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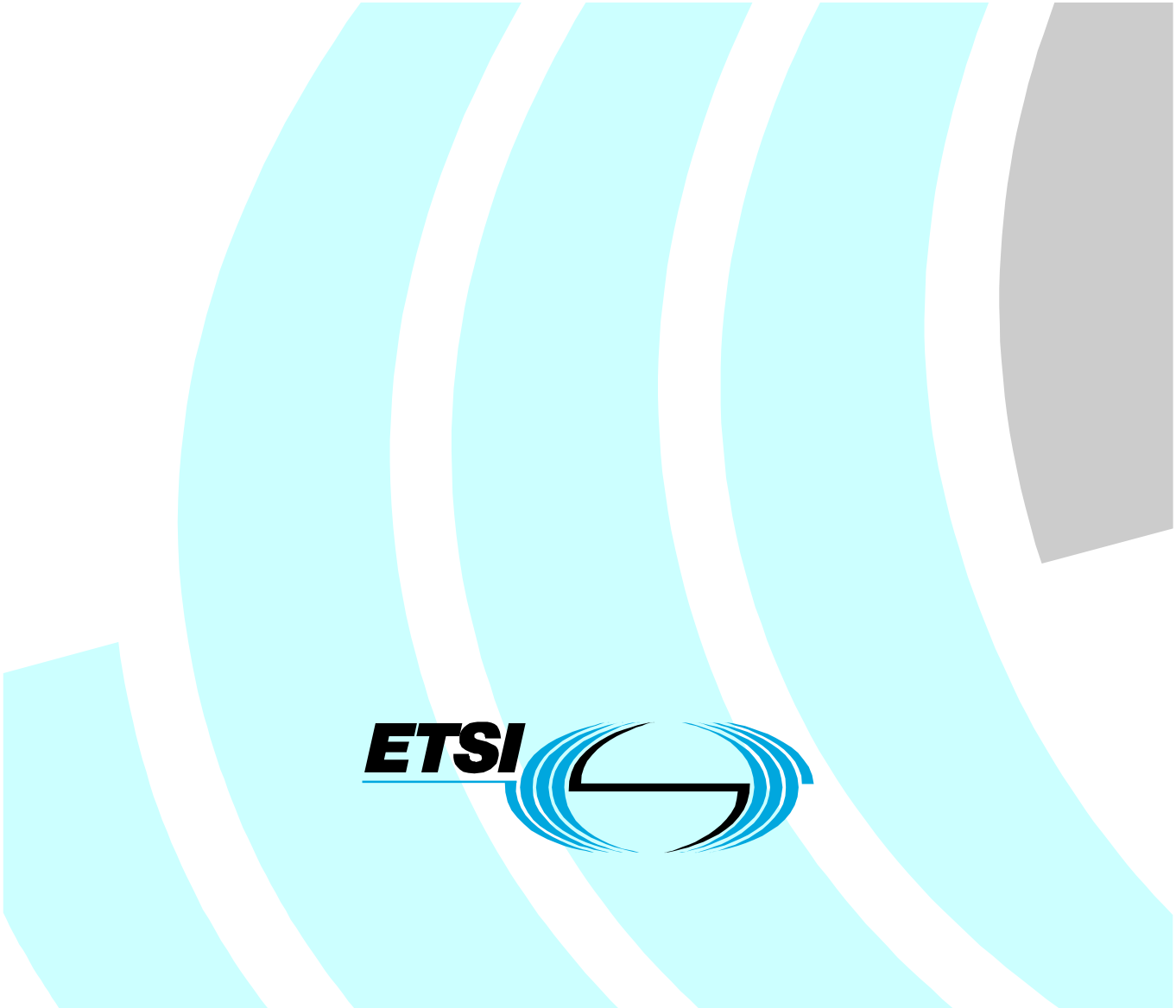
Technical Report

Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics of multiple gigabit wireless systems in the 60 GHz range System Reference Document



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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Introduction

The present document covers applications that require wireless systems delivering multiple gigabits of data throughput operating on license-exempt radio frequencies in the 60 GHz range. These applications provide economic benefits to a variety of markets including communications, computing, consumer electronics.

The purpose of producing the present document is, in particular, to support the co-operation between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT), and the international harmonization of a class of innovative and useful products.

Status

The present document was developed by TC-BRAN and the information in version 1.1.1_0.0.7 had been forwarded to CEPT. As a result of the consultation by WG ERM-RM, closed October 5th 2006, a new version, V 1.1.1_0.0.8 was drafted. The present version is offered to the consideration of TC-ERM

NOTE: Previous versions of this document, referenced above, are available in the ETSI collaborative portal for the appropriate TC-BRAN (http://portal.etsi.org/docbox/bran/bran/Docfile) or ERM-RM (http://portal.etsi.org/docbox/erm/ermrm) session or the ERO document server for the appropriate WG FM (http://www.ero.dk) session as indicated in the History section of this document.

1 Scope

The present document describes the requirements for radio frequency usage of multiple gigabit wireless applications in the 59 GHz to 66 GHz range.

These applications provide short-range information exchange for communication, computing, consumer electronics, and LAN extension at very high data rates. The potential to use these applications not only in fixed, nomadic and mobile applications requires a change of the present frequency designation within CEPT.

It includes:

- Market information (annex A).
- Technical information (annex B).
- Expected sharing and compatibility issues (annex C).

2 References

For the purposes of this Technical Report (TR) the following references apply:

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

[1] Australia Radiocommunications Class License 2000.

NOTE: See http://matt.ucc.asn.au/nowire/lipd.html

[2] Canada rss-210, issue 6, september 2005.

[3] ECC Recommendation (05)02: "Use of the 64 - 66 GHz Frequency Band for Fixed Service".

[4] ERC Recommendation 12-09: "Radio frequency channel arrangement for Fixed Service systems operating in the band 57.0 - 59.0 GHz which do not require frequency planning".

[5] ERC Report 25: "The European table of frequency allocations and utilizations covering the frequency band range 9 KHz to 275 GHz".

