GSMA™

The 15th GSMA EMF Forum

Evidence-based EMF policy

Tuesday, 13 October 2026



© GSMA 2026

#EMFFORUM

Introduction



Dr Jack Rowley
Senior Director,
EMF & Deployment Policy
GSMA



Mike Wood
Telstra
Chair GSMA EMF and Health

Welcome

Celebrating 15th GSMA EMF Forum

2010

2010: 4G arrives

In December 2009, Ericsson launched the world's first commercial 4G network in collaboration with TeliaSonera (previously Swedish PTT Televerket). The network was based on the new standard for mobile telecommunication systems: LTE, Long Term Evolution.



In December 2009 TeliaSonera launched the world's first and largest commercial Long Term Evolution (LTE) service in Stockholm, supplied by Ericsson. This historic rollout was completed well ahead of plan.

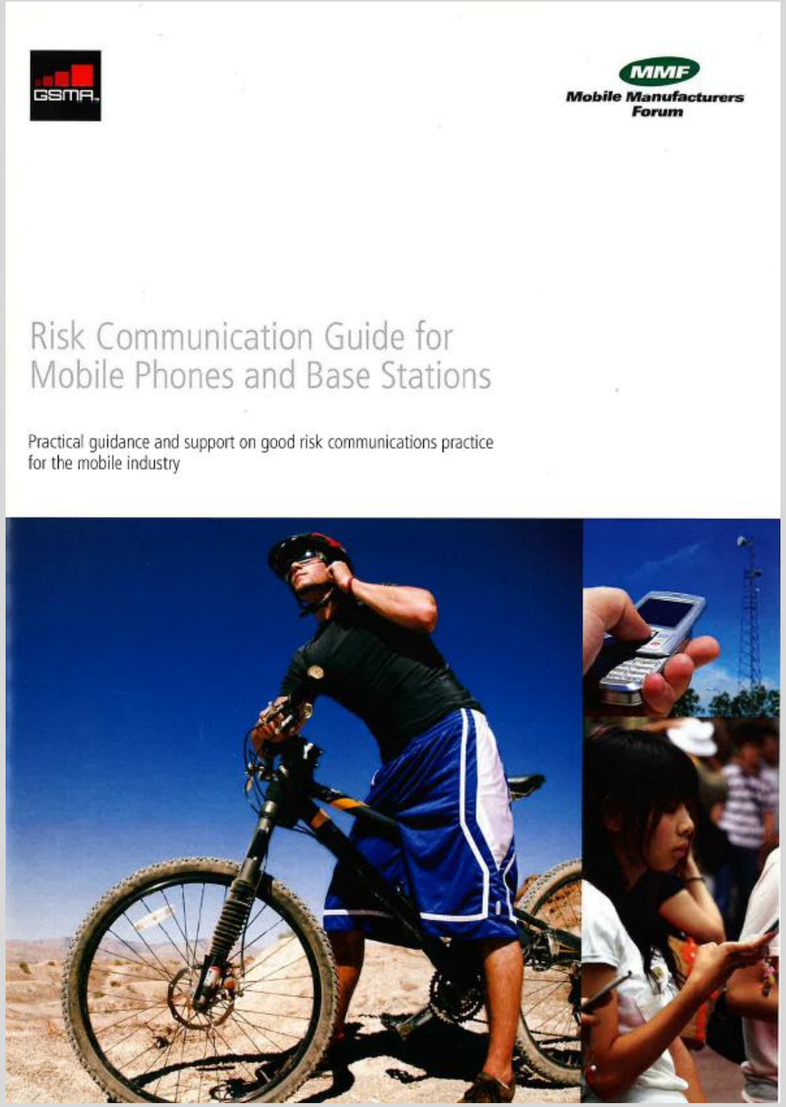
© GSMA 2026

2010



© GSMA 2026

2010







© GSMA 2026

2010

Invitation
13-14 October 2010
GSMA Europe
Park View – 4th floor
Chaussée d'Etterbeek 180
B- 1040 Brussels

GSMA EUROPE MEMBERS' EMF FORUM

GSMA Europe is pleased to confirm your participation to our members' forum on electromagnetic fields which will take place on 13-14 October 2010 in our Brussels offices.

The aim of this Forum is to provide an update on science and research as well as on public policies related to EMF at the international and EU level. The format will be highly interactive and case study driven with a focus on the exchange of good practice between participants. The agenda will allow time for sharing risk communication experiences and knowledge sharing from across Europe, making the Forum an event by members for members.

© GSMA 2026

2011

World Health Organization

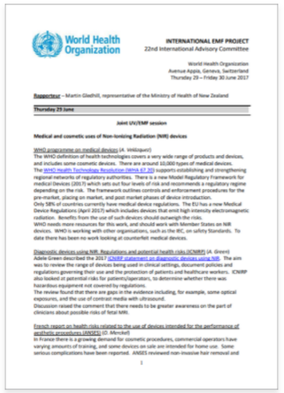
Health Topics | Countries | Newsroom | Emergencies | Data | About WHO

Home / Publications / Overview / EMF Project - International Advisory Committee 2011

EMF Project - International Advisory Committee 2011

Meeting minutes

16 May 2011 | Publication



INTERNATIONAL EMF PROJECT
22nd International Advisory Committee

World Health Organization
Avenue Appia, Geneva, Switzerland
Thursday 29 – Friday 30 June 2017

Rapporteur – Martin Gledhill, representative of the Ministry of Health of New Zealand

Thursday 29 June

Joint UV/EMF session

Medical and cosmetic uses of Non-Ionizing Radiation (NIR) devices

WHO programme on medical devices (A. Velikayazi)
The WHO definition of health technologies covers a very wide range of products and devices, and includes some cosmetic devices. There are around 10,000 types of medical devices. The WHO Health Technology Resolution (WHA 67.20) supports establishing and strengthening regional networks of regulatory authorities. There is a new Model Regulatory Framework for medical Devices (2017) which sets out four levels of risk and recommends a regulatory regime depending on the risk. The framework outlines controls and enforcement procedures for the pre-market, placing on market, and post market phases of device introduction.
Only 58% of countries currently have medical device regulations. The EU has a new Medical Device Regulations (April 2017) which includes devices that emit high intensity electromagnetic radiation. Benefits from the use of such devices should outweigh the risks.
WHO needs more resources for this work, and should work with Member States on NIR devices. WHO is working with other organisations, such as the IEC, on safety Standards. To date there has been no work looking at counterfeit medical devices.

Diagnostic devices using NIR: Regulations and potential health risks (ICNIRP) (A. Green)
Adele Green described the 2017 ICNIRP statement on diagnostic devices using NIR. The aim was to review the range of devices being used in clinical settings, document policies and regulations governing their use and the protection of patients and healthcare workers. ICNIRP also looked at potential risks for patients/operators, to determine whether there was hazardous equipment not covered by regulations.
The review found that there are gaps in the evidence including, for example, some optical exposures, and the use of contrast media with ultrasound.
Discussion raised the comment that there needs to be greater awareness on the part of clinicians about possible risks of Near NIR.

French report on health risks related to the use of devices intended for the performance of aesthetic procedures (ANSES) (O. Merckel)
In France there is a growing demand for cosmetic procedures, commercial operators have varying amounts of training, and some devices on sale are intended for home use. Some serious complications have been reported. ANSES reviewed non-invasive hair removal and

Download (472.4 kB)

Overview

The mandate of the International Project is to assess the health and environmental effects of exposure to static and time varying electric and magnetic fields in the frequency range 0 - 300 GHz. For the purposes of the EMF Project, this range is divided into: static (0 Hz), extremely low frequency (ELF, >0-300 kHz), intermediate frequencies (IF, >300Hz to 10MHz), and radiofrequency (RF, 10 MHz-300 GHz) fields. The international advisory committee (IAC) meets annually.

Read more about Radiation and health

NUMBER OF PAGES

14

© GSMA 2026

2021



© GSMA 2026

2026





© GSMA 2026

2026

This year’s theme, **“Evidence-Based EMF Policy”**, focuses on translating scientific research into practical policy approaches that support public confidence, technological innovation and the continued development of mobile connectivity.

The 15th GSMA EMF Forum 2026



Start: Tuesday 13 October 2026 09:00

End: Tuesday 13 October 2026 16:30

Venue: Le Louise Hotel

Location: Brussels

+ google map

© GSMA 2026



Dr Mani Manimohan
Head of Digital Infrastructure
Policy and Regulation, GSMA

Opening remarks



EVIDENCE TO DEPLOYMENT

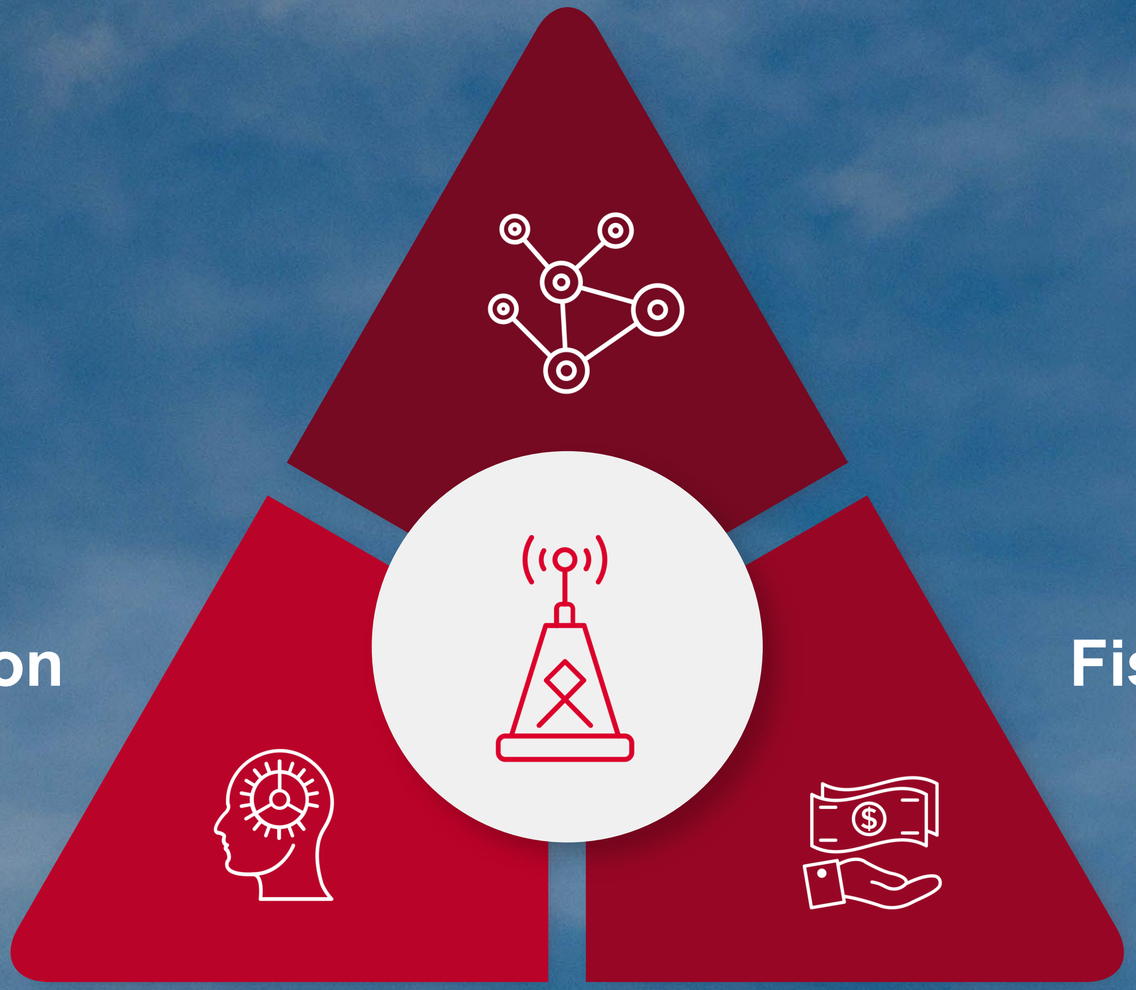
Building Confidence for Digital Infrastructure

Dr. V. B. Manimohan (‘Mani’)

Head of Digital Infrastructure Policy & Regulation, GSMA

The challenge is predictability

Deployment



Innovation

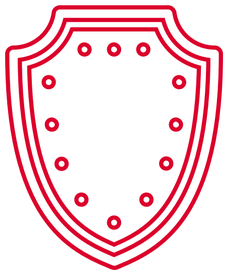
Fiscal

Dr V B Manimohan

GSMA™

EMF limits include safeguards

ICNIRP:
built-in safety factor



50×

Reduction factor for the whole-body public limit

0.08 W/kg public limit

Ofcom:
measurements below the limit



“The published measurements have consistently shown that EMF exposure levels are well within the internationally agreed levels published in the ICNIRP Guidelines.”

Sources: ICNIRP RF Guidelines (2020). Ofcom London repeat EMF audits

Dr V B Manimohan

GSMA™

Regulatory quality gets the balance right



Opening remarks



Elsa Sependa
Head of Public Policy, Europe
GSMA

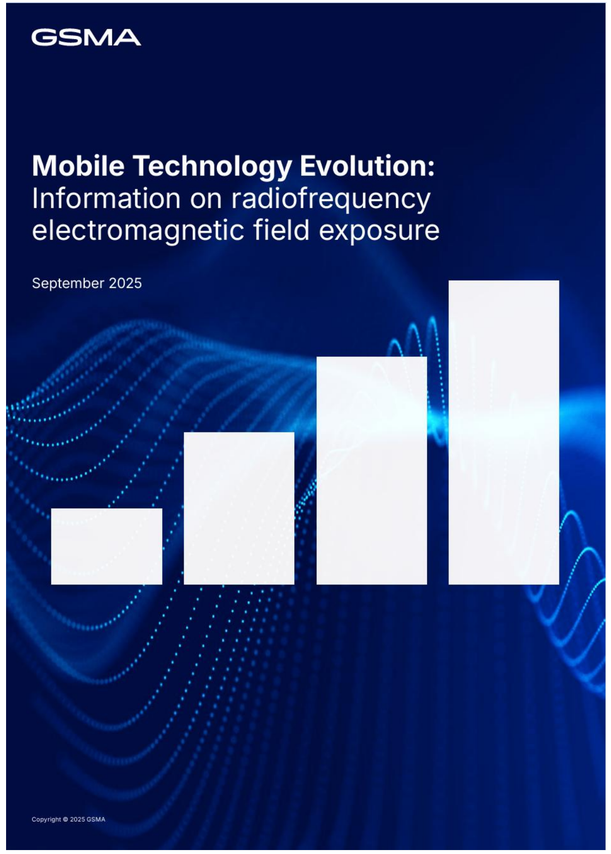
The EMF Year in Review



Dr Jack Rowley
Senior Director,
EMF & Deployment Policy
GSMA

GSMA™

October, November, December 2025



anses

ANSES Opinion
Request No 2016-SA-0176

The Director General

Maisons-Alfort, 24 October 2025

OPINION
of the French Agency for Food, Environmental and Occupational Health & Safety

on the "radiofrequencies and cancer" expert appraisal

ANSES undertakes independent and pluralistic scientific expert assessments.
ANSES's public health mission involves ensuring environmental, occupational and food safety as well as assessing the potential health risks they may entail.
It also contributes to the protection of the health and welfare of animals, the protection of plant health, the evaluation of the nutritional characteristics of food and the protection of the environment by assessing the impact of regulated products.
It provides the competent authorities with all necessary information concerning these risks as well as the requisite expertise and scientific and technical support for drafting legislative and statutory provisions and implementing risk management strategies (Article L.1313-1 of the French Public Health Code).
Its opinions are published on its website. This opinion is a translation of the original French version. In the event of any discrepancy or ambiguity the French language text dated 24 October 2025 shall prevail.

On 2 August 2016, the French Directorate General for Health made a formal request to ANSES to analyse the preliminary results of the US National Toxicology Program study on the carcinogenicity of radiofrequencies in rodents and then, considering the final results of this study, to assess whether these results were likely to change the classification of radiofrequencies as "possibly carcinogenic to humans" (Group 2B), established by the International Agency for Research on Cancer (IARC) in 2011. The formal request (see Annex 1) was registered under No 2016-SA-0176.

In 2019, in anticipation of the availability of new scientific knowledge published since ANSES's previous expert appraisal on the health effects of radiofrequencies in 2013, ANSES began the process of updating its expert appraisal on the carcinogenicity of exposure to radiofrequencies.

Rewolucja w eterze. Bilans 5 lat od zmiany limitów PEM w Polsce: infrastruktura, środowisko i lęki społeczne

18.12.2025

- 20% more base stations
- 15,000 5G sectors
- Average RF-EMF ~0.01 W/m^2

‘The challenge for the coming years, therefore, lies not in the sphere of technology or medicine, but in education and rebuilding public trust in science.’

© GSMA 2026

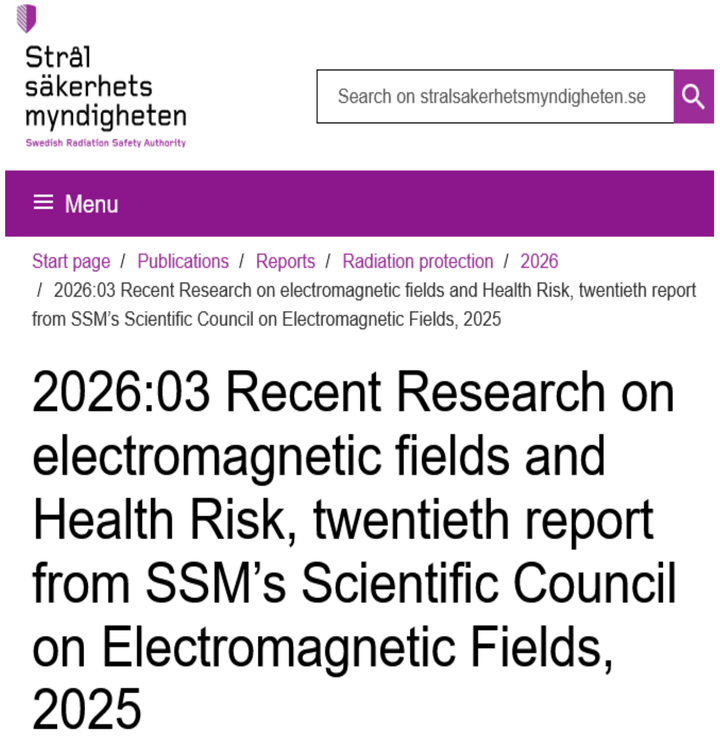
GSMA

January, February, March 2026



A comprehensive review from the Norwegian Institute of Public Health (NIPH) shows that electromagnetic fields from mobile phones or wireless networks do not cause adverse health effects. Foto: leungchopan/MostPhotos

No health effects from radiation from mobile phones or wireless networks can be documented



JEIC Academic Information

Produced by JEIC 電磁界情報センター Japan EMF Information Center

'… National authorities will welcome these results since they confirm that there is a high level of safety for the general public and workers from the ICNIRP RF guideline limits.'

© GSMA 2026

April, May, June 2026



Antenna Office › Current › News

Letter to Parliament regarding the scarcity of antenna sites

News item | 24-04-2026 | 12:11

Mobile operators are experiencing a shortage of antenna sites for mobile communication. State Secretary Aerdts (Digital Economy and Sovereignty) informed the House of Representatives about this by letter on April 15.



World Health Organization

Executive Board
158th session

Agenda item 23 EB158(9)

5 February 2026

Radiation and health: strengthening global protection, preparedness and response

(5) to continue collaboration, through existing WHO initiatives and networks … and other relevant international partners, such as the International Commission on Non-Ionizing Radiation Protection and the International Commission on Radiological Protection, to harmonize standards, share data and strengthen global coordination on radiation and health;



Journal of Environmental Psychology

Date: June 2026

Show more

Research article ● Open access Under a Creative Commons license ↗

Get rights and content ↗

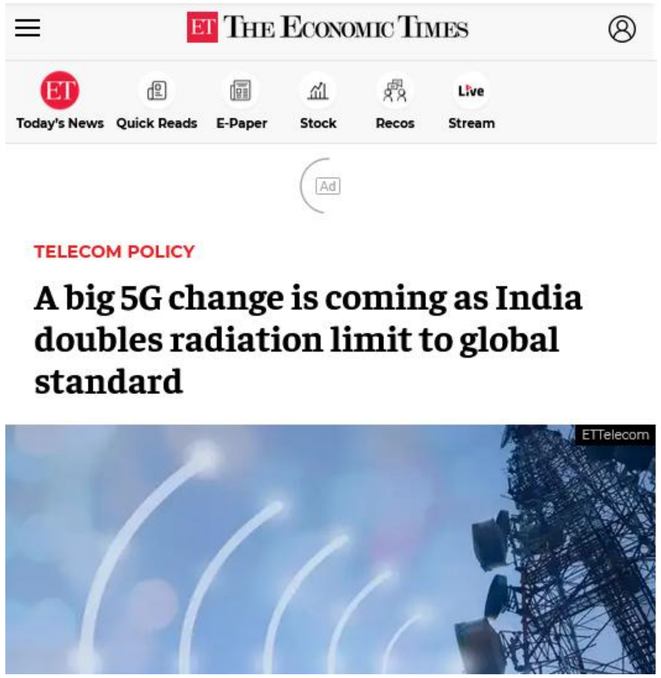
The further away the better? Factors influencing the public's location preferences for mobile phone base stations. A 10-country study

Since the most distant location is usually not the technically most feasible solution, good science and risk communication could help to improve the public's understanding of how mobile communications work.

© GSMA 2026

July, August, September 2026





RF-EMF brain dose from mobile phones and the role of reception quality – a simulation study using the ETAIN 5G Scientist App

Lea Beláčková [a], Hamed Jalilian [b c],

Highlights

- Suboptimal network quality results in higher exposure with the same phone usage.
- Exposure is higher if connected to 4G-LTE compared to 5G-NR network.

© GSMA 2026

GSMA™

The 15th GSMA EMF Forum

Evidence-based EMF policy

Tuesday, 13 October 2026



© GSMA 2026

#EMFFORUM



DI Manfred Ruttner
A1 Telekom Austria
GSMA EMF and Health
Deputy Chair

Introduction to session 1: WHO assessment of health effects of exposure to RF-EMF

WHO Task Group on Radiofrequency Fields and Health Risks



Professor Hajo Zeeb
WHO RF-EMF Task Group Chair
Leibniz-Institute for Prevention Research and Epidemiology-BIPS and University of Bremen (Germany)

GSMA™

GSMA 2026, Bruxelles, Belgium

WHO Monograph on Radiofrequency Fields and Health Risks – process and status



Professor Hajo Zeeb
Leibniz Institute for Prevention Research and Epidemiology
Bremen, Germany
Chair of the Task Group

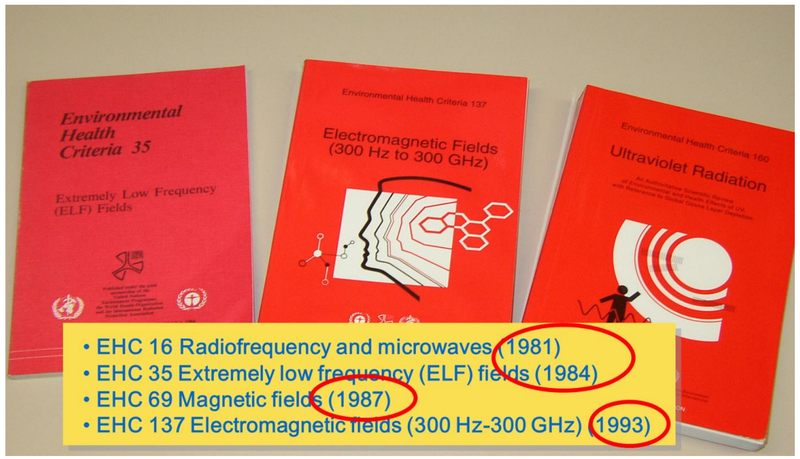
Dr Emilie van Deventer
Unit Head of Chemicals, Radiation and Health (CRH)
Department of Environment, Climate Change, One Health and Migration and Health
World Health Organization, Geneva, Switzerland

World Health Organization

WHO mandate and purpose

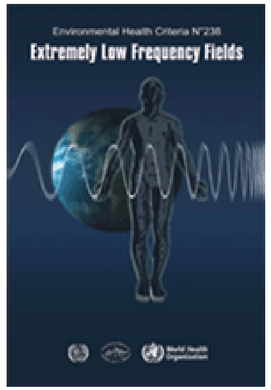
- WHO is undertaking a health risk assessment of RF-EMF for an EHC monograph.
- The RF monograph will complement the static-fields and ELF monographs and update the 1993 RF monograph.
- WHO’s task is broader than hazard identification alone; it is to assess potential health risks across studied outcomes.

WHO Environmental Health Criteria monographs on radiation





2006



2007

RF

RF Environmental Health Criteria
Scope and target audience

- Scope
  - Radiofrequency fields from 100 kHz to 300 GHz
  - Public and occupational exposures (not medical exposures)

- Target audience
  - National policy-makers in Ministries of Health, Environment, Labour, Telecommunications, ...
  - Bodies involved in recommending or setting exposure guidelines for RF EMF, such as non-governmental organizations
  - Professional societies and academics studying the health effects of RF EMF

Major outputs completed

- A WHO scoping review mapping the literature, 16 chapters and more than 3000 references.
- A systematic-review programme comprising nine protocols and twelve systematic reviews.
- The programme reflects four years of work involving more than 80 experts.



Environment International

Open access

19.0
CiteScore

9.7
Impact Factor

Special issue

WHO assessment of health effects of exposure to radiofrequency electromagnetic fields: systematic reviews

Last update 5 September 2025

The World Health Organization is in the process of assessing potential health effects of exposure to radiofrequency electromagnetic fields (RF EMF) in the general and working population. To this end, a series of systematic reviews investigating associations between exposure to RF EMF and various human health outcomes are being conducted. This Special Issue gathers these systematic reviews, presents the context of the work, and summarises important methodological information about the approaches taken.

Guest Editors:

Dr. Paul Whaley
(Lancaster University, Lancaster, United Kingdom)

Dr. Jean-François Doré
(Honorary Research Director at INSERM)

Dr. Sarah Drießen
(RWTH Aachen University Medical Faculty, Aachen, Germany)

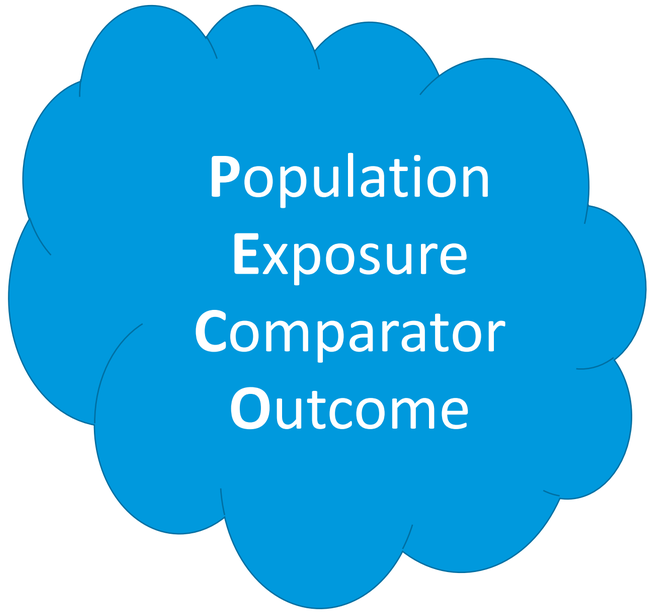
Dr. Nicolas Roth
(Center for Primary Care and Public Health, Department of Occupational and Environmental Health, Biopole Lausanne-Epalinges, Switzerland)

Dr. Sharea Ijaz
(Bristol Medical School, University of BRISTOL, London)

World Health Organization

Priority review topics

- Cancer
- Female fertility and pregnancy outcomes
- Male fertility
- Cognitive performance
- Symptoms
- Oxidative stress



- The reviews report findings across 158 PECO combinations

World Health Organization

Systematic reviews

Observational and experimental studies

Human Observational studies	Human Experimental studies	Animal Experimental studies	In-vitro studies
SR1 - Cancer		SR2 - Cancer	
SR3 - Adverse reproductive outcomes		SR4 - Adverse reproductive outcomes	SR4 - Adverse reproductive outcomes
SR5 - Cognitive impairment	SR6 - Cognitive impairment		
SR7 - Symptoms	SR8 – Symptoms		
		SR9 - Oxidative stress	SR9 - Oxidative stress
~~SR10 – Heat and pain, burns, cataract, etc.~~	~~SR10 – Heat and pain, burns, cataract, etc.~~		

World Health Organization

https://www.sciencedirect.com/special-issue/1092DR596MG

Protocols

Cancer
SR1 SR2

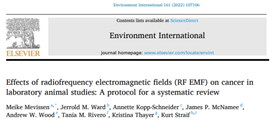
Fertility
SR3 SR4

Cognition
SR5 SR6

Symptoms
SR7 SR8

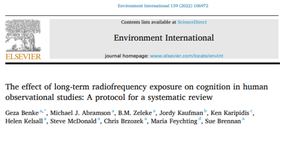
ROS
SR9

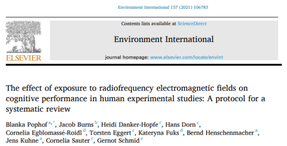

Environment International 157 (2021) 106828
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A protocol for a systematic review of human observational studies
Susanna Lagorio[a,*], Maria Blettner[b], Dan Baaken[b], Maria Feychting[c], Ken Karipidis[d], Tom Loney[e], Nicola Orsini[f], Martin Röösli[g], Marilia Silva Paulo[h], Mark Elwood[i]

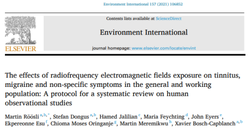

Environment International 161 (2022) 107106
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Effects of radiofrequency electromagnetic fields (RF EMF) on cancer in laboratory animal studies: A protocol for a systematic review
Meike Mevissen[a,*], Jerrold M. Ward[b], Annette Kopp-Schneider[c], James P. McNamee[d], Andrew W. Wood[e], Tania M. Rivero[f], Kristina Thayer[g], Kurt Straif[h,i]

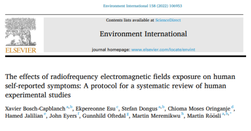

Environment International 158 (2022) 106968
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency exposure on male fertility and adverse reproductive outcomes: A protocol for two systematic reviews of human observational studies with meta-analysis
Ryan P.W. Kenny[a,*], Evelyn Barron Millar[a], Adenike Adesanya[a], Catherine Richmond[a], Fiona Beyer[a], Carolina Calderon[a], Judith Rankin[a], Mireille Toledano[a], Maria Feychting[b], Mark S Pearce[a], Dawn Craig[a], Fiona Pearson[a]


Environment International 157 (2021) 106806
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on male fertility and pregnancy and birth outcomes: Protocols for a systematic review of experimental studies in non-human mammals and in human sperm exposed *in vitro*
Francesca Pacchierotti[a,*], Lucia Ardoino[a], Barbara Benassi[a], Claudia Consales[a], Eugenia Cordelli[a], Patrizia Eleuteri[a], Carmela Marino[a], Maurizio Sciortino[a], Martin H. Brinkworth[b], Guangdi Chen[b], James P. McNamee[c], Andrew William Wood[c], Carlijn R. Hooijmans[d], Rob B.M. de Vries[d]


Environment International 159 (2022) 106972
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of long-term radiofrequency exposure on cognition in human observational studies: A protocol for a systematic review
Geza Benke[a,*], Michael J. Abramson[a], B.M. Zeleke[a], Jordy Kaufman[a], Ken Karipidis[a], Helen Kelsall[a], Steve McDonald[a], Chris Brzozek[a], Maria Feychting[b], Sue Brennan[a]


Environment International 157 (2021) 106783
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: A protocol for a systematic review
Blanka Pophof[a,*], Jacob Burns[b], Heidi Danker-Hopfe[c], Hans Dorn[c], Cornelia Eglhofmaier-Roldó[d], Torsten Eggert[e], Kateryna Fuks[f], Bernd Henschenmacher[a], Jens Kuhne[a], Cornelia Sauter[a], Gernot Schmid[a]


Environment International 157 (2021) 106852
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A protocol for a systematic review on human observational studies
Martin Röösli[a,b,*], Stefan Dongus[a,b], Hamed Jalilian[a], Maria Feychting[c], John Eyers[a], Ekpereonne Esu[a], Chioma Moses Oringanje[a], Martin Meremikwu[a], Xavier Bosch-Capblanch[a,b]


Environment International 158 (2022) 106932
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A protocol for a systematic review of human experimental studies
Xavier Bosch-Capblanch[a,*], Ekpereonne Esu[a], Stefan Dongus[a,b], Chioma Moses Oringanje[a], Hamed Jalilian[a], John Eyers[a], Gunnhild Oftedal[a], Martin Meremikwu[a], Martin Röösli[a,b]


Environment International 158 (2022) 106932
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of radiofrequency electromagnetic fields (RF-EMF) on biomarkers of oxidative stress *in vivo* and *in vitro*: A protocol for a systematic review
Bernd Henschenmacher[a,*], Annette Bitsch[b], Tonia de las Heras Gala[c], Henry Jay Forman[d,e], Athanasios Fragoulis[f], Pietro Ghezzi[g,h], Rupert Kellner[i], Wolfgang Koch[j], Jens Kuhne[a], Dmitrij Sachno[a], Gernot Schmid[a], Katya Tsaioun[a], Jos Verbeek[k], Robert Wright[l]

Systematic Reviews


Environment International 191 (2024) 108983
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies – Part I: Most researched outcomes
Ken Karipidis[a,*], Dan Baaken[b,c], Tom Loney[d], Maria Blettner[e,f], Chris Brzozek[a], Mark Elwood[d], Clement Narh[f], Nicola Orsini[g], Martin Röösli[h,i], Marilia Silva Paulo[j], Susanna Lagorio[k]


Environment International 196 (2025) 109274
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Full length article
The effect of exposure to radiofrequency fields on cancer risk in the general and working population: A systematic review of human observational studies – Part II: Less researched outcomes
Ken Karipidis[a,*], Dan Baaken[b,c,f], Tom Loney[d], Maria Blettner[e,f,i], Rohan Mate[a], Chris Brzozek[a], Mark Elwood[d], Clement Narh[f], Nicola Orsini[g], Martin Röösli[h], Marilia Silva Paulo[j], Susanna Lagorio[k,l]


Environment International 199 (2025) 109482
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review[☆]
Meike Mevissen[a,*,1], Angélique Ducray[a,b], Jerrold M. Ward[b], Annette Kopp-Schneider[c], James P. McNamee[c], Andrew W. Wood[c], Tania M. Rivero[c], Kurt Straif[d,e]


Environment International 190 (2024) 108856
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency exposure on adverse female reproductive outcomes: A systematic review of human observational studies with *dose–response meta-analysis*


Environment International 189 (2025) 108978
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on pregnancy and birth outcomes: A systematic review of experimental studies on non-human mammals
Eugenia Cordelli[a,*], Lucia Ardoino[a], Barbara Benassi[a], Claudia Consales[a], Patrizia Eleuteri[a,1], Carmela Marino[a], Maurizio Sciortino[a,2], Paola Villani[a], Martin H. Brinkworth[b], Guangdi Chen[b], James P. McNamee[c], Andrew W. Wood[c,3], Lea Belackova[d], Jos Verbeek[d], Francesca Pacchierotti[a,3,4]


Environment International 190 (2024) 108817
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency exposure on male fertility: A systematic review of human observational studies with dose–response *meta*-analysis
Ryan PW Kenny[a,*], Eugenie Evelynne Johnson[a], Adenike M. Adesanya[a], Catherine Richmond[a], Fiona Beyer[a], Carolina Calderon[a], Judith Rankin[a], Mark S Pearce[a], Mireille Toledano[a], Dawn Craig[a], Fiona Pearson[a]


Environment International 189 (2024) 108599
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Effects of radiofrequency electromagnetic field (RF-EMF) exposure on male fertility: A systematic review of experimental studies on non-human mammals and human sperm *in vitro*
Eugenia Cordelli[a,*], Lucia Ardoino[a], Barbara Benassi[a], Claudia Consales[a], Patrizia Eleuteri[a,1], Carmela Marino[a,2], Maurizio Sciortino[a,2], Paola Villani[a], Martin H. Brinkworth[b], Guangdi Chen[b], James P. McNamee[c], Andrew W. Wood[c,3], Lea Belackova[d], Jos Verbeek[d], Francesca Pacchierotti[a,3,4]


Environment International 188 (2024) 108779
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Full length article
The effects of radiofrequency exposure on cognition: A systematic review and *meta*-analysis of human observational studies
Geza Benke[a,*], Michael J. Abramson[a], Chris Brzozek[b], Steve McDonald[a], Helen Kelsall[a], Masoumeh Sanagou[c], Berihun M. Zeleke[a], Jordy Kaufman[a], Sue Brennan[a], Jos Verbeek[d], Ken Karipidis[a]


Environment International 191 (2024) 108899
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effect of exposure to radiofrequency electromagnetic fields on cognitive performance in human experimental studies: Systematic review and *meta*-analyses
Blanka Pophof[a,*], Jens Kuhne[a], Gernot Schmid[a], Evelyn Weiser[a], Hans Dorn[a], Bernd Henschenmacher[a,1], Jacob Burns[a], Heidi Danker-Hopfe[b,2], Cornelia Sauter[a,2]


Environment International 183 (2024) 108338
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency electromagnetic fields exposure on tinnitus, migraine and non-specific symptoms in the general and working population: A systematic review and meta-analysis on human observational studies
Martin Röösli[a,b,*], Stefan Dongus[a,b], Hamed Jalilian[a,1], John Eyers[a], Ekpereonne Esu[a], Chioma Moses Oringanje[a], Martin Meremikwu[a], Xavier Bosch-Capblanch[a,b]


Environment International 187 (2024) 108652
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
Full length article
The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A systematic review of human experimental studies
Xavier Bosch-Capblanch[a,*], Ekpereonne Esu[a], Chioma Moses Oringanje[a], Stefan Dongus[a,b], Hamed Jalilian[a,b], John Eyers[a], Christian Auer[a,b], Martin Meremikwu[a], Martin Röösli[a,b]


Environment International 194 (2024) 108900
Contents lists available at ScienceDirect
Environment International
journal homepage: www.elsevier.com/locate/envint
The effects of radiofrequency electromagnetic field exposure on biomarkers of oxidative stress *in vivo* and *in vitro*: A systematic review of experimental studies
Felix Meyer[a,*], Annette Bitsch[b], Henry Jay Forman[c,d], Athanasios Fragoulis[e], Pietro Ghezzi[f,g], Bernd Henschenmacher[a], Rupert Kellner[h], Jens Kuhne[a], Tonia Ludwig[a], Dmitrij Sachno[a], Gernot Schmid[a], Katya Tsaioun[a], Jos Verbeek[i], Robert Wright[j]

World Health Organization

12 SR published

High-level summary

- Cancer (human observational): the evidence was consistently negative with moderate certainty, including that mobile phone use likely does not increase brain cancer risk and that base-station/broadcasting RF likely does not increase childhood cancer risk.
- Fertility/reproduction: human observational findings were largely null with very low certainty; animal studies reported adverse effects at high exposures with low to moderate certainty depending on outcome.
- Cognition and symptoms: the reviewed human evidence largely shows no effect in the studied domains, with certainty varying by question.
- Oxidative stress: very low certainty evidence because of inconsistent results.

