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| **PLENARY MEETING** | **Addendum 3 to Document RA15/PLEN/34-E** |
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| CEPT – European Conference of Postal and Telecommunications Administrations |
| Draft NEW question ITU-R [EUR/VISIBLE LIGHT] |
| Study on characteristics of visible light or optical communications for broadband communications |
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# 1 Introduction

No. 78 of Article 12 of the ITU Constitution states that a function of the Radiocommunication Sector includes “…carrying out studies without limit of frequency range and adopting recommendations”.

Technology development and especially digital technology development is an on-going and continuous process and also opens new ways for communications. Especially optical communications might offer an additional opportunity to satisfy the increasing demand for (data) communication.

The issue in recently gaining strong interest, not only from a scientific point of view such as from universities, but also a number of companies show a growing interest in the issue. The first aim is to investigate under which conditions optical communications, to be used indoor and for relatively short distances, can facilitate the increasing demand for broadband (data) communications.

Optical communications is not a new issue for ITU and in the past studies resulted in several Recommendations and Reports on various applications of optical links. No information has been provided to indicate that interference between optical systems is a concern.

Documentation related to the issue that has been developed within ITU-R until now does not refer to “optical” communication, because in the past no agreement could be reached on a definition of “optical.” In some communities, “optical” = “visible.” In others, “optical” = “visible + near infrared.” Attempts have been undertaken in creating new terms such as “photocommunication” or “photonic communication” but this debate also did not lead to a common understanding. In the end, several radio terms to optical technology are used. Therefore, the Recommendations talk about frequencies in the area of 283 THz.

A summary of technical and operational studies done until now and related ITU-R Recommendations on the issue is annexed to this document (Annex 1), as well as an overview from the documentation developed within ITU-R until now (Annex 2).

# 2 Previous studies on free space optical links

In the past studies have been done, based on a WRC-07 Resolution related to free-space optical communication systems operating in the Earth-to-space, space-to-Earth and space-space directions for long distance communications.

Aim of the studies was to determine whether it was necessary to adapt the Radio Regulations, since the part of the spectrum, which these links use, is outside the current frequency table of Article 5 of the RR. The WRC-07 Resolution called for studies on sharing aspects with other services, a clear definition of the band limits and measures to be considered if allocations to various services in the Radio Regulations above 3 000 GHz are considered feasible. A number of studies were performed and at WRC-12 it was concluded that no changes to the Radio Regulations were necessary in order to accommodate these applications.

# 3 Current situation

Potential visible light communications (VLC) data rates at over 10 Gb/s have been recently demonstrated using light emitting diodes (LEDs). However, laser diodes (LDs) can be considered as an even better promising alternative for a better utilization of the visible light spectrum for communication purposes. This work investigates the communication capabilities of the off-the-shelf LDs in a number of scenarios with illumination constraints. The results indicate that optical wireless access data rates in the excess of 100 Gb/s are possible at standard indoor illumination levels.

# 4 Proposal

Europe notes that “optical communications” operate in the unregulated part of the frequency spectrum and therefore do not require an allocation in the Radio Regulations. Europe further notes that the issue of new possibilities of broadband use requires further study within ITU and, therefore, proposes that the Radio Assembly adopts a new ITU-R Question to study the characteristics of visible light or optical communications for broadband communications.

draft new QUESTION ITU-R [EUR/VISIBLE LIGHT]

Characteristics for use of visible light for broadband communications

(2015)

The ITU Radiocommunication Assembly,

considering

*a)* that technology development is an on-going process that also opens new ways for use of spectrum;

*b)* that the use of visible light for communications currently receives renewed attention;

*c)* that visible light communications operate in the unregulated part of the frequency spectrum and therefore do not require an allocation in the Radio Regulations;

*d)* that the topic of possibilities of broadband use via visible light requires further study within ITU,

decides that the following Questions should be studied

1What are the distinctive characteristics and efficiency gains of the use of visible light for broadband communications in terms of their use of the spectrum?

2 What are the overall objectives and user needs for the development of short distance broadband communication in the spectrum area of visible light?

3 What are the new applications associated with visible light used for broadband communications?

4 What are the technical and operational characteristics needed for the further development of visible light communications?

5 What can be learned from findings from other areas, e.g. the space- and satellite industry, considering optical communications?

further decides

1 that the results of the above studies should be included in one or more Recommendation(s) and/or Report(s);

2 that the above studies should be completed by 2019.

