

# Review of Pulsed Radio-Frequency Standards and Public Health Awareness

## 1. Introduction

This report conducts a review of Public Health Guidelines, Regulatory Reporting and Public Awareness of non-ionising radiation (NIR) exposure limits contained within 1998 ICNIRP guidelines, EU Recommendation 1999/519/EC, EU Directive 2013/35/EU.

Research has a particular focus on Specific energy absorption levels (SA) and auditory effect limits. Report does not focus on ICNIRP 2020 guidelines as these guidelines removed Sensory effect limits (SA levels) and therefore contravene existing EU Directive 2013/35/EU

### Main Takeaways

1. During the 21<sup>st</sup> Century, the World Health Organization (WHO), failed to inform the Public about microwave hearing, and known eye damage caused by exposure to pulsed microwave signals (non-thermal levels)
2. During the 21<sup>st</sup> Century, UK/EU Regulators failed to measure and report on combined pulsed microwave signal exposures in the range 300Mhz – 10Ghz
3. For the entire 21<sup>st</sup> Century, the World Health Organization (WHO) have failed to inform the general public, and those workers who care for Children, about legally known and recognised health risks, from exposure to intense pulsed microwave wireless signals (2G – 5G, Wi-Fi etc.)

Please note, document has been proof read, however there may be some outstanding typo's, if you spot any, feel free to let me know.

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## 2. Methods

Analysis of 1998 ICNIRP Guidelines, EU Recommendation 1999/519/EC, EU Directive 2013/35/EU, Communication Regulator Site-surveys (Ireland<sup>iiiiiv</sup>, UK<sup>v</sup>, Netherlands<sup>vi</sup>), Reviewed websites and publications of WHO, EU Commission, Pubmed, Internet Archive, CWNP, BioElectromagnetic Society's online library, IEEE publications, UN Convention on the Rights of the Child, Technical Reference Manuals etc.

## 3. Background

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) was formed at the eighth international conference of the International Radiation Protection Association (IRPA, Montreal 8<sup>th</sup> – 22<sup>nd</sup> May 1992). ICNIRP's Charter of Incorporation states the organisation was '*established for the purpose of advancing **Non-Ionizing Radiation Protection for the benefit of people and the environment**, and in particular to provide guidance and recommendation on protection from NIR exposure*'<sup>vii</sup>.

ICNIRP has international standing and is '*formally recognized non-governmental organization in NIR protection for the WHO, the International Labour Organization (ILO), and the European Union (EU)*' (page 175 – Health Physics Vol 74).

ICNIRP published guidelines in 1998 for, '*limiting EMF exposure that will provide protection against known adverse health effects*'<sup>viii</sup>.

Reference levels contained within 1998 ICNIRP are incorporated into EU Recommendation 1999/519/EC

Research report, reviews Public Protection Guidelines, EU Recommendations, Regulatory reporting of Reference levels, and WHO Public Information and Awareness campaigns.

## 4. 1998 ICNIRP Guidelines

- 4.1 Page 506 of ICNIRP Guidelines contain details about 'well known microwave hearing effects' which can happen to people with normal hearing, and who are exposed to pulsed microwave signals in the range 200Mhz to 6.5Ghz. Using 2.45Ghz spectrum as an example, ICNIRP advise that energy threshold levels of between 100-400mJ/m<sup>2</sup> will cause a Specific energy absorption (SA) of 4–16mJ/kg<sup>-1</sup>. Also on page 506, ICNIRP advise retinal damage can occur at SA levels of 2.6mJ/kg<sup>-1</sup> for people who use timolol maleate<sup>ix</sup>. Timolol nitrate is used in treating glaucoma.

To protect the public, ICNIRP introduced an SA reference limit of 2mJ/kg<sup>-1</sup> and 10mJ/kg<sup>-1</sup> for workers (page 509, Reference Levels Table 4, Point 7<sup>x</sup>). Frequency range 200Mhz – 6.5Ghz used in microwave hearing example on page 506. ICNIRP reference Table 4 expands this spectrum range to 0.3Ghz – 10Ghz.

### 4.2 Signal Energy and SA extrapolation

When a 2.45Ghz signal with energy of 400mJ/m<sup>2</sup> generates an SA of 16mJ/kg<sup>-1</sup> and a signal of 100mJ/m<sup>2</sup> causes an SA of 4mJ/kg<sup>-1</sup>, by extrapolation we can say a signal of 250mJ/m<sup>2</sup> will generate an SA of 10mJ/kg<sup>-1</sup>, and a signal of 50mJ/m<sup>2</sup> results in an SA of 2mJ/kg<sup>-1</sup>. See below:

When 400(mJ)=16 (SA) and 100(mJ)=4(SA), we can estimate the following: 400=16, 300=12, 200=8, 100=4, ergo 50(mJ)=2(SA) and 250(mJ)=10(SA)

### 4.3 Unit conversion – energy (mJ) to power/density (mW/m<sup>2</sup>)

When converting units of measurement, a wireless signal travelling through free space with an energy of 1 millijoule per metre per second is said to have a power/density of 1mW/m<sup>2</sup><sup>xxix</sup>. Therefore from a power/density perspective, and using ICNIRPs' example we can determine, signals using 2.45Ghz spectrum with a power/density of circa 250mW/m<sup>2</sup> and 50mW/m<sup>2</sup> will respectively generate SAs' of 10mJ/kg<sup>-1</sup> and 2mJ/kg<sup>-1</sup>

#### 4.3.1 Technical note:

Due to 21<sup>st</sup> Century technical developments, 2.45Ghz Wi-Fi signals using OFDM & OFDMA<sup>xiii</sup> have increased Channel bandwidth, MIMO/MU-MIMO, use beacon frames (ms), inter-frames (μs), transmission control (ns) frames<sup>xiv</sup> etc. This combination of developments means when operating at high data rates/duty cycles, energy consumption of today's 50mW/m<sup>2</sup> pulsed signals (2.45Ghz), are not the same as those referenced in 1998 ICNIRP Guidelines e.g. at 100% duty cycle and full operational capacity, a 50mW/m<sup>2</sup> OFDMA signal will generate more than 50mJ of energy