Post-publication discussion and critical appraisals

- A number of critical commentaries and correspondence papers have been published following the WHO-commissioned systematic reviews, including several in *Environment International* and related literature.
- These papers raise concerns primarily in three areas:
  - **Methodological issues** (study selection, meta-analysis approaches, heterogeneity, data interpretation)
  - **Interpretation of findings**, including conclusions of “no effect” or “no clear evidence”
  - **Process-related issues**, including transparency, independence, and potential biases

Post-publication discussion and critical appraisals

- Some critiques argue that:
  - weaknesses in primary studies and limited data reduce confidence in conclusions
  - heterogeneity and analytical choices may affect robustness of meta-analyses
  - the reviews should **not be interpreted as evidence of safety**
- WHO position:
  - the systematic reviews are **inputs to the monograph**, not final WHO conclusions
  - Final step: the **evidence integration phase**

One issue of particular importance: the Mevissen animal cancer review

- A protocol for the animal cancer review was published in 2022. It set out a WHO-guided systematic-review framework using PECO criteria, PRISMA 2020, OHAT risk-of-bias assessment and GRADE.
- The final Mevissen et al. 2025 review states that diverse study designs prevented quantitative meta-analysis and that the studies were therefore synthesized using a narrative approach.
- A 2026 commentary states explicitly that, deviating from the pre-published protocol, the review did not perform meta-analyses, and that the commentators' re-analysis led to lower certainty-of-evidence conclusions than the original review.
- This issue is worth flagging clearly because it has become a focal point in the post-publication discussion around the animal cancer evidence.



Environment International

Open access

19.0
CiteScore

9.7
Impact Factor

27 April 2026

Environment International 2025 Most Downloaded Paper Awards

We are pleased to announce the 2025 Most Downloaded Paper Awards for ***Environment International*** (EI). This award recognizes the papers published in 2025 that achieved the highest number of downloads or full article views on ScienceDirect during the year. This year, a total of 10 papers are being honored.

The 2025 Most Downloaded Paper Awards go to:

- Mevissen, M., et al., 2025. Effects of radiofrequency electromagnetic field exposure on cancer in laboratory animal studies, a systematic review. Environment International, 199.

Interpretation of the current debate

- Scientific debate in a field like RF-EMF is **expected**
- The systematic reviews are **important evidence inputs**, but they are **not the final WHO monograph**
- The central task (done by the **task group**) is **evidence integration across streams**, not treating any single paper as the WHO endpoint

What has been done for the monograph - status: very close to completion

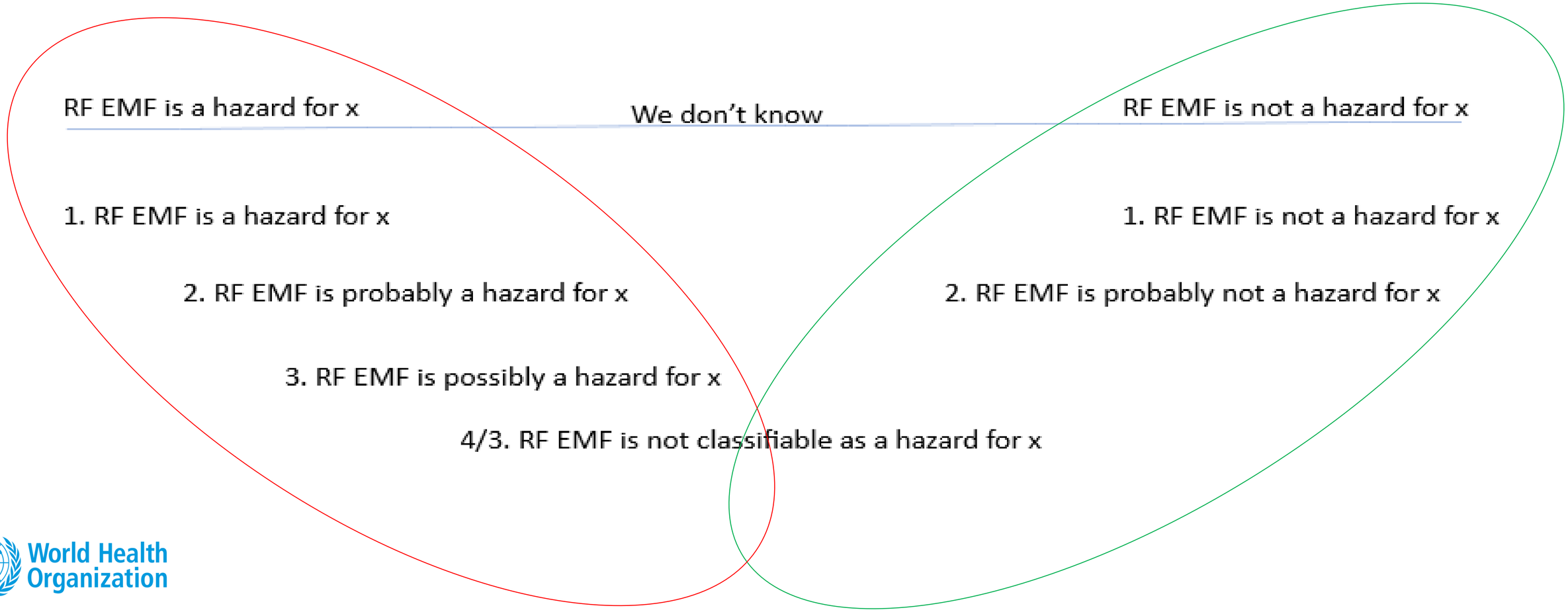
- Integrate the scoping review and systematic reviews into an overall health risk assessment for each outcome
- Identify research gaps.
- Review good practice interventions nationally.
- Move from review outputs to the final **EHC monograph**
    - **Currently entering final editing phase**

Decisions of Task Group

- Health risk assessment
    - Hazard identification >>>>

Hazard classification

- We have assessed if RF EMF is a hazard for each adverse health outcome



World Health Organization

Decisions of Task Group

- Health risk assessment
  - Hazard identification
  - Exposure-response for specific outcome
  - Exposure assessment – how frequent is the actual exposure (at which level)?
  - Risk characterization (put everything into context)

- Evidence integration (epidemiological and experimental streams of evidence)
- Exposure level classification for different streams of evidence (local and whole-body exposure)
  - high, moderate, low

Details of exposure classification as decided by the task group

Local exposure:

- low: up to 2 W/kg SAR;
- moderate: > 2 W/kg SAR and < 10 W/kg SAR;
- high: > 10 W/kg SAR

Whole body exposure:

low: ≤ 0.08 W/kg SAR;

moderate: > 0.08 W/kg and < 0.4 W/kg SAR;

high: > 0.4W/kg SAR

What can be expected from the final monograph?

Conclusions on the hazard (*and partly for the population risk*) for about **80** separate outcomes

- Numerous individual cancers
- Thermal effects (4 outcomes)
- Reproductive outcomes (male, female)
- Neuroendocrine functions
- Cognitive/psychological/biological outcomes (brain) (17 different)
- Etc

Example (pre-final)

Priority adverse health outcomes: *Thermal injury and illness*

RF EMF **is a hazard** for pain and burns and **is probably a hazard** for thermal discomfort and heat stroke.

Risk assessment:

- **Low exposure**: no risk of thermal injury or illness; the risk of thermal discomfort could not be determined.
- **Moderate exposure**: no risk of pain, burns or heat stroke, but thermal discomfort may occur.
- **High exposure**: there is a small risk of pain and burns and probably of heat stroke that increases with exposure.

Final monograph -
Implications for Member States / regulators / stakeholder audiences

- Ministries and regulators need to know where the evidence base is now
- NGOs and other interested parties need to understand both the substance and the process – transparency is key
- A transition from evidence production to evidence integration

Take-home messages

- A substantial WHO evidence-review programme has now been completed, including the scoping review plus nine protocols and twelve systematic reviews.
- The reviews provide an important, systematic evidence base across the six priority topic areas.
- Post-publication criticism has emerged, including methodological debate around the Mevissen animal cancer review and broader concerns about interpretation.
- Ongoing: formal integration into the WHO EHC monograph. 80 different outcomes reviewed
- External review is ongoing
- Editorial work started
- Publication early 2027

Thank you

For more information, please contact:

Hajo Zeeb

Chair, Task Group

Email: zeeb@leibniz-bips.de

E. van Deventer
Head, Unit on Chemicals, Radiation and Health
Email: vandeventere@who.int

World Health Organization

75 HEALTH FOR ALL

Q&A: WHO Task Group on Radiofrequency Fields and Health Risks



Professor Hajo Zeeb
WHO RF-EMF Task Group Chair
Leibniz-Institute for Prevention Research and Epidemiology-BIPS and University of Bremen



DI Manfred Ruttner
A1 Telekom Austria
Deputy Chair GSMA EMF and Health



Natalie Mack
Telstra, Australia
GSMA EMF and Health Delegate

International harmonization of RF-EMF policy

GSMA™

International harmonization of RF-EMF policy



Dr Jack Rowley
Senior Director, EMF & Deployment Policy
GSMA

GSMA™

International Harmonization of RF-EMF Policy

October 2026



© GSMA 2026

GSMA™

ICNIRP limits are protective of health



‘The ICNIRP 2020 RF EMF guidelines protect against all potential adverse health effects relating to exposure to RF EMF, including from 5G technologies.’



‘There is no evidence that additional precautionary measures will result in a benefit to the health of the population.’



ICNIRP strongly recommends that countries update to the latest guidelines

Source: https://www.icnirp.org/

© GSMA 2026

Independent reports and statements

Listed are over 200 reports, statements, RF-EMF standards produced by official expert national and international organisations. The consensus among experts is that there are no established health risks from exposure to low-level radiofrequency electromagnetic fields (RF-EMFs) typically encountered in everyday life, such as those from radio transmitters and devices.

Note: Translations to English or inserted words are indicated by []. The current website is provided, where the organisation name has changed.

Index of reports and statements

Filters | Location | Source | Author | Year | Type

Results 252

Recent Research on EMF and Health Risk, Nineteenth report from SSM's Scientific Council on Electromagnetic Fields, 2025. Report No. 2026:03. SSM. February 2026.. No new established causal relationships between EMF exposure and health risk have been identified.

2026 Sweden

Informe sobre Radiofrecuencias y Salud 2023/2025, Cáncer y radiofrecuencia: la evidencia científica más robusta revisada por la OMS, Comité Científico Asesor en Radiofrecuencias y Salud (CCARS) [Radiofrequency and Health Report 2023/2025, Cancer and radiofrequency: the most robust scientific evidence reviewed by the WHO, Scientific Advisory Committee on Radiofrequencies and Health]. 2026.. [The report concludes that epidemiological evidence in humans does not show a compelling association, even though experimental evidence in laboratory animals has found a slight increase in certain types of tumors in male rats. This divergence between evidence in animals and humans is a central conclusion of the report and defines current scientific debate.]

2026 Spain

[Weak radio-frequency electromagnetic fields and health effects – an umbrella review.] The Norwegian Institute of Public Health (NIPH). 26 January 2026.. A comprehensive review from the Norwegian Institute of Public Health (NIPH) shows that electromagnetic fields from mobile phones or wireless networks do not cause adverse health effects.

2026 Norway

https://www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/regulatory-environment/emf-and-health/expert-reports/

© GSMA 2026

RF-EMF levels are low regardless of regulatory limits

RF-EMF siting exclusion policies should be reviewed

5.10 Exposure assessment in areas around hospitals, schools, etc.

With respect to human exposure, currently there is no technical requirements for any special consideration for locating BSs close to areas such as hospitals and schools due to the fact that existing exposure guidelines incorporate in the exposure limits safety margins that are applicable to all locations.

NOTE – Using the mobile telephone within areas of good reception also decreases exposure as it allows the telephone to transmit at reduced power [b-WHO 2014].

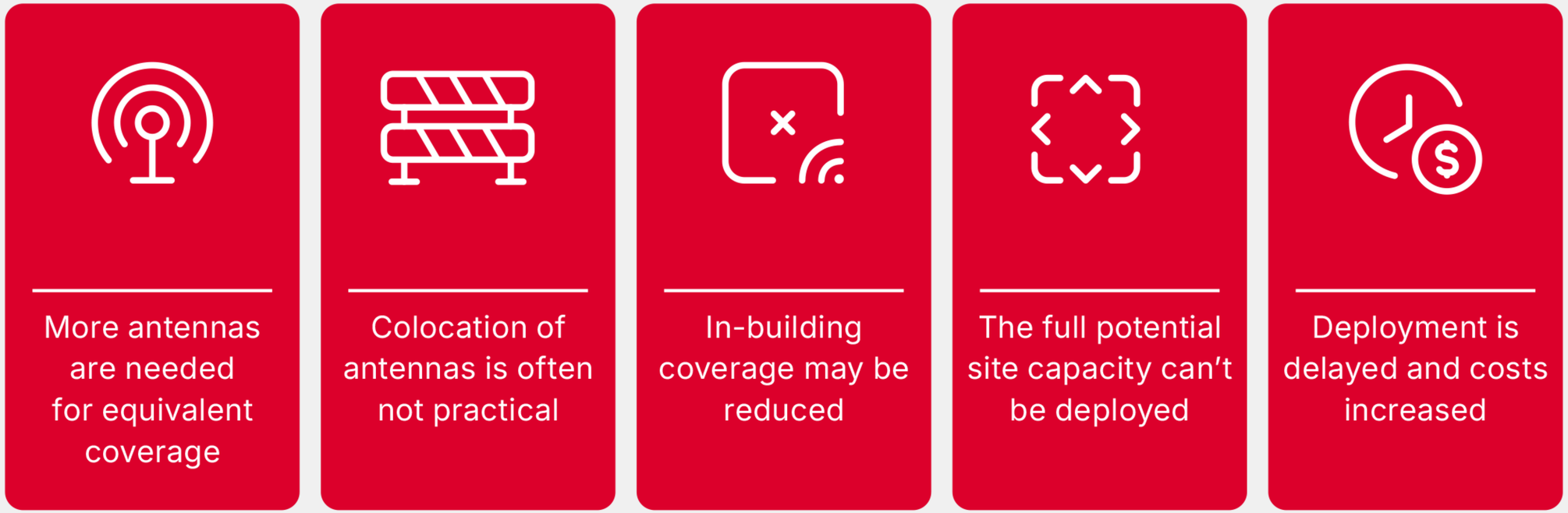
Source: ITU-T K.91, 2024

© GSMA 2026

Unintended outcomes of restrictive EMF policies

Figure 11

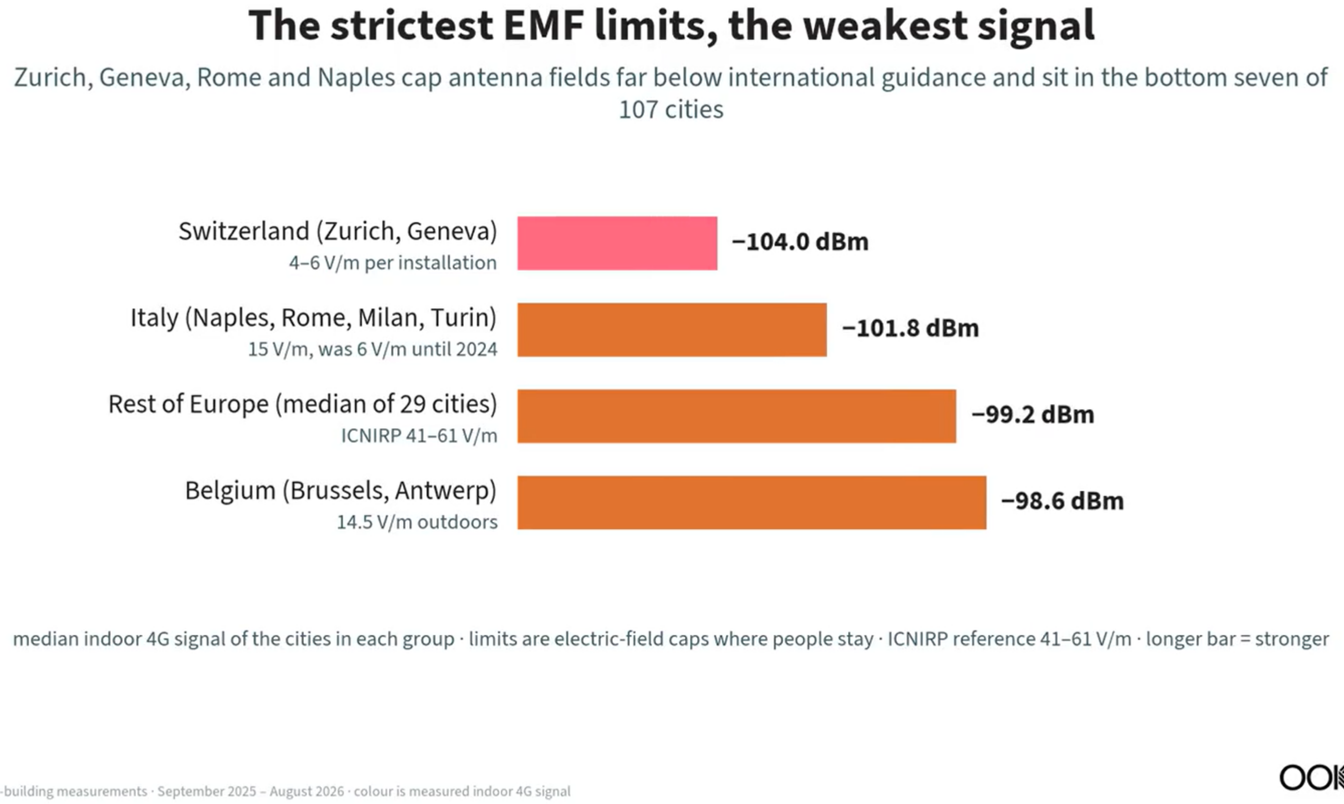
Restrictive RF-EMF limits can negatively impact mobile networks



Source: GSMA, 2025

© GSMA 2026

Poor EMF policy restricts mobile connectivity



90%

of our time is spent indoors

80%

of data is consumed indoors

Source: Ookla via LinkedIn, 2026; Ericsson, 2023

© GSMA 2026

GSMA

Good EMF policy supports mobile connectivity

4G networks in Madrid compared to Rome

Madrid (ICNIRP)	Rome (restrictions)
About three times more good or excellent RSRP values	Approximately double the number of base station sites in survey area

Note: RSRP = Reference Signal Received Power. Good or excellent RSRP >-90 dBm.

Source: Galán-Jiménez and Chiaraviglio, 2021

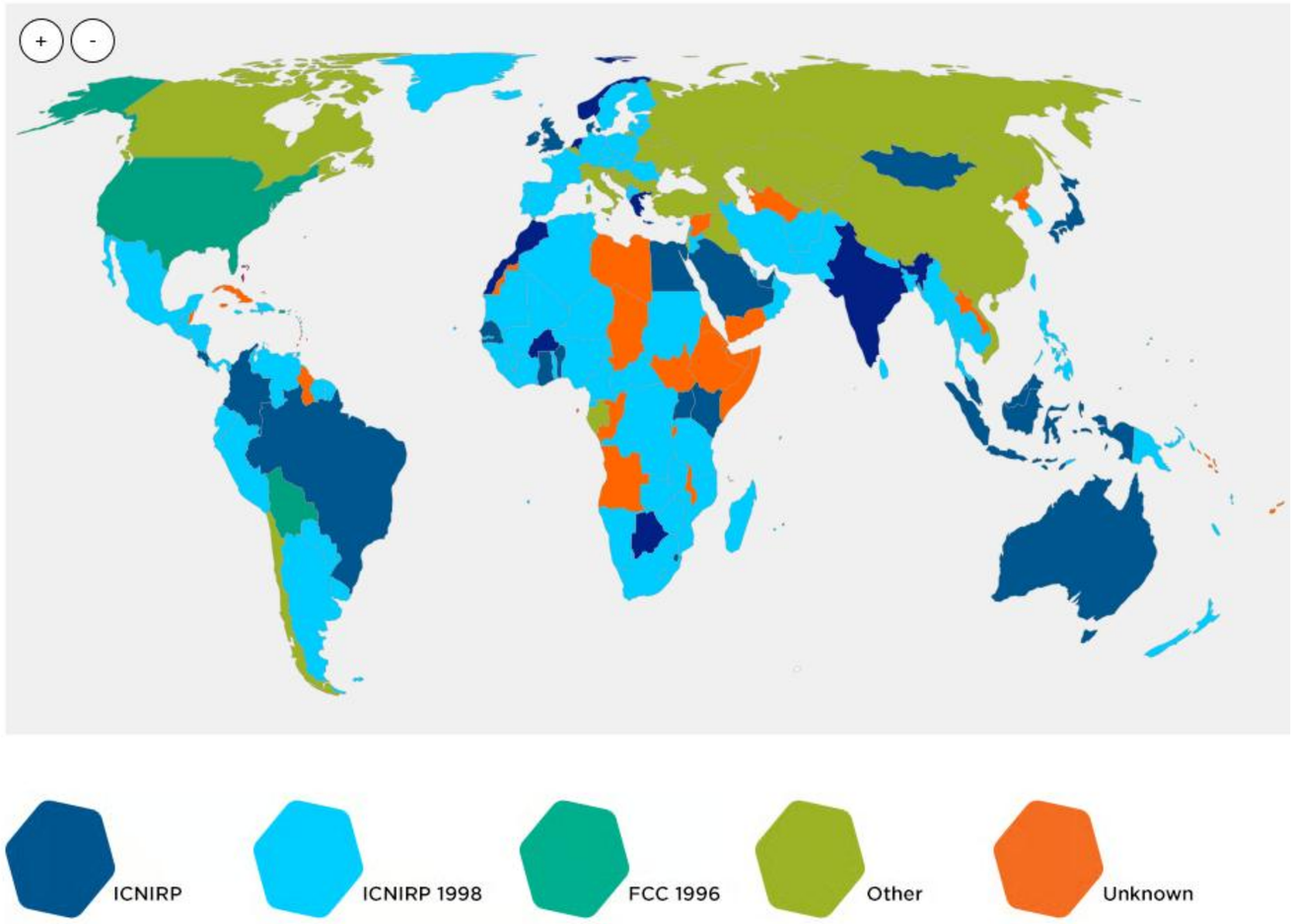
© GSMA 2026

RF-EMF limit harmonization is underway

Country	Prior Limit (>2 GHz) W/m²	Year of ICNIRP Adoption	International Limit (> 2GHz) W/m²
New Zealand	2.0	1999	10
Czech Republic	0.05	2000	10
Australia	2.0	2003	10
Slovakia	0.1	2004	10
Hungary	0.1	2004	10
North Macedonia	2.0	2014	10
Lithuania	1.0 (0.1 before 2015)	2020	10
Poland	~0.1	2020	10
India	5 (1 from 2012)	2026	10

© GSMA 2026

ICNIRP (2020) adoption progressing



Note: public limits for mobile networks

Australia	2021
Bahamas	2026?
Benin	2021
Botswana	2024
Brazil	2024
Brunei Darussalam	2024
Burkina Faso	2023
Cambodia	2026?
Colombia	2023
Congo, Democratic Republic of	2021
Costa Rica	2024
Ireland	2020
Kenya	2025
Denmark	2022
Egypt	2022
Eswatini	2023
Ghana	2023
Hong Kong	2022
India	2026
Indonesia	2022
Malaysia	2021
Malta	2021
Mauritius	2021
Mongolia	2020
Morocco	2023
Netherlands	2021
Norway	2020
Saudi Arabia	2021
Senegal	2021
Singapore	2023
Tanzania	2026?
Trinidad and Tobago	2026?
Uganda	2020
United Arab Emirates	2021
United Kingdom	2021

https://www.gsma.com/solutions-and-impact/connectivity-for-good/public-policy/regulatory-environment/emf-and-health/emf-policy/

© GSMA 2026

GSMA

RF-EMF assessment method flexibility

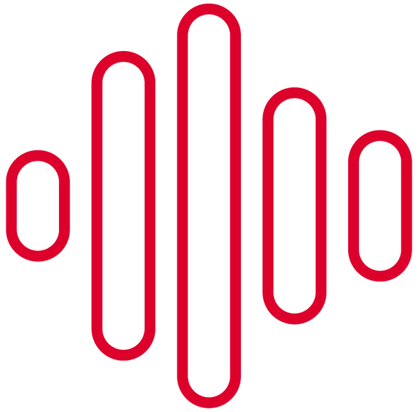
Simplified



Calculation



Measurement

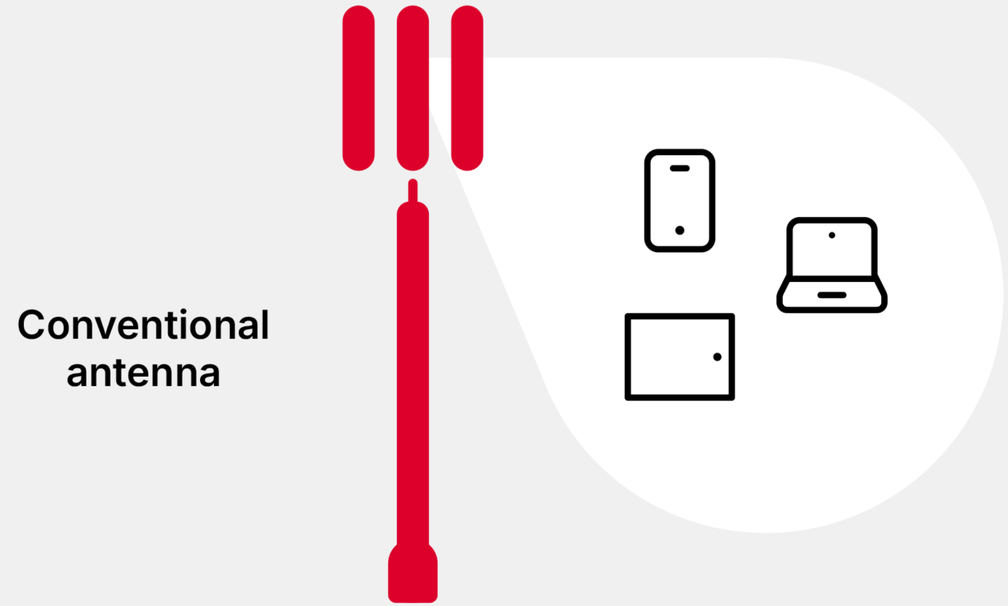


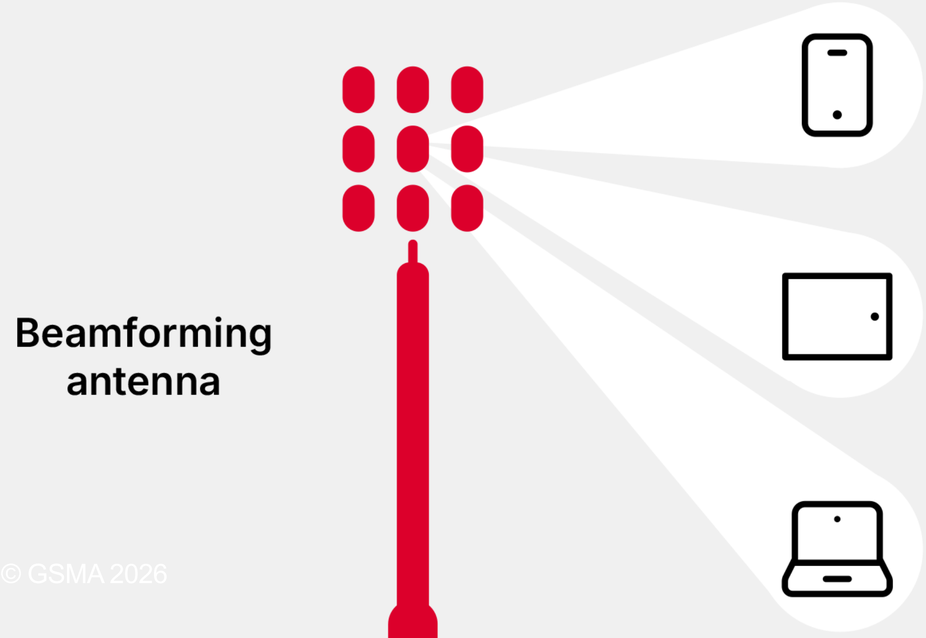
Australian regulator

- **100% of operator predicted RF-EMF levels were higher than actual measured levels**
  - At 99% of measured sites the total RF-EMF was less than 50% of the predicted level

Source: ACMA, 2022

© GSMA 2026





Update assessment methods

- Actual transmit power
- Beamforming

IEC

- IEC 62232 standard
- IEC TR62669 technical report

ITU

- ITU-T K.52 recommendation
- ITU-T K.100 recommendation

Incorporate by reference (where possible)

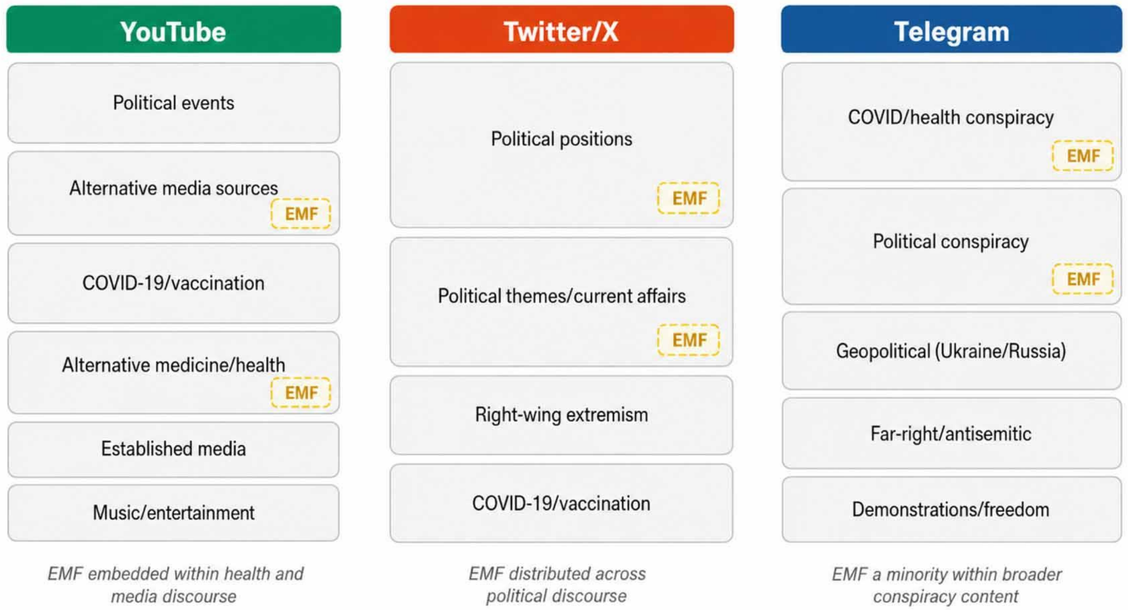
Watch the tutorials from the GSMA EMF Forum 2024

© GSMA 2026

GSMA™

EMF mis- and dis- information has not gone away

EMF mis- and disinformation on German-language social media



Conspiracy ecosystems

Pseudo-expertise

Complementary platforms

Commercial interests

'While the volume of EMF-related content has declined since 2020–2022, the channels, accounts, and cross-platform linkages that carried it persist.'