[6] ETSI BRAN 34d018: "Evolution of WLAN/WPAN towards Higher Frequencies and High Throughput: From 5 to 60 GHz", (October 2003).

[7] ETSI TS 102 329: "Fixed Radio Systems; Point-to-Point equipment; Radio equipment and antennas for use in Point-to-Point High Density applications in the Fixed Services (HDFS) frequency band 64 GHz to 66 GHz".

[8] ETSI TR 102 400: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Intelligent Transport Systems (ITS); Road Traffic and Transport Telematics (RTTT); Technical characteristics for communications equipment in the frequency band from 63 GHz to 64 GHz; System Reference Document".

[9] FCC 47 CFR Part 15.255: "Operation within the band 57-64 GHz".

[10] FCC NPRM, ET Docket No. 94-124, RM 8308: "Amendment of Parts 2, 15, and 97 of the Commission's Rules to Permit Use of Radio Frequencies Above 40 GHz for New Radio Applications".

[11] IEEE 802.15.3c: "Millimeter-wave based Alternative Physical Layer Extension for IEEE Standard 802.15.3-2003 titled, Part 15: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for High Rate Personal Area Networks (WPANs)".

[12] IST-2001-32686 Broadway, WP 5: "D11, Spectrum Study and Standardization Status", (November 2003).

[13] ITU-R Recommendation P.676-6: "Attenuation by atmospheric gases".

[14] Japan Regulations for Enforcement of the Radio Law 6-4-2 Specified Low Power Radio Station (11) 59-66 GHz Band.

[15] Ofcom Study on Higher Frequency Bands (> 30 GHz) for License Exempt Operations, 2005.

[16] WIGWAM - A Wireless Gigabit System with Advanced Multimedia Support, In VDE-Kongress Berlin, October 2004.

[17] Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general publicto electromagnetic fields (0 Hz to 300 GHz).

[18] CENELEC EN 50392: "Generic standard to demonstrate the compliance of electronic and electrical apparatus with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz) - General public".

[19] ERC Recommendation 74-01: "Spurious emissions".

[20] Comments of the National Aeronautics and Space Administration on ET Docket No. 94-124, January 30, 1995.

[21] FCC Report No. SPB-29, November 1, 1995.

[22] Reply Comments of Hewlett-Packard Co. in the Matter of Proposed Rulemaking for Frequencies above 40 GHz, ET Docket No. 94-124, February 28, 1995.

[23] Ex Parte Letter from Wireless Communications Association International, RM-11104, September 30, 2004.

[24] Comments from Harmonix Corp., ET Docket No. 94-124, RM-8308, August 20, 1998.

[25] Comments from New England Digital Distribution, ET Docket No. 94-124, RM-8308, September 14, 1998.

[26] Fujitsu Ten, Comments on the Notice of Proposed Rulemaking, ET Docket No. 94-124, February 7, 1995.

[27] American Honda Motor, Comment for Reconsideration of Vehicular Radar Bands, ET Docket No. 94-124, January 30, 1995.

[28] Mitsubishi Electric, Comment for Reconsideration of Vehicular Radar Bands, ET Docket No. 94-124, January 30, 1995.

[29] EIA/CEA-861 (July 2006): "A DTV Profile for Uncompressed High Speed Digital Interfaces".

[30] ITU-R Recommendation BT.656: "Interfaces for Digital Component Video Signals in 525-line and 625-line Television Systems operating at the 4:2:2 level of Recommendation ITU-R BT.601 (Part A)".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

60 GHz range or 60 GHz band: one of the variously permitted frequencies of operation, typically from 59 GHz to 66 GHz

NOTE: This is also commonly described by the following frequency designation terms.

millimetre wave, milliwave or mmwave band: frequency designation in the 60 GHz range as referenced in ERC Report 25 [5]

Fixed Local Area Network Extensions (FLANE): radiocommunications used in short range line of sight circumstances

NOTE: Total range and performance will vary depending on the environment, but full FLANE performance is typically expected at ranges of 100 meters to 1 000 meters.

Wireless Local Area Network (WLAN): radiocommunications used in short range, non-line-of-sight circumstances

NOTE: Total range and performance will vary depending on the environment, but full WLAN performance is typically expected at ranges of between 10 and 100 meters in an indoor environment.

Wireless Personal Area Network (WPAN): radiocommunications used in line-of-sight or near-line-of-sight circumstances

NOTE: Total range and performance will vary depending on the environment, but full WPAN performance is typically expected at ranges of less than 10 meters or within a single room in an indoor environment.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dBm	deciBel relative to one milliwatt
GHz	billions of cycles

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

e.i.r.p	equivalent isotropically radiated power
FLANE	Fixed Local Area Network Extensions
OBE	On-board Equipment
RF	Radio Frequency
WARC	World Administrative Radio Conference
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network

4 Comments on the System Reference Document

As a result of the consultation by WG ERM-RM, closed October 5th 2006, a new version, V 1.1.1_0.0.8 was drafted. It takes into account the various comments received. No other comments are known to date.

5 Executive summary

5.1 Background information

The present document describes the spectrum requirements of wireless systems operating at multiple gigabits of throughput primarily indoors in the 59 GHz to 66 GHz range.

This band has historically been limited in use based on the difficulty of radio propagation through air and other materials in this frequency range and the cost of producing commercial products. With the recent availability in various international markets of high power, license exempt spectrum in this range, the economies of scale in supporting commercial and scientific applications in the 60 GHz band has changed dramatically.

Products available in this range combine simple radio modulation techniques with high gain antennas to deliver low cost products for a variety of applications. These basic radio designs deliver gigabit-level data rates, taking advantage of the attenuation characteristics of the band and highly directional antennas to support scalability and a high level of frequency reuse. The maximum operating distance for WLAN and WPAN equipment at these data rates is expected to not exceed 10 meters.