## 4.4 Extracts from 1998 ICNIRP Guidelines

### 4.4.1 *Microwave hearing*

Special considerations for pulsed and amplitude-modulated waveforms (Page 506)'*Compared with continuous-wave (CW) radiation, pulsed microwave fields with the same average rate of energy deposition in tissues are generally more effective in producing a biological response...The microwave hearing" effect is a well known example of this (Frey 1961; Frey and Messenger 1973; Lin 1978): people with normal hearing can perceive pulse-modulated fields with frequencies between about 200 MHz and 6.5 GHz.*

*The auditory sensation has been variously described as a buzzing, clicking, or popping sound, depending on the modulation characteristics of the field. The microwave hearing effects have been attributed to a thermoelastic interaction in the auditory cortex of the brain, with a threshold for perception of about 100–400 mJ/m<sup>2</sup> for pulses of duration less than 30 μs at 2.45 GHz (corresponding to an SA of 4–16 mJ/kg<sup>-1</sup>). Repeated or prolonged exposure to microwave auditory effects may be stressful and potentially harmful'*

#### 4.4.2 **Retinal damage**

Some reports suggest that retina, iris, and corneal endothelium of the primate eye are sensitive to low levels of pulsed microwave radiation (Kues et al. 1985; UNEP/ WHO/IRPA 1993). Degenerative changes in light-sensitive cells of the retina were reported for absorbed energy levels as low as 26mJ/kg<sup>-1</sup>. After administration of timolol maleate<sup>xvi</sup>, the **threshold for retinal damage by pulsed fields dropped to 2.6 mJ/kg<sup>-1</sup>**. Note: Timolol Maleate is a well-known Glaucoma treatment

#### 4.4.3 **Reference levels – page 509, Table 4, Point 7**

Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, **in order to limit or avoid auditory effects** caused by thermoelastic expansion, **an additional basic restriction is recommended**. This is that the SA should not exceed 10 mJ/kg<sup>-1</sup> for workers and **2m mJ/kg<sup>-1</sup> for the general public**, averaged over 10 g tissue

4.4.4 Specific energy absorption (SA) – page 522. The energy absorbed per unit mass of biological tissue, (SA) expressed in joule per kilogram (J/kg<sup>-1</sup>)

## 5. **EU Recommendation 1999/519/EC**

5.1 As ICNIRP are formally recognised by the EU in the field of non-ionising radiation (NIR) protection, auditory effect limits contained in Annex II Basic restrictions, Table 1, Point 8 of EU Recommendation 1999/519/EC<sup>xvii</sup> are the same as those listed in ICNIRP's 'basic restrictions for time varying electric and magnetic fields for frequencies up to 10 Ghz' (Table 4, point 7<sup>xviii</sup>).

**SA levels for the general public should not exceed 2mJ/kg<sup>-1</sup> and 10mJ/kg<sup>-1</sup> for workers.**

## 6. **EU Communication Regulators & Regulatory Reporting**

6.1 As part of their spectrum management function, Communication Regulators in the UK & EU conduct non-ionizing radiation site-surveys to measure and report on public exposure from radio/antenna equipment used by Mobile Telecommunications providers, TV & Radio stations etc. Typical emissions measured include: GSM, LTE, UMTS, NR, TETRA, FM, WiMAX, Wi-Fi.

Prior to 2020, when conducting measurements of non-ionising radiation emissions, Ireland's Communications Regulator (ComReg) used a methodology<sup>xix</sup> that incorporated measurement procedures contained in ECC Recommendation (02)04<sup>xx</sup>, CENELEC - EN 50492<sup>xxi</sup>, and NIR exposure limits contained in EU Recommendation 1999/519/EC and 1998 ICNIRP guidelines.

Upon review of the non-ionising methodology document, page 114 lists ICNIRP Reference Table 6. This is not the correct reference table. ICNIRP's Reference Table 6 is for Workplaces, not the General Public – *Reference levels for occupational exposure to time-varying electric and magnetic fields (unperturbed rms values)*.

**Table 6 does not contain Auditory effect limits, which are used to protect the Public from microwave hearing.**

**Table 4 contains the Auditory Effect Limit – *Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 Ghz.***

This omission of ICNIRP's Table 4, and omission of Basic Restrictions contained in EU Recommendation 1999/519/EC (Annex II, Table 1, Point 8), helps explain why official site-survey measurements, conducted on behalf of EU/UK Communication Regulators do not contain auditory effect limits. There has been no measurement and reporting of combined pulsed microwave exposures in the range 0.3 – 10Ghz.

**Exclusion of ICNIRP's Reference Table 4 (Basic Restrictions up to 10Ghz), helps explain why Auditory Effect Limits have not been measured and reported by EU/UK Communication Regulators for over 20 years**

## 7. World Health Organisation (WHO)

### 7.1 WHO Symposium – 1973 (Warsaw, Poland)

In his opening remarks and welcome speech, Bernd H Deiterich (WHO, Division of Environmental Health) thanked all 60 participants for attending, and went on to say,

***'For the last five years, the WHO has been concerned about the health implications of the growing use of devices producing non-ionizing radiation and particularly microwave radiation'***

*'In view of the potential magnitude and significance of environmental pollution from microwaves, there appears to be a need for a national and international public health programs concerned with the evaluation and control of human exposure to microwave radiation.'*

The symposium reviewed 39 scientific papers over the course of 6 sessions. While a detailed analysis and review of all papers and recommendations is outside the scope of this report, it is interesting to note the following.

#### 7.1.1 'Retinal changes in microwave workers'

(B. Tengroth and E. Aurell, Dept of Ophthalmology, University of Gothenburg)

'The cataractogenic effect of exposure to microwaves has been reported by several authors... It is unknown whether the effect is thermal or nonthermal in origin. In this paper the authors show that in a factory where radar and other microwave equipment was tested an over-representation of lens opacities could be observed in personnel in the lower age groups. Furthermore it was noted that changes in the retina resembling chorioretinal scars were present in a significant number of workers.

#### 7.1.2 'Microwave cataract in man associated with concomitant annotated pathologies'

(M.M Zarat, Newy York, USA).

Zarat advised 'microwave cataracts can be classified as: (i) acute, (2) subacute or (3)delayed, and presented case study reports. 'Each of the case reports has a prima facie evidence of mW injury. A clear history of inhabiting mW environments and the signature radiation cataract. These cases have been selected from a reservoir of more than 50 patients having primary microwave cataract'.