Source: Eder et al., 2026

© GSMA 2026

Share

Follow

6G falsely linked to hantavirus despite not yet existing

William Summers June 12, 2026



Source: AAP, 2026

© GSMA 2026

The challenge of communicating uncertainty

Conclusions

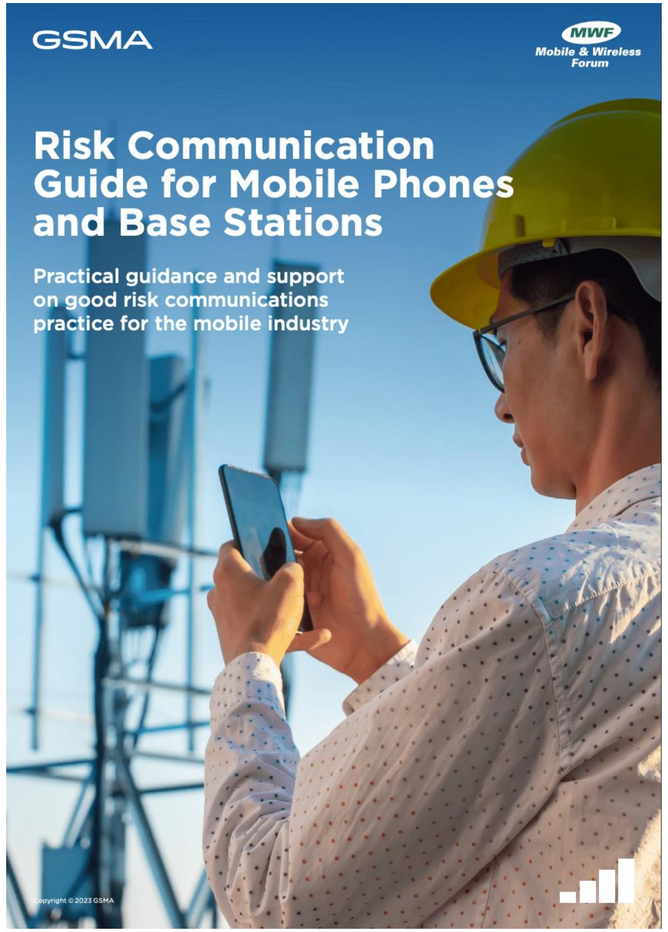
Our experiments provide several implications for reporting uncertainties. They show that informing about uncertainties is not always a means for improving trust and credibility. Science skeptics and activists with a particular political agenda might instrumentalize uncertainty for spreading distrust in science, primarily when uncertainty refers to hazard identification. Risk communicators should be aware that admitting uncertainty is a double-edged sword. Laypersons might attribute it to the lack of professional expertise.

Source: Wiedemann et al., 2021

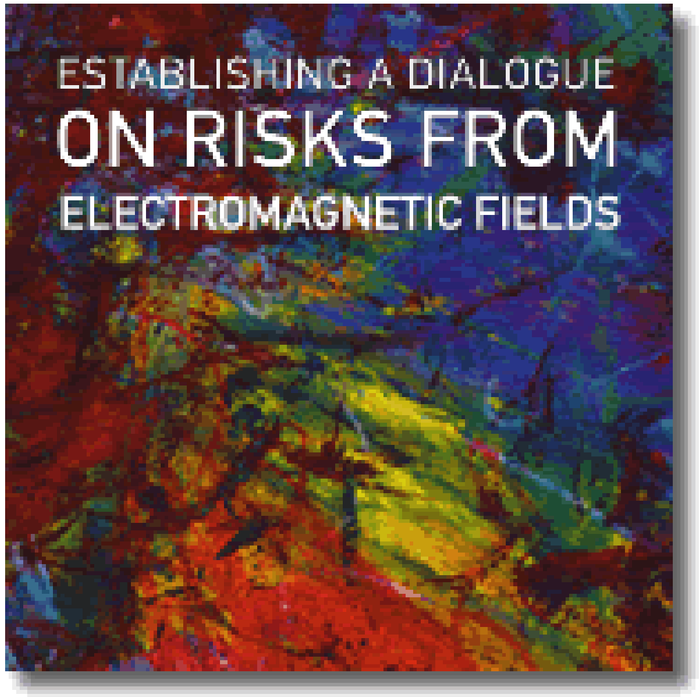
© GSMA 2026

Good practice EMF communication guides

GSMA & MWF



WHO



NextGEM



Source: GSMA & MWF, 2023; WHO, 2002; NextGEM, 2026

© GSMA 2026

Now is the time for action

- WHO health risk assessment for RF-EMF
- Review/implement national RF-EMF policies
- Adopt national limits based on ICNIRP (2020)
- Apply updated assessments methods from IEC/ITU
- Implement evidence-based communication

© GSMA 2026

Thank you

© GSMA 2026

Panel: Practical experience of RF-EMF policy implementation



Dr Maria Christopoulou
Greek Atomic Energy Commission, Greece



Dr Azadeh Peyman
UK Health and Security Agency



Lisette Kruit
Antenna News Agency, Netherlands



Natalie Mack
Telstra, Australia
GSMA EMF and Health Delegate



Dr Maria Christopoulou
Greek Atomic Energy Commission (EEAE)

Practical experience of RF-EMF policy implementation

EEAE ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΑΤΟΜΙΚΗΣ ΕΝΕΡΓΕΙΑΣ
GREEK ATOMIC ENERGY COMMISSION

Maria Christopoulou | Greece
Greek Atomic Energy Commission (EEAE)
Non-Ionizing Radiation Unit

tmia@eeae.gr | maria.christopoulou@eeae.gr

The 15th GSMA EMF Forum, 13 October 2026

Our responsibilities

- involved in the licensing procedure (approving the technical radio emission and environmental studies, before BS installation and/or their modification)
- perform annually in situ (spot) measurements in the vicinity of at least 20% of all licensed antenna stations installed in urban areas

2008-2025	2025
> 29000	2369

- 24/7 National Observatory of EMF (NOEF), since 2015



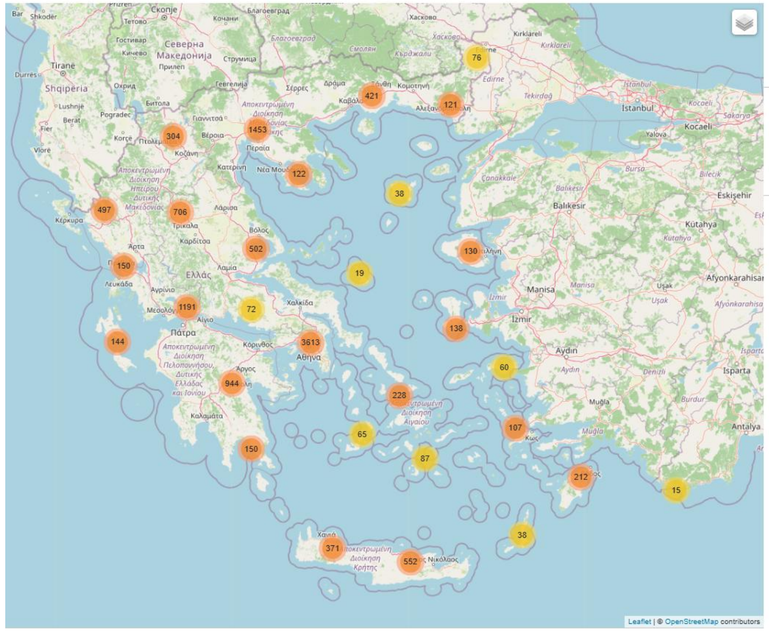




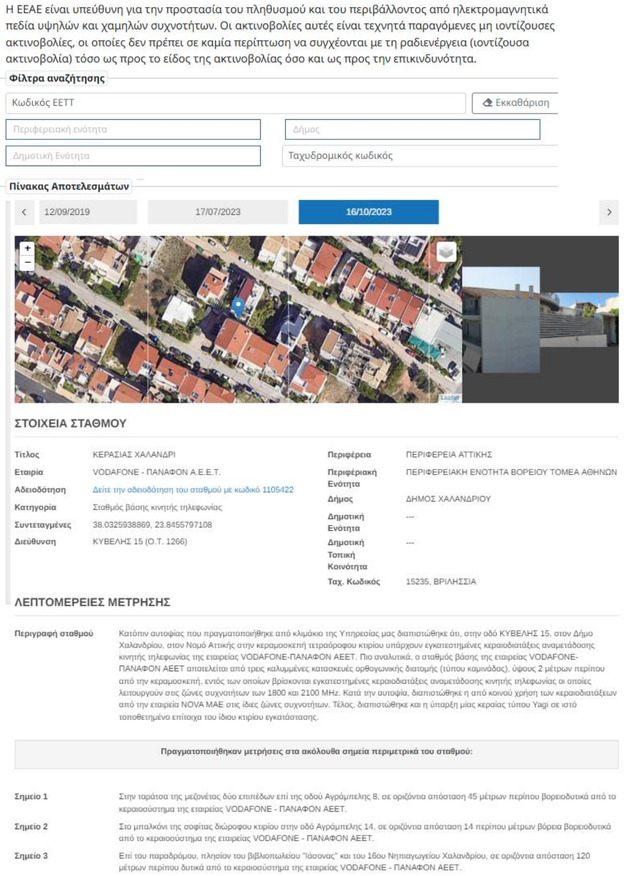


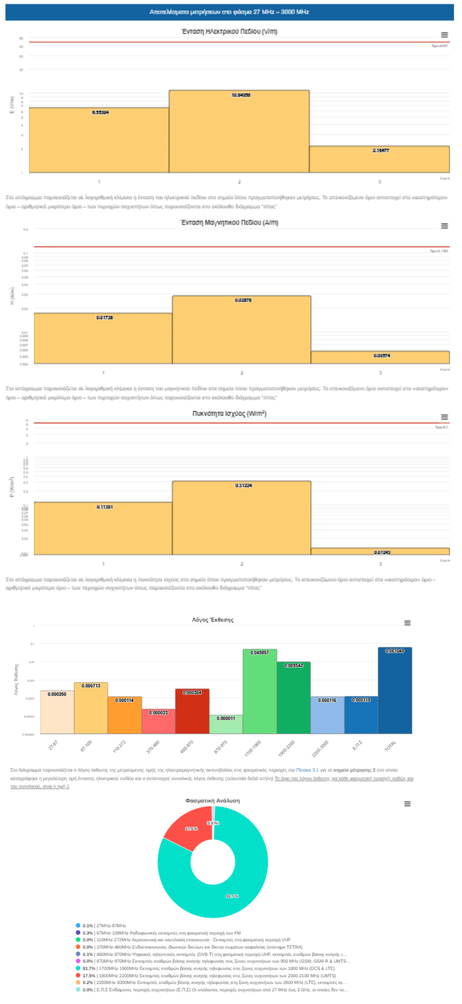


Public access to the in-situ measurement data



eeae.gr







ekeraies.gr provides public information about EMF with *in situ* measurement results



www.eeae.gr

National Observatory of EMF
fixed and mobile monitoring 24/7

Continuous monitoring (100 kHz - 7 GHz) of general public exposure to high-frequency electromagnetic fields through a network of fixed and mobile EMF monitoring stations

paratiritirioemf.eeae.gr

ΕΘΝΙΚΟ ΠΑΡΑΤΗΡΗΤΗΡΙΟ ΗΛΕΚΤΡΟΜΑΓΝΗΤΙΚΩΝ ΠΕΔΙΩΝ

33
frequency selective

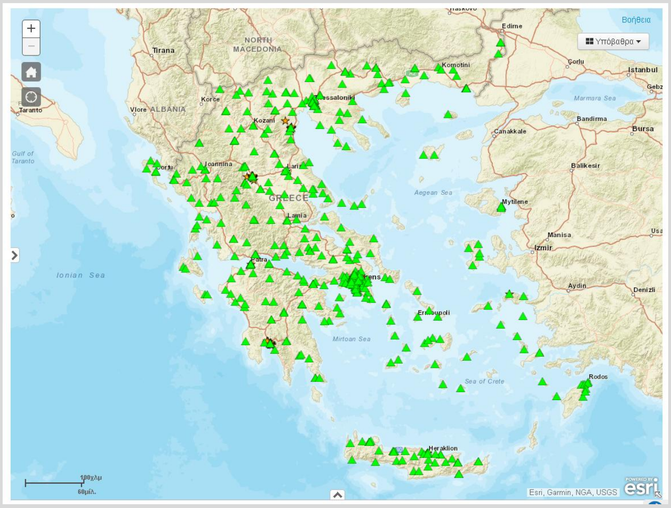


480
broadband



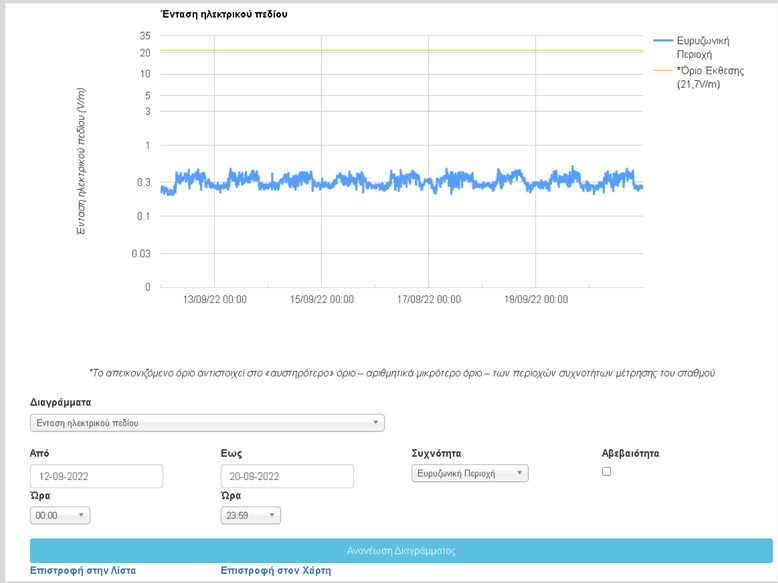
schools, kinder gardens, public buildings,
in the proximity of squares

www.eeae.gr

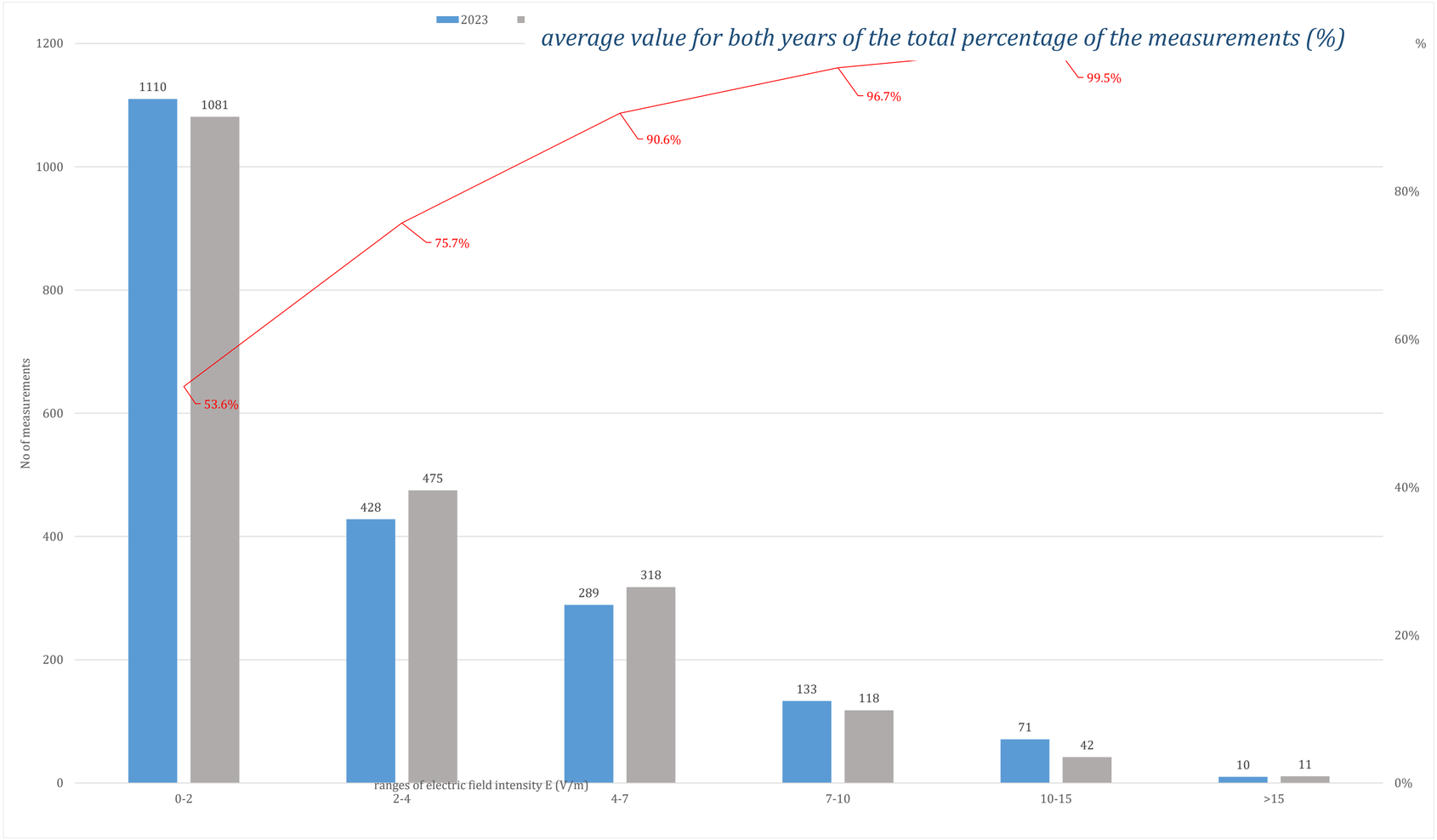






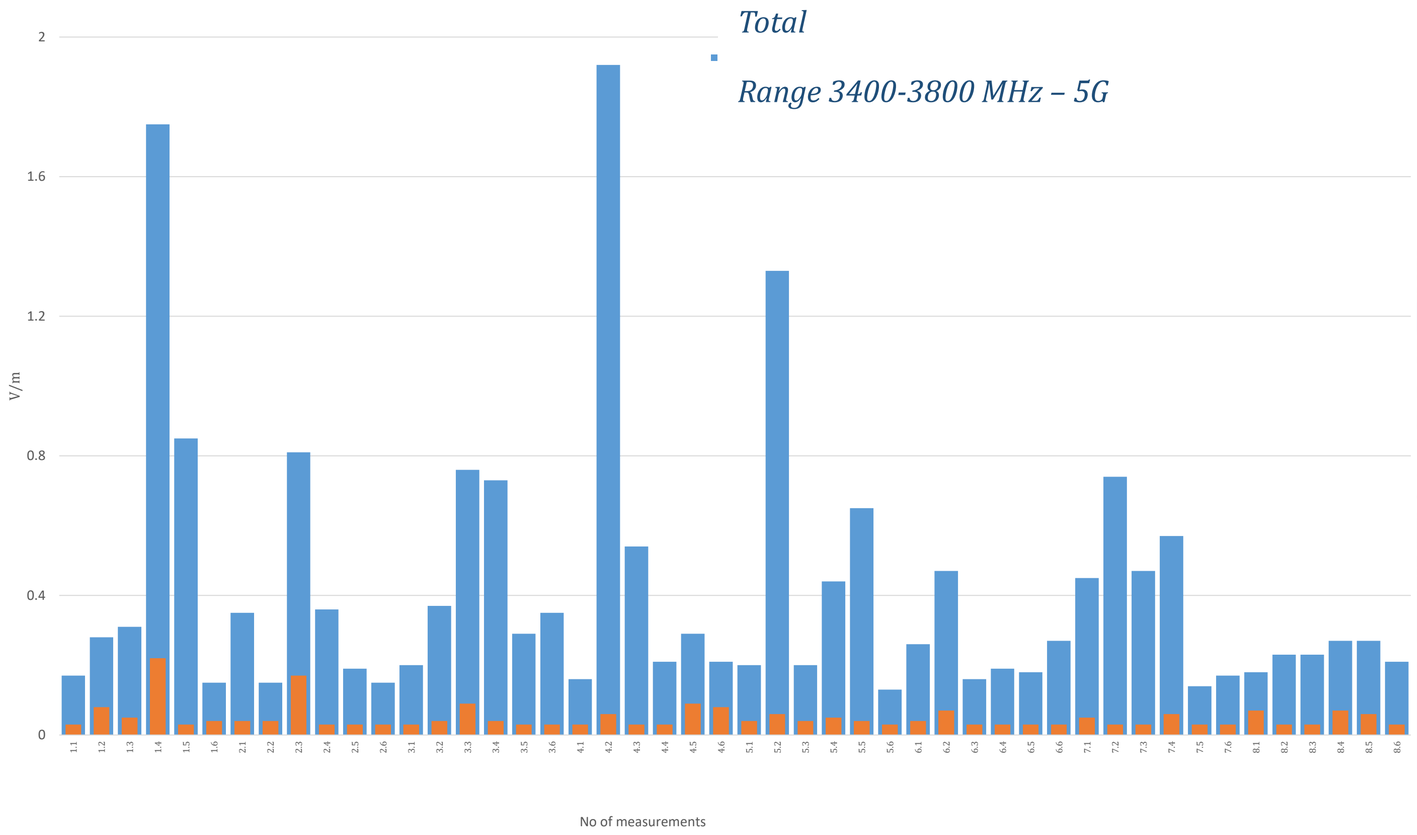


Total E-field for years 2023 and 2024

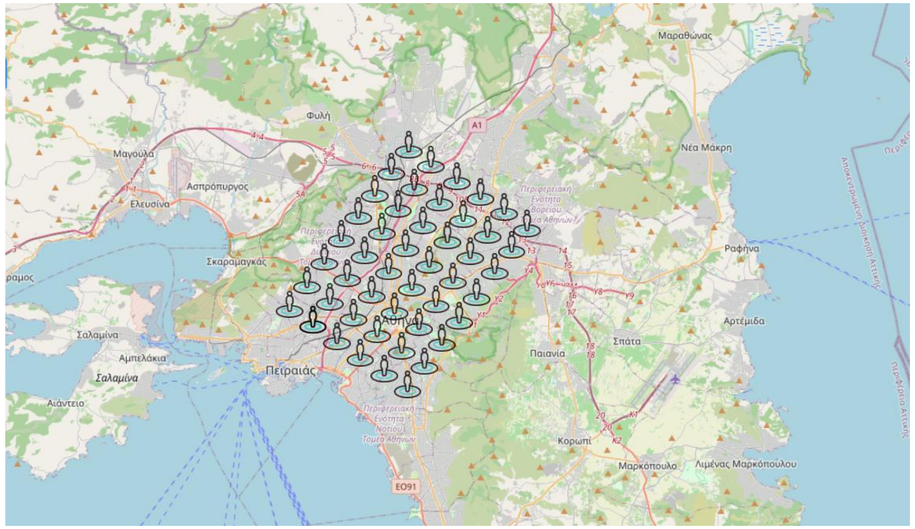


value (V/m)	2023	2024
no of measurements	2041	2045
median	1,7	1,9
mean	2,9	2,8
max	27,0	22,8
min	0,083	0,079
std	3,0	2,8

Measurements on the ground (2025)
total and 5G FR1

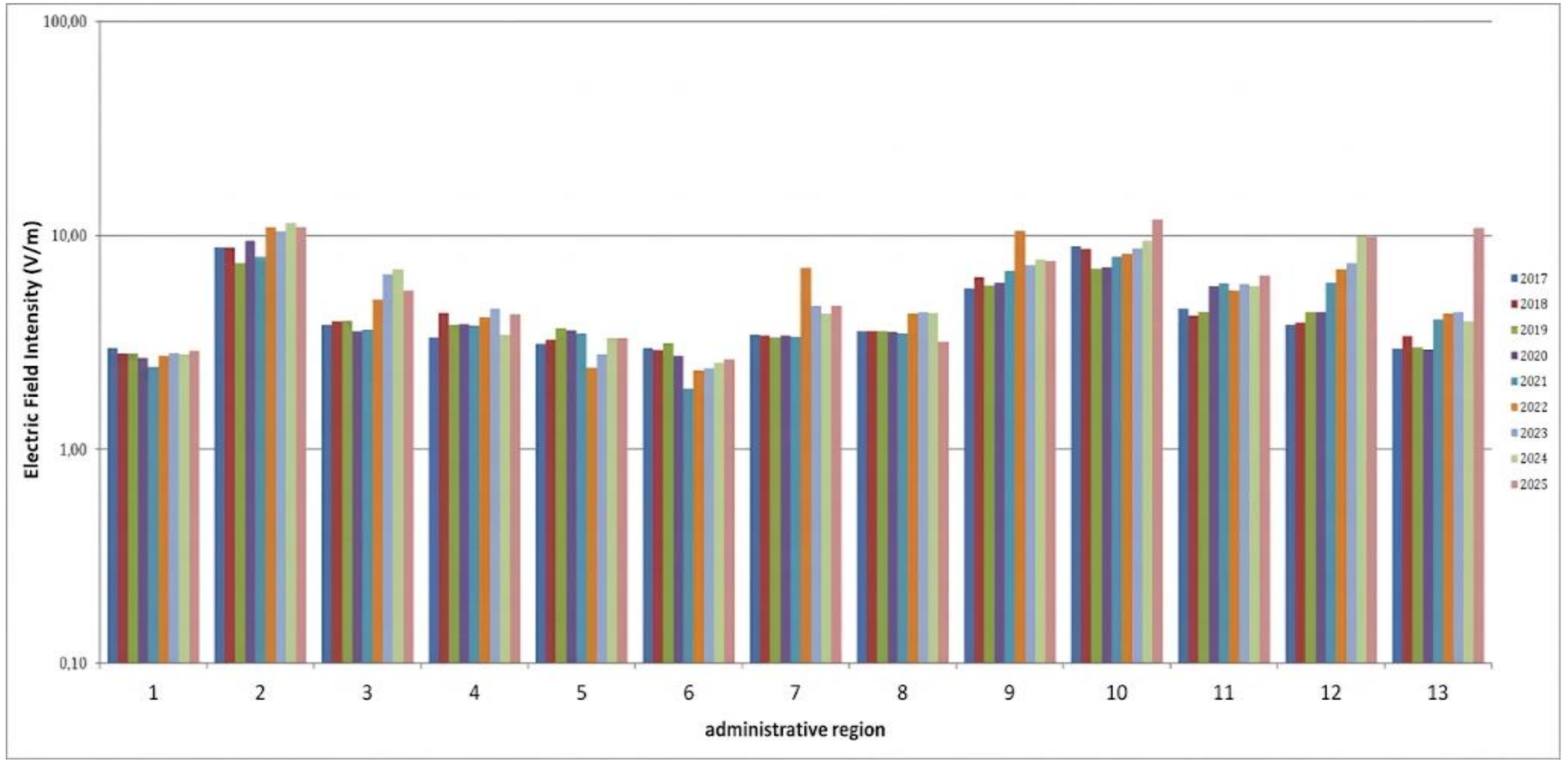


48 points, 140 square kilometers



NOEF broadband measurements

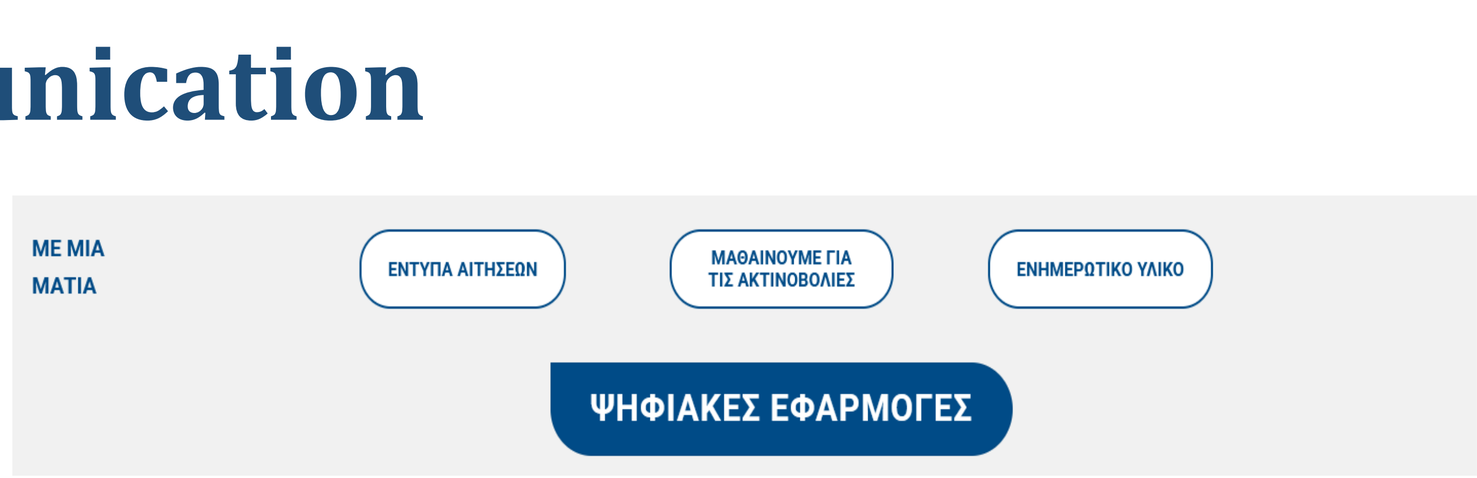
max daily average values of electric field



Scientific communication







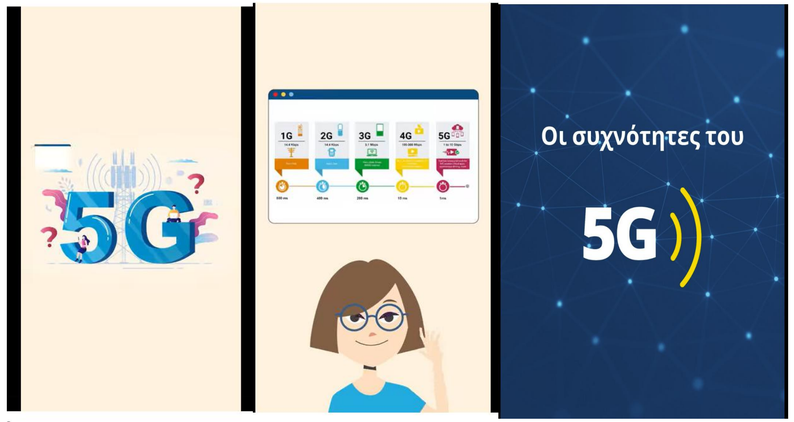


ΤΕΧΝΟΛΟΓΙΑ 5G ΚΑΙ ΥΓΕΙΑ

1) Τι είναι η τεχνολογία *5G NR;*

Η τεχνολογία 5ης γενιάς (5G NR-New Radio) είναι η πιο πρόσφατη και σημαντική εξέλιξη της τεχνολογίας ασύρματων κινητών επικοινωνιών μετά από αυτήν της 4ης γενιάς. Χρησιμοποιήθηκε για πρώτη φορά το 2019, ενώ στην Ελλάδα ξεκίνησε στις αρχές του 2020.