The sparsely used oxygen absorption band in the 60 GHz band has been designated by various regulatory authorities [1], [2], [5], [9], [14] as well-suited for high speed communications in dense environments. Many radiocommunications methods that deliver the link energy budgets necessary for high data rate coverage also increase the range at which interference with other RF systems is possible. The attenuation characteristics around the 60 GHz range enable a high degree of spectrum reuse by limiting the ratio of undesirable interference to desirable coverage areas while enabling the link budgets necessary for gigabit-level communications. Though consideration is be made for radio astronomy observations that may be carried out in 64 GHz to 65 GHz [5], the oxygen absorption limits the potential for interference with satellite applications from sources other than aeronautical mobile. It is also noted that the range from 59 GHz to 63 GHz may be used for military radio (fixed, mobile and radar), and there is a SRDoc for intelligent transportation systems in the 60 GHz range.

5.2 Market information

License-exempt operations in the 60 GHz range are expected to encompass applications for wireless digital video, audio, and control applications, as well as multiple gigabit wireless local area networks. The total available market addressed by these applications in the 60 GHz range is expected to be 50 million units by 2010. Further details are in annex A.

5.3 Radio spectrum requirement and justification

To achieve international harmonization with bands approved for use in Australia, Canada, Japan, and the United States, and under final review in the Republic of Korea, license exempt usage in Europe is desired for the frequency range from 59 GHz to 66 GHz. Enabling the full band would enable consumers to legitimately access devices created for the various international markets. Previous sharing and compatibility studies cited in clause C.2 note that this band is currently sparsely used given its propagation disadvantages and historically high cost of implementation. Expansion of license exempt regimes to the 60 GHz would reduce spectrum congestion at lower, license exempt frequencies and increase the availability of low cost, gigabit and faster wireless systems in Europe.

Recent technological advances in high frequency, wide band radios are enabling low cost, mass-market implementations that use air interfaces between 500 MHz and 2 500 MHz of bandwidth, and use the propagation characteristics of the band along with directional antennas to enable a high level of spectrum reuse. Thus, a designation of 7 000 MHz in the frequency tuning range from 59 GHz to 66 GHz is requested to enable multiple, co-located wireless designs with similar characteristics to those in North America and the Pacific Rim.

As a percentage of the carrier frequency, the bandwidth of individual channels and requested license-exempt designation in the 60 GHz range as a whole is comparable to the proportions of license-exempt bands at lower frequencies.

In delivering a set of harmonized system requirements, the needs of CEPT territories can be effectively addressed by international organizations involved in the process of developing standards for the 60 GHz range [11], [12] and [16].

5.4 Regulations

5.4.1 Current regulations

The 60 GHz band is the subject of existing European frequency allocations [5], but there is no existing European harmonized regulation for license-exempt operation. The provisional CEPT allocation for 54,25 GHz- 66 GHz in ERC REC T/R 22-03 Athens 1990 has been withdrawn.

ECC REC(05)(02) [3] describes use of 64 GHz - 66 GHz for fixed service under a light licensing regime [3] with TS 102 329 [7] describing radio equipment and antennas for such systems [7]. TR 102 400 [8] describes technical characteristics for intelligent transportation systems from 63 GHz - 64 GHz [8].

5.4.2 Proposed regulation and justification

The following frequency ranges are proposed to be considered by the ECC for high speed wireless personal area network applications:

Table 5.1: Proposed candidate frequency band to be considered

Candidate band	Remarks
59 GHz - 66 GHz	Frequencies in this band are also currently approved for license-exempt use in Australia, Canada, Japan, Republic of Korea and the United States. The existing etiquette rules, spectrum sharing studies, and other analyses in these countries may be a model for considering the needs of commercial, military, and scientific uses of these frequencies.

The proposed candidate tuning band is mentioned in the table 5.1 are based on the bands available on a license-exempt basis in markets referenced by [1], [2], [9] and [14], and will support the availability of devices compliant with a harmonized standard [11], [12] and [16]. Details of current allocations in the 60 GHz range are contained in annex B.

The following limits are proposed as input values for the discussions and considerations in ECC. Applications operating in this range require up to 2,5 GHz of contiguous spectrum for multiple gigabit operation. For the purpose deploy multiple simultaneous systems as detailed in annex A, a complete 7 GHz of license-exempt spectrum, as harmonized with territories outside Europe in the 59 GHz to 66 GHz should be allocated.

While the use of directional antennas and the characteristics of the 60 GHz band already enables a significant amount of spectrum and channel reuse, the designation of 7 GHz would support international harmonization, usage models, and products focused on up to three simultaneous, co-located wireless links. These include, for example, high definition displays with uncompressed baseband video links to up to two video sources (for picture-in-picture purposes) plus a third device such as an audio video receiver, digital video recorder, or multi-channel wireless speaker system. These applications are further described in the annex A marketing clause.

Table 5.2: Proposed regulations

Frequency band	Maximum transmit power	Duty cycle	Channel spacing	Notes
The tuning range of 59 GHz to 66 GHz is requested to be license-exempt with an individual application requirement of 2,5 GHz.	40 dBm EIRP maximum mean power 27 dBm maximum peak conducted power	No restriction	No restriction	Measured over any continuous period of 53 seconds. The maximum power is for an emission bandwidth of greater than 500 MHz.
NOTE: A license-exempt scheme is proposed to the National Regulatory Authorities for applications other than aeronautical mobile and inter-satellite communications. Users may not claim protection from interference from other users within the same spectrum for this kind of application.				

The frequency tuning range use and transmit power is harmonized with values representative of license exempt usage in the above referenced markets.

6 Expected ETSI actions

TC BRAN is targeted to approve this deliverable in July 2006 with approval by ERM RM by September 2006 and submission to ECC.

7 Requested ECC actions

It is proposed that ECC considers the proposed regulation in clause 6 and identifies the final frequency tuning band for 59 GHz to 66 GHz license-exempt operation. It is proposed that National Authorities implement the full 7 000 MHz frequency designation.

Therefore, ETSI requests ECC to consider the present document, which includes necessary information to support the co-operation under the MoU between ETSI and the Electronic Communications Committee (ECC) of the European Conference of Post and Telecommunications Administrations (CEPT).

ETSI would appreciate if the ECC would be able to finalize the new deliverable(s) by the end of 2006.