#### 7.1.3 'Interaction of Electromagnetic Fields and Living Systems'

(C. Romero-Sierra, J.A. Tanner and J. Bigu del Blanco)

The authors had been working for over a decade on electromagnetic interaction and had put forward 3 field intensity categories corresponding to identifiable biological effects.

- Non-thermal ( $1\mu\text{W}-100\mu\text{W}/\text{cm}^2$ ),
- Thermal, non-heating ( $100\mu\text{W}-10\text{mW}/\text{cm}^2$ )
- Heating ( $10\text{mW}/\text{cm}^2$ ).

Note1:  $1\mu\text{W}/\text{cm}^2 = 10,000\mu\text{W}/\text{m}^2 = 10\text{mW}/\text{m}^2$  xxii

Note2:  $50\text{mW}/\text{m}^2$  (auditory effect limit) is 5x higher than 1973 non-thermal field intensity recommendation

## 7.2 WHO – Public Awareness Campaigns

- 7.2.1 To date there is no listing of any WHO Public Information and Awareness campaign, informing the General Public about risks of microwave cataracts and eye damage from non-thermal exposure to pulsed microwave signals
- 7.2.2 To date there is no listing of any WHO Information and Awareness campaign, informing the general public about 'well known' microwave hearing effects and related SA levels
- 7.2.3 To date there is no listing of any WHO requests requiring EU/UK Communication Regulators, to Measure, Report, and Inform the General Public about audio-visual health risks from pulsed wireless microwave exposure in the range 0.3Ghz – 10Ghz (non-thermal levels).

## 7.3 WHO – Global Health Observatory, Radio-frequency limits (Children, Schools, Hospitals etc.)

- 7.3.1 In 2017, as part of its Global Health Observatory data repository, the WHO published Radio-frequency limits for a selected number of countries, re:900Mhz & 1800Mhz spectrum.

As WHO EMF guidelines are listed as 'basic', 2017 listings provided the public with examples of Countries/Regions where more advanced guidelines are in operation, especially for areas frequented by Children, and those considered to be 'Sensitive Use' or require 'Special Attention' e.g. Hospitals, Nurseries, Schools and places where people spend more than 4 hours (e.g. peoples homes).

Below are examples of countries with more advanced pulsed radiation public protection:

- Belgium – Brussels 96 mW/m<sup>2</sup> (max total, each operator gets 33% of the total)
- Chile – exposure limits of 1,000 mW/m<sup>2</sup> for base stations (800-2200Mhz)
- Chile – 'sensitive areas' e.g. schools, hospitals and nurseries exposure limit reduced to 100mW/m<sup>2</sup>
- Israel – maximum power density exposure equals 10% of ICNIRP reference levels - 450mW/m<sup>2</sup> (900Mhz) and 900mW/m<sup>2</sup> (1800Mhz)
- Israel – mandatory for each base station to obtain a specific permit with the minimum exposure possible that enables provision of needed coverage and capacity
- Italy – maximum power/density exposure level is set at 1,000mW/m<sup>2</sup> (90% lower for schools & homes)
- Italy – Schools, Homes, Playgrounds and areas people spend more than 4 hours, an 'attention value' of 100mW/m<sup>2</sup> (100mW/m<sup>2</sup>) is used (averaged over 24 hrs)
- Turkey – Total EMF exposure inside hospital 3V/m (all frequency ranges)
- Turkey – 270mW/m<sup>2</sup> (900Mhz) and 550mW/m<sup>2</sup> (1800Mhz)
- **ICNIRP Levels = 4,500mW/m<sup>2</sup> (900Mhz) and 9,000 mW/m<sup>2</sup> (1800Mhz)**

Unfortunately this information is no longer published on the WHO's website. However it is possible to review published 2017 data by accessing the internet archive<sup>xxiii</sup> and using this URL<sup>xxiv</sup>.

Example screen-captures of WHO Data Repository are listed on pages 10 - 12

**Note 1:** 1800Mhz and 900Mhz are within the spectrum range 0.3 – 10Ghz, yet no reference is made to the auditory effect limit promoted by WHO

**Note 2:** As per section 4.3, whilst acknowledging conversion limitations,  $50\text{mW}/\text{m}^2 = 4.34\text{V}/\text{m}^{\text{xxv}}$

As many countries face energy constraints, the position taken by Israel seems to make particular sense. Requiring mobile providers to optimise energy use, and limit pulsed microwave emissions to operational levels is something that appears sensible.

In order to save energy, and conserve wireless spectrum, it does seem logical that mobile operators in all countries would introduce similar spectrum/energy saving strategies as Israel.



## 8. WHO Global Health Observatory and Protection Limits for Children

As intense, and chronic pulsed wireless exposure is a legally recognised health risk, the Public have a right to be informed about up-to-date public exposure levels.

In demonstrating a bias for Children, and Public Health, it seems appropriate the WHO would consider the following:

1. Re-introduce and make publicly available an updated version of it's Data Repository containing accurate listings of all countries that adopted WHO basic EMF guidelines. This listing would also contain exposure limits/policies relating to licensed and unlicensed microwave spectrum bands (0.3 – 10Ghz), with a particular focus on pulsed radiation emission policies affecting Children, Schools, Hospitals other areas of 'sensitive use'.
2. Re-iterate the 2011 warning (Resolution 1815<sup>xxvi</sup>) sent by the Council of Europe to Governemnts in the USA, UK and all EU members states regarding pulsed microwave radiation exposure and health risks to Children. Most especially, call on schools to opt for wired networks, and where Wi-Fi is already in place, ensure no child is exposed to intense, energy wasting levels of pulsed microwave radiation, that may cause headaches, brain fog etc.
3. Provide an advisory for schools that already have Wi-Fi, to limit children's exposure to active use only. Active use simply means only use Wi-Fi when needed, and turn Off Wi-Fi when it's not required. This simple, straight forward step will also save school energy use.
4. Call on Schools/Hospitals and all Workplaces in the EU to actively implement legally required wireless risk assessments, and staff training contained in (EU Directive 2013/35/EU). This will ensure all staff members are aware of a) At particular risk worker groups, b) Dangers and Risks from wireless exposure (non-thermal), c) Legal obligations re:General & Specific EMF risk assessments, d) Workplace Sensory Effect Limits, e) Mitigation policies to eliminate intense exposures e.g. not sitting close to a Wi-Fi router, Wi-Fi printer etc.
5. With regards to Children, and acting in their best interests. WHO would call upon authorities to introduce new legislation that protects Children. Working adults are currently entitled to wireless workplace protection, and have 'at particular groups' legally recognised. Not providing similar legal protections for Children (and General Public), discriminates and contravene's Guiding Principle 2 of United Nations Convention on the Rights of the Child, – Best Interests of the Child (UNCRC <sup>xxvii</sup>).
6. With regards to the General Public, the WHO can demand it's Public Auditory Effect limit listed in 1998 guidelines are strictly implmented, and adhered to.

