintaining simultaneous long range multiple connectivity in high mobility situations.

### Technical Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence that the project is technically feasible within the time frame of the project. At a minimum, address the following items to demonstrate technical feasibility:

1. Demonstrated system feasibility.

There have been sufficient test results, demonstrations, measurements and simulations, both academic and commercial, verifying that OCC capabilities needed for this amendment are feasible.

1. Proven similar technology via testing, modeling, simulation, etc.

The components used for OCC are widely used in illumination and other applications and are produced in large volumes, showing that the technologies required are proven. Fabrication and testing techniques are used for volume manufacture of optoelectronic components demonstrating that the testing required is reasonable

### Economic Feasibility

Each proposed IEEE 802 LMSC standard shall provide evidence of economic feasibility. Demonstrate, as far as can reasonably be estimated, the economic feasibility of the proposed project for its intended applications. Among the areas that may be addressed in the cost for performance analysis are the following:

1. Balanced costs (infrastructure versus attached stations).

Since the primary target is adding capability to existing applications and hardware, this amendment in no way upsets the existing acceptable cost balance

1. Known cost factors.

The cost factors are well known. The software that is to be installed for OCC is relatively small in size. Therefore, the prospective installations and testing will be cost-effective.

1. Consideration of installation costs.

Primarily firmware upgrades

1. Consideration of operational costs (e.g., energy consumption).

No real change over current operational costs in existing applications

1. Other areas, as appropriate.

None