Η τεχνολογία 5G έχει σχεδιαστεί για να ανταποκριθεί στην πολύ μεγάλη ανάπτυξη στη σημερινή σύγχρονη κοινωνία στο διαδίκτυο των πραγμάτων (Internet of Things-IoT) και στην ανάγκη μετάδοσης μεγάλου όγκου δεδομένων, αλλά και της συνδεσιμότητας με διοεκατομμύρια συνδεδεμένες συσκευές. Η τεχνολογία 5G λειτουργεί σε συνδυασμό με τις υφιστάμενες υποδομές των δικτύων κινητής τηλεφωνίας έως ότου εξελιχθεί σε πλήρως αυτόνομο δίκτυο. Χαρακτηρίζεται από υψηλή χωρητικότητα και ταχύτητα δεδομένων και εξαιρετικά αξιόπιστη απόκριση. Με την πλήρη ανάπτυξη της τεχνολογίας 5G αναμένεται:



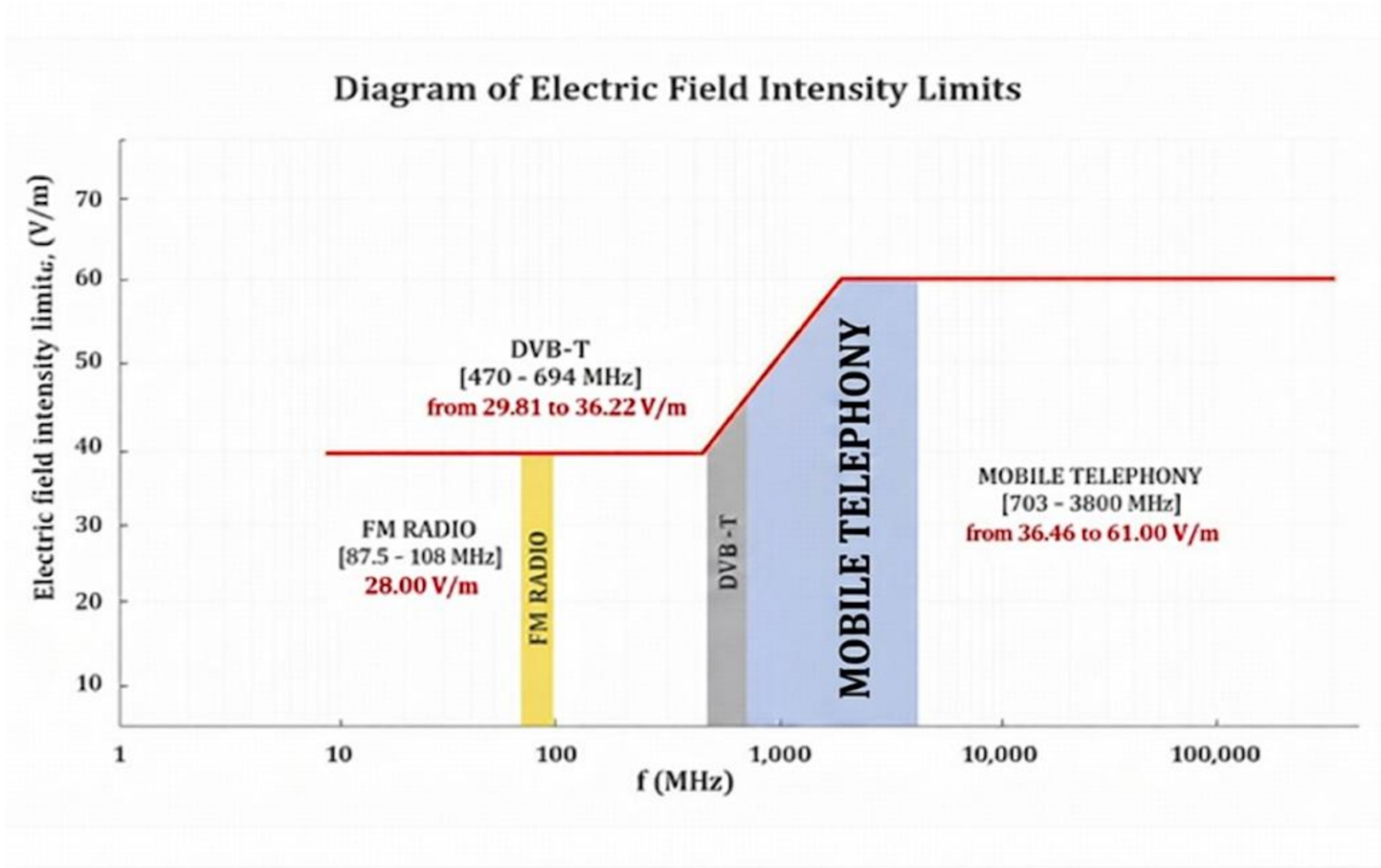
www.eeae.gr

Reference levels harmonization with 1999/519/EC [December 2025]

Law No 5256/2025

The established safety limits for general public exposure in the vicinity of all kinds of antenna stations are aligned with

1999 EU Council Recommendation on basic restrictions and reference levels values (1999/519/EC,1999)



2 years harmonization procedure

Greek legislation had foreseen the establishment of a scientific committee of experts which would assess the necessity of adopting ICNIRP reference levels in Greece.



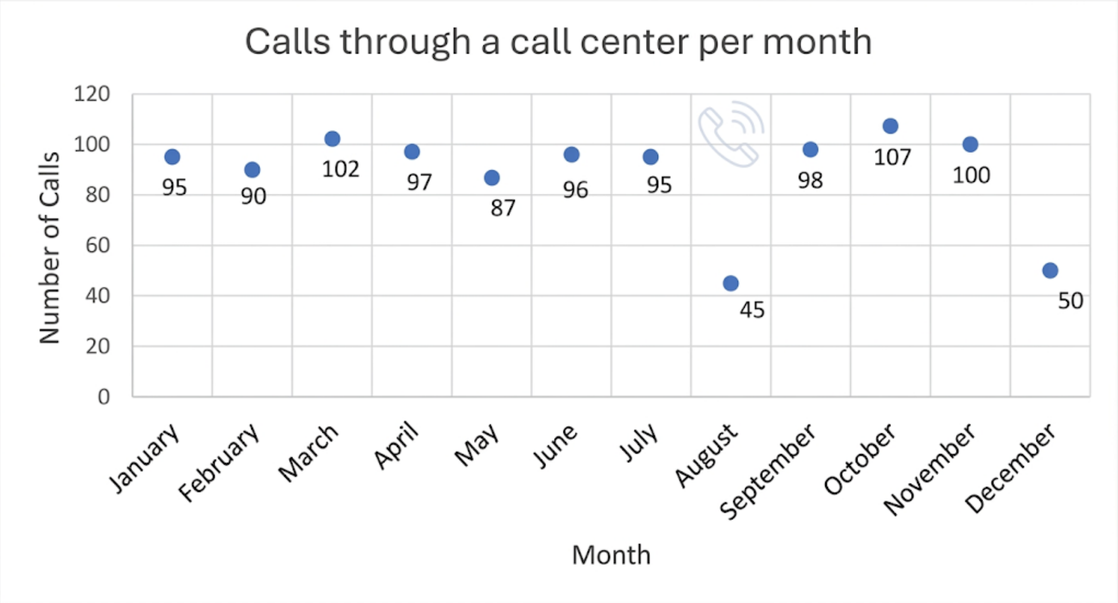
This harmonization procedure was run by the Ministry of Digital Governance, Health, Environment. Additionally, authorities and universities were involved (interested parties), providing their aspects and scientific input.

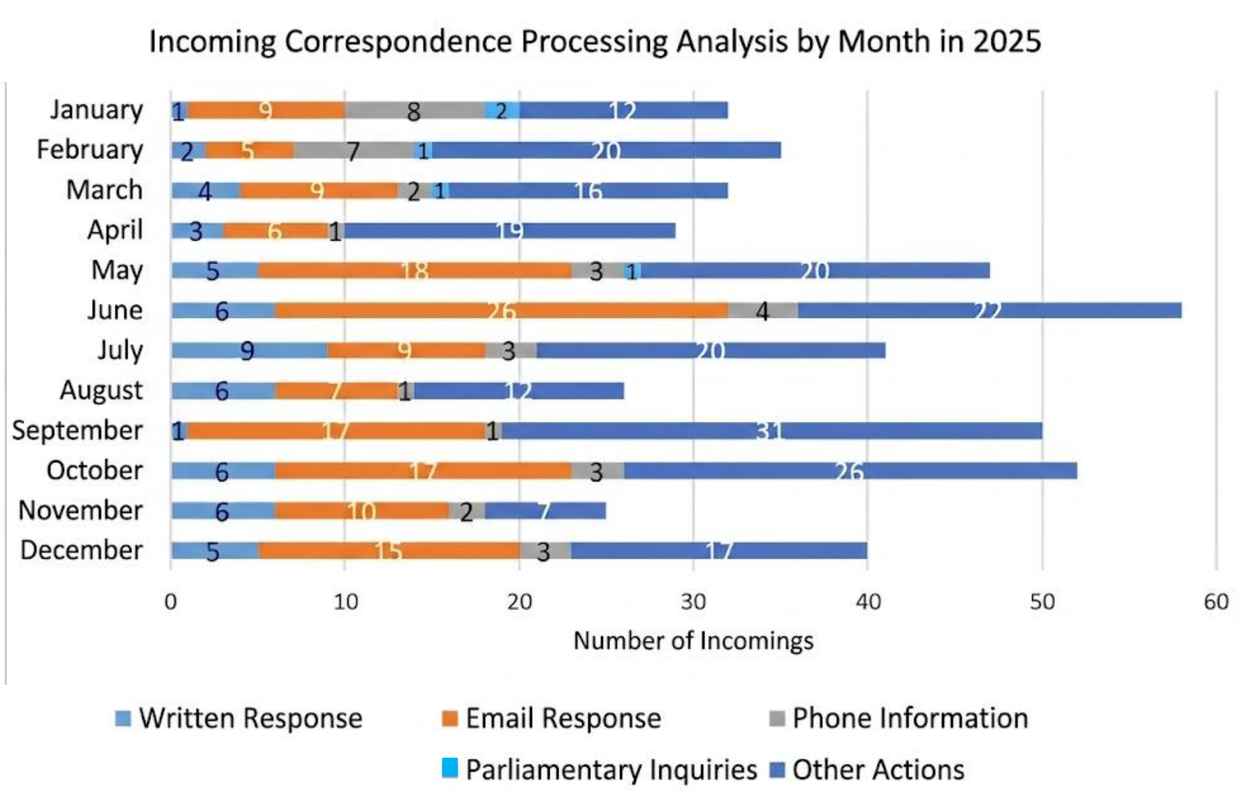
The legislative text concerning the harmonization of limits with 1999/519/EC was put out for public consultation and was open to comments from citizens. This procedure lasted almost a month.

Mild reactions by the general public



Phone calls and incoming docs management





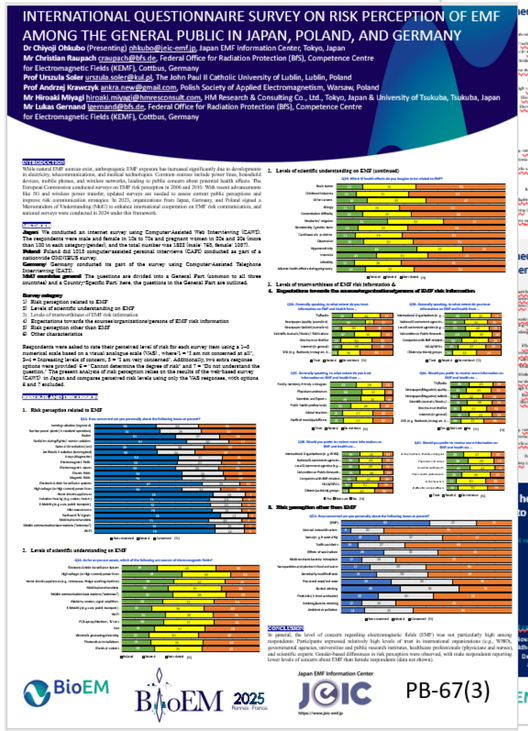
Online survey

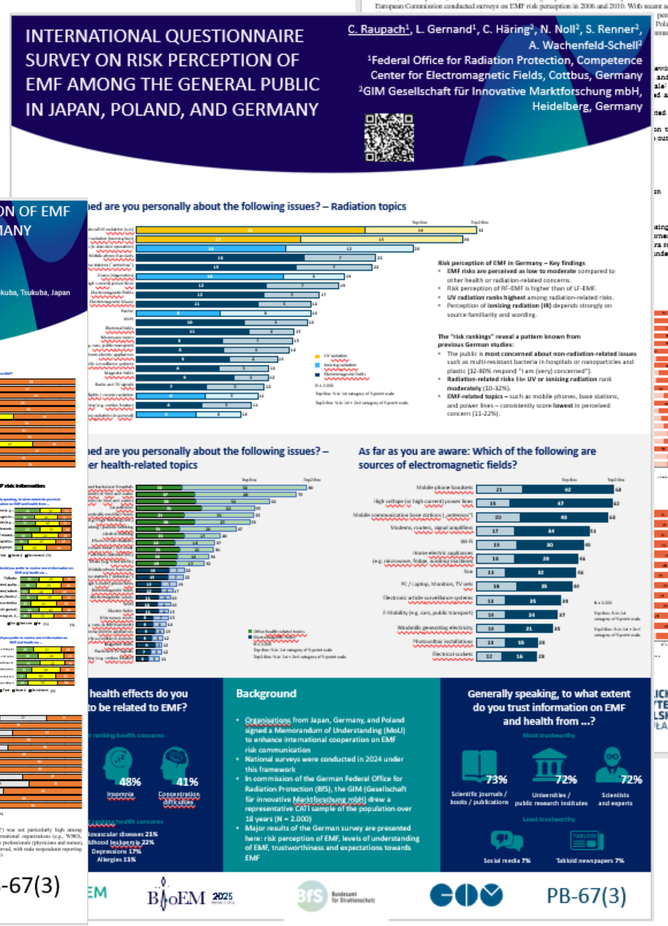
Countries: **Japan, Poland, Germany, Greece, France**

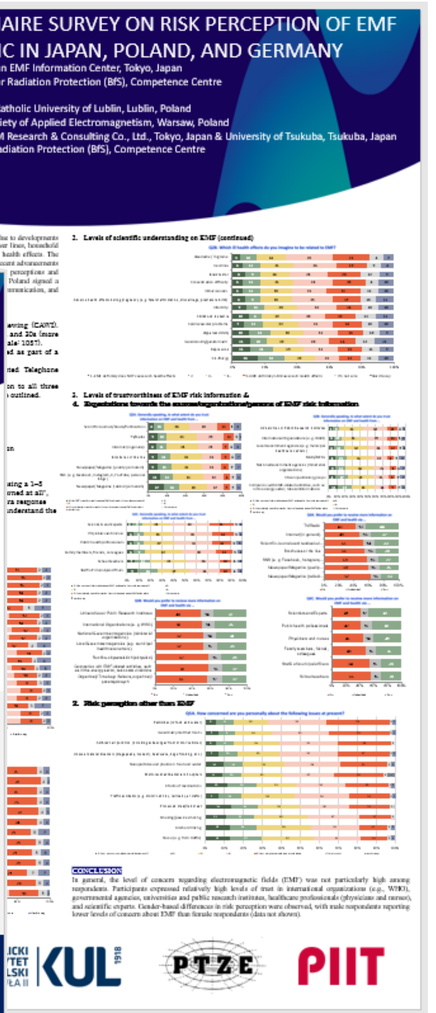
RF EMF
Radiation
Other hazards

general public perception
information sources
trust in organizations

31% of the sample worries about EMF







www.eeae.gr

EEAE ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΑΤΟΜΙΚΗΣ ΕΝΕΡΓΕΙΑΣ
GREEK ATOMIC ENERGY COMMISSION



Maria Christopoulou | Greece
Greek Atomic Energy Commission (EEAE)
Non-Ionizing Radiation Unit

tmia@eeae.gr | maria.christopoulou@eeae.gr

The 15th GSMA EMF Forum, 13 October 2026



Lisette Kruit
Antenna Agency,
Netherlands

Practical experience of RF-EMF policy implementation



Antenne Bureau

Lisette Kruit
Coordinating advisor Antenne Bureau

13 October 2026

The Antenne bureau

- Information office of national government, part of the Dutch Authority for Digital Infrastructure

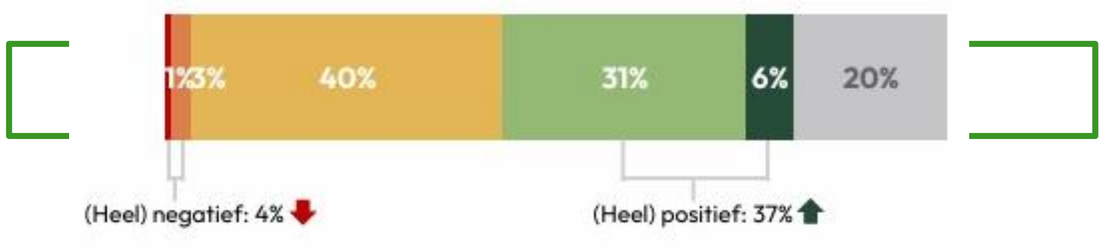
- Goal: providing factual information for citizens to enable them to form an opinion about antennas and contributing to a realistic image of EMF in the environment

- Provides information about technology, EMF and legislation to citizens, local government and professionals

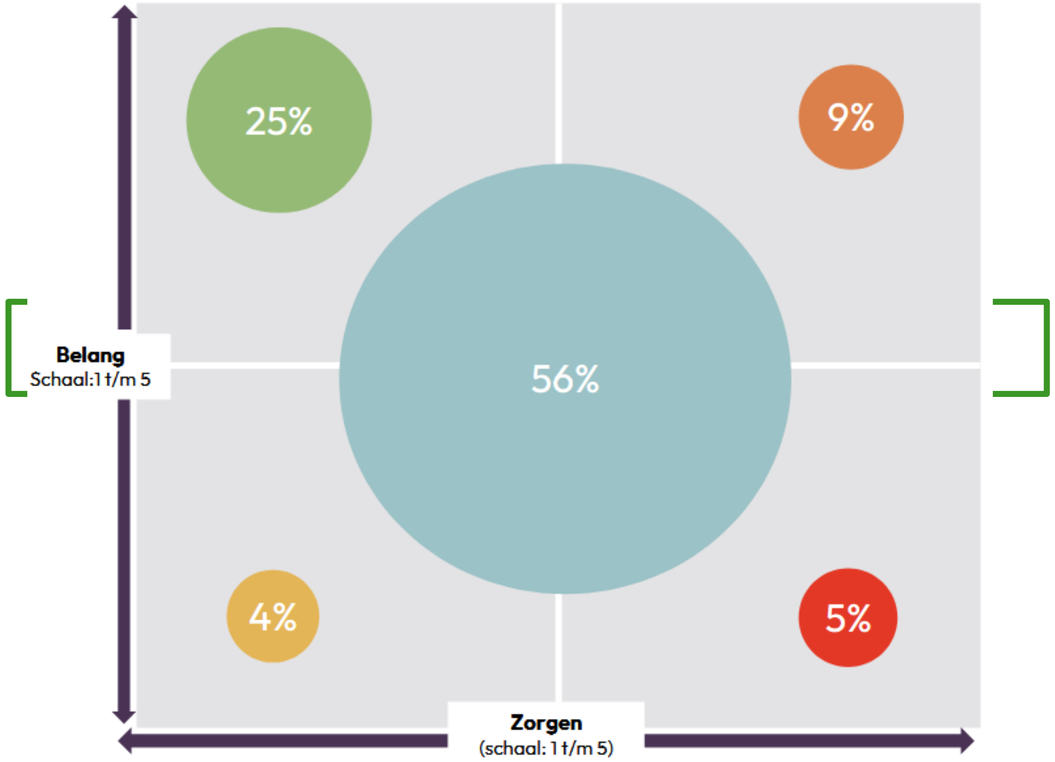
Our communication strategy

- Mostly reactive communication strategy
  - Publicly available information (e.g. website, factsheets etc.)
  - Information sessions on location are organized on demand
- Actively informing local government

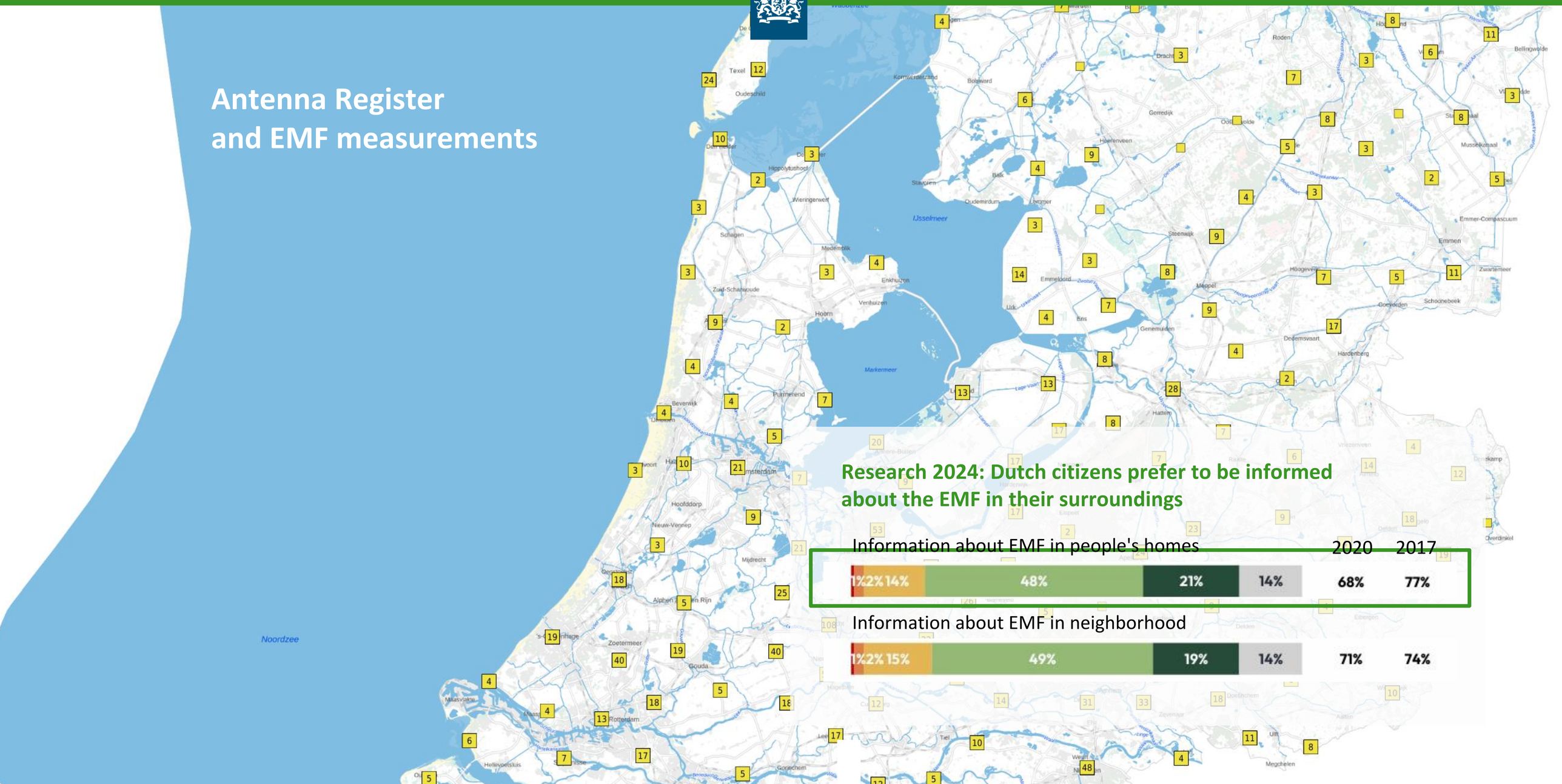
Research 2024: Dutch citizens more positive about 5G



Research 2024: most Dutch citizens not worried about EMF



Antenna Register and EMF measurements



Research 2024: Dutch citizens prefer to be informed about the EMF in their surroundings

Information about EMF in people's homes

1%	2%	14%	48%	21%	14%	2020	2017
						68%	77%

Information about EMF in neighborhood

1%	2%	15%	49%	19%	14%	2020	2017
						71%	74%

Research 2024: communicating with the silent majority

- Polarization in society

- How to communicate with the silent majority?
  - No one-size-fits-all
  - Societal context
  - Room for nuance and empathy
  - Know your position as a source

Research: Communicating with the silent majority (2024)
By: Het PON & Telos
In Dutch: https://www.antennebureau.nl/documenten/2025/07/25/rapport-onderzoek-communiceren-met-het-stille-midden

Practical experience of RF-EMF policy implementation



Dr Azadeh Peyman
UK Health and Security Agency

UK Health Security Agency

5G Technologies; Radio Waves and Health

Azadeh Peyman
Senior Scientific Group Leader - Electromagnetic Field Dosimetry
Radiation, Chemicals, Climate and Environmental Hazards Directorate

UKHSA Copyright
Not to be redistributed without written permission

UK Health Security Agency (UKHSA)

Protecting people from health threats and strengthening the UK's health security

- Protecting people from **health threats** by preventing and reducing harm from infectious diseases, chemicals, **radiation**, climate change impacts and **environmental hazards**.
- Providing **scientific**, clinical, **public health** and operational leadership to strengthen the UK's health security and emergency preparedness.
- Working with **local**, **national** and **international** partners to safeguard public health as an **executive agency** of the Department of Health and Social Care (DHSC).

Our strategic framework

MISSION	Protect people from health threats		
VISION	Science-led, data-driven, operationally excellent		
PILLARS	**Understand**	**Prevent**	**Respond**
	Surveillance, analysis, insight and translation	Intelligence, guidance, intervention and innovation	Preparedness, agility, effectiveness and direction
FOUNDATIONS	Expertise and infrastructure		
	Leadership and collaboration		



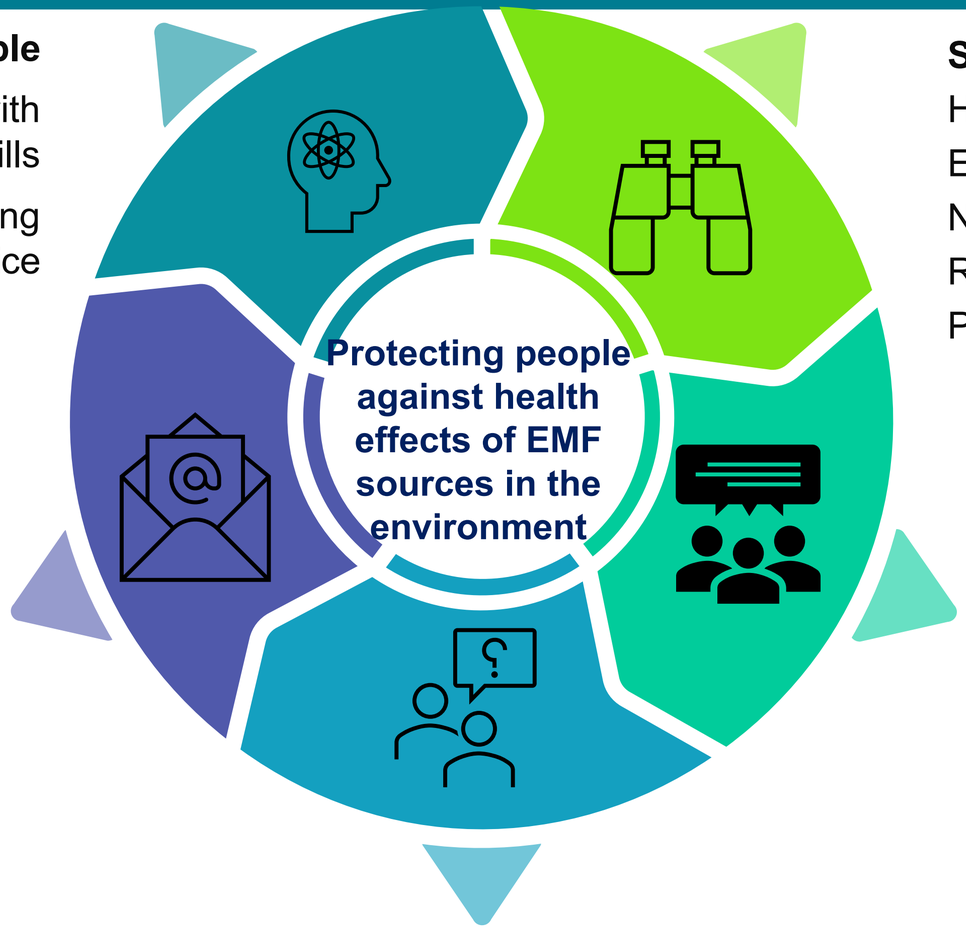
UK Health Security Agency

Radiation Protection Sciences
Electromagnetic Field Dosimetry Group

People

Unique expertise with strong analytical skills

National point of providing evidence-based advice



Scientific activities

Horizon scanning

Experimental studies

National and international collaborations

Research impact

Project management

Public and parliamentary enquiries

Advisory correspondence

Daily basis and short deadlines

Policy development and risk communication

Stakeholder mapping

Development of evidence-based advice

Training and knowledge transfer

Standardisation

Expert witness

Consultancy and support for expert groups

COMARE (EMF and Health Subgroup)

WHO

BioEM community

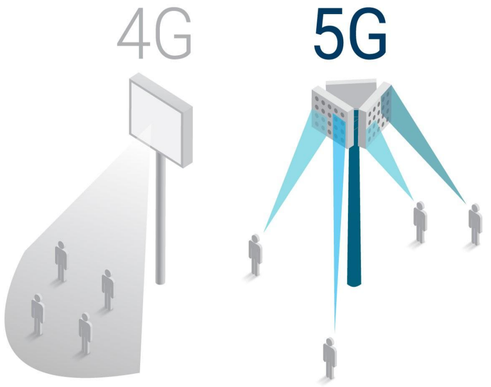
5G and health in UK
EMF Enquiries Received by UKHSA

- Hundreds of health-related queries
- 4 Petitions specifically to stop/delay deployment of 5G based on health concerns (up to ~56k signatures)
- Westminster Hall debate
- Legal challenge against the Government

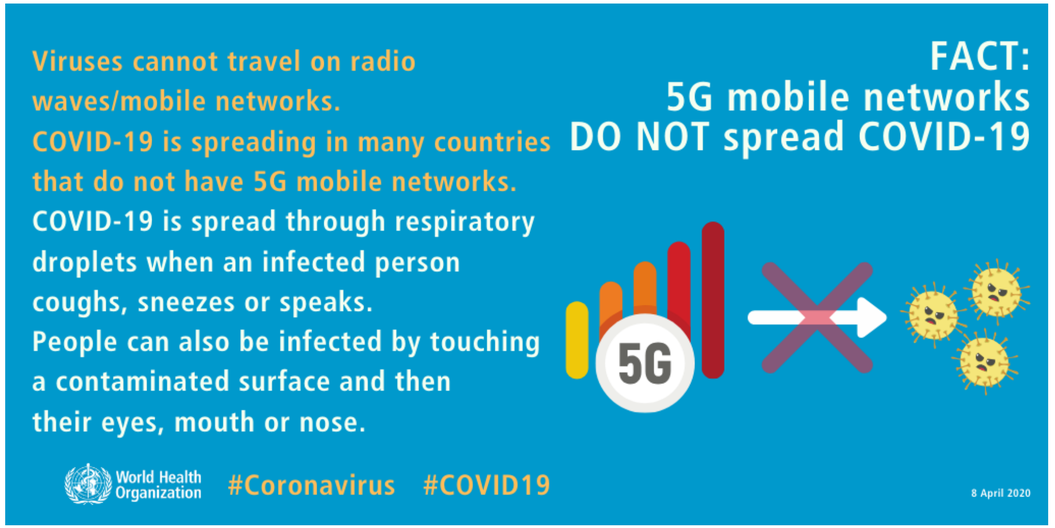
Year	Number of enquiries	
	Total	5G mentioned
2016	176	0
2017	208	5
2018	259	51
2019	466	225
2020	306	128
2021	176	39
2022	156	34
2023	144	37
2024	136	28
2025	129	21

Myths, misinformation and concerns about 5G

- Increase in number of base stations may increase the exposure slightly but overall exposure is well below international guidelines
- Higher frequency does not mean higher exposure
- Massive MIMO
  - Antennas are NOT ‘massive’ in size – similar in size to previous generations- but made up of a larger number of smaller antennas
  - Targeted beams- signals are directed for efficiency as well as to reduce incidental radio wave exposure levels in the environment
- Covid-19 – no link whatsoever
- Not in my backyard (NIMBY)







Environmental assessment work

Horizon scanning

5G is the latest mobile telecommunications technology

Increased public concern observed

Research: UKHSA measurement campaign

Sample across various mast types, microenvironments, network operators and cities

Applied latest methods in standardization (IEC 62232)

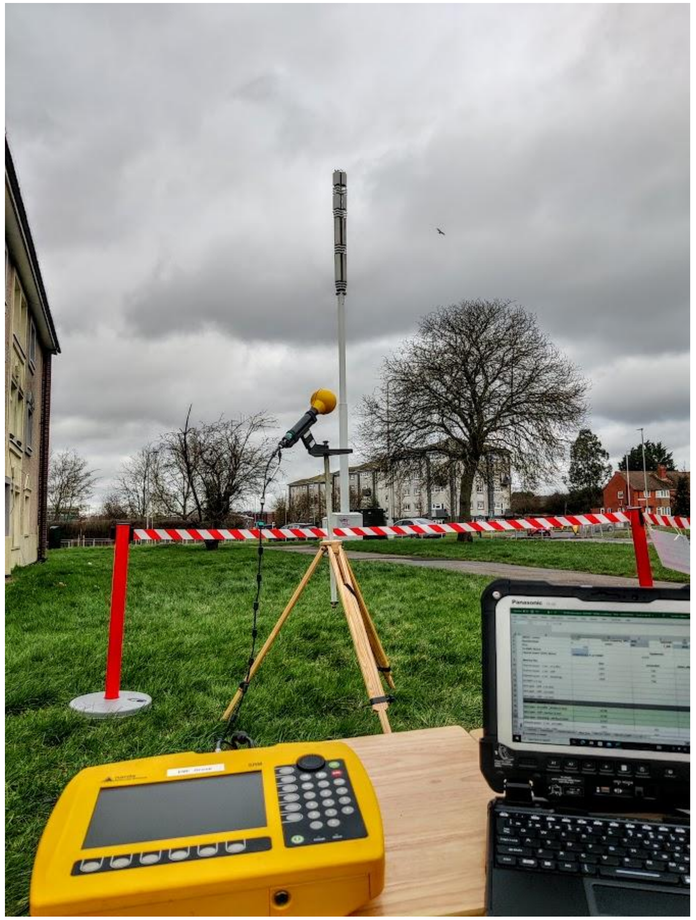
Provision of advice

Publication

New 5G gov.uk webpage

Input to IEC standard

UK input to GSMA database



Contribution to IEC 62232

- Adopted by IEC 62232 as a case study, providing real-world evidence to support RF exposure assessment methods at operational 5G sites.