## 9. Conclusions

- 9.1 EU and UK Communication Regulatory agencies have failed to report on pulsed microwave radiation limits contained in 1999/519/EC & 1998 ICNIRP guidelines
- 9.2 Combined pulsed microwave signal exposures in the range 0.3Ghz – 10Ghz have not been measured, reported, and shared with the General Public. This represents a clear failure to inform the Public, by UK/EU Communication Regulators
- 9.3 Public are unaware of microwave hearing, retinal damage, and related health risks from intense levels (non-thermal) of pulsed microwave exposures (Wi-Fi, 2-5G etc.)
- 9.4 Existing official site-survey measurements confirm children and general public, are currently subjected to pulsed microwave signals which significantly exceed auditory effect limits e.g. in the Utrecht region of the Netherlands public exposure is over 60 times 1998 ICNIRP's auditory effect limit.
- 9.5 For over 20 yrs, WHO have failed to inform the Public about known health risks from intense, non-thermal levels of Wi-Fi exposure, and other sources of pulsed microwave signals (2G - 5G, etc.)
- 9.6 For over 20 yrs, WHO have not advised or informed the Public, about the failure of Communication Regulators to Measure, Report, and Publish information regarding Auditory Effect Limits and levels.

# WHO Data Repository – 900MHz & 1800MHz Exposure Limits By Country

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### Exposure limits for radio-frequency fields (public) Data by country

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Country	Year	Radiofrequency						
		Electric field (V/m) <sup>i</sup>		Power density (W/m <sup>2</sup> ) <sup>i</sup>		Specific absorption rate (SAR) (W/kg) <sup>i</sup>		
		900 MHz	1800 MHz	900 MHz	1800 MHz	Whole body	Head and trunk	Limbs
Argentina	2017	41.25	58.36	4.5	9	0.08	2	4
Australia	2017	41.1 <sup>i</sup>	58.1 <sup>i</sup>	4.5 <sup>i</sup>	9 <sup>i</sup>	0.08	2	4
Austria	2017	41.25	58.34	4.5	9	0.08	2	4
Bahrain	2017	41	58	4.5	9	0.08	2	4
Belgium	2017	<sup>i</sup>	<sup>i</sup>	<sup>i</sup>	<sup>i</sup>			
Brazil	2017	41.25	58.34	4.5	9	0.08	2	4
Bulgaria	2017	6.14 <sup>i</sup>	6.14	0.1 <sup>i</sup>	0.1			
Canada	2017	32.1 <sup>i</sup>	40.07 <sup>i</sup>	2.74 <sup>i</sup>	4.4 <sup>i</sup>	0.08	1.6 <sup>i</sup>	4
Chile	2017			0.1/1.0 <sup>i</sup>	0.1/1.0 <sup>i</sup>	1.6/2 <sup>i</sup>	1.6/2 <sup>i</sup>	1.6/2 <sup>i</sup>

## No Auditory Effect Limits contained in WHO 2017 Data Repository

### 1800MHz & 900MHz within Auditory Effect Limit range

Auditory Effect Limit  
E-field 4.34V/m  
P/D 50mW/m<sup>2</sup> = 0.05W/m<sup>2</sup>

Turkey only country with limit lower than Auditory Effect Limit (hospital 3V/m)

No English speaking country listed with improved protection limits for Children, Schools, Hospitals or any defined 'Sensitive' / 'Attention' areas

## WHO Data Repository – Country exposure limit, Turkey

### Exposure limits for radio-frequency fields (public) Data by country

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		Radiofrequency						
		Turkey, 2017, Radiofrequency, Electric field (V/m), 900 MHz						
		<p>3 V/m: limit per antenna for schools and hospitals (for hospitals a 3 V/m limit (not frequency dependent) is required inside the building for EMC reasons); 10.23 V/m: limit for a single installation; 41 V/m: limit for cumulative exposure from multiple antenna locations. The total exposure cannot exceed ICNIRP and per antenna it should not exceed 1/4 of ICNIRP field limits (1/16 power density).</p> <p><b>Comment:</b></p> <p>Value: 3/10.23/41.0</p> <p>Details: WHO region: Europe, Exposed: Public</p> <p>Effective date: 2017-05-31</p> <p>Close</p>						
Country	Year	900 MHz	1800 MHz	Whole body	Head and trunk	Limbs		
Russian Federation	2017			1	1			
Saudi Arabia	2017	41.25	58.34	4.5	9	0.08	2	
South Africa	2017	[41.0]	[58.0]	[4.5]	[9.0]	[0.08]	[2]	
Sweden	2017	[41.25]	[58.33]	[4.5]	[9]	[0.08]	[2]	
Switzerland	2017	4/41.25 <sup>i</sup>	6/58.34 <sup>i</sup>					
Tunisia	2017	41	58	4.5	9	0.08	2	
Turkey	2017	3/10.23/41.0 <sup>i</sup>	3/14.5/58 <sup>i</sup>	0.27	0.55		2	
United Kingdom of Great Britain and Northern Ireland	2017	[41.25]	[58.34]	[4.5]	[9.0]	[0.08]	[2]	