ETSI BRAN intends to create a new Harmonized European Standard for this equipment.

Annex A:
Detailed market information

A.1 Range of applications

A variety of computing, communications, and consumer electronics applications operating at gigabit-level data rates will operate in this band. Because of the high level of oxygen absorption, this band is well-suited to short range applications operating at relatively high power levels while permitting a very high level of re-use.

The market assessment below covers two application areas with substantial markets:

Wireless Digital Video, Audio and Control

As new content-delivery technologies begin showing up in the home, consumers want to be able to view or hear their video or music anywhere in the home. Many consumers have no desire to spend the dollars needed to string unsightly wire through the house, so they are looking at wireless solutions to facilitate their entertainment addictions. This enables the customer to more easily install their home theatre system without worrying about component placement or about how to creatively conceal the myriad of required cables. It is a well known fact that consumer electronics companies are seeking solutions to deliver high quality digital video streams over wireless networks. The physical properties of 60 GHz enable a large amount of spectrum reuse to support large numbers of devices in heavily populated areas. International availability of significant spectrum with high allowable transmit power enables the use of low cost RF modulation and radio design techniques with the link margins necessary to support high reliability, high definition display techniques and future video and audio quality enhancements.

Wireless Local Area Networks

Residential WLAN adoption is highly correlated to that of broadband deployment since many such deployments integrate router functionality and entice the user to share that connection wirelessly around the house or office. These wireless networks are increasingly taking on more responsibilities than just email and Internet access. New applications, such as content sharing of music, pictures and video are becoming a regular expected function of the home network. In the very near future, distribution of voice and video services will be added to the mix. New WLAN technologies are expected to increase coverage and data rates, and operation in the 60 GHz band will relieve congestion and reduce the demand for spectrum in the lower frequency bands.

Given the continued interest and work of consumer electronics manufacturers in devices supporting the 60 GHz band to support high bandwidth video and audio applications, one possible development of the use of traditional, lower frequency technologies for WLAN connectivity, bridging to 60 GHz WPAN for final distribution to consumer electronics devices.

The above depicted applications are predominantly indoor applications.

Fixed Local Area Network Extensions

FLANE applications use same basic equipment and function blocks as WLAN equipment. Adding a highly directional antenna (typical beam width of $< 2^{o}$) and implementing the equipment in an outdoor environment in a direct line-of-sight situation, LANs can be extended between buildings. The main application of FLANE would be building-to-building, particularly in European industrial parks that host different offices of one company in several buildings.

A.2 Expected market size and value

The total available market (TAM) addressed by applications in the 60 GHz band is expected to be 50 million units totaling revenue potential of 1 400 Million Euros in 2010. This forecast is based on studies by Cahners Instat (December 2005) and other research groups with details cited below.

Wireless Digital Video, Audio and Control

Although other markets will eventually be larger, this market represents the majority of the immediate TAM opportunity due to its product cycles and interest by consumer electronics manufacturers. These manufacturers are seeking wireless solutions for high quality, high definition video and the studies assume penetration rates of new wireless capabilities based on historical actual acceptance of other digital video technologies.

Wireless Local Area Networks
The combined residential WLAN market itself is forecasted to grow from 1 200 Million Euros in 2005 to 3 000 Million Euros in 2010. With the availability of hundreds of Mbps of throughput using smart antenna systems beginning in 2006, it is likely that market will require a transition to gigabit level systems by 2010. The 60 GHz band is an option to address this market and address the issues of scalability and congestion in lower bands.

Fixed Local Area Network Extensions

The FLANE application is considered a subset of, and included in the market for WLAN applications.

A.3 Traffic and equipment density forecast

Expected traffic and equipment density in the 60 GHz band is included by reference in the regulations and studies cited in clauses C.2 and C.3

In particular, FCC ET Docket 94-124 [10] includes a variety of sharing studies from civil, military, and space authorities and referenced in clause C.3. The Ofcom (UK) study [15] considers the impact of license exempt operations in frequency bands higher than 30 GHz.

Annex B:
Detailed technical information

B.1 Detailed technical description

The proposed system parameters are based on the operation of current and expected future products in the 60 GHz band. In the absence of harmonized European regulations, these products are being developed to the specifications of the Millimetre Wave Working Group cited in clause C.2 and other international markets' regulations.

Table B.1: System parameters

Parameter	Value	Comments
Maximum radiated mean power	+40 dBm e.i.r.p.	The maximum mean e.i.r.p. parameter established by existing sharing studies. A variety of antennas may be used according to specific applications. The use of maximum mean power is used given the widespread usage of multiple carrier digital modulation methods such as orthogonal frequency division multiplexing (OFDM) with varying peak-to-mean power ratios. At the 60 GHz carrier frequency, the aperture size of an antenna is typically less than 10 cm.
Antenna beam shape/gain	None	No beam shape is specified yet. However, public exposure limit considerations may require a certain minimum antenna gain depending on maximum conducted output power. The user may specify a beam shape in accordance with the coverage required by the set of applications to be supported, or the manufacturer will offer a number of antenna options. Typical beam widths of existing products in this band is less than 5 degrees.
Examples of typical modulation schemes	ASK, FSK, QPSK, OFDM	Modulation schemes currently used by broadband wireless air interfaces
Typical data rates	0,1Gbps - 10 Gbps physical layer	Depending on the channel size and modulation method
Typical Channel Bandwidth (examples, other channel bandwidths may also be of use)	0,2 GHz - 2,5 GHz	Depending on desired data rate
Communication mode	Half Duplex, Full Duplex, broadcast	Duplex and broadcast are believed to be adequate for the applications considered to date.
Typical minimum sensitivity, BER, noise figure, etc.	None	Depending on the application and technology used.

B.2 Technical parameters and justifications for spectrum

B.2.1 Transmitter parameters

B.2.1.1 Radiated Power

The set of parameters in clause 5.4.2 (proposed regulations) is derived first of all from the operational requirements (i.e. link budget considerations) . In addition, it is useful to consider the power density limits from a safety perspective. The public exposure limit for the 59 GHz to 66 GHz band is 10W/m² for a duration of 53 seconds. For a continuous EIRP of 40 dBm, this level is found at a range of approximately 0.28 meters (in the boresight direction).