Annex 1

Analysis of the results of studies performed within the ITU[[1]](#footnote-1)

The following summarizes the relevant findings of concluded studies:

The performance of earth stations operating with satellites at frequencies above 30 THz is strongly influenced by the atmosphere. Propagation considerations include atmospheric absorption, Rayleigh and Mie scattering, refraction, and turbulence. To avoid atmospheric loses as much as possible, optimal locations for an earth station are typically at high altitudes, usually at least 2 km above sea level. In addition, it is difficult to maintain an optical communication link with an earth station operating with an elevation angle below 40due to the atmospheric effects at lower angles.

Atmospheric absorption, scattering and turbulence are also significant considerations for terrestrial free-space optical systems. These systems may also operate with some degradation through fog, rain and snow.

Free-space optical communication systems operating in the Earth-to-space, space-to-Earth and space-space directions are all exemplified by very narrow beams. The largest fields of regard are used between non-GSO spacecraft during acquisition mode but are still no more than 700 μradian (0.04º). Their field of view typically reduces to the order of 10 μradian (0.0006º) for regular communication. Unwanted energy received in the side lobes of the receiving antenna pattern may be neglected in the course of interference analyses. Typical transmitting beamwidths are also on the order of 10 μradian.

In the future, like fibre-optic broadband wireless connections, free-space optical links will be a promising system to provide point-to-point line-of-sight networks. For terrestrial applications, the beam divergence of the transmitting signal and the field of view of the receiver are typically a few milliradians or less. However, in the case of initial acquisition of the target terminal, a combination of higher power beacon with larger beam divergence and sensitive acquisition sensor with wide field of view, such as a CCD (Charge Coupled Device) image sensor, is frequently used for terrestrial applications. Terrestrial free-space optical links may be deployed at any time and in any place. This is based on today’s assumption that no coordination is required to avoid interference between such links operated by different operators. Theoretically, interference between free-space optical links may occur. However, the interference will never have harmful effects unless two links operate under a quite limited geographical environment.

There are many telescopes in the world with the capability to make astronomical observations in the THz bands, and the number is increasing. Although the “antenna beams” are individually narrow, so that the probability for beam-to-beam coupling is low, most of these telescopes are imagers, with an array of many pixels at the focus, “seeing” collectively a patch of sky that could be a substantial fraction of a degree across. Since telescopes observing at frequencies above 100 THz are based at isolated, high-altitude sites, there are few suitable places in the world, and in general these are far from population concentrations (Mauna Kea, USA is a possible exception). It is, therefore, feasible to avoid transmitting towards such sites. Providing spatial separation is large enough, the low attenuation windows in the atmosphere may be used both by active and passive services.

Active and passive sensing devices utilizing spectrum above 3 000 GHz offer the most diverse technical and operational characteristics of any technology studied with sensitivities and fields of view varying by orders of magnitude. Active sensors take the form of light detection and ranging (LIDAR) devices used by the EESS (active) and terrestrial MetAids type applications. Beamwidths and receiver fields of view of terrestrial applications are wider than those of space-based active sensors but are typically no more than a few mradian. Terrestrial meteorological aid systems also make active measurements by transmitting pulsed signals from a fixed source. Atmospheric conditions are determined by analyzing signal characteristics received at the other end of the path. To minimize effects of energy from other sources, EMI (electromagnetic interference) filters are placed on the receivers of these types of systems.

EESS passive systems collect information relating to the characteristics of the Earth and its natural phenomena, including data relating to the state of the environment. Instruments operating above 3 000 GHz may be present on about half of all EESS spacecraft. About one to three new EESS systems utilizing spectrum above 3 000 GHz are anticipated to be launched each year for the foreseeable future, with additional instruments being temporarily deployed on space shuttles and the International Space Station. The majority of EESS systems utilize non-geostationary orbits, with a significant portion of these systems in sun-synchronous orbits. Each EESS system has unique technical characteristics and mission requirements that directly influence instrument sensitivity. Sensitivity requirements will also vary with solar illumination, measurement subject, and even instrument age. As for passive meteorological aid devices, they conduct measurements such as sunshine detection and sky luminance. Both utilize sensors which may be exposed to direct sunlight.