## WHO Data Repository – Country exposure limit, Italy

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		Radiofrequency						
		Electric field (V/m) <sup>i</sup>		Power density (W/m <sup>2</sup> ) <sup>i</sup>		Specific absorption rate (SAR) (W/kg) <sup>i</sup>		
Country	Year	900 MHz	1800 MHz	900 MHz	1800 MHz	Whole body	Head and trunk	Limbs
Germany	2017	41.25	58.34	4.5	9	0.08	2	4
Greece	2017	31.9/34.5 <sup>i</sup>	45.1/48.8 <sup>i</sup>	2.7/3.15 <sup>i</sup>	5.4/6.3 <sup>i</sup>	0.048/0.056/0.08 <sup>i</sup>	1.2/1.4/2.0 <sup>i</sup>	2.4/2.8/4.0 <sup>i</sup>
Iran (Islamic Republic of)	2017	41.25	58.34	4.5	9			
Israel	2017	[13.0]	[18.0]	[0.45] <sup>i</sup>	[0.9] <sup>i</sup>	[0.08]	[2]	[4]
Italy	2017	6/20 <sup>i</sup>	6/20 <sup>i</sup>	0.1/1.0 <sup>i</sup>	0.1/1.0 <sup>i</sup>	0.08	2	4
Japan	2017	47.5	64.4	6	12	0.08	2	4
Russia	2017	41.25	58.34	4.5	9	0.08	2	4

Italy, 2017, Radiofrequency, Power density (W/m<sup>2</sup>), 900 MHz

The exposure limit is 1 W/m<sup>2</sup>. Moreover, in homes, schools, playgrounds and places where people may stay for longer than 4 hours, an 'attention value' of 0.1 W/m<sup>2</sup> is applied and averaged over any 24 hour period. A 'quality goal' for new installations is identical to the attention value.

**Comment:**

Value: 0.1/1.0

Details: WHO region: Europe, Exposed: Public

Effective date: 2017-05-31

Close

Italy, 'attention value' (100mW/m<sup>2</sup>) for homes, schools, & places where people stay more than 4 hours is twice 'auditory effect limit' (1999/519/EC)

## ICNIRP Reference Table 6, used by Regulators for Site-Survey Analysis

Frequency range	E-field strength (V m <sup>-1</sup> )	H-field strength (A m <sup>-1</sup> )	B-field (μT)	Equivalent plane wave power density $S_{eq}$ (W m <sup>-2</sup> )
up to 1 Hz	—	$3.2 \times 10^4$	$4 \times 10^4$	—
1–8 Hz	10,000	$3.2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8–25 Hz	10,000	$4,000/f$	$5,000/f$	—
0.025–0.8 kHz	$250/f$	$4/f$	$5/f$	—
0.8–3 kHz	$250/f$	5	6.25	—
3–150 kHz	87	5	6.25	—
0.15–1 MHz	87	$0.73/f$	$0.92/f$	—
1–10 MHz	$87/f^{1/2}$	$0.73/f$	$0.92/f$	—
10–400 MHz	28	0.073	0.092	2
400–2,000 MHz	$1.375f^{1/2}$	$0.0037f^{1/2}$	$0.0046f^{1/2}$	$f/200$
2–300 GHz	61	0.16	0.20	10

<sup>a</sup> Note:

1.  $f$  as indicated in the frequency range column.
2. Provided that basic restrictions are met and adverse indirect effects can be excluded, field strength values can be exceeded.
3. For frequencies between 100 kHz and 10 GHz,  $S_{eq}$ ,  $E^2$ ,  $H^2$ , and  $B^2$  are to be averaged over any 6-min period.
4. For peak values at frequencies up to 100 kHz see Table 4, note 3.
5. For peak values at frequencies exceeding 100 kHz see Figs. 1 and 2. Between 100 kHz and 10 MHz, peak values for the field strengths are obtained by interpolation from the 1.5-fold peak at 100 kHz to the 32-fold peak at 10 MHz. For frequencies exceeding 10 MHz it is suggested that the peak equivalent plane wave power density, as averaged over the pulse width does not exceed 1,000 times the  $S_{eq}$  restrictions, or that the field strength does not exceed 32 times the field strength exposure levels given in the table.
6. For frequencies exceeding 10 GHz,  $S_{eq}$ ,  $E^2$ ,  $H^2$ , and  $B^2$  are to be averaged over any  $68/f^{1.65}$ -min period ( $f$  in GHz).
7. No E-field value is provided for frequencies <1 Hz, which are effectively static electric fields. perception of surface electric charges will not occur at field strengths less than  $25 \text{ kV m}^{-1}$ . Spark discharges causing stress or annoyance should be avoided.

**Table 34: ICNIRP 1998 Reference levels for general public exposure to time-varying electric and magnetic fields (unperturbed rms values)<sup>44</sup>**

<sup>44</sup> Source ICNIRP 1998, p. 511

**ICNIRP Reference Table 6 (above) contains No Public Auditory Effect Limit**

## ICNIRP Reference Table 4 - Basic restrictions up to 10GHz (auditory effects)

**Table 4.** Basic restrictions for time varying electric and magnetic fields for frequencies up to 10 GHz.<sup>a</sup>

Exposure characteristics	Frequency range	Current density for head and trunk (mA m <sup>-2</sup> ) (rms)	Whole-body average SAR (W kg <sup>-1</sup> )	Localized SAR (head and trunk) (W kg <sup>-1</sup> )	Localized SAR (limbs) (W kg <sup>-1</sup> )
Occupational exposure	up to 1 Hz	40	—	—	—
	1–4 Hz	40/ <i>f</i>	—	—	—
	4 Hz–1 kHz	10	—	—	—
	1–100 kHz	<i>f</i> /100	—	—	—
	100 kHz–10 MHz	<i>f</i> /100	0.4	10	20
	10 MHz–10 GHz	—	0.4	10	20
General public exposure	up to 1 Hz	8	—	—	—
	1–4 Hz	8/ <i>f</i>	—	—	—
	4 Hz–1 kHz	2	—	—	—
	1–100 kHz	<i>f</i> /500	—	—	—
	100 kHz–10 MHz	<i>f</i> /500	0.08	2	4
	10 MHz–10 GHz	—	0.08	2	4

<sup>a</sup> Note:

1. *f* is the frequency in hertz.
2. Because of electrical inhomogeneity of the body, current densities should be averaged over a cross-section of 1 cm<sup>2</sup> perpendicular to the current direction.
3. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by  $\sqrt{2}$  (~1.414). For pulses of duration  $t_p$ , the equivalent frequency to apply in the basic restrictions should be calculated as  $f = 1/(2t_p)$ .
4. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
5. All SAR values are to be averaged over any 6-min period.
6. Localized SAR averaging mass is any 10 g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure.
7. For pulses of duration  $t_p$ , the equivalent frequency to apply in the basic restrictions should be calculated as  $f = 1/(2t_p)$ . Additionally, for pulsed exposures in the frequency range 0.3 to 10 GHz and for localized exposure of the head, in order to limit or avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed 10 mJ kg<sup>-1</sup> for workers and 2mJ kg<sup>-1</sup> for the general public, averaged over 10 g tissue.