The duration of 53 seconds is for the public exposure limit measurement as in EN 50392 [18].

Because there is no minimum antenna gain, it is beneficial to introduce a maximum total transmitted power to avoid the situation in which a high power flux density could be obtained when a low gain antenna is used, and the only limit is set on EIRP.

The above safety limit complies with field strength limits for human exposure to electromagnetic fields as provided by EC Recommendation 1999/519/EC [17] and the method for compliance demonstration in EN 50392 [18].

Existing license exempt regulations in the U.S., Australia, Canada, Japan, Korea range from a maximum mean transmit power of +40 dBm e.i.r.p. [2] and [9] without occupied bandwidth requirements to +57 dBm e.i.r.p. [14] with 2,5 GHz maximum occupied bandwidth. Typical transmitter powers into the antenna of these products is no more than +20 dBm, though integrated antenna designs popular with 60 GHz products may not enable direct measurement of nominal conducted power.

Three factors affect consideration of radiated power issues in the 60 GHz range differently than at other frequencies currently used under license exempt schema.

The first factor is the Friis Transmission Equation in the 60 GHz range [10]. This holds that relative power at the receiver is proportional to the square of the wavelength, so the effective transmit power at the receiver in the 60 GHz range at a given distance will suffer 144x more attenuation or 22 dB greater loss than an equivalent transmission at 5 GHz.

The second and third factors are described below in overviews of the path loss characteristics of the 60 GHz range as a function of atmospheric gas absorption and construction material absorption [10] and [13]. These factors deliver up to 16 dB and 23 dB greater loss, respectively, at 60 GHz than at the license exempt 5 GHz range.