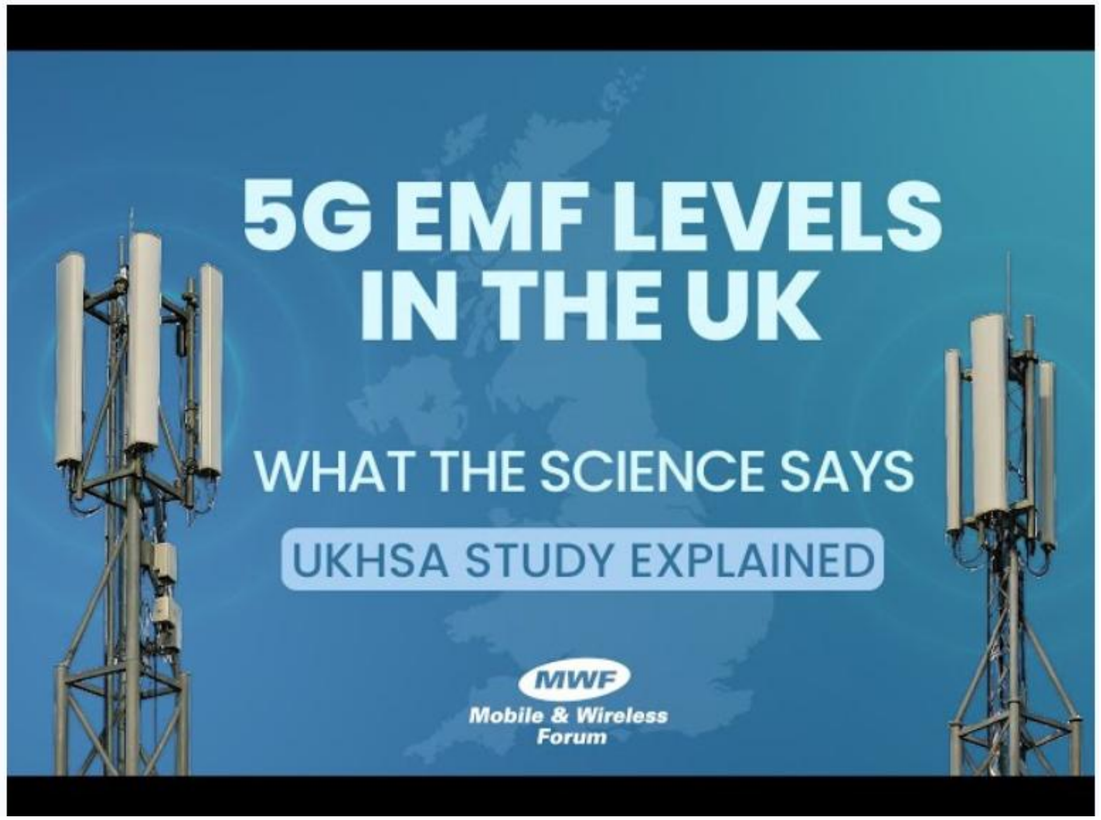
- Identified opportunities to strengthen future IEC 62232 guidance for advanced 5G features, limited site data scenarios, evolving network configurations, and realistic exposure assessment parameters.



From Research to Public Communication

MWF produced a public-facing explainer video based on our UKHSA 5G study

Real-world 5G base station exposures in the UK



On-going and further work

- 5G exposure assessment in London Transport System (leaky cables and small cells)
- Plan for 5G FR2 measurement campaign
- Keep up with 6G developments



UK Health Security Agency

Thank You

Panel: Practical experience of RF-EMF policy implementation



Dr Maria Christopoulou
Greek Atomic Energy Commission, Greece



Dr Azadeh Peyman
UK Health and Security Agency



Lisette Kruit
Antenna News Agency, Netherlands



Natalie Mack
Telstra, Australia
GSMA EMF and Health Delegate

Session 2

The future is here: EMF aspects of emerging mobile technologies



DI Manfred Ruttner
A1 Telekom Austria,
Deputy Chair GSMA EMF and Health



Patricia Martigne
Orange France,
GSMA EMF and Health Delegate

The future is here:
EMF aspects of emerging mobile technologies

13.10.2026, M. Ruttner
A1 Telekom Austria AG, Vienna, Austria
E-mail: manfred.ruttner@a1.at

A1. Responsibility for Austria

10.000 m² space
one of the largest operator of datacenters in Austria

~80,000 households
connected to the A1 Fiber Network in 2025



990,000 households
Supplied with FTTH/B (Homes Passed)



Fiber to the Basestation
7,550 base stations connected to the fiber-optic network

~500 mn euros per year
investments in infrastructure



~90% 5G coverage
4G/LTE more than 99%



~40 mn euros per year
investments in security



Test victories 2025

Chip Best 5G Network
connect Readers' Choice
connect Shoptest & Service Apps
nperf Broadband & Mobile Network
Smartphone Best Customer Service
Smartphone Fiber Internet & 5G Cubes

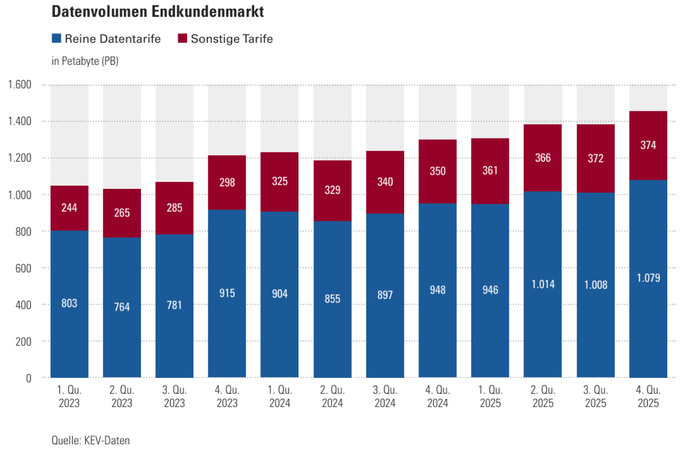
The largest fiber optic network in Austria
with a length of 80,000 km



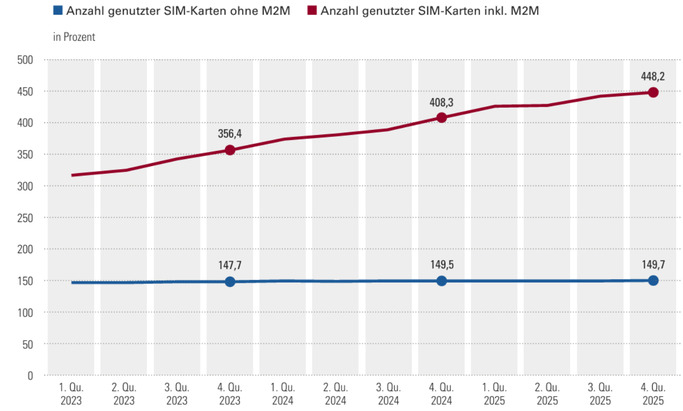
Mobile Communications
The Road from 5G to 6G

Traffic Growth

- RTR Telecommunications Monitor Annual Report 2025 (10 August 2026) www.rtr.at



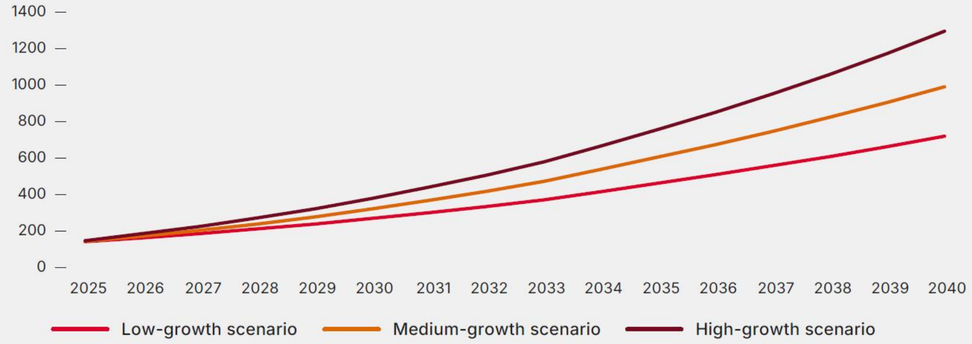
Quelle: KEV-Daten



Quelle: KEV-Daten, Statistik Austria

- GSMA Vision 2040: Future Spectrum Needs www.gsma.com/connectivity-for-good/spectrum/gsma_resources/vision-2040-future-spectrum-needs/

Figure 5a:
Global traffic growth by scenario, 2025–2040 (EB/month)



Source: GSMA Intelligence
Note: Includes mobile, FWA and IoT traffic.

5G now covers more than half the world’s population

- Network Coverage and Infrastructure
  The State of Mobile Internet Connectivity 2025
  www.gsma.com/somic/network-coverage-and-infrastructure/

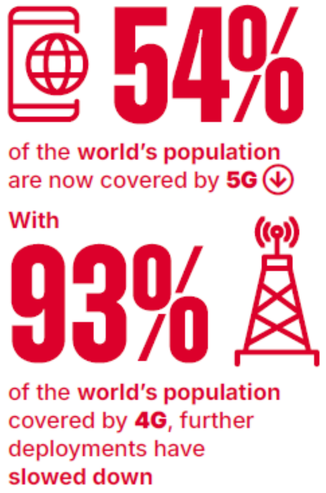
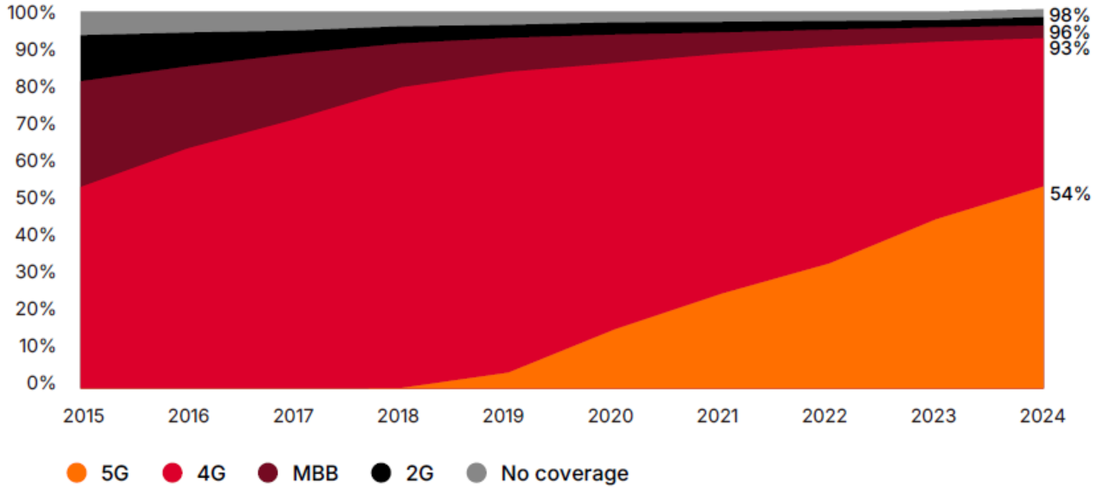


Figure 2: Global population coverage by technology, 2015–2024



Source: GSMA Intelligence

Network sunsets

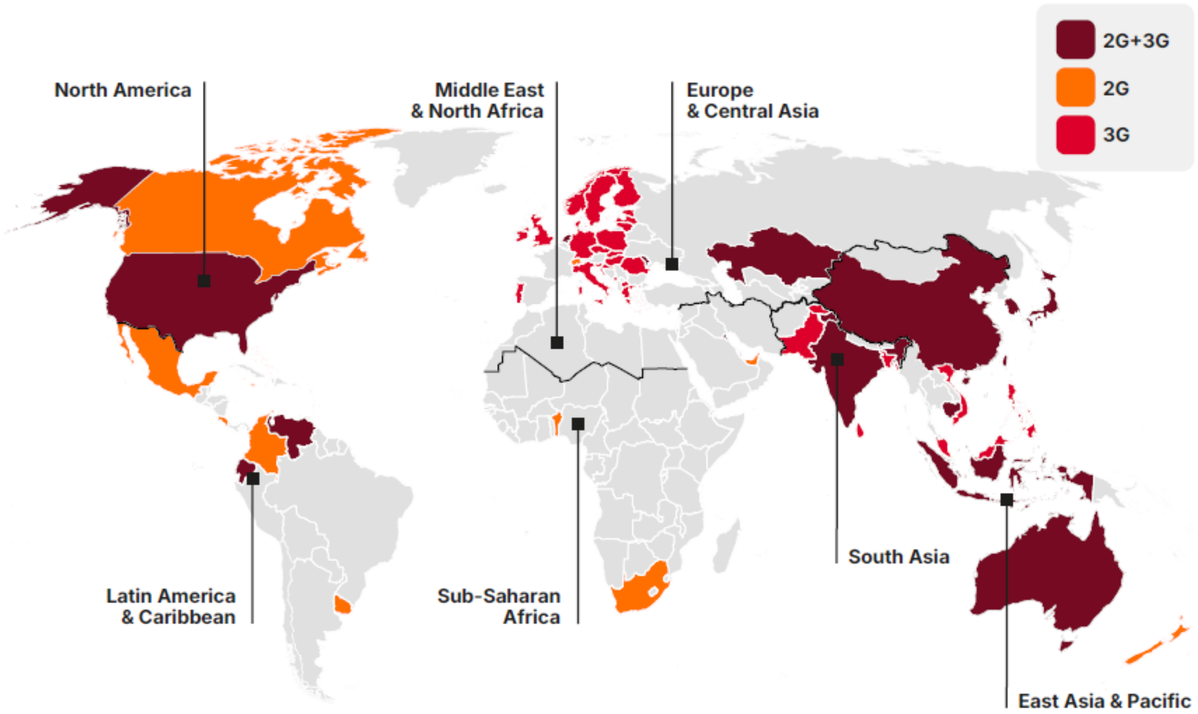
- Network Coverage and Infrastructure
  The State of Mobile Internet Connectivity 2025
  www.gsma.com/somic/network-coverage-and-infrastructure/

- Network sunsets in Austria
  - 3G/UMTS 2025
  - 2G: A1 Mai 2028

  } Spectrum reused by more efficient 4G, 5G

2G is a mobile communications standard from the early 1990s and no longer meets today's requirements for security, efficiency, and performance.
www.a1.net/2g

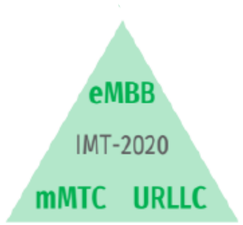
Figure 4: Network sunsets completed



Note: A country is assigned completed status when at least one operator in the country has shut down the respective network generation. Data correct to 31 March 2025.
Source: GSMA Intelligence

Usage Scenarios 5G

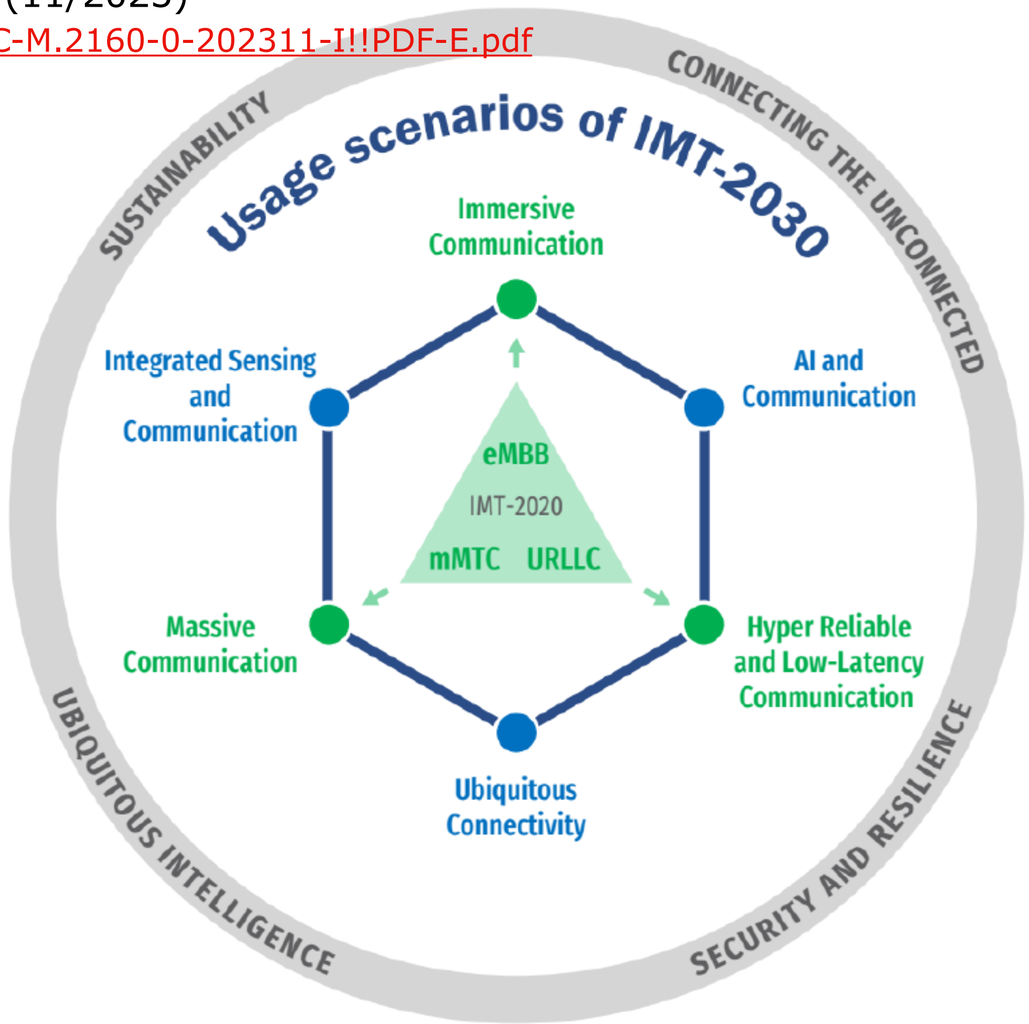
- ITU Recommendation ITU-R M.2160-0 (11/2023)
  www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2160-0-202311-I!!PDF-E.pdf



eMBB	Enhanced Mobile Broadband
mMTC	Massive Machine-Type Communication
URLLC	Ultra-Reliable Low Latency Communications

Usage Scenarios 6G

- ITU Recommendation ITU-R M.2160-0 (11/2023)
  www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2160-0-202311-I!!PDF-E.pdf



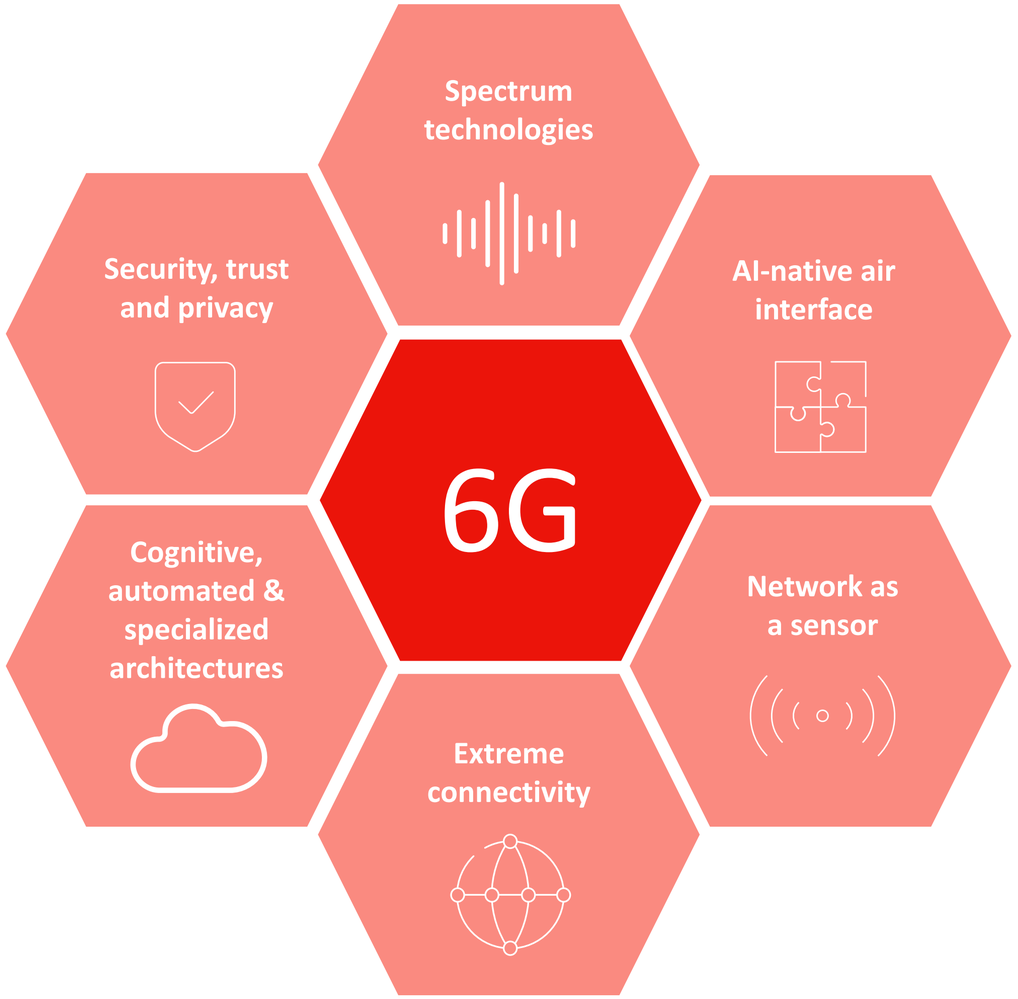
eMBB	Enhanced Mobile Broadband
mMTC	Massive Machine-Type Communication
URLLC	Ultra-Reliable Low Latency Communications

6G - Bringing the future to life

Six key technology areas for the 6G essential infrastructure

6G Networks that

- Sense
- Think
- Act



Key value drivers for 6G







Green by design

▲10X capacity increase with 50% power reduction, compared to 5G

Security and privacy

▲Increasing security and privacy risks require higher levels of control

Digital inclusion

▲Aims to address three key factors: accessibility, affordability and consumability

New and emerging mobile use cases

- GSMA Vision 2040: Future Spectrum Needs
  www.gsma.com/connectivity-for-good/spectrum/gsma_resources/vision-2040-future-spectrum-needs/

Use case	Description
XR[4]	XR is an umbrella term encompassing virtual reality (VR), augmented reality (AR) and mixed reality (MR), which involve immersive experiences blending the physical and digital worlds. XR devices include head-mounted displays (e.g. Oculus/Meta Quest), AR glasses, MR headsets (e.g. Microsoft HoloLens) and wearable haptics, enabling applications such as gaming, training, industrial maintenance and collaborative design.
Network sensing	Integrated sensing and communication (ISAC), or joint communication and sensing (JCAS), is a new use case envisioned for 6G. It will include applications such as object positioning and monitoring, imaging and real-time wireless map construction (including potentially 3D-mapping for automated transport and robot collaboration). It will also help to improve the performance and efficiency of the communication system itself, by optimising the utilisation of radio resources when sensing information is taken into account.
Digital twins	Digital twins are digital equivalents of the real world for interaction, control, maintenance and management (e.g. for manufacturing, construction, city infrastructure and smart cities). In a 6G environment, digital twins will enable users to explore, monitor and interact with real-world systems in a virtual space, potentially in real time and without temporal or spatial constraints, relying on high-capacity, low-latency network connections.
Network-assisted Mobility	Network-assisted mobility involves sensing and positioning being used together with communication and network intelligence to enable services such as physical scene analysis, tracking, context awareness, trajectory prediction, navigational support and collision avoidance (e.g. for cars, automated guided vehicles and drones). Connected cars could be a key 6G use case, particularly for the transfer of sensor data, processed telemetry, feature information, images and coordination messages that require real-time communication with the network or other vehicles. Data that is processed entirely in the vehicle or over fixed networks at home does not contribute to mobile network traffic, so only network-dependent exchanges impact the radio access network (RAN).
Collaborative robots	Collaborative robots include intelligent, collaborative and mobile robots with the ability to move, to sense their environment and perform a productive task. Application domains include home robots, robots for facility management and robots in daycares or hospitals. In the context of 6G, these robots may leverage network-assisted coordination, edge processing and real-time data exchange to enhance performance and safety.
Holographic communication[5]	Holographic communication involves real-time or non-real-time gestures and facial expressions presented by means of a holographic display and content obtained by means of capture, transmission and 3D-rendering techniques.

Source: GSMA Intelligence[6]

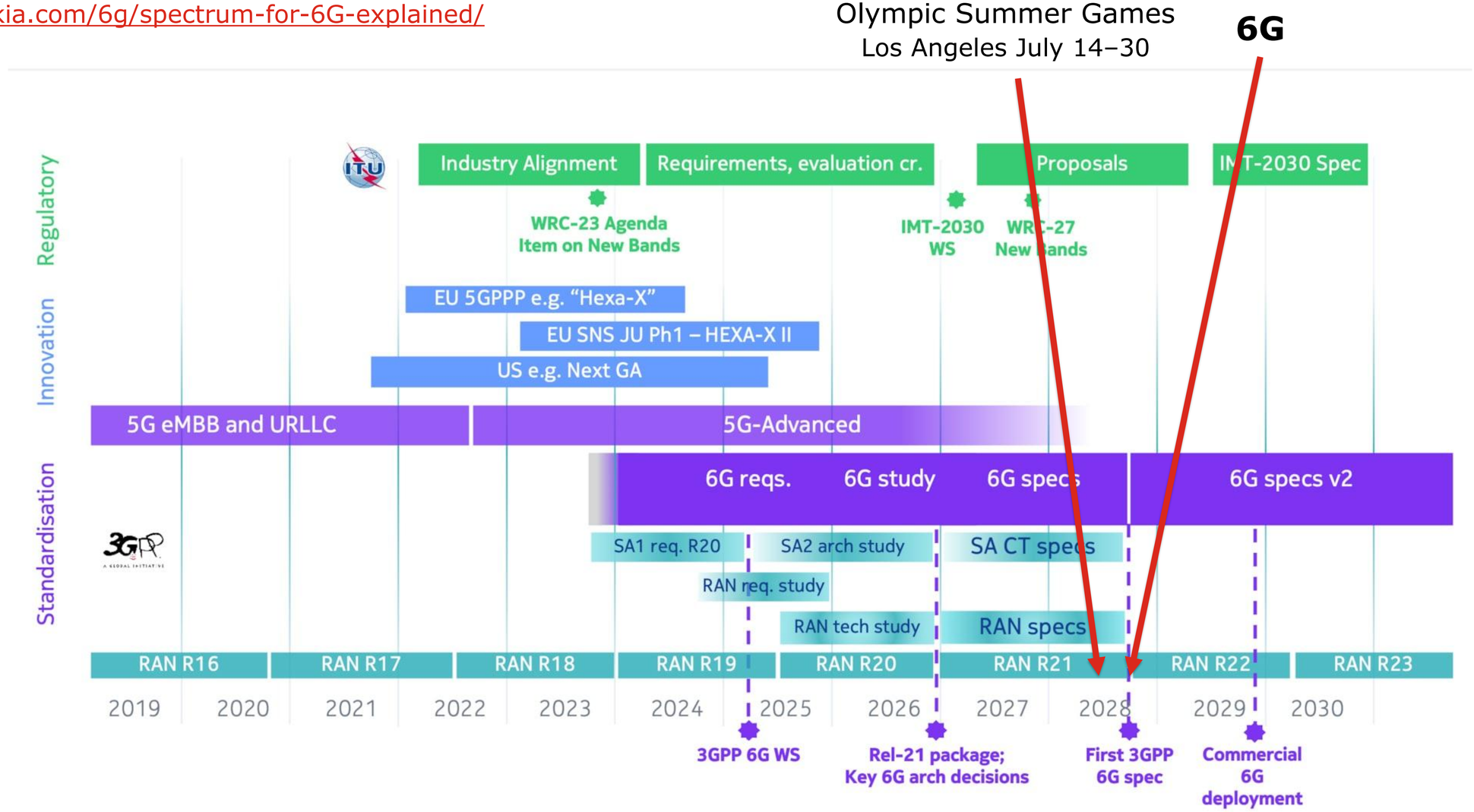
4 For mobile demand forecasts, we focus on smart glasses (e.g. Ray Ban Meta and Virture Luma) as they represent the most realistic mobile use case. This can be modelled based on requirements being bursty (short high-data interactions) or recurrent (regular streams), reflecting variability in network load.

5 For holographic communication, we assume non-real-time is the most likely mobile use case. This can be modelled in a similar manner to messaging, but with a much higher downlink and uplink requirement.

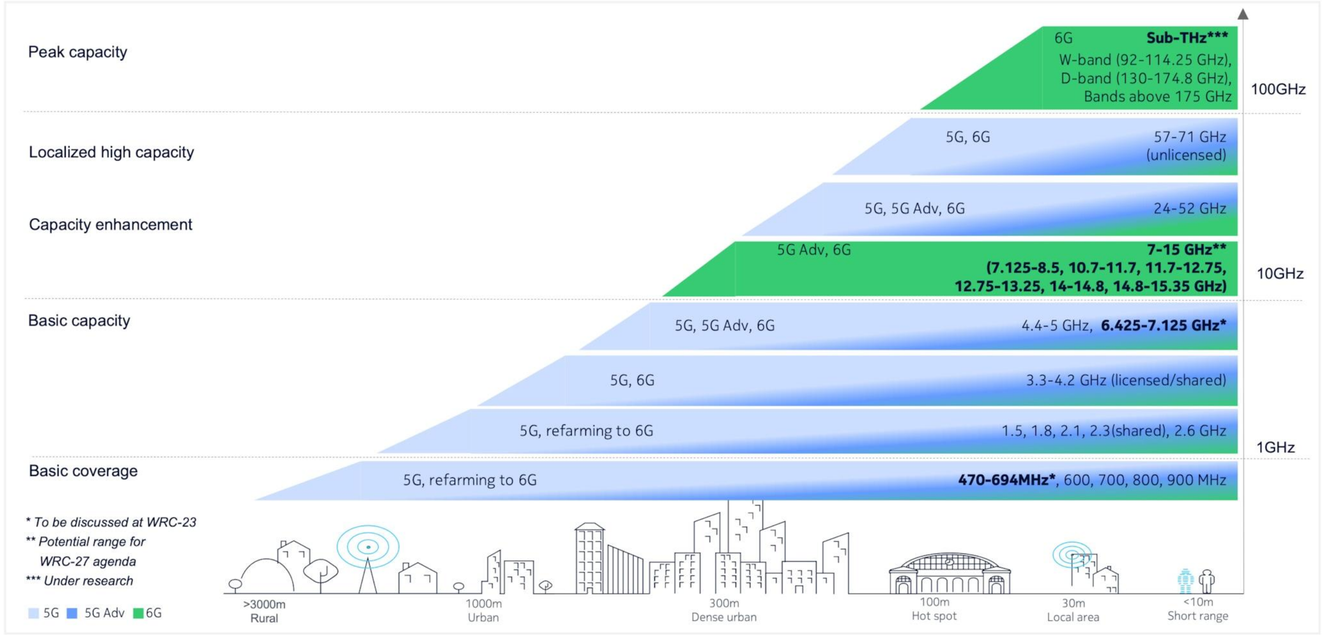
6 For further details on new 6G use cases, including potential performance requirements, see for example IMT-2030 (6G) Spectrum Needs Analysis, GSA, 2023; IMT-2030 (6G) use cases, GSA, 2022; 6G spectrum – enabling the future mobile life beyond 2030, Ericsson, 2024; Integrated Sensing and Communications, 5G Americas, 2025; Deliverable D1.2: 6G Use Cases and Requirements, Hexa-X-II, 2023; Deliverable D1.2: Expanded 6G vision, use cases and societal values, Hexa-X-II, 2021; and Deliverable D1.3: Targets and requirements for 6G – initial E2E architecture, Hexa-X-II, 2022.