Table 4 (above) excluded from site-survey documentation used by Communication Regulators

**Communication Regulators in countries that adopted 1998 ICNIRP, have not measured, and informed the Public about 'Auditory Effect Limits'**

## EU Recommendation 1999/519/EC

### Annex II, Table 1, Point 8 contains 'Auditory Effect Limits'

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4. For frequencies up to 100 kHz, peak current density values can be obtained by multiplying the rms value by  $\sqrt{2}$  ( $\sim 1,414$ ). For pulses of duration  $t_p$  the equivalent frequency to apply in the basic restrictions should be calculated as  $f = 1/(2t_p)$ .
5. For frequencies up to 100 kHz and for pulsed magnetic fields, the maximum current density associated with the pulses can be calculated from the rise/fall times and the maximum rate of change of magnetic flux density. The induced current density can then be compared with the appropriate basic restriction.
6. All SAR values are to be averaged over any six-minute period.
7. Localised SAR averaging mass is any 10g of contiguous tissue; the maximum SAR so obtained should be the value used for the estimation of exposure. These 10g of tissue are intended to be a mass of contiguous tissue with nearly homogeneous electrical properties. In specifying a contiguous mass of tissue, it is recognised that this concept can be used in computational dosimetry but may present difficulties for direct physical measurements. A simple geometry such as cubic tissue mass can be used provided that the calculated dosimetric quantities have conservative values relative to the exposure guidelines.
8. For pulses of duration  $t_p$  the equivalent frequency to apply in the basic restrictions should be calculated as  $f = 1/(2t_p)$ . Additionally, for pulsed exposures, in the frequency range 0,3 to 10 GHz and for localised exposure of the head, in order to limit and avoid auditory effects caused by thermoelastic expansion, an additional basic restriction is recommended. This is that the SA should not exceed  $2\text{mJ kg}^{-1}$  averaged over 10 g of tissue.

**EU Regulators have failed to Measure, and Publish, Public Protection limits contained in 1999/519/EC**

**EU/UK Regulators have failed to inform the Public about Auditory Effects**



## Examples of Public Exposure Levels Exceeding Auditory Effect limits

### Site-Survey Analysis Published by Regulators – Netherlands, Ireland & UK

Explanatory conversion note:

Comparisons are made by converting published site-survey V/m readings to mW/m<sup>2</sup> and comparing those figures to 50mW/ m<sup>2</sup> (auditory effect limit). As mentioned and acknowledged in section 4.3, conversions are not 100% accurate and exact for all operating conditions, however they will suffice for demonstration purposes. Official and published site-surveys, conducted on behalf of Communication Regulators in Ireland, Netherlands and UK, demonstrate public exposure levels exceed auditory effect limits contained in EU Recommendation 1999/519/EC.

#### Netherlands – Utrecht (2020)

- Max exposure 35.54V/m approx 6,700% above auditory limit
- 35.54V/m = P/D 3,350mW/m<sup>2</sup>
- Min exposure 9.551V/m approx 500% above auditory limit
- 9.551V/m = 242mW/m<sup>2</sup>
- Avg exposure 13.80V/m approx 1,000% above auditory limit
- 13.80V/m = 505mW/m<sup>2</sup>


## 5. Meting

### 5.1 Breedband meting

Tijdens de breedbandmeting (100 kHz t/m 6 GHz) is er zes minuten continu gemeten.

*Maximum* de hoogste veldsterkte die (kortstondig) is waargenomen tijdens meting.  
*Average* de gemiddelde veldsterkte gerekend over meting.  
*Minimum* de laagste veldsterkte die is waargenomen tijdens meting.

#### Breedbandige veldsterktemeting 1, op het balkon

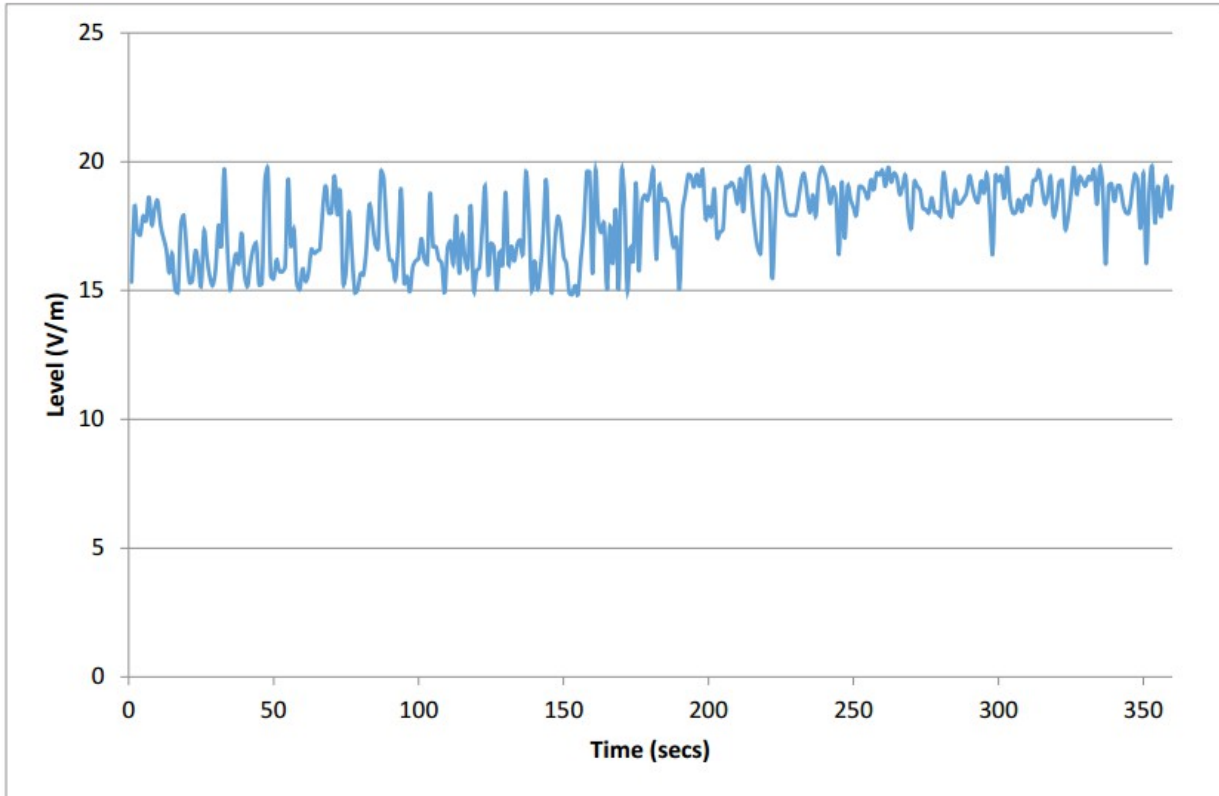
Values	Graph	Info	General	
		Date	08/19/2020	
		Time	10:04:42 AM	
<b>Meter</b>	<b>Probe</b>	<b>Coordinates</b>		
Model: NBM-550	Model: EF0691	Latitude:	52.09267	
S/N: G-0682	S/N: H-0216	Longitude:	5.11796	
Result Type	Actual	Maximum	Average	Minimum
E-Field	16.65 V/m	35.54 V/m	13.80 V/m	9.551 V/m