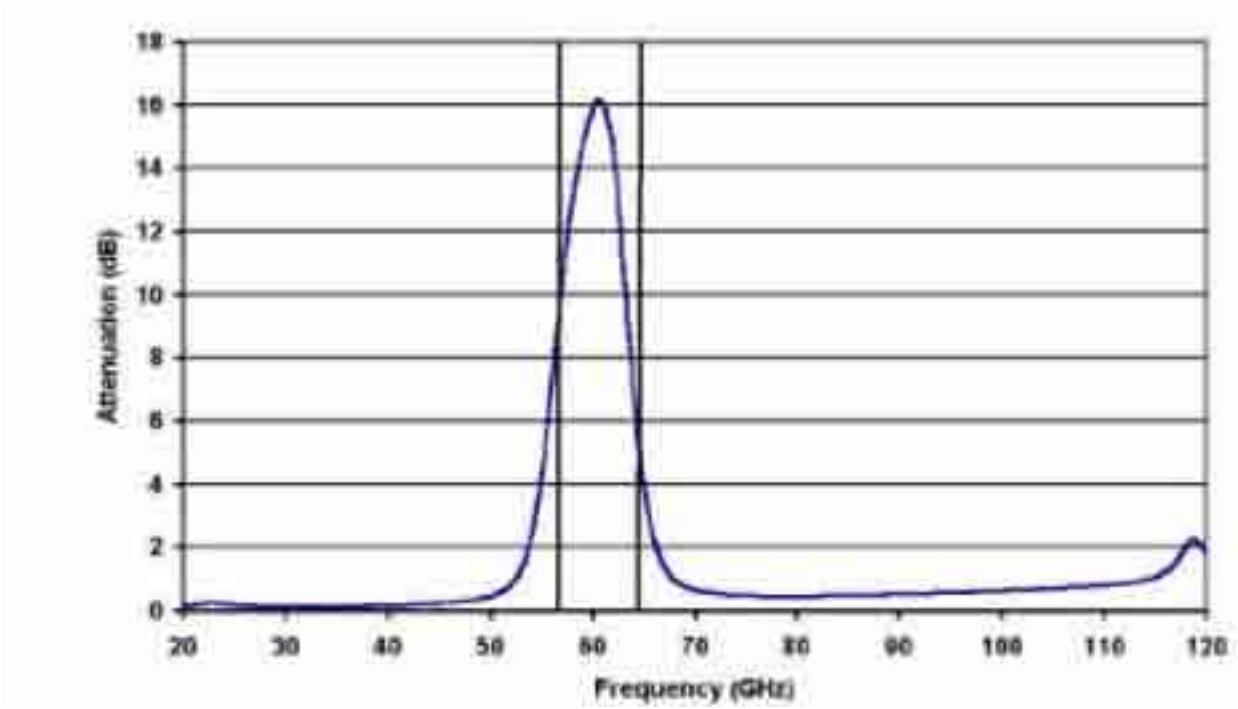

Figure B.1: Atmospheric Gas Absorption at 1 km

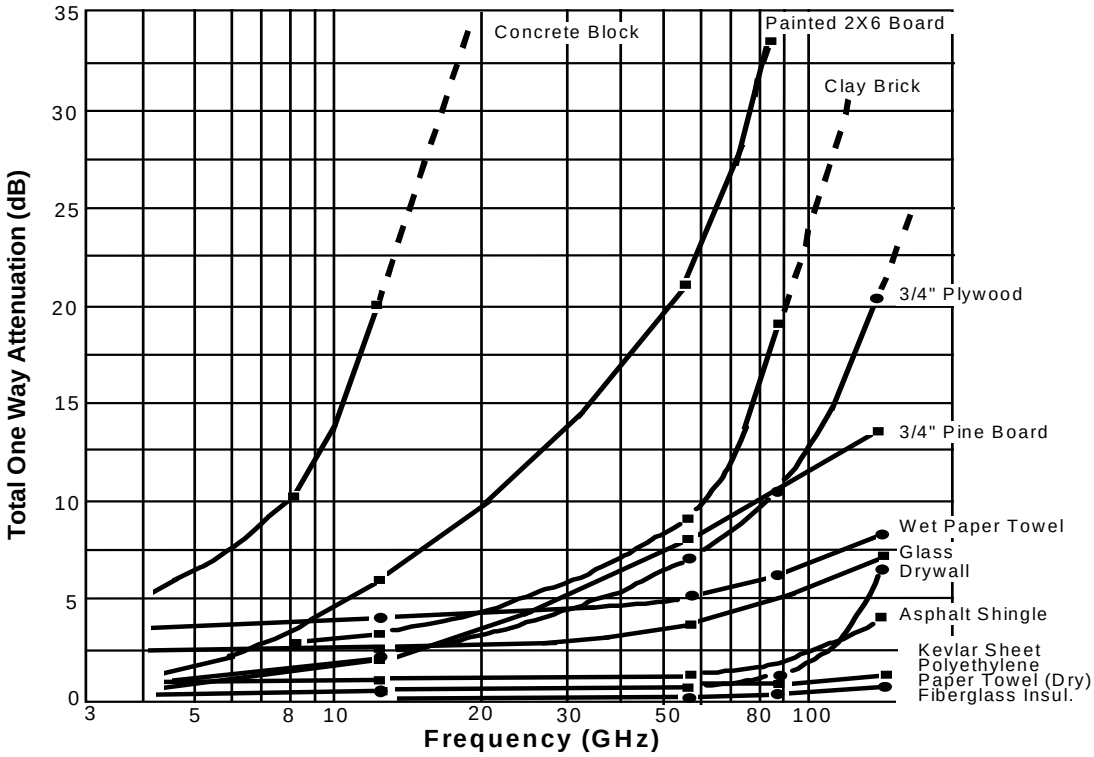

Figure B.2: Material Absorption at High Frequency

The net result is that in the 60 GHz range, a WPAN application, for example, may expect to find over 10 meters approximately 93 dB to 108 dB of path loss. An e.i.r.p. of 40 dBm supports typical receiver sensitivities in the -68 dBm to -53 dBm for 1 Gbps to 10 Gbps designs with respective bandwidths between 500 MHz and 2 500 MHz.

The need to support data rates up to 10 Gbps is dictated by the baseband bandwidth requirements of video systems ranging from the existing EIA/CEA-861 [29] and ITU-R Recommendation BT 656 [30] standards to the Fraunhofer Institute's 5k format.

B.2.1.2 Operating Frequency

For Europe, it is proposed to have the frequency range from 59 GHz to 66 GHz being identified for applications with multiple gigabit of throughput.

License exempt operation from 59 GHz to 66 GHz would be harmonized with allocations in other major markets for 60 GHz band products. The Canada and U.S. markets permit license-exempt operation from 57 GHz to 64 GHz while Japan permits licensed operation from 54,25 GHz to 59 GHz and license-exempt operation from 59 GHz to 66 GHz. Draft Korean regulations also support a license-exempt range from 59 GHz to 66 GHz.

B.2.1.3 Bandwidth

Devices intended for the 60 GHz band typically range from 200 MHz to 2 500 MHz of occupied bandwidth. FCC (U.S.) and Industry Canada (Canada) certification requirements assume, but do not require a minimum bandwidth of 100 MHz, and MCC (Japan) regulations limit bandwidth to 2 500 MHz. The magnitude of effects of spatial diversity and directional antennas in this range enable significant spectrum reuse within the same space. As noted earlier, as a proportion of the carrier frequency, these parameters are consistent with implementations in lower frequencies, but take advantage of a lower overall information and energy density to enable low cost implementations.

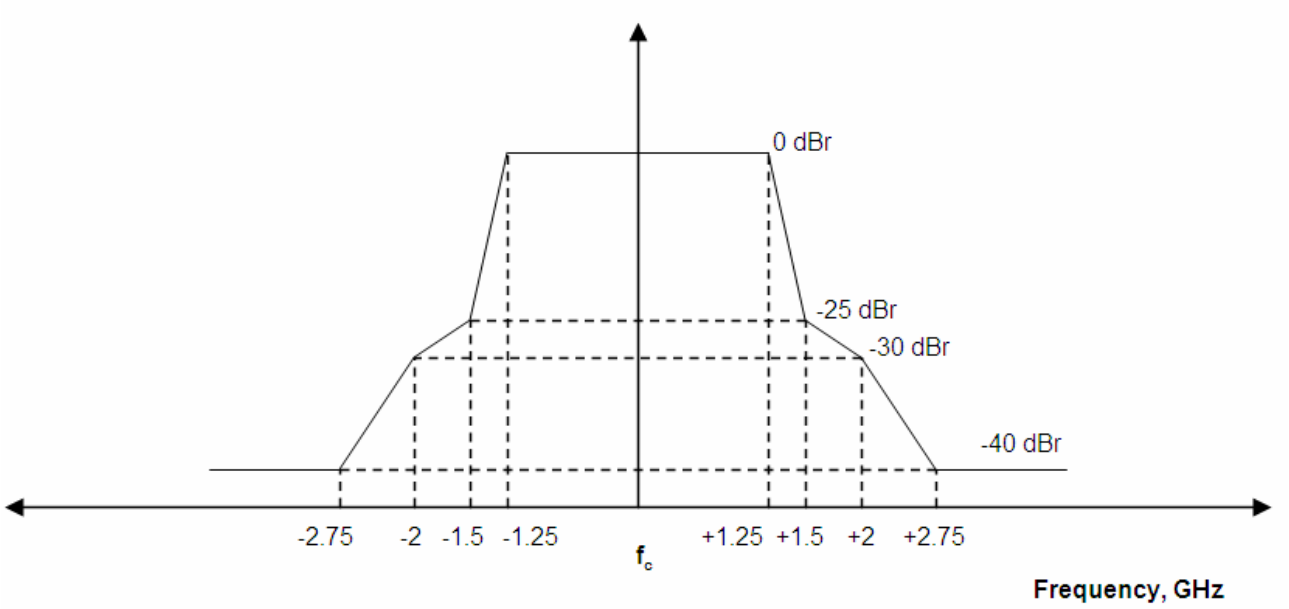

Figure B.3: Maximal Transmission Mask at 60 GHz

B.2.1.4 Spurious emissions

The equipment will comply with spurious emission limits as in ERC Recommendation 74-01 [19]. This includes, by [19], a maximum emission level of -30 dBm/MHz outside of the intended frequency designation over the full out-of-band domain.