The standard is evolving

- NOKIA: Spectrum for 6G explained
  www.nokia.com/6g/spectrum-for-6G-explained/

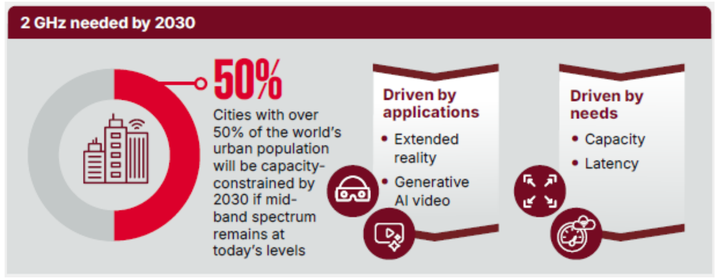


Spectrum for 6G



- NOKIA: Spectrum for 6G explained
  www.nokia.com/6g/spectrum-for-6G-explained/

- GSMA Vision 2040: Future Spectrum Needs

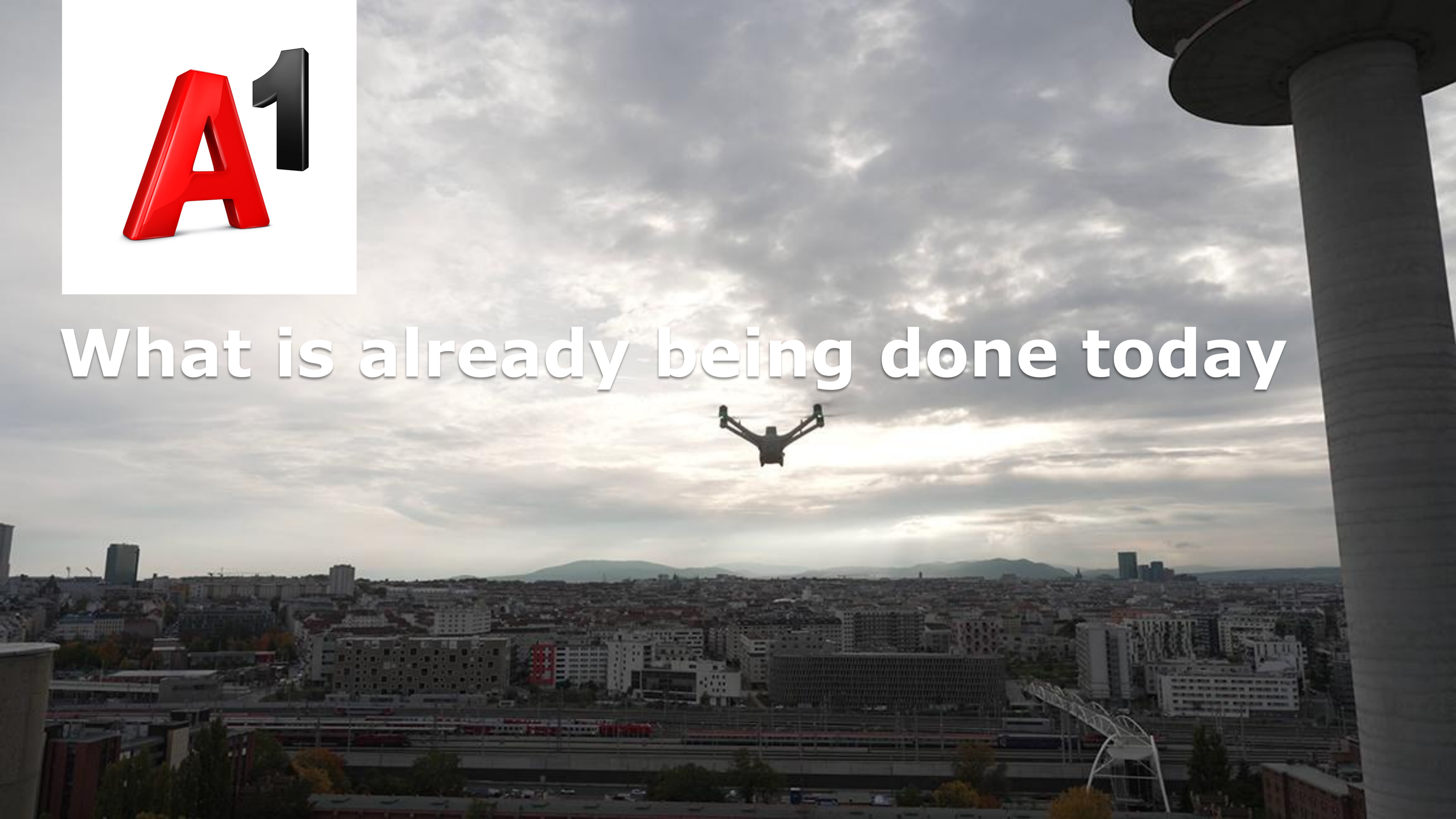


- Public consultation on Draft Radio Spectrum Policy Group Opinion on a 6G spectrum roadmap
  https://radio-spectrum-policy-group.ec.europa.eu/consultations-0_en

  A1 Response: Key Bands for 6G

Upper 6 GHz (6.425-7.125 GHz)	6G capacity band
7-8 GHz Range	future extension for 6G - important for high-demand applications
600 MHz Band (470-694 MHz)	6G coverage band

What is already being done today

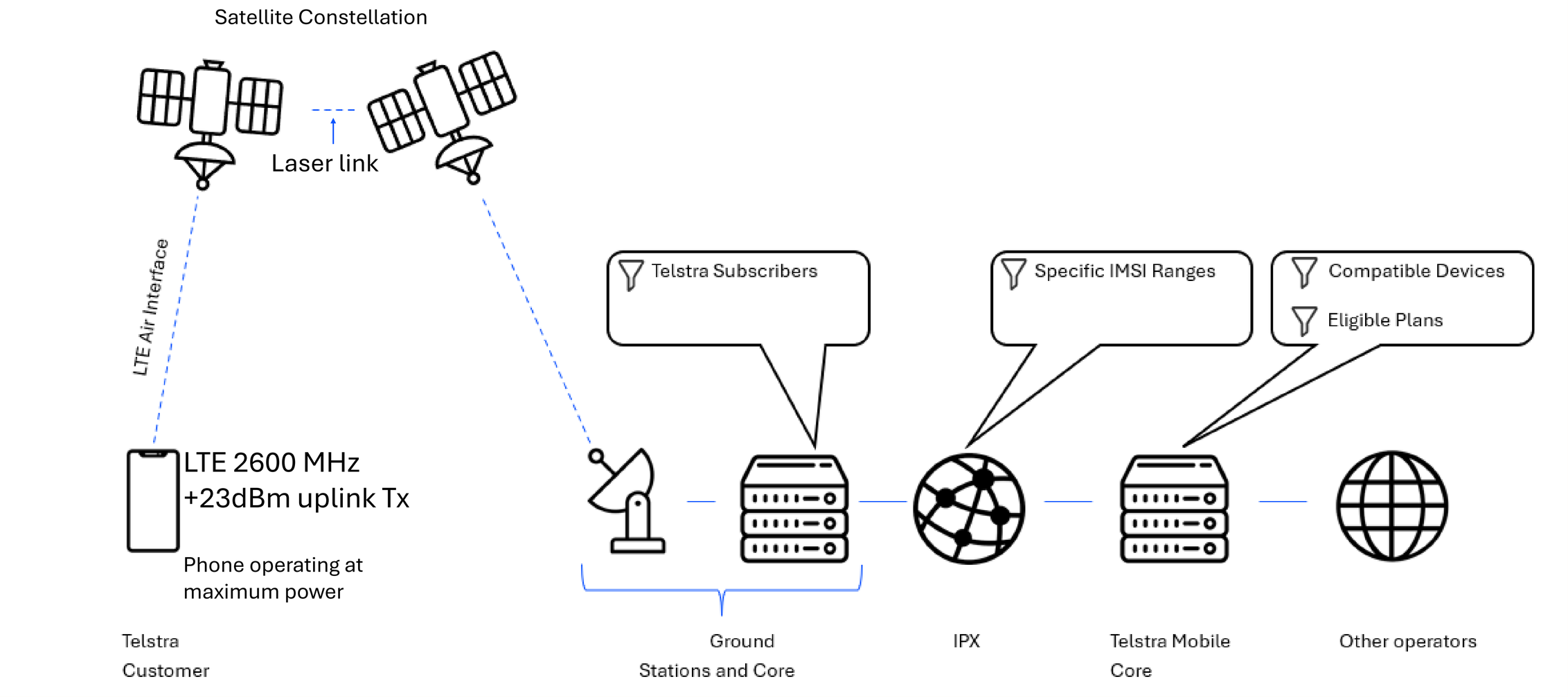


Telstra’s Satellite Messaging

EME Testing

Copyright Telstra©

How does Telstra Satellite Messaging Work?



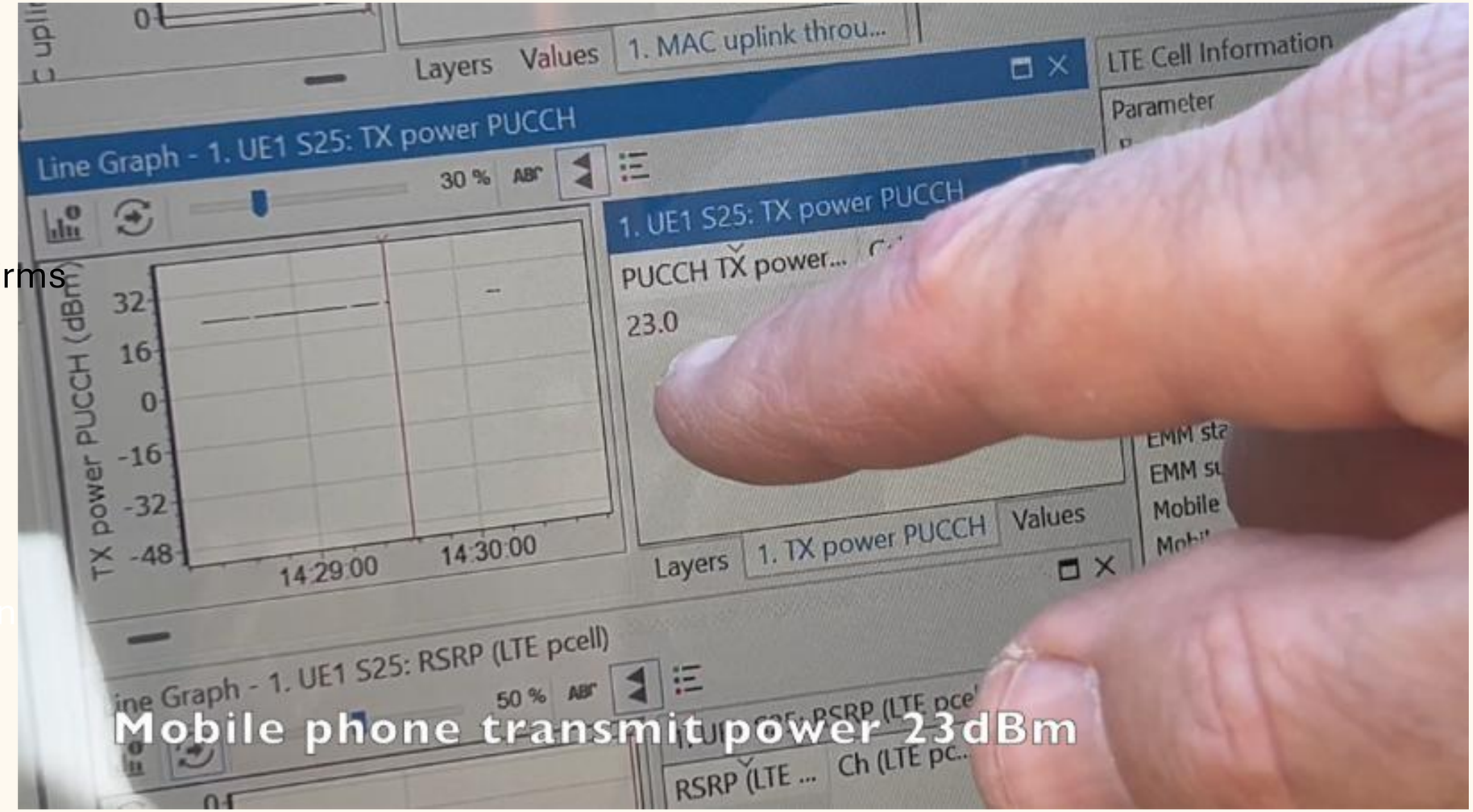
Copyright Telstra©

Telstra Satellite Messaging - Device Testing

Transmit power

Max Tx power = +23dBm

NEMO test software confirms this



Copyright Telstra©

Telstra Satellite Messaging – EME Summary

What is the EME like from the satellites on earth?

The LEO satellites are over 300km away and the radio signal is extremely low.

We measured receive levels of less than -110dBm on the remote beach and in rural areas.

This is millions of times below the EME public safety limits and thousands of times below TV and radio broadcast EME levels.

Uplink



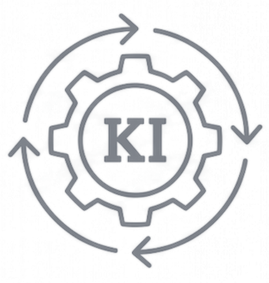
Copyright Telstra©

A1 turns the mobile network into an Austria-wide sensor



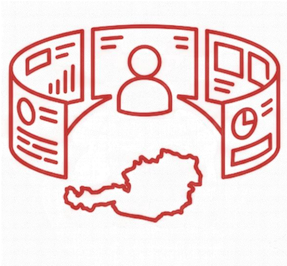
Monitoring & Analysis of Radio and Sensor Signals

- ISAC - Integrated sensing and communication for high-precision detection and 3D location determination, regardless of weather and visibility conditions
- GNSS sensors integrated for
  - Detection of jamming
  - Recording of weather data
  - Integrated and operated by A1



Automated AI Analysis

- Classification of objects
  - Type
  - Direction of movement
  - Detection of drones
  - Detection of birds and other creatures
- Analysis of GNSS signals for the detection of jamming activities and weather forecasts
- Can be integrated into various systems



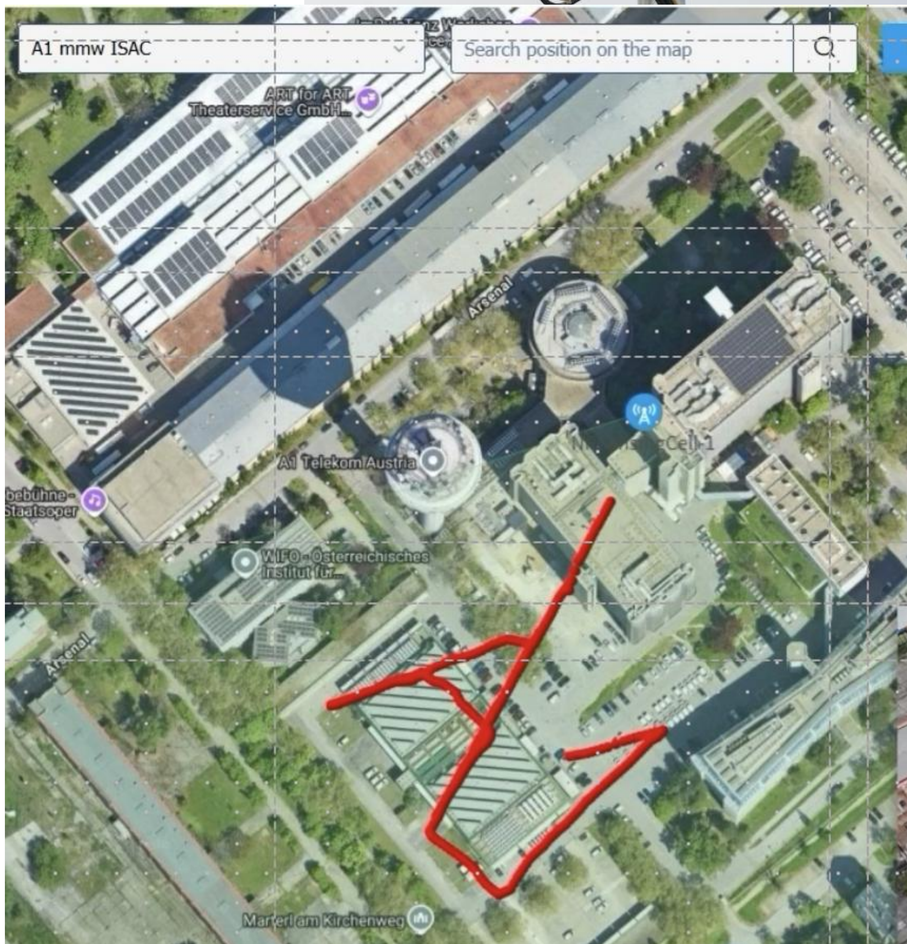
Central Command&Control Platform

- Holistic situation picture with all relevant information
- Definition of the area to be monitored
- Alerting according to company requirements when threats are detected
- Reporting of detected activities in the defined area

ISAC – Integrated Sensing and Communication

- ISAC will be integrated directly into A1's 5G network and will enable continuous transmission of radio waves
- Reflected 5G signals are evaluated in real time to capture accurate position and motion data
- Algorithms determine position, speed and direction of movement with centimeter precision

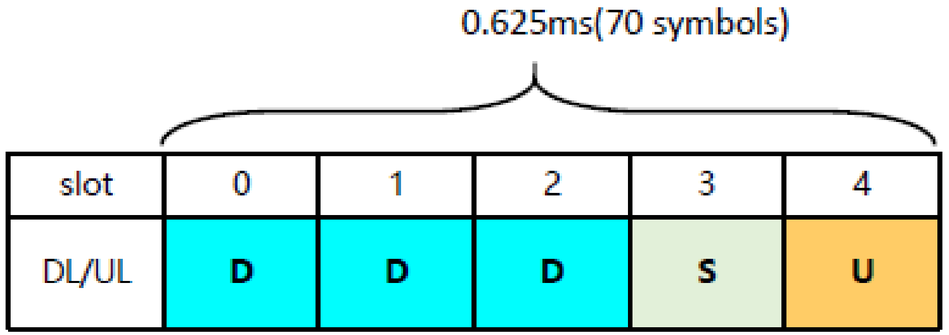


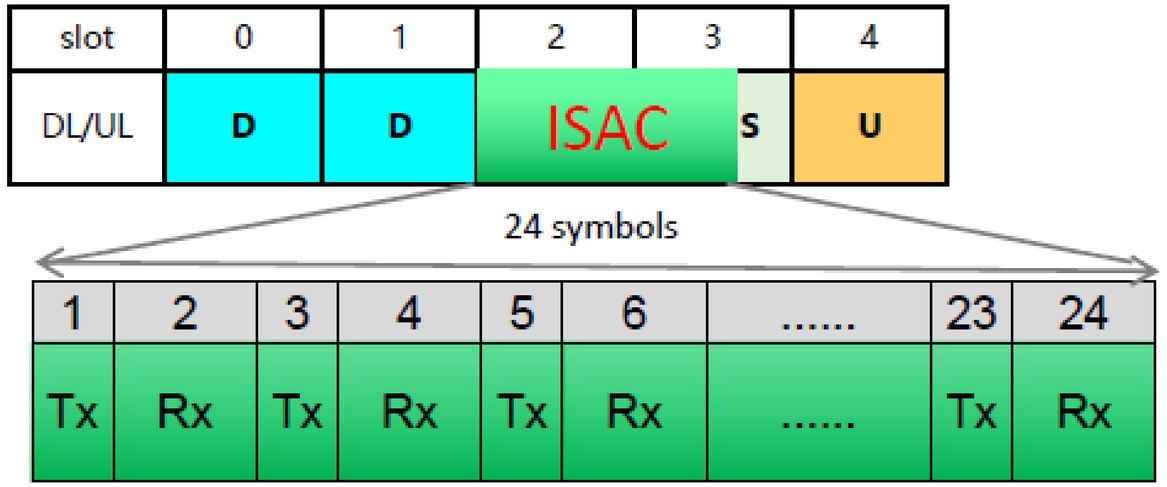


ISAC – Safety Distance Calculation

Input Power - TDD DL ratio / Gain / Reference level

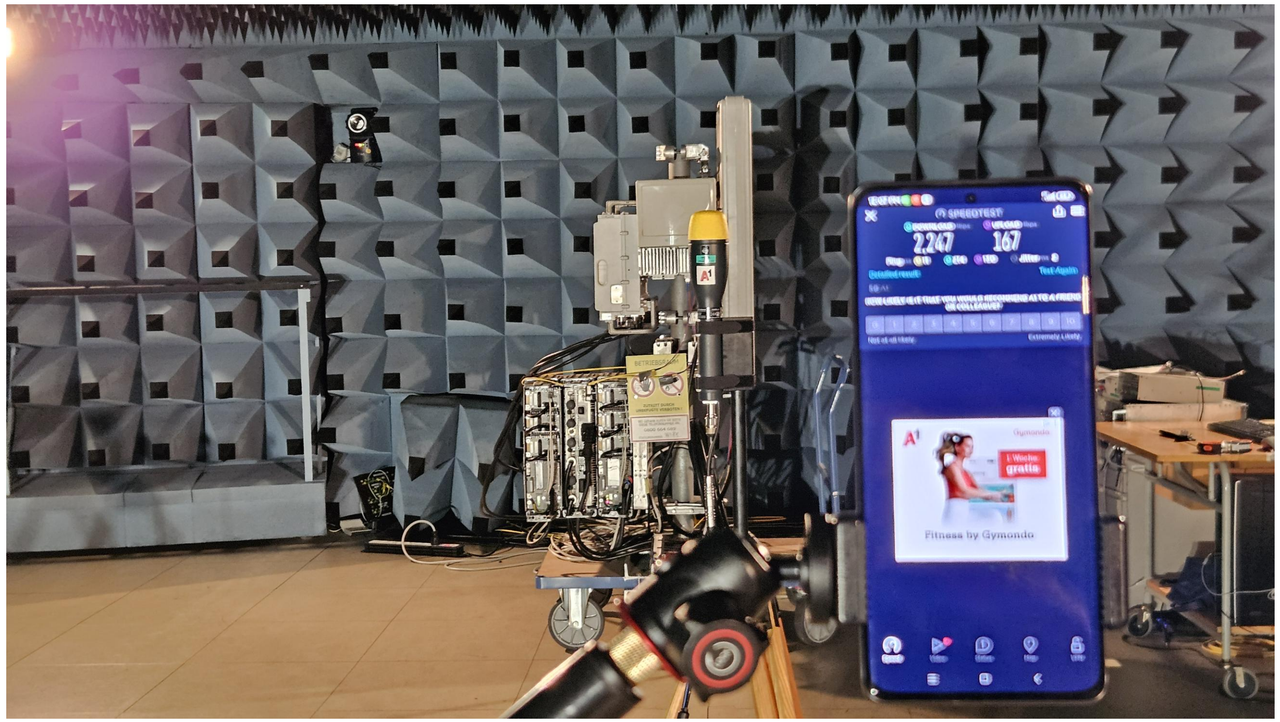
- Communication mode -> Safety Distance: **6,84m**
- Sensing mode -> Safety Distance: **4,64m**

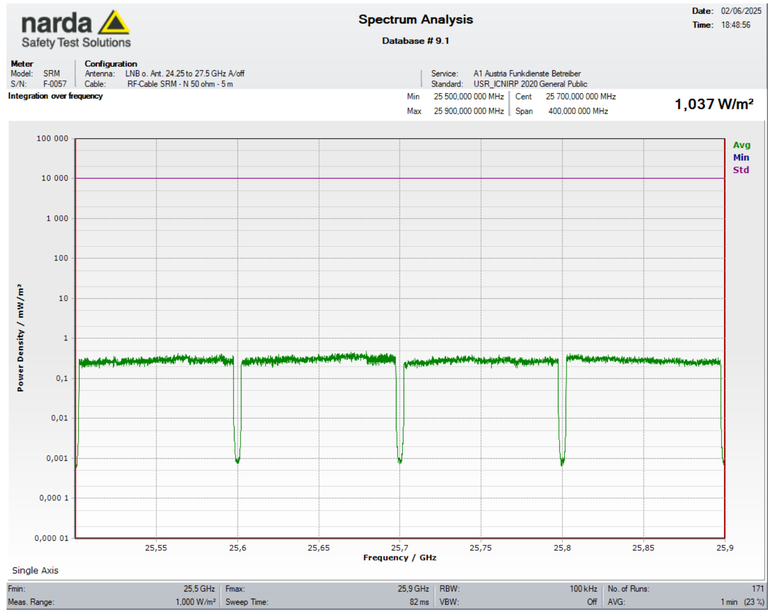


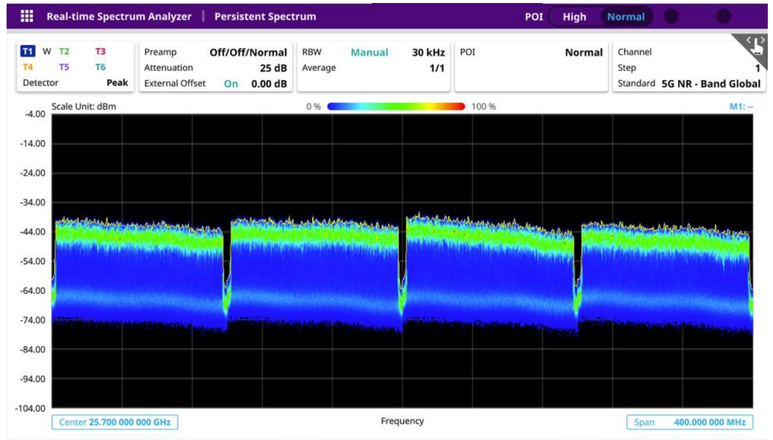



Measurements @26GHz and @6GHz

Measurement under maximum traffic load





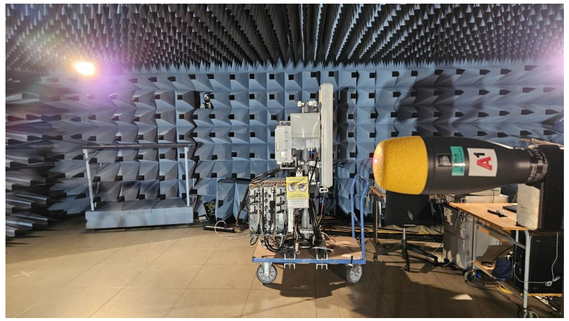


26GHz –Orientation of antenna – deep dive

vertical



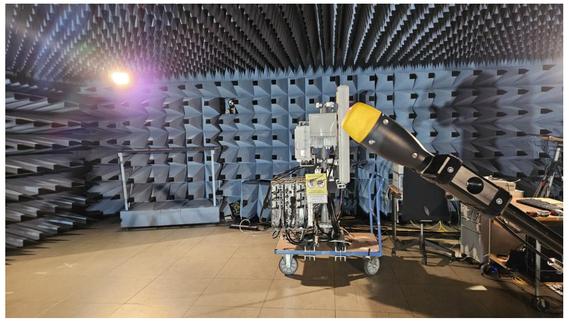
horizontal



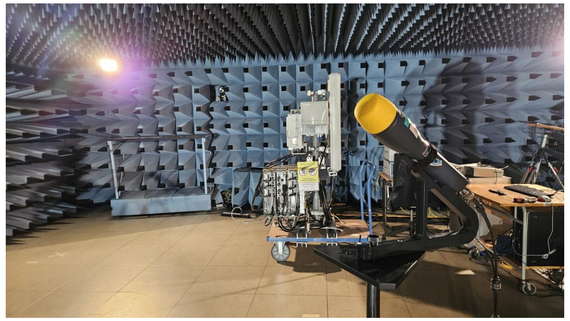
+45°

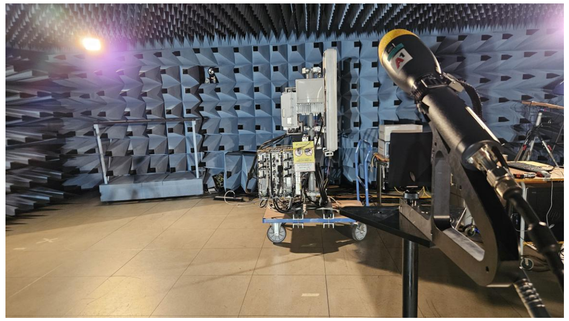


-45°



Quasiisotropic



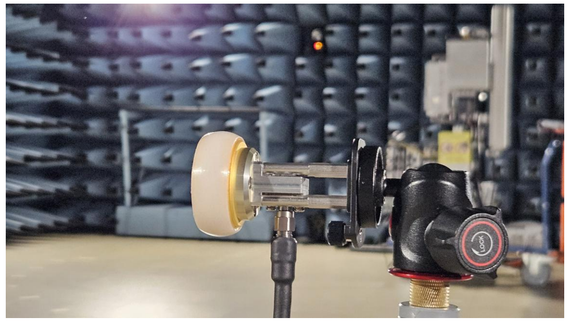




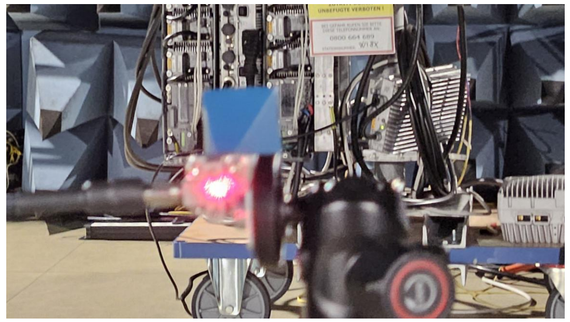
26GHz –Orientation of antenna – deep dive

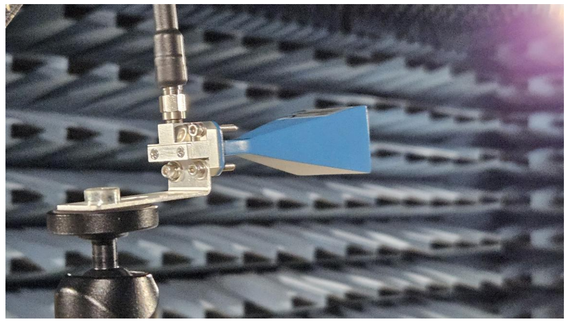
vertical

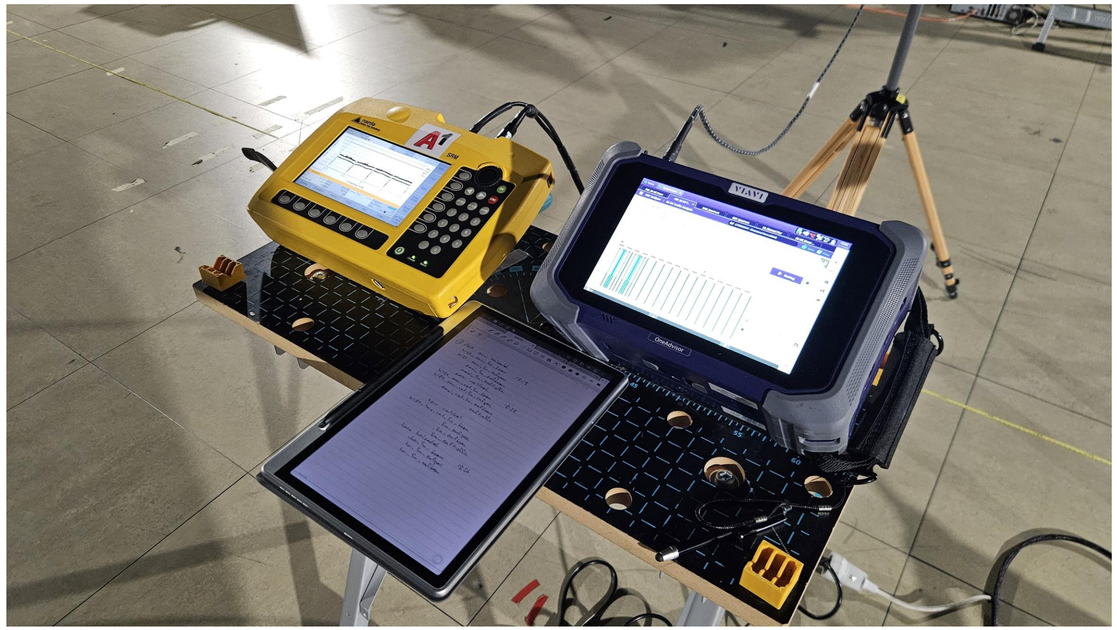
horizontal









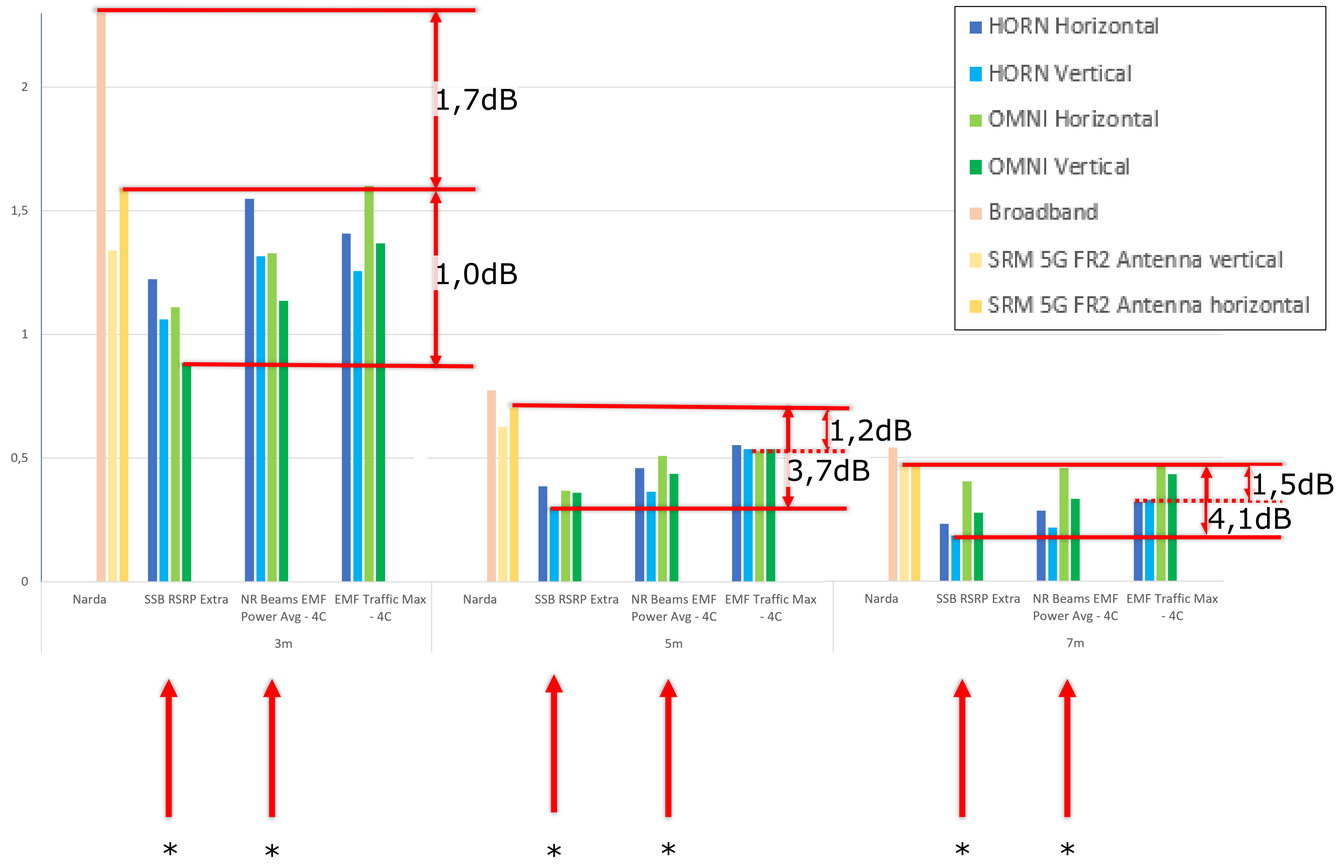


26GHz – Comparison (artificial load 100%)

- All EMF measurements show similar values with both manufacturers, three antennas, and both polarizations: Horizontal and Vertical
- <=1,5dB between frequency selective and EMF traffic measurement
- *) No $F_{extBeam}$

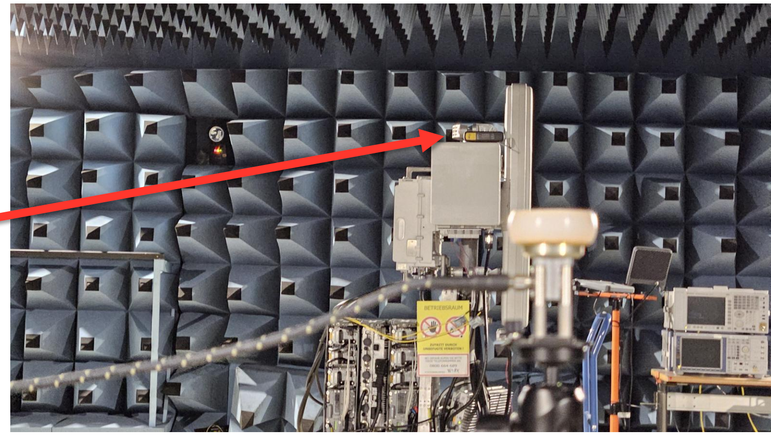
- The results are being prepared for the presentation at EuCAP 2027 - 18-23 April 2027

Thanks to Prof. Darko Suka for the collaboration!