**Ireland – Cork, Grafton Mall (2021)**

- **Peak exposure 19.81V/m approx 2,000% above auditory limit**
- 19.81V/m = P/D 1,041mW/m<sup>2</sup>
- **Mean exposure 17.68V/m approx 1,600% above auditory limit**
- 17.68V/m = P/D 829mW/m<sup>2</sup>

Electric field strengths recorded over 6 minute period using 3 GHz probe at point of maximum NIR



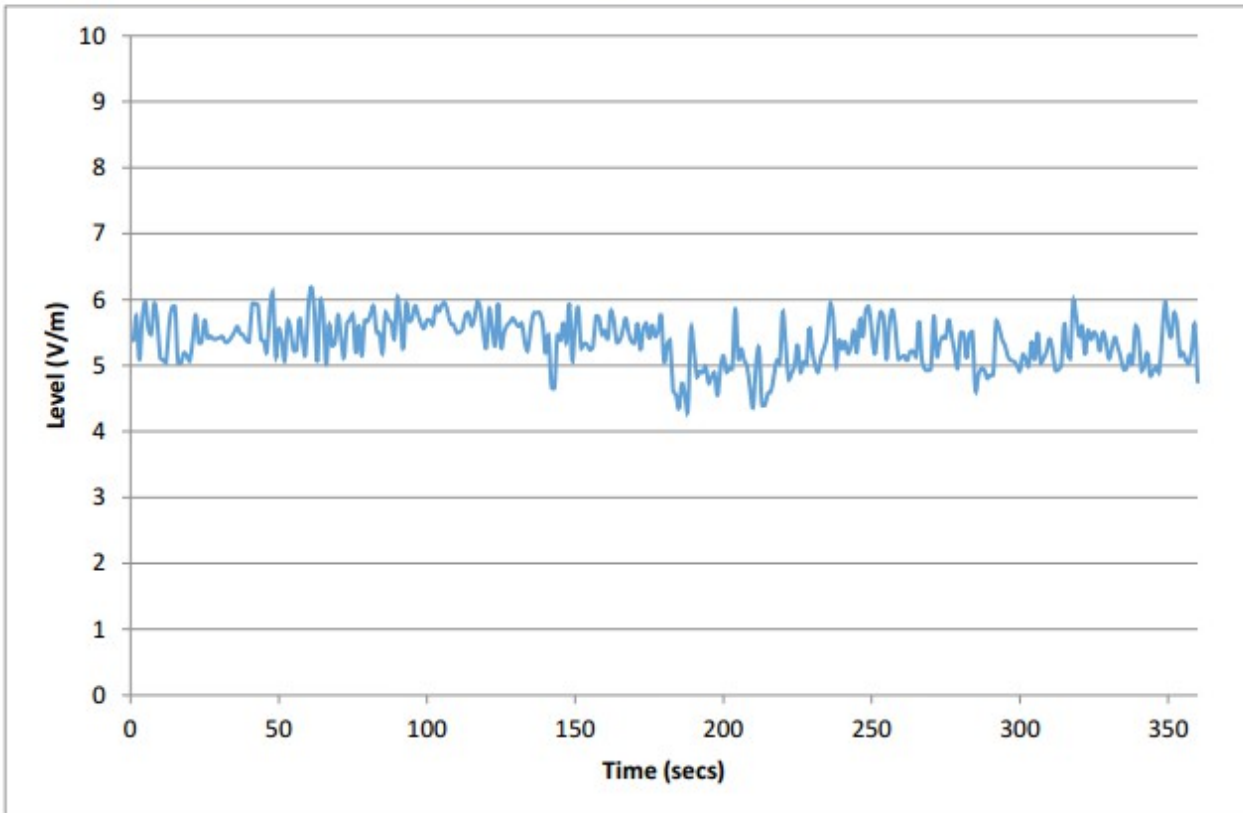
Acquisition Mode: 1 Sec. Sampling

<b>Mean Measurement V/m:</b>	17.68 V/m	<b>Peak Measurement V/m:</b>	19.81 V/m
<b>Date:</b>	22/06/2021	<b>Start Time:</b>	10:52
<b>Meter:</b>	NBM-550	<b>Probe:</b>	EF3091
<b>Frequency Range:</b>	100 kHz – 3 GHz		

## Ireland – Waterford City, 2018

- Peak exposure 6.19V/m, approx 200% above auditory limit
- $6.19\text{V/m} = \text{P/D } 102\text{mW/m}^2$
- Mean exposure 5.36V/m approx 50% above auditory limit
- $5.36\text{V/m} = \text{P/D } 76\text{mW/m}^2$