In summary, because emitters used in near-infrared free-space links have extremely narrow beamwidths, and terrestrial emitters can only cause interference over very short distances, cases of terrestrial interference will be very rare and easily resolved on a local basis. Moreover, interference between inter-satellite links would also be rare due to directed and narrow beamwidths, and the vast geometry of space.

No evidence up until now has been provided that interference between free-space optical systems is a concern. Existing ITU-R Recommendations and Reports sufficiently address free-space optical links. Furthermore, no possible procedures have been identified for free-space optical links.

Annex 2

Summary of technical and operational studies
and relevant ITU-R Recommendations

ITU-R P.1621 – Propagation data required for the design of Earth-space systems operating between 20 THz and 375 THz

This Recommendation contains propagation data regarding the possible use of spectrum between 20 THz and 375 THz for communications in near-Earth and deep space environments.

It recommends that methods for predicting the propagation parameters giving in the Annex to the Recommendation be adopted for planning Earth-space systems in the respective ranges of validity indicated in the Annex.

ITU-R P.1622 – Prediction methods required for the design of Earth-space systems operating between 20 THz and 375 THz

This Recommendation contains prediction methods required for a proper planning of Earth-space systems operating between 20 THz and 375 THz for certain space based communications in near-Earth and deep space environments.

It recommends that the methods for predicting propagation-related system impacts given in the Annex to the Recommendation be used or planning Earth-space systems in the respective ranges of validity indicated in the Annexes to the Recommendation.

ITU-R S.1590 – Technical and operational characteristics of satellites operating in the range 20‑375 THz

This Recommendation contains information on the technical and operational characteristics of satellites operating in the range 20-375 THz.

It recommends that sharing studies of satellites operating in the range 20-375 THz take into account the technical and operational parameters presented in the Annex to the Recommendation.

ITU-R RA.1630 – Technical and operational characteristics of ground-based astronomy systems for use in sharing studies with active services between 10 THz and 1 000 THz

This Recommendation contains information on the technical and operational characteristics of ground-based astronomy stations for use in sharing studies with active service between 10 THz and 1 000 THz.

It recommends that astronomers take into account the possibility of interference from transmitters operating between 10 THz and 1 000 THz in their choices of observatory sites and in the design of instrumentation. Furthermore it recommends that astronomers provide the appropriate ITU-R Study Groups with information on the latest technological advances to ground-based astronomical observations in the indicated bands and that studies on interference into astronomy systems operating in the indicated bands take into account the technical and operational parameters given in the Annexes to the Recommendation.

ITU-R SA.1742 – Technical and operational characteristics of interplanetary and deep-space systems operating in the space-to-Earth direction around 283 THz

This Recommendation specifies technical parameter (frequencies, link, signal and data characteristics, antenna parameters, etc.) and operational characteristics of interplanetary and deep‑space systems operating in the space-to-Earth direction around 283 THz, which could be used in sharing studies.

ITU-R SA.1805 – Technical and operational characteristics of space-to-space telecommunication systems operating around 354 THz and 366 THz

This Recommendation specifies technical parameters (frequencies, link direction, signal and data characteristics, antenna parameters, etc.) and operational characteristics of telecommunication systems operating in the space-to-space direction around 354 THz and 366 THz, which could be used in sharing studies.

ITU-R RS.1744 – Technical and operational characteristics of ground-based meteorological aids systems operating in the frequency range 272-750 THz

This Recommendation provides the operational and technical characteristics of representative MetAids systems operating in the optical frequency range 272-750 THz.

It recommends that operators of meteorological aids operating in the optical frequency range should take into account the possibility of interference from other optical transmitters in their choices of observatory sites and the design of sensors. Furthermore that studies of interference to and from optical meteorological aids systems should take into account the technical and operational parameters provided in the Annex to the Recommendation.

Other relevant ITU-R Recommendations and Reports: Recommendations ITU-R P.1814, ITU-R P.1817 and ITU-R RS.1804, and Reports ITU-R F.2106 and ITU-R RA.2163

It can be concluded that these studies do not refer to the use of optical communications for broadband communications.

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1. Source: CPM Report to WRC-12 on agenda item 1.6 – part of the agenda item was related to “consider possible procedures for free-space optical-links, taking into account the results of ITU-R studies, in accordance with Resolution 955 (WRC-07)”. [↑](#footnote-ref-1)