B.2.2 Receiver parameters

Typical receiver sensitivities of -68 dBm to -53 dBm are cited above in clause B.2.1.1. Since these are typically achieved in conjunction with antennas with up to +47 dBi of gain (with very low conducted power transmitters), beam widths of less than 5 °, and apertures less than 10 cm, typical measures of channel selectivity with isotropic or omnidirectional antennas are not applicable. Channel sharing and reuse is primarily enabled by spatial diversity of intended transmitters and receivers.

B.2.3 Channel access parameters

Frequency reuse in this band is primarily enabled by propagation characteristics, narrow beam widths, and spatial diversity, and additional mechanisms such as carrier sense are typically not used.

B.3 Information on relevant standards and studies

License-exempt operation for high speed communications in the 60 GHz has been the subject of various CEPT and ETSI-sponsored projects including BROADWAY, HIPERSPOT, and WIGWAM. These operations are also the subject of a new IEEE project to which harmonized European requirements could contribute.

The BROADWAY project [12] supported by the European Commission under the IST-2001-32686 [12] studied hybrid dual frequency systems that extended HIPERLAN/2 WLANs at 5 GHz with an extension at 60 GHz named HIPERSPOT. This concept extended and complementing WLAN systems by providing a new solution for very dense urban deployments and hot spot coverage.

The WIGWAM project [16] is a collaboration of 27 European partners from industry, research institutes, and universities to define a gigabit-level air interface for Wireless Gigabit with Advanced Multimedia. Its primary band of operation is 5 GHz with support for bands at 17 GHz, 24 GHz, 38 GHz, and 60 GHz. WIGWAM project members include Alcatel, DaimlerChrysler, IHP, Infineon, Medav, Nokia, Philips, Siemens, Telefunken, and TU Dresden.

The IEEE 802.15.3c [11] project is in the process of creating a WPAN standard for operation in this band, and the development of a European harmonized set of regulations would help set the project's technical characteristics.

A SRDoc has been developed and is under review for intelligent transportation systems from 63 to 64 GHz. These technical characteristics are referenced in TR 102 400 [8].

Annex C:
Expected sharing and compatibility issues

C.1 Current ITU and European Common Allocations

The following radio services are allocated in frequency bands in the 60 GHz range.

Table C.1: European Common Allocations and Applications in the Proposed Frequency Bands

FREQUENCY BAND	ALLOCATIONS	APPLICATIONS
59,0 GHz to 59,3 GHz	Earth Exploration-Satellite (passive) Fixed Inter-Satellite Mobile Radiolocation Space Research (passive)	Passive sensors (satellite) (52,6 GHz to 59,3 GHz) Defense Systems (59,0 GHz to 61,0 GHz)
59,3 GHz to 62,0 GHz	Fixed Inter-Satellite Mobile Radiolocation	Defense Systems (59,0 GHz to 61,0 GHz) Fixed Links ISM Non-specific SRDs Radio LANs
62,0 GHz to 63,0 GHz	Inter-Satellite Mobile Radiolocation	Land Mobile Radiolocation (Military) (62,0 GHz to 64,0 GHz
63,0 GHz to 64,0 GHz	Inter-Satellite Mobile Radiolocation	Radiolocation (Military) (62,0 GHz to 64,0 GHz) RTTT
64,0 GHz to 65,0 GHz	Fixed Inter-Satellite Mobile except Aeronautical Mobile	Fixed Links (64,0 GHz to 66,0 GHz)
65,0 GHz to 66,0 GHz	Earth Exploration-Satellite Fixed Inter-Satellite Mobile except Aeronautical Mobile Space Research	Fixed Links (64,0 t GHz o 66,0 GHz) Land Mobile

C.2 Sharing and compatibility studies

A significant body of sharing and compatibility studies has been conducted internationally in this band, and are included here by reference so as to support harmonization of regulations for license-exempt operations in the 60 GHz range. European harmonization in the 60 GHz range will serve as a position of leadership in guiding the on-going development of international standards for operation such as IEEE 802.15.3c [11].

The Australian Agency ACMA (Australian Communications and Media Authority) in [1] considered devices capable of 60 GHz band operation to be LIPD (Low Interference Potential Devices), which do not require individual frequency coordination for interference management. This enabled the establishment of a class license for these devices where any person is permitted to operate them without payment of license fees, and authorized users of designated segments of this spectrum to operate on a shared basis. This class licensed enables operation at +10 dBm transmitter power into the antenna and +51,8 dBm maximum e.i.r.p. from 59,4 GHz to 62,9 GHz.

Canadian Regulatory requirements in RSS-210 [2] include studies that provide for license-exempt operation at +27 dBm peak transmitter output power and +40 dBm maximum average e.i.r.p. from 57,05 GHz to 64 GHz with 57,00 GHz to 57,05 GHz reserved for a publicly-accessible coordination channel.

The Canadian requirements are harmonized with the U.S. FCC Part 15.255 requirements cited in [9] that were developed in response to the NPRM (Notice of Proposed Rulemaking) in ET Docket 94-124 [10]. This docket item included inputs and studies conducted by several automobile manufacturers and their suppliers, manufacturers of computer equipment, terrestrial and satellite communications companies and their suppliers, as well as industrial equipment manufacturers (Apple Computer, Cutler-Hammer, Fujitsu Ten, Hewlett-Packard, Honda Motor, Hughes, Lockheed Martin, Mitsubishi Electric, Motorola, NASA, *et. al.*) requesting a variety of considerations and protections of existing and future use of the 60 GHz band. This led to the commission of a group of interested parties known as the MMWWG (Millimetre Wave Working Group) and the establishment of license-exempt operation requirements noted earlier of +27 dBm peak transmitter output power, +40 dBm maximum average e.i.r.p. from 57,05 GHz to 64 GHz with spurious emissions at 90 pW/cm^2 from 40 GHz to 200 GHz at 3 meters and 500 uV/m from 960 MHz to 40 GHz.