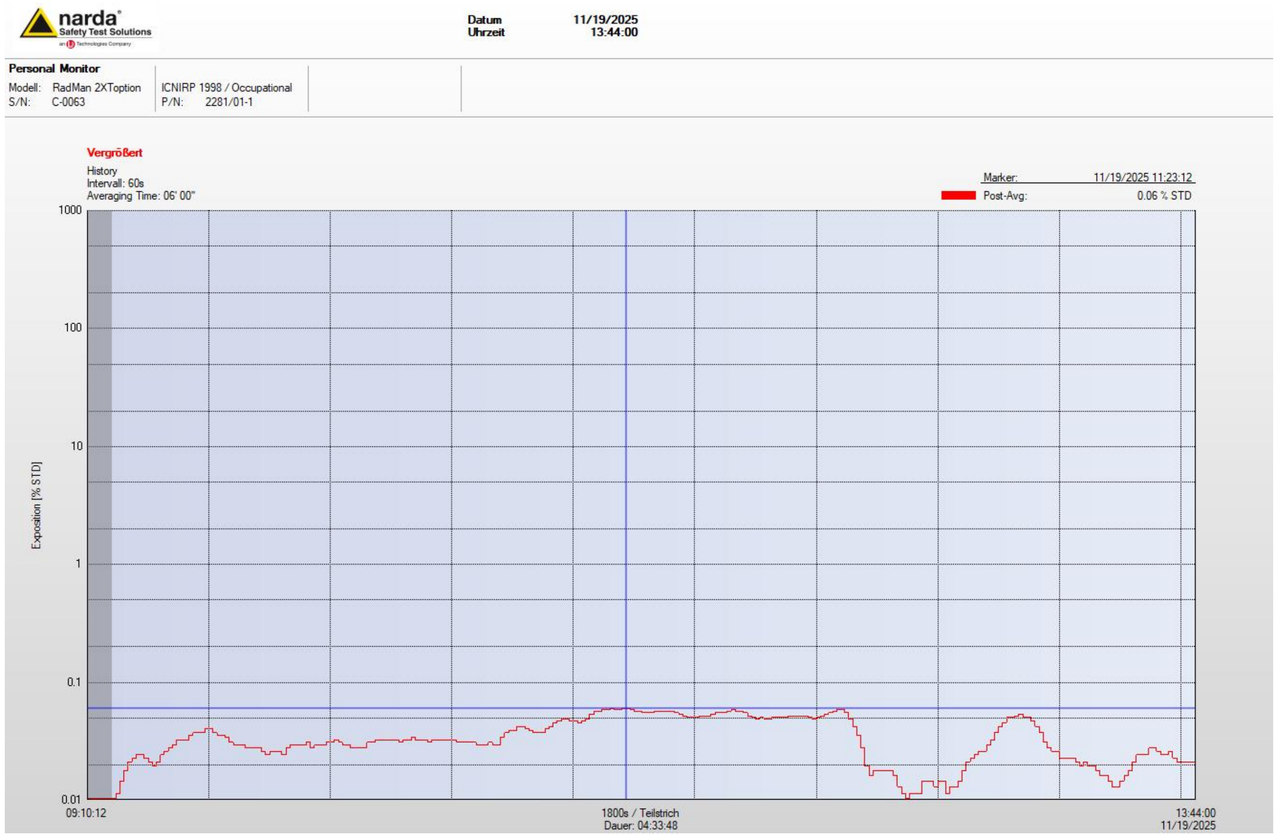


26GHz – Occupational Safety

- Occupational Safety:
  - RadMan XT placed directly on the top of the antenna during all measurements
  - MAX (6min average): 0,06%







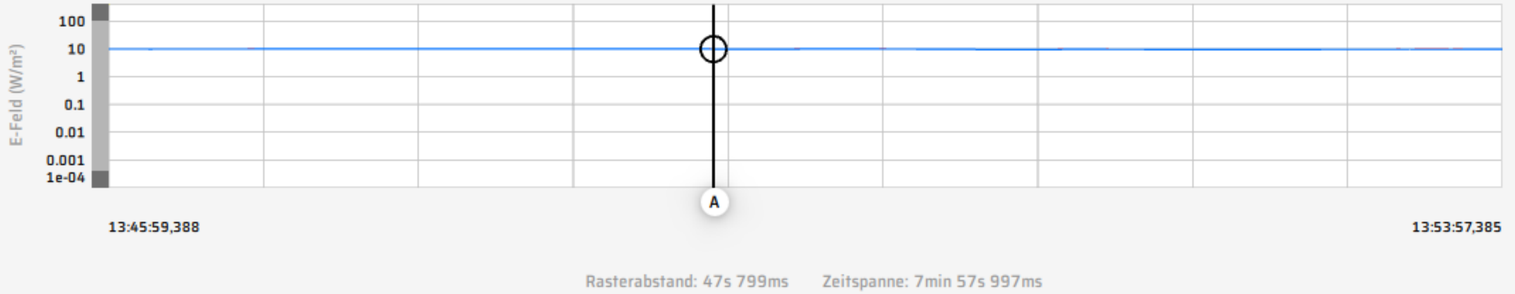
26GHz – General Public

- General Public – artificial load 100% -> Distance 1,17m

MESSGERÄT		SONDE		FELD		ERFASSUNG	
Modell:	FieldMan	Modell:	EF6091	Bereich:	100 MHz-60 GHz	Detektor:	RMS
S/N:	B-0139	S/N:	01165	Feldtyp:	E-Feld		

Diagramm

ZEITSTEMPEL	A	13:49:25,379
MAX FELD	A	9.845 W/m²
AVG FELD	A	9.82 W/m²



Rasterabstand: 47s 799ms Zeitspanne: 7min 57s 997ms

Messwerte

Messwerte - Feldstärke

EINHEIT W/m²

ZEITSTEMPEL	AKTUELL	MAX	MAX AVG	AVG	MIN
19.11.2025 13:53:57,...	9.689 W/m²	10.06 W/m²	9.88 W/m²	9.769 W/m²	9.456 W/m²



26GHz - Outdoor

- 10th February 2025
- Two measurement points
  - MP1: 61m in 73°
  - MP2: 102m in 35°
- Both in an area where the main beam hits the ground
- Frequency selective measurement with forced maximum traffic load







BS

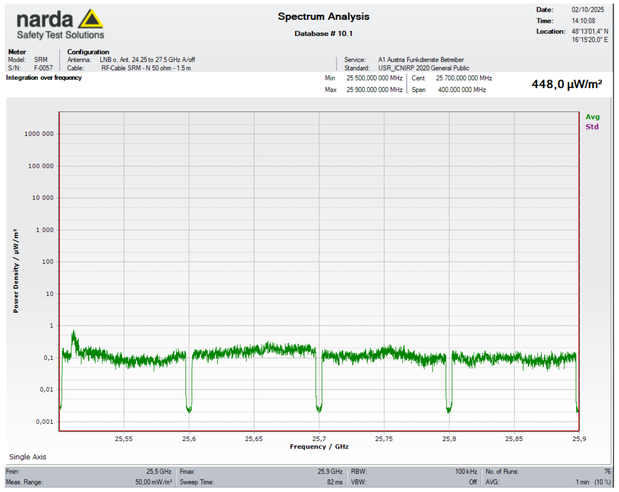
MP2

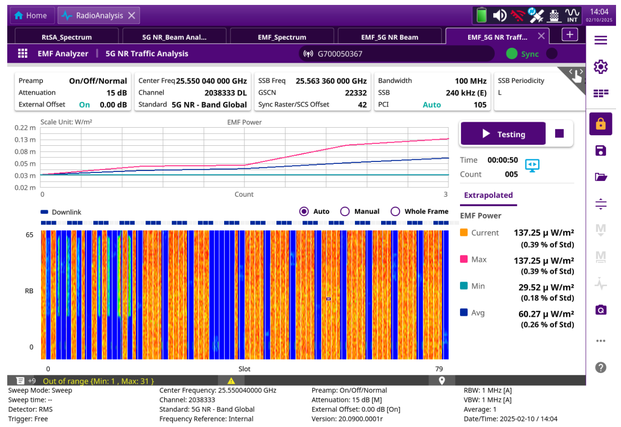
MP1

26GHz – Outdoor - Results

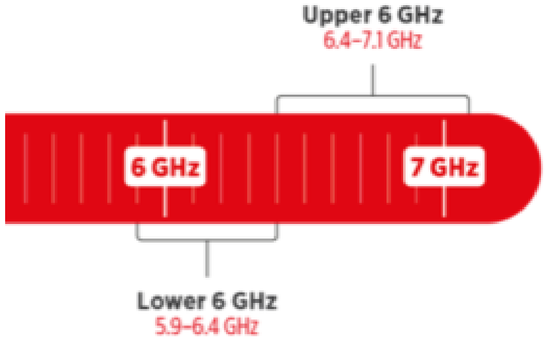
- Frequency selective measurement with forced maximum traffic load
- Orientation of the measurement antenna horizontal and vertical

MP	Antenna horizontal [W/m²]	% of Ref. general public	Antenna vertikal [W/m²]	% of Ref. general public	Extrapol. Horn Antenna [W/m²]
1	0,000246	0,0025%	0,000560	0,0056%	0,000224
2	0,000529	0,0053%	0,000448	0,0045%	0,000137





6GHz – Outdoor



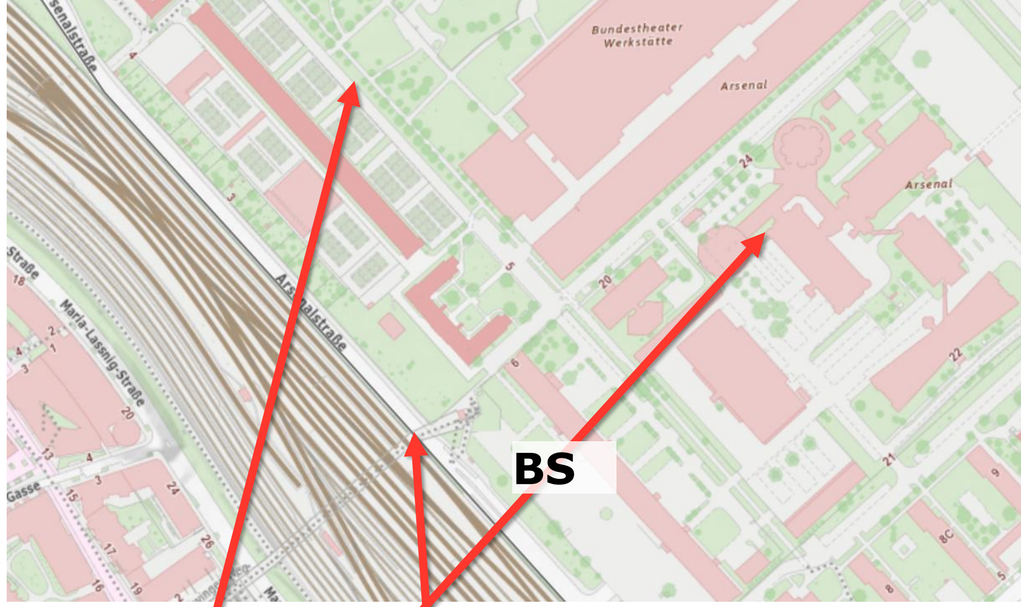
- Testing the measurement and extrapolation methods based on spectrogram measurements under forced traffic load @7,05GHz:

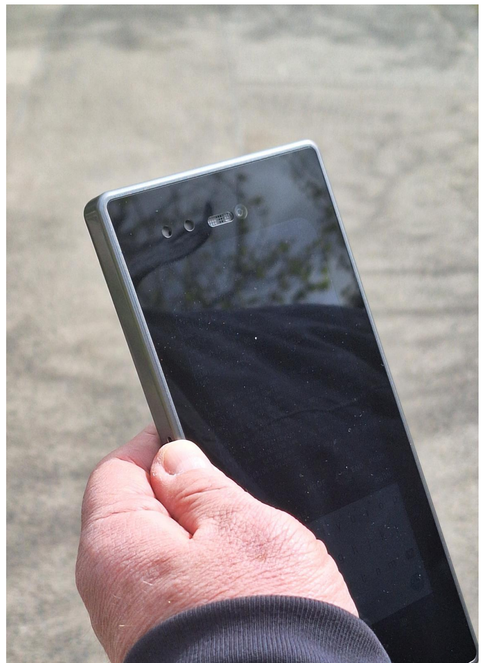




6GHz – Outdoor

- 7. May 2025
- Two measurement points
- points in the surrounding with maximum data rate and LOS
  - MP1: 325m in 284°
  - MP2: 330m in 240°
- Frequency selective measurement with forced maximum traffic load



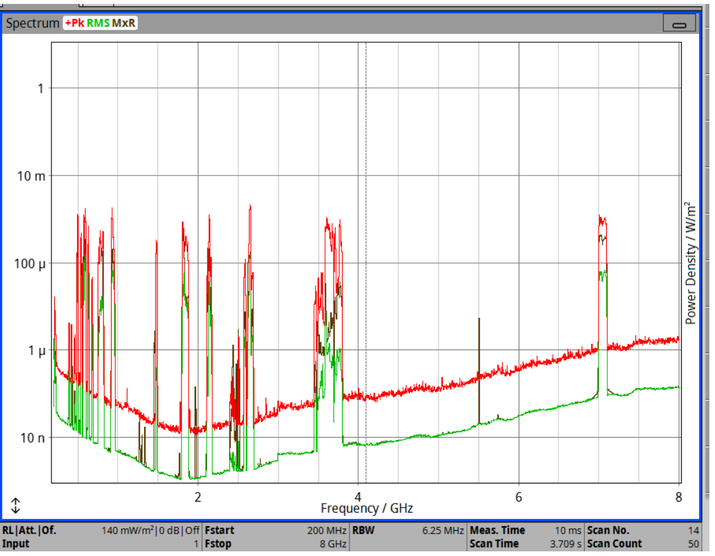


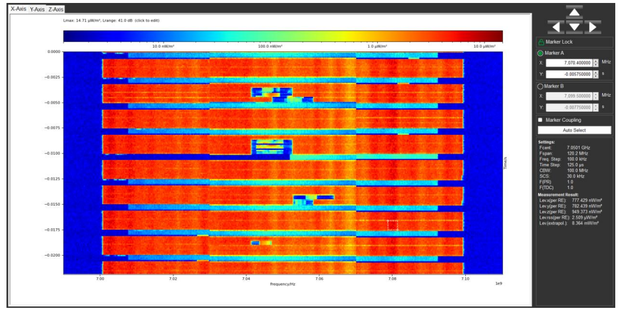


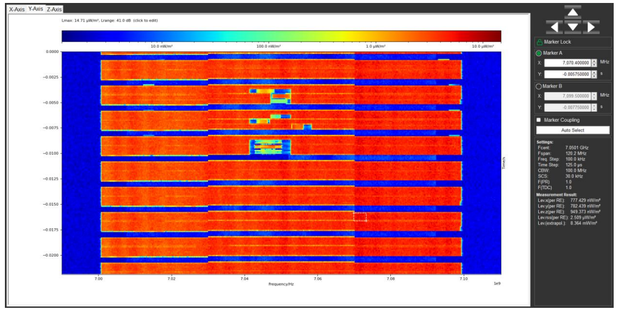


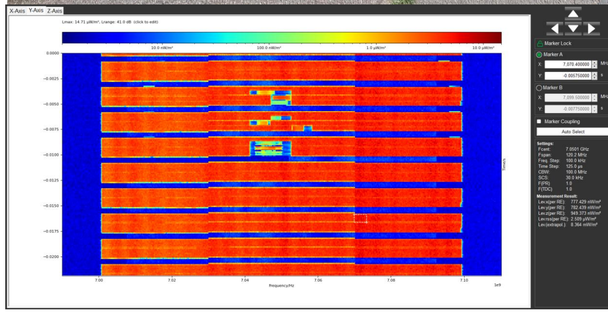
6GHz – Outdoor - Results

- Extrapolation based on spectrogram measurements
  - MP 1: 0,008 364 W/m²







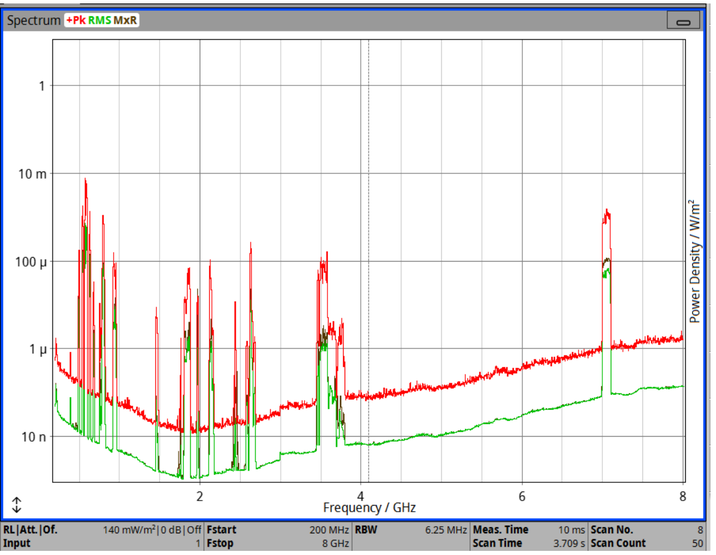


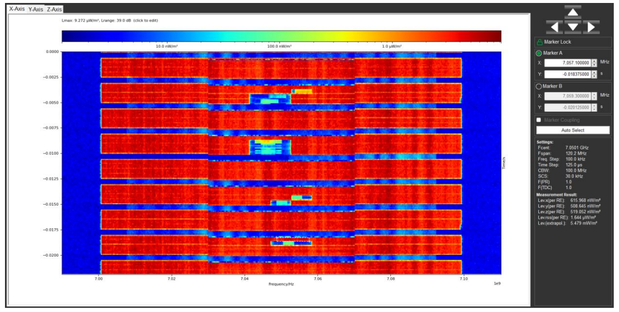


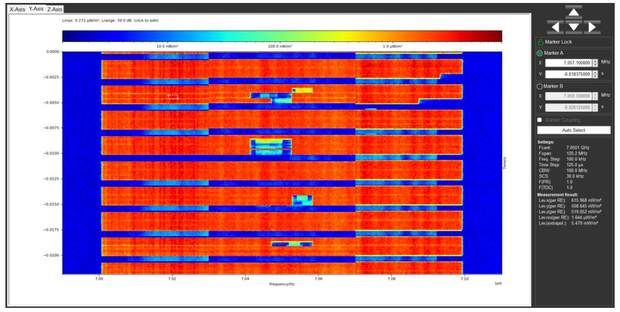
6GHz – Outdoor - Results

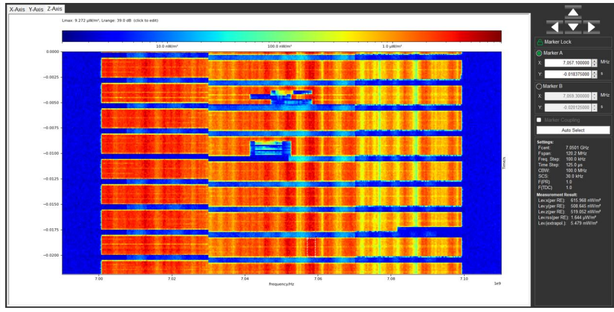
- Extrapolation based on spectrogram measurements
  - MP 2: 0,005 479 W/m²











Spectrum for 6G – upper 6GHz

e& UAE launches world’s first commercial U6GHz network

29.09.2026 United Arab Emirates

www.zawya.com/en/business/e-uae-launches-worlds-first-commercial-u6ghz-network-1404909

- „Engineered to deliver single-user peak throughput of up to 10 Gbps downlink and 1 Gbps uplink, the network provides fibre-like broadband performance over the air. Its advanced beamforming capabilities also overcome the physical propagation limitations typically associated with higher frequency bands, achieving site-for-site coverage levels comparable to existing 3.5 GHz C-band infrastructure.”

EMF Exposure From Large Massive MIMO Base Stations

Power Reduction Factor of Actual Maximum EMF Exposure From Large Massive MIMO Radio Base Stations for 5G-Advanced and 6 G

- S. A. Chowdhury, C. D. Paola and B. Xu,
- in IEEE Antennas and Wireless Propagation Letters, https://doi.org/10.23919/MIKON60251.2024.10633966

"The resulting PRF is 16%, which is lower than the well-recognized 32% PRF for 8-column 5 G massive MIMO arrays."

Evaluation of the Actual EMF Exposure from Extreme Massive MIMO Base Stations around 10 GHz using Channel Modelling

- M. Rybakowski, K. Bechta, C. Grangeat and P. Kabacik, „
- 2024 25th International Microwave and Radar Conference (MIKON), Wroclaw, Poland, 2024, pp. 47-52, https://doi.org/10.1109/LAWP.2026.3733778

„The actual maximum approach has been implemented as recommended in IEC 62232:2022. The modelling results provide a range of power reduction factors (FPR) from −7.1dB to -10.7 dB with increasing antenna array size."

Key Takeaways

- We have exposure limits for all frequency ranges in which 6G is specified to operate
  -> ICNIRP GUIDELINES 100kHz to 300GHz
- Network sunsets allow spectrum to reused by more RF efficient technologies
- 6G is more of an evolution than a revolution
- The air interface will be more or less the same as with 5G
- The technology is and remains radio, and radio has been used for information transmission for many decades
- Therefore, we can also calculate exposure and safety distances for 6G
- All testing to date show that we can measure 6G well and correctly using the existing standards
  -> IEC 62232

Thank you

Manfred Ruttner

E manfred.ruttner@a1.at
M +43 664 6622964

Copyrights Telekom Austria AG.
All rights reserved. The information contained in this document may not be published, broadcasted or otherwise distributed without prior written authority.

NextGEM



Dr Nikolaos Petroulakis
NextGEM Coordinator - Institute of Computer Science, Foundation for Research and Technology-Hellas (FORTH-ICS), Greece



Mike Wood
Telstra Australia,
GSMA EMF and Health Chair

NextGEM

n Integrated Sensing and Analytical System for Monitoring and Assessing Radiofrequency EMF and Health

HORIZON-HLTH-2021-ENVHLTH-02-01:Exposure to electromagnetic fields (EMF) and health
Duration: 1/7/2022-30/6/2026
Budget: 7.559.039 Total EU Funding

NextGEM Project Overview

Dr Nikolaos Petroulakis (Project Coordinator)
Institute of Computer Science (ICS)
Foundation for Research and Technology - Hellas (FORTH)

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No. 101057527.

GSMA EMF Forum - Brussels, 13 October 2026

European Cluster on EMF and Health

CLUE-H is formed from the projects selected for funding from the call HORIZON-HLTH-2021-ENVHLTH-02-01 Exposure to electromagnetic fields (EMF) and health to optimise synergies, avoid overlaps and increase the impact of the projects

NextGEM — Next Generation Integrated Sensing and Analytical System for Monitoring and Assessing RF-EMF Exposure and Health

SEAWave — Scientific-based Exposure and risk Assessment of radiofrequency and mm-Wave systems from children to elderly

ETAIN — Exposure To electromAgnetic fIelds and plaNetary health

GOLiAT — 5G expOsure, causaL effects, and rIsk perception through citizen engagement

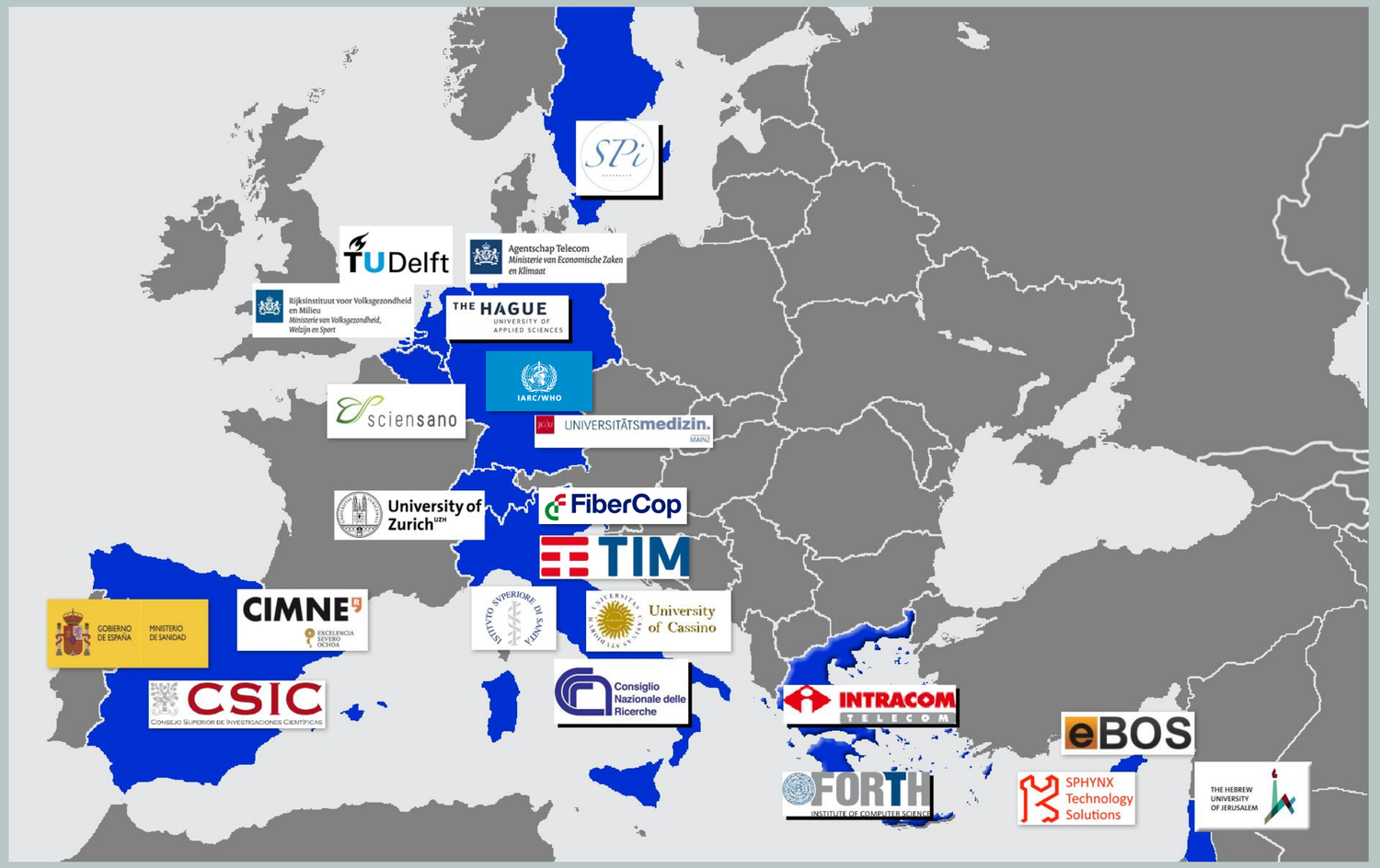
Working Groups

- Science translation for policy and practice
- Data management
- Dissemination Communication
- Exposure assessment
- Experimental studies



The CLUE-H network involves more than 70 European research organisations in 4 research consortia with additional contribution from scientists in the USA, Korea and Japan

Consortium



22 partners (9 EU Members, Swiss Israel)

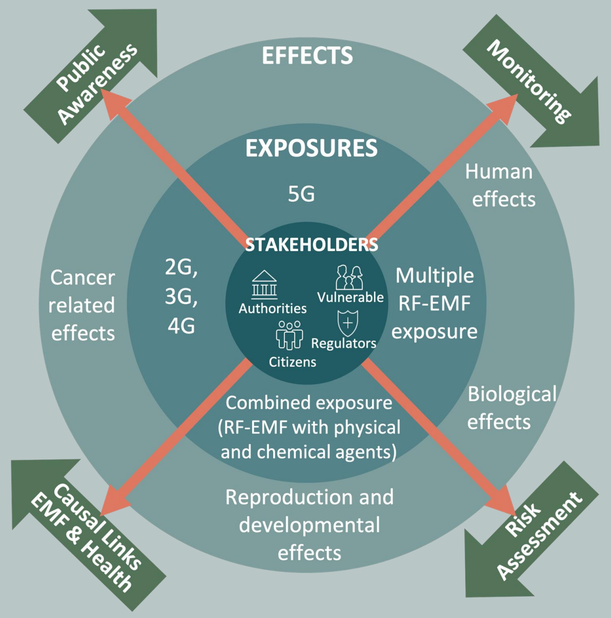
4 years

7.6 million € (EU)

- 4 Research Institutions
- 6 Universities
- 3 Small and Medium Enterprises
- 3 Industrial Partners
- 5 Public and Government Organizations
- 1 International Organization

Overall scope

Ensure EU citizens' safety by generating relevant knowledge of EMF exposure in the residential, public, and occupational settings



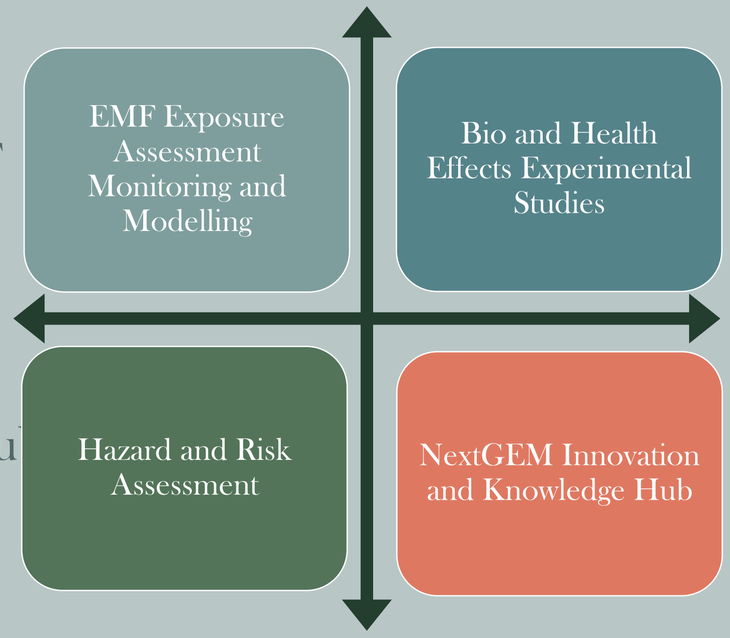
Objective 1: Measurement and modelling of RF sources based on innovative monitoring

Objective 2: Health effects and action mechanisms of EMF exposures by experimental and human studies

Objective 3: Causal links and risk assessment of EMF exposure and health outcomes

Objective 4: Develop NextGEM Innovation Knowledge Hu (NIKH) and validate it through real case studies

Objective 5: Achieve impact maximisation through wide dissemination, exploitation and clustering activities



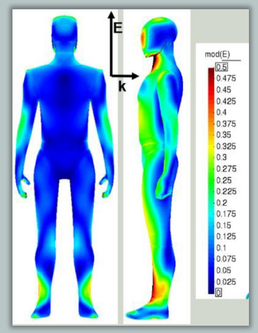
Exposure assessment modelling and measurements

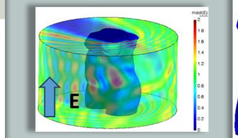


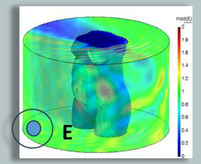
Scope

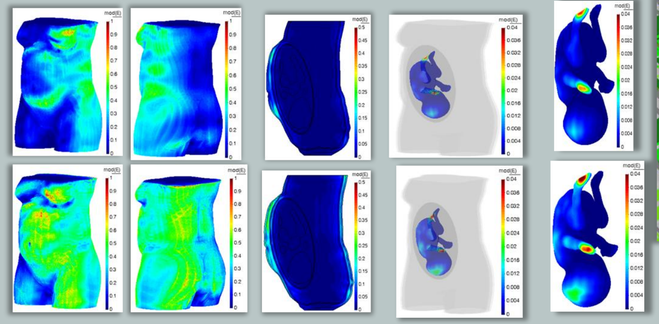
- Multi-scale model-based assessment of EMF exposure in the human body
- EMF exposure and self-monitoring
- Exposure compliance assessment and environmental protection

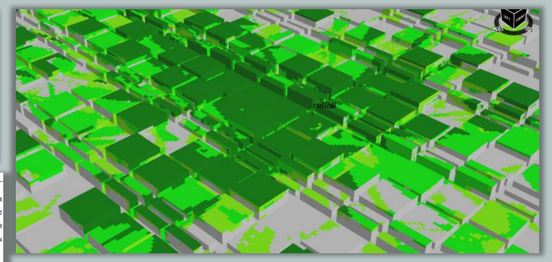
RF-EMF modelling and dosimetry methodologies

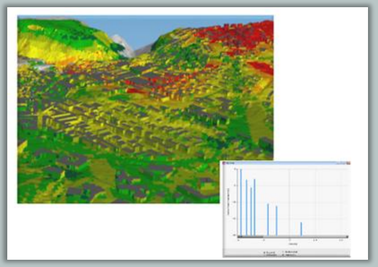


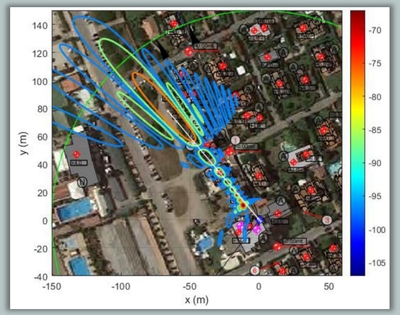


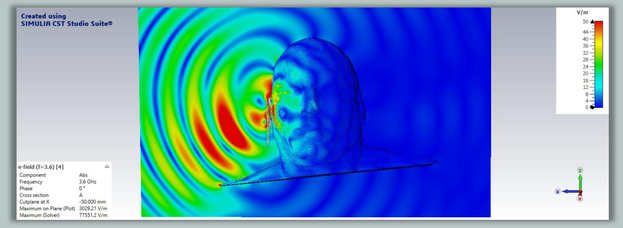


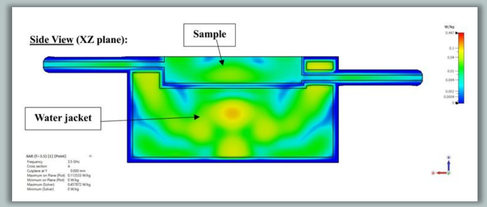












Conditions

- Realistic *in-silico* models developed for skin and pregnant women at 14 and 32 weeks of gestation
- Extension of ERMES simulator to FR1/FR2 and detailed human models, including pregnant women
- RF-EMF distribution and exposure in maternal, fetal and skin tissues

Results

- Development of controlled exposure systems and numerical dosimetry for biological studies
- Numerical models developed for active antenna systems in FR1/FR2
- Indoor, outdoor, urban exposure simulated in realistic 5G NR FR1/FR2 scenarios using MaMIMO antennas

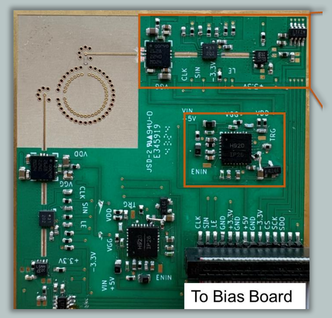
NextGEM

Low-cost RF-EMF measurement devices

Conditions

- FR1/FR2 instrument review and wearable sensor requirements
- Sensor benchmarking against reference spectrum analyser measurements
- SDR-based platforms, calibration, validation, and monitoring solutions
- Real-world exposure characterized across frequencies, locations, traffic conditions and LoS/NLoS scenarios







Results

- Development and deployment of low-cost FR1/FR2 portable and body-worn sensors
- Validation measurements conducted in lab, indoor/outdoor, and commercial-network in the Netherlands and Italy

Real-world 5G exposure & monitoring







Conditions

- 5G exposure measurements conducted in commercial networks and realistic environments
- FR2 commercial-network measurement capability established through a dedicated 5G site
- Long-term exposure and daily exposure evolution characterized
- Exposure measured across different real-world conditions and network configurations

Results

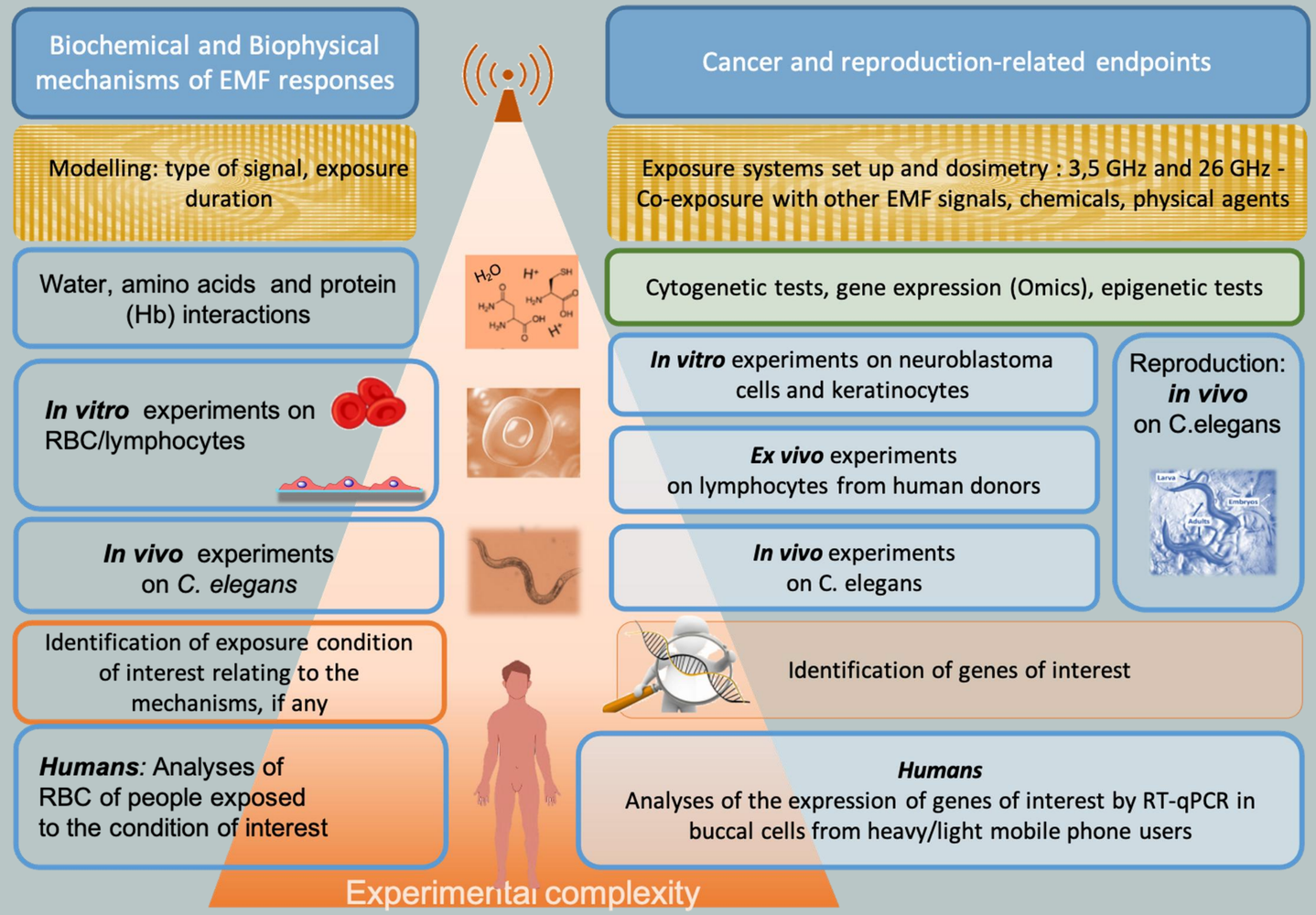
- 5G exposure measurements in tested scenarios were below applicable ICNIRP limits

NextGEM

Experimental studies

Scope

- In vitro studies on mammalian cell lines
- In vivo studies on C. elegans
- Biological effects of EMF exposure in humans
- Effects of EMF exposure on human RBCs
- Biophysical and Biochemical mechanisms of EMF exposure in blood and RBC



NextGEM

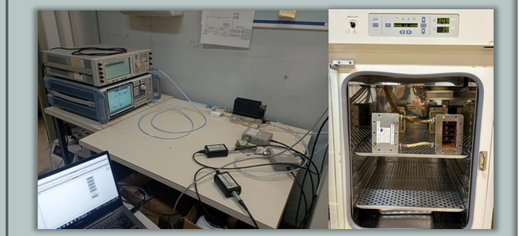
Experimental studies on RF-EMF and potential effects

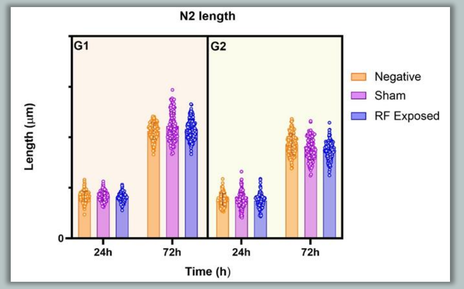
Conditions

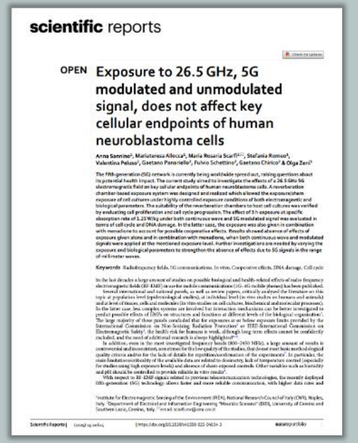
- Harmonised and validated protocols for in vitro, in vivo, under FR1/FR2 exposure
- Mammalian cell studies on genotoxic and non-genotoxic cancer-related endpoints
- C. elegans studies on reproductive and developmental effects
- Validated exposure systems and dosimetry across labs, through protocol exchange, staff mobility, and parallel experiments

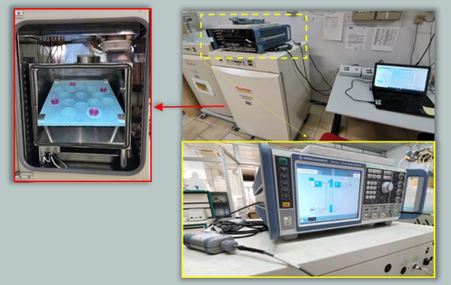
Results

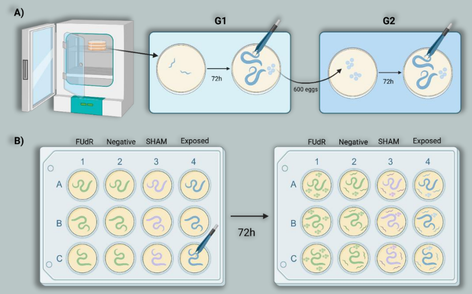
- No effects of RF exposure on genotoxic and non-genotoxic cancer-related endpoints in human-cell models on FR1/FR2
- No relevant transcriptomic/ epigenetic effects detected in the FR1/FR2 cell studies
- FR2 exposure did not affect C. elegans viability, development, behaviour, reproduction or gene expression

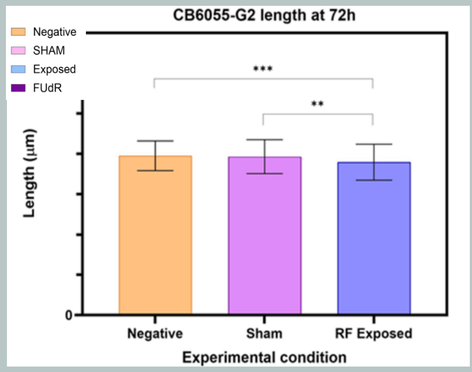












Controlled human study on RF-EMF exposure









Conditions

- Human study protocols finalised, ethically approved, and implemented
- Localised exposure of the inner wrist, in a room with a low background emf ; thermal camera included
- 5G FR2 exposure (45 min) effects on blood and red blood cell (RBC) parameters in healthy volunteers
- Assessment of laboratory blood count, and nitric oxide, glutathione, parameters in RBC responses

Results

- No significant differences observed between real and sham exposure
- No effect on blood count observed in the human FR2 pilot study

NextGEM

Standard Operating Procedures (SOPs)

SOPs for RF-EMF exposure and biological research, supporting reproducibility and quality assurance

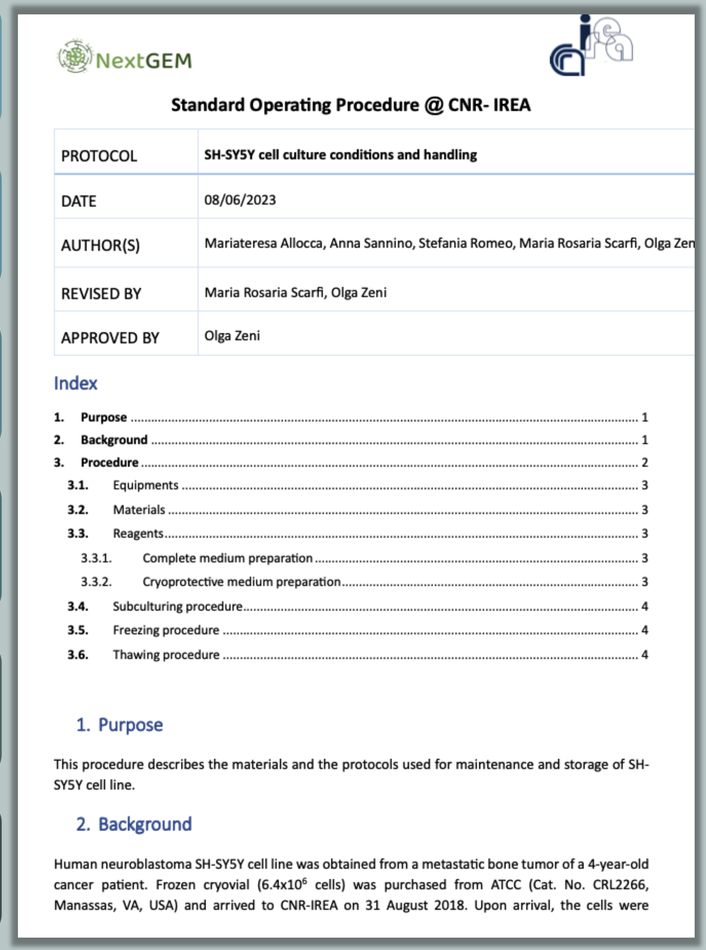
Methodological quality criteria established for in-vitro, in-vivo and human studies, including dosimetry

SOPs developed for in-vitro RF exposure/co-exposure and biological assays

Experimental protocols developed for 4G, 5G and multiple-signal exposure/co-exposure

Contributions made to standardization bodies and quality-assurance practices

22 GLP-like harmonised SOPs by NextGEM
23 SOPs by the 3 other CLUE-H projects



NextGEM

Standard Operating Procedure @ CNR- IREA

PROTOCOL	**SH-SY5Y cell culture conditions and handling**
DATE	08/06/2023
AUTHOR(S)	Mariateresa Allocca, Anna Sannino, Stefania Romeo, Maria Rosaria Scarfì, Olga Zen
REVISED BY	Maria Rosaria Scarfì, Olga Zeni
APPROVED BY	Olga Zeni

Index

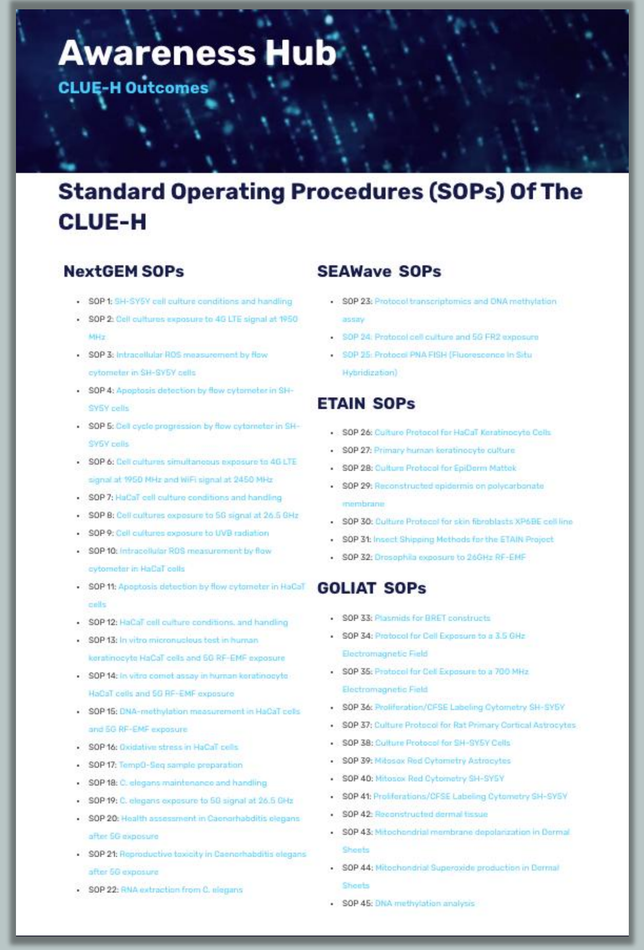
1. **Purpose** 1
2. **Background** 1
3. **Procedure** 2
   - 3.1. Equipments 3
   - 3.2. Materials 3
   - 3.3. Reagents 3
     - 3.3.1. Complete medium preparation 3
     - 3.3.2. Cryoprotective medium preparation 3
   - 3.4. Subculturing procedure 4
   - 3.5. Freezing procedure 4
   - 3.6. Thawing procedure 4

1. Purpose

This procedure describes the materials and the protocols used for maintenance and storage of SH-SY5Y cell line.

2. Background

Human neuroblastoma SH-SY5Y cell line was obtained from a metastatic bone tumor of a 4-year-old cancer patient. Frozen cryovial (6.4x10^6 cells) was purchased from ATCC (Cat. No. CRL2266, Manassas, VA, USA) and arrived to CNR-IREA on 31 August 2018. Upon arrival, the cells were



Awareness Hub

CLUE-H Outcomes

Standard Operating Procedures (SOPs) Of The CLUE-H

NextGEM SOPs

- SOP 1: SH-SY5Y cell culture conditions and handling
- SOP 2: Cell cultures exposure to 4G LTE signal at 1950 MHz
- SOP 3: Intracellular ROS measurement by flow cytometer in SH-SY5Y cells
- SOP 4: Apoptosis detection by flow cytometer in SH-SY5Y cells
- SOP 5: Cell cycle progression by flow cytometer in SH-SY5Y cells
- SOP 6: Cell cultures simultaneous exposure to 4G LTE signal at 1950 MHz and WiFi signal at 2450 MHz
- SOP 7: HaCaT cell culture conditions and handling
- SOP 8: Cell cultures exposure to 5G signal at 26.5 GHz
- SOP 9: Cell cultures exposure to UVB radiation
- SOP 10: Intracellular ROS measurement by flow cytometer in HaCaT cells
- SOP 11: Apoptosis detection by flow cytometer in HaCaT cells
- SOP 12: HaCaT cell culture conditions, and handling
- SOP 13: In vitro micronucleus test in human keratinocyte HaCaT cells and 5G RF-EMF exposure
- SOP 14: In vitro comet assay in human keratinocyte HaCaT cells and 5G RF-EMF exposure
- SOP 15: DNA-methylation measurement in HaCaT cells and 5G RF-EMF exposure
- SOP 16: Oxidative stress in HaCaT cells
- SOP 17: TempO-Seq sample preparation
- SOP 18: C. elegans maintenance and handling
- SOP 19: C. elegans exposure to 5G signal at 26.5 GHz
- SOP 20: Health assessment in Caenorhabditis elegans after 5G exposure
- SOP 21: Reproductive toxicity in Caenorhabditis elegans after 5G exposure
- SOP 22: RNA extraction from C. elegans

SEAWave SOPs

- SOP 23: Protocol transcriptomics and DNA methylation assay
- SOP 24: Protocol cell culture and 5G FR2 exposure
- SOP 25: Protocol PNA FISH (Fluorescence In Situ Hybridization)

ETAIN SOPs

- SOP 26: Culture Protocol for HaCaT Keratinocyte Cells
- SOP 27: Primary human keratinocyte culture
- SOP 28: Culture Protocol for EpiDerm Mattek
- SOP 29: Reconstructed epidermis on polycarbonate membrane
- SOP 30: Culture Protocol for skin fibroblasts XP6BE cell line
- SOP 31: Insect Shipping Methods for the ETAIN Project
- SOP 32: Drosophila exposure to 26GHz RF-EMF

GOLIAT SOPs

- SOP 33: Plasmids for BRET constructs
- SOP 34: Protocol for Cell Exposure to a 3.5 GHz Electromagnetic Field
- SOP 35: Protocol for Cell Exposure to a 700 MHz Electromagnetic Field
- SOP 36: Proliferation/CFSE Labeling Cytometry SH-SY5Y
- SOP 37: Culture Protocol for Rat Primary Cortical Astrocytes
- SOP 38: Culture Protocol for SH-SY5Y Cells
- SOP 39: Mitosox Red Cytometry Astrocytes
- SOP 40: Mitosox Red Cytometry SH-SY5Y
- SOP 41: Proliferation/CFSE Labeling Cytometry SH-SY5Y
- SOP 42: Reconstructed dermal tissue
- SOP 43: Mitochondrial membrane depolarization in Dermal Sheets
- SOP 44: Mitochondrial Superoxide production in Dermal Sheets
- SOP 45: DNA methylation analysis

NextGEM

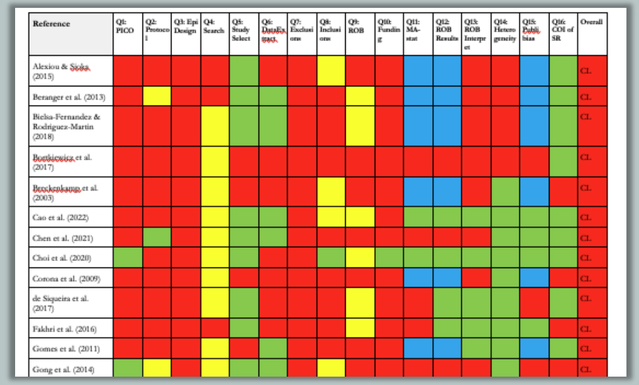
Umbrella reviews on RF-EMF and cancer risk

Conditions

Developed and registered (PROSPERO) an umbrella review protocol on RF-EMF and cancer risk

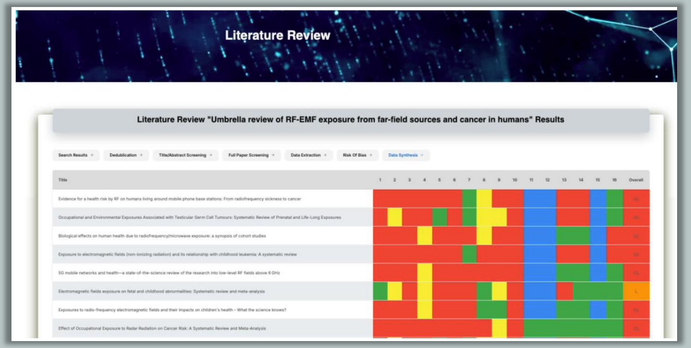
2 umbrella reviews on near-field and far-field RF-EMF exposure and cancer in humans

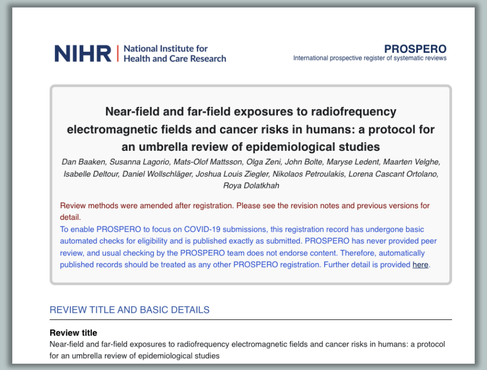
39 systematic reviews/meta-analyses on RF-EMF exposure and cancer risk identified and appraised



Reference	Q1: PICO	Q2: Protocol	Q3: Epi Design	Q4: Search	Q5: Study Select	Q6: Data Extract.	Q7: Exclusions	Q8: Inclusions	Q9: ROB	Q10: Funding	Q11: MA-stat	Q12: ROB Results	Q13: ROB Interpret	Q14: Hetero geneity	Q15: Pub. bias	Q16: COI of SR	Overall
Alexiou & Sioka (2015)																	CL
Beranger et al. (2013)																	CL
Bielsa-Fernandez & Rodriguez-Martin (2018)																	CL
Bortkiewicz et al. (2017)																	CL
Bruckenkamp et al. (2003)																	CL
Cao et al. (2022)																	CL
Chen et al. (2021)																	CL
Choi et al. (2020)																	CL
Corona et al. (2009)																	CL
de Siqueira et al. (2017)																	CL
Fakhri et al. (2016)																	CL
Gomes et al. (2011)																	CL
Gong et al. (2014)																	CL

Development of Literature Review Tool in the NIKH, based on the essential steps for conducting an umbrella review





NIHR | National Institute for Health and Care Research

PROSPERO
International prospective register of systematic reviews

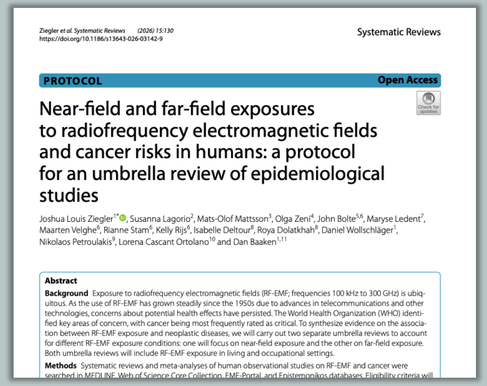
Near-field and far-field exposures to radiofrequency electromagnetic fields and cancer risks in humans: a protocol for an umbrella review of epidemiological studies

Dan Baaken, Susanna Lagorio, Mats-Olof Mattsson, Olga Zeni, John Bolte, Maryse Ledent, Maarten Velghe, Isabelle Deltour, Daniel Wollschläger, Joshua Louis Ziegler, Nikolaos Petroulakis, Lorena Cascant Ortolano, Roya Dolatkhah

Review methods were amended after registration. Please see the revision notes and previous versions for detail.
To enable PROSPERO to focus on COVID-19 submissions, this registration record has undergone basic automated checks for eligibility and is published exactly as submitted. PROSPERO has never provided peer review, and usual checking by the PROSPERO team does not endorse content. Therefore, automatically published records should be treated as any other PROSPERO registration. Further detail is provided here.

REVIEW TITLE AND BASIC DETAILS

Review title
Near-field and far-field exposures to radiofrequency electromagnetic fields and cancer risks in humans: a protocol for an umbrella review of epidemiological studies



Ziegler et al. Systematic Reviews (2026) 15:130
https://doi.org/10.1186/s13643-026-03142-9

Systematic Reviews

PROTOCOL Open Access

Near-field and far-field exposures to radiofrequency electromagnetic fields and cancer risks in humans: a protocol for an umbrella review of epidemiological studies

Joshua Louis Ziegler[1*], Susanna Lagorio[2], Mats-Olof Mattsson[3], Olga Zeni[4], John Bolte[5,6], Maryse Ledent[7], Maarten Velghe[8], Rianne Stam[9], Kelly Rijs[9], Isabelle Deltour[8], Roya Dolatkhah[8], Daniel Wollschläger[1], Nikolaos Petroulakis[9], Lorena Cascant Ortolano[10] and Dan Baaken[1,11]

Abstract

Background Exposure to radiofrequency electromagnetic fields (RF-EMF; frequencies 100 kHz to 300 GHz) is ubiquitous. As the use of RF-EMF has grown steadily since the 1950s due to advances in telecommunications and other technologies, concerns about potential health effects have persisted. The World Health Organization (WHO) identified key areas of concern, with cancer being most frequently rated as critical. To synthesize evidence on the association between RF-EMF exposure and neoplastic diseases, we will carry out two separate umbrella reviews to account for different RF-EMF exposure conditions: one will focus on near-field exposure and the other on far-field exposure. Both umbrella reviews will include RF-EMF exposure in living and occupational settings.

Methods Systematic reviews and meta-analyses of human observational studies on RF-EMF and cancer were searched in MEDLINE, Web of Science Core Collection, EMF-Portal, and Epistemonikos databases. Eligibility criteria will

Results

Limited number of primary and secondary studies

Substantial heterogeneity and methodological limitations identified across existing reviews

Inconsistent quality, incomplete reporting, and methodological flaws hindered reliable conclusions

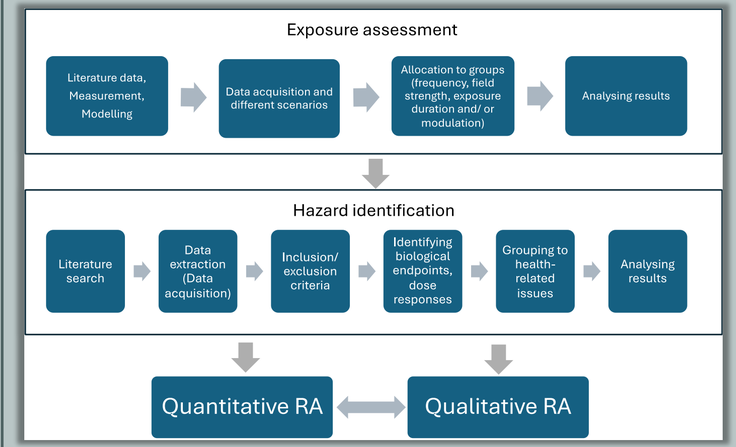
Evidence from the highest-quality reviews did not indicate increased cancer risk for several major outcomes

NextGEM

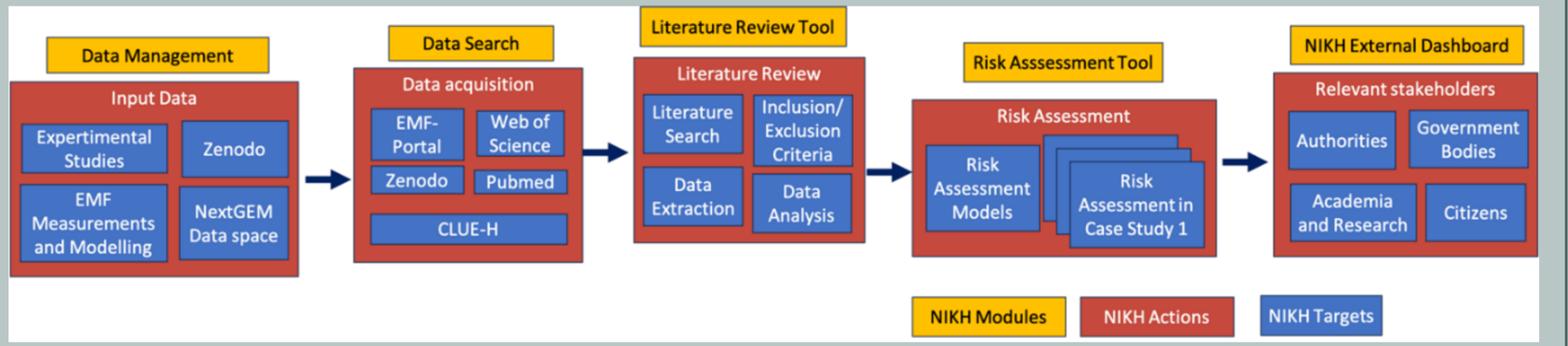
RF-EMF hazard identification and risk assessment

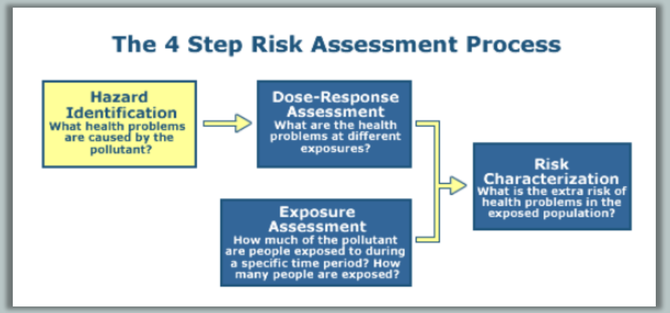
Human risk assessment models in complex multifactorial exposure environments

Risk Assessment framework integrated experimental protocols, multiple evidence sources, and qualitative and quantitative risk models

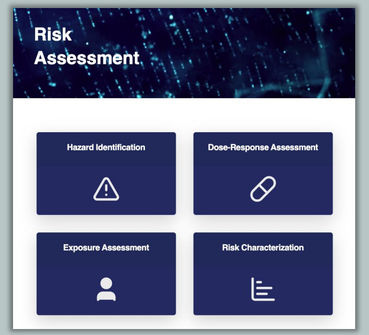


Designed to support researchers, authorities, regulators, policymakers, healthcare, and industry



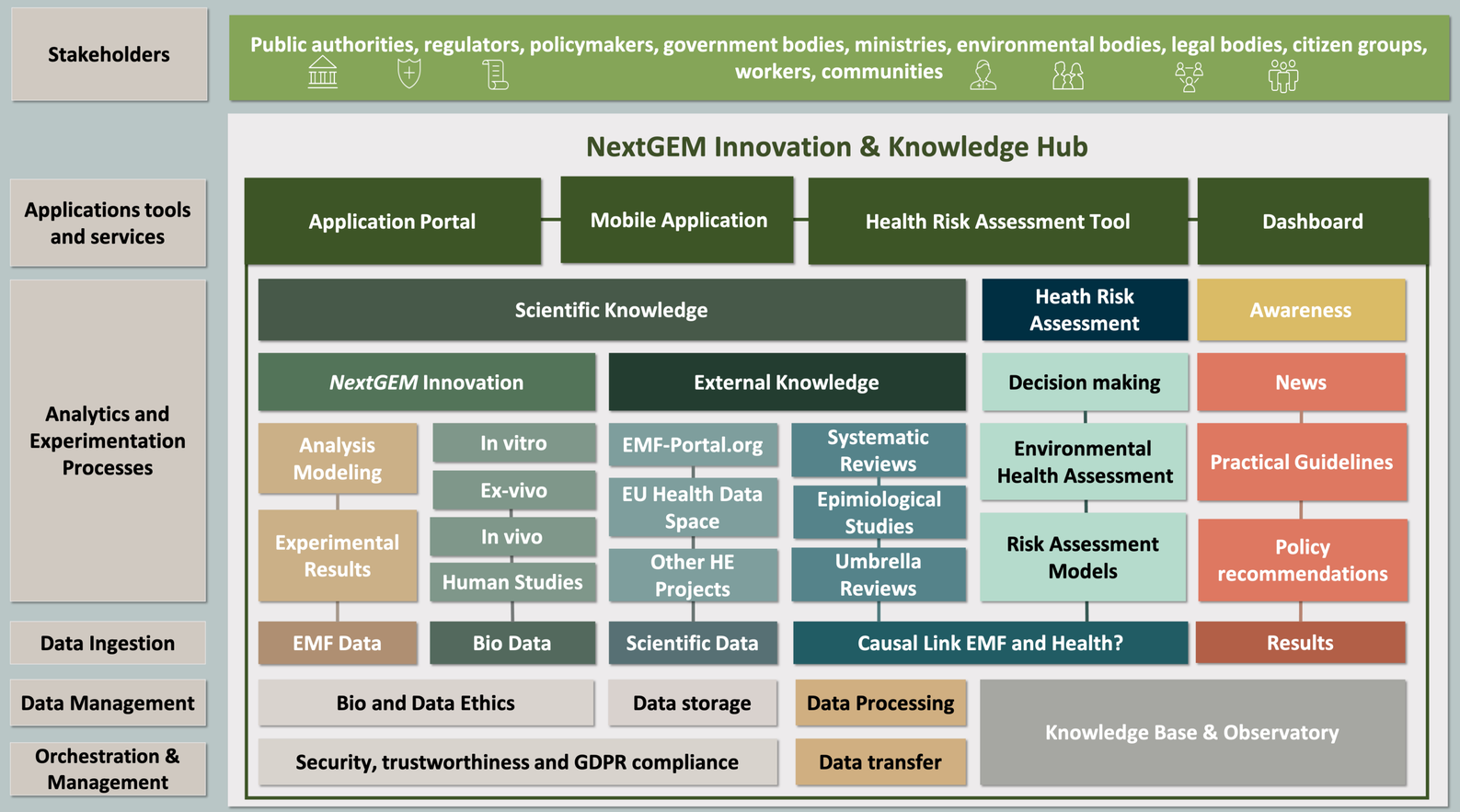


Risk Assessment Tool developed and validated within NIKH for hazard, dose-response, exposure, risk characterisation, and final assessment



NextGEM

NextGEM Innovation and Knowledge Hub (NIKH)