Electric field strengths recorded over 6 min period using 3 GHz probe at point of max NIR:



Acquisition Mode: 1 Sec. Sampling

Mean Measurement V/m:	5.36 V/m	Peak Measurement V/m:	6.19 V/m
Date:	27/06/2018	Start Time:	11:10
Meter:	NBM-550	Probe:	EF3091
Frequency Range:	100 kHz – 3 GHz		

## UK, England – Canary Wharf & Charing Cross

Auditory effect limit = 50mW/m<sup>2</sup> (1999/519/EC & 1998 ICNIRP)

Auditory effect limit = 0.5% of Max Device Exposure Limit (10W/m<sup>2</sup>)

Canary Wharf and Charing Cross are both greater than 0.5% (auditory limit)

- Canary Wharf exposure, approx 300% above auditory limit
- Charing Cross exposure, approx 20% above auditory limit

**Table 4.1: Highest average exposure levels at all locations visited<sup>13</sup>**

City	Measurement location	Highest All Band value (% of ICNIRP level)	Highest 5G Band value (% of ICNIRP level)
Belfast	Lanyon Place	0.0807	0.0006
Birmingham	Mailbox Birmingham	0.4688	0.0386
Bristol	Aztec West Business Park	0.1431	0.0010
	St Augustine's Parade	0.0460	0.0068
Cardiff	Newport Road	0.0978	0.0016
	The Senedd	0.1195	0.0060
	St David's Centre	0.0823	0.0041
Edinburgh	Gorgie Road	0.1419	0.0004
Glasgow	Renfrew Street	0.1399	0.0044
	Harker Street	0.4608	0.0239
Liverpool	Lawrence Road	0.1371	0.0069
	Hatton Garden	0.0894	0.0011
	Canary Wharf	1.4960	0.0000
London	Charing Cross	0.5970	0.0014
	Grays Inn Road	0.0420	0.0013
	Pentonville Road	0.0711	0.0117
	Victoria Station	0.2483	0.0042
	Waterloo Station	0.3828	0.0065
Manchester	Chester Road	0.3017	0.0053
	Crumpsall Vale	0.0736	0.0016
	Great Bridgewater Street	0.2460	0.0019

## **About the author: Allan Brennan**

Allan has held a number of senior positions within the Tech/Telecoms Industry. Worked for Global Corporations, and Tech startups. Founded two wireless companies, developed and promoted wireless services, interested in wireless regulatory & operational requirements, spectrum/energy saving, and related activities.

Became aware of workplace wireless health & safety requirements in 2017. Has a particular interest in Children's Health, and reducing known health risks from intense/chronic levels of Wi-Fi exposure, and other sources of pulsed microwave radiation

- Bio-Electromagnetic Society (Associate member)
- Children's Health Defense (Senior Wireless Fellow)
- Director of Irish Internet Society
- Founder GigaBeam Ireland
- Founder WiFi Projects
- Introduced Commercial mmW spectrum (71-86Ghz) – 30 month Programme, 1<sup>st</sup> EU Test license
- Awarded Fellow of Irish Computer Society – For Contribution/Promotion of Irish Wireless Industry
- SAP Technical Consultant – BASIS, ITS, Workflow
- Technical Manager – ESAT/BT

- i [https://www.comreg.ie/\\_fileupload/Dublin%20Blackrock%20Main%20St%200982\\_1.pdf](https://www.comreg.ie/_fileupload/Dublin%20Blackrock%20Main%20St%200982_1.pdf)
- ii <https://www.comreg.ie/media/2022/11/Galway-Tesco-Express.pdf>
- iii <https://www.comreg.ie/media/2023/03/Elm-Park-New-Ross.pdf>
- iv <https://www.comreg.ie/media/2022/03/Wexford-New-Ross.pdf>
- v [https://www.ofcom.org.uk/\\_data/assets/pdf\\_file/0015/190005/emf-test-summary.pdf](https://www.ofcom.org.uk/_data/assets/pdf_file/0015/190005/emf-test-summary.pdf)
- vi <https://antenneregister.nl/Html5Viewer/Index.html?viewer=Antenneregister%5Fextern> (NIR Report conducted on 19&20<sup>th</sup> Aug 2020 at Vinkenburgstraat, Utrecht. *Max 35.54V/m, Minimum 9.551V/m, Average Mean 13.80, Actual 16.65V/m* Spectrum range 100Khz – 6Ghz)
- vii <http://www.icnirp.org/cms/upload/doc/charter.pdf>
- viii <https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf> (page 494)
- ix <https://www.globalresearchonline.net/journalcontents/volume3issue1/Article%20005.pdf>
- x <https://www.icnirp.org/cms/upload/publications/ICNIRPemfgdl.pdf> (page 509, table 4, point 7)
- xi <https://www.britannica.com/science/joule>
- xii <https://www.convertunits.com/from/millijoule/second/to/milliwatt>
- xiii <https://blogs.arubanetworks.com/solutions/the-power-of-ofdma/>
- xiv [https://www.cwnp.com/uploads/802-11\\_arbitration.pdf](https://www.cwnp.com/uploads/802-11_arbitration.pdf)
- xv <https://www.cwnp.com/6thingstoexpectfromax/>
- xvi <https://www.globalresearchonline.net/journalcontents/volume3issue1/Article%20005.pdf>
- xvii <https://op.europa.eu/en/publication-detail/-/publication/9509b04f-1df0-4221-bfa2-c7af77975556/language-en> (Page 1999/65 Annex II Basic Restrictions, Table 1, Note 8)
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- xx <https://docdb.cept.org/download/1889>
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- xxii <https://www.unitjuggler.com/convert-power-from-microwatt-to-mW.html?val=10000>
- xxiii <https://archive.org/web/>)
- xxiv <https://apps.who.int/gho/data/node.main.EMFLIMITSPUBLICRADIOFREQUENCY?lang=en>)
- xxv <https://www.powerwatch.org.uk/science/unitconversion.asp>
- xxvi <https://assembly.coe.int/nw/xml/XRef/Xref-XML2HTML-en.asp?fileid=17994>
- xxvii <https://www.unicef.org/armenia/en/stories/four-principles-convention-rights-child>