Japanese regulations designate license-exempt operation in [14] at +10 dBm peak transmitter power into the antenna and +57 dBm maximum e.i.r.p. from 59 GHz to 66 GHz with maximum spurious emissions of 100 uW. The Republic of Korea has also designated the use of these operating parameters with a frequency allocation harmonized with the United States.

The UK regulator and competition authority Ofcom has also conducted studies of operations in the 60 GHz range as part of a study of license exempt operations at frequencies greater than 30 GHz [15].

Based on the experiences of WIGWAM project [16] in the EU and demonstration systems of the Fraunhofer Institute, the high oxygen, window, and building material absorption and the propagation behaviour in the 60 GHz range provide sufficient isolation between multiple applications operating with the same maximum radiated mean power using different antennas. These statements are based on calculations including those cited below.

Item			I v V	PP v WW/FH	PP v WW	PP v FH	PP v FH
Wavelength	m			5.00E-03	5.00E-03	5.00E-03	5.00E-03
Interferer Distance	**m**			20	6	9	115
Free Space Loss L_s	dB			94	84	87	109
Oxygen induced Loss	dB	16	dB/km	0	0	0	2
Window Barrier Loss		15	dB				
Path Loss	dB			109	99	102	126
Thermal Noise Floor		-174	dBm/Hz				
Victim Receiver Bandwith	**MHz**			325	325	325	325
Bandwidth Factor	dBHz			85	85	85	85
Victim Receiver Noise Figure	**dB**			10	10	10	10
Victim Receiver Noise Power	dBm			-79	-79	-79	-79
Noise/Interferer Threshold	dB			6	6	6	6
Victim Receiver Interferer Limit	**dBm**			**-85**	**-85**	**-85**	**-85**
Interferer Power P_t	dBm			0	0	0	0
Interferer Transmit Antenna Gain G0	**dBi**			38	38	38	38
Interferer EIRP	dBmi			38	38	38	38
Interferer Parasitic Siedelobe Gain G1	dBi			14	14	14	14
Interferer Effective Gain Gt				14	14	14	14
Received Isotropic Interferer Power	dBm			-95	-85	-88	-112
Victim Receiver Antenna Gain G_r	**dBi**			10	0	3	27
Received Interferer Power P_r	**dBm**			**-85**	**-85**	**-85**	**-85**
Margin	dB			0	0	0	0
Case				1	2	10	11
				PP side lobe aligend to FH high gain (27dBi) side lobe or aligend to WW low gain (10dBi) main beam	PP side lobe aligend to WW low gain (10dBi) side lobe	PP side lobe aligend to FH half omni	PP side lobe aligend to FH high gain (27dBi) main beam
							probability=
					/1,2/		0.08%

Figure C.1: Interference Calculations at 60 GHz

C.3 Sharing and compatibility issues

Frequency bands in 60 GHz range have been allocated in many countries outside the CEPT on both license-exempt and licensed bases for a variety of applications. The high frequency re-use achievable in the oxygen-absorption band reduces the requirement for sophisticated frequency planning techniques and offers the possibility of an international deregulated telecommunications environment for various low-power, low cost, short-range applications.

A number of new or existing systems could thus operate successfully in the range of 59 GHz - 66 GHz, thus relieving frequency congestion and reducing the demand for spectrum in lower frequency bands.

The current allocations in the 60 GHz range have led to a number of sharing and compatibility analyzes that are cited here. In particular, the consideration of sharing issues with earth-exploration satellite, fixed link wireless, and intelligent transportation systems had led to a significant amount of correspondence in the course of the FCC NPRM [10]. While similar studies were conducted in the course of the establishment of other unlicensed allocations [1], [2] and [14], the widespread participation in and availability of the former sharing studies have led to their frequent citation in the present document.

Earth-Exploration Satellite and Inter-Satellite

Certain of the frequency bands in the 60 GHz range are allocated and used for spaceborne remote sensing, and were first allocated at the 1979 World Administrative Radio Conference (WARC). Based on the analysis by NASA [20] and supported by Hughes and Lockheed-Martin [21], sharing between spaceborne sensors and a large number of terrestrial devices in this range is feasible. This is enabled by the attenuation characteristics of the oxygen absorption band and the orbital and sensor parameters of satellites using this frequency range. Taking into account a typical interference threshold of -166 dBw in a reference bandwidth of 100 MHz and orbital altitudes of 850 km, the interference level by a single transmitter is approximately 180 dB to 200 dB below the interference threshold, allowing up to 10^{19} transmitters in the main beam of a satellite-based sensor without causing interference. Other analysis [22] notes the lower interest in this range by satellite communications manufacturers.

Fixed Link

The adoption of license-exempt operation for the 60 GHz range had generally been supported by carriers and equipment manufacturers in the fixed link industry as an enabler of widely available, low cost customer premises equipment. These parties currently favour further expansion and liberalization of the license-exempt U.S. allocation [23]. The principal comments related to the relaxation of any requirements for a call sign or transmitter identification mechanism [24] and [25]. The possibility that spurious signals from new applications in the 60 GHz range would cause interference to existing fixed link networks operating at lower frequencies was not mentioned in any of the comments from the fixed link industry. That is, there were no concerns that sub-harmonics of 60 GHz radio systems would interfere with existing or planned systems operating in lower portions of the spectrum. Moreover, no concerns were expressed that spurious and harmonic signals at multiples of the 60 GHz range might interfere with communications systems operating all the way to frequencies above 100 GHz.

Intelligent Transportation Systems

Industry representatives from automobile manufacturers and tier 1 suppliers [26], [27] and [28] participated in the development of the U.S. allocation, which explicitly permit the mobile use of the 60 GHz range for mobile applications. Rationale was similar to the fixed link parties in the use of license-exempt regulation to enable the availability of vehicular on-board equipment (OBE). An exception to license-exempt usage was designated for field disturbance sensors, including vehicle radar systems, which primarily used the 76 GHz - 77 GHz range, consistent with European allocations.

History

Document history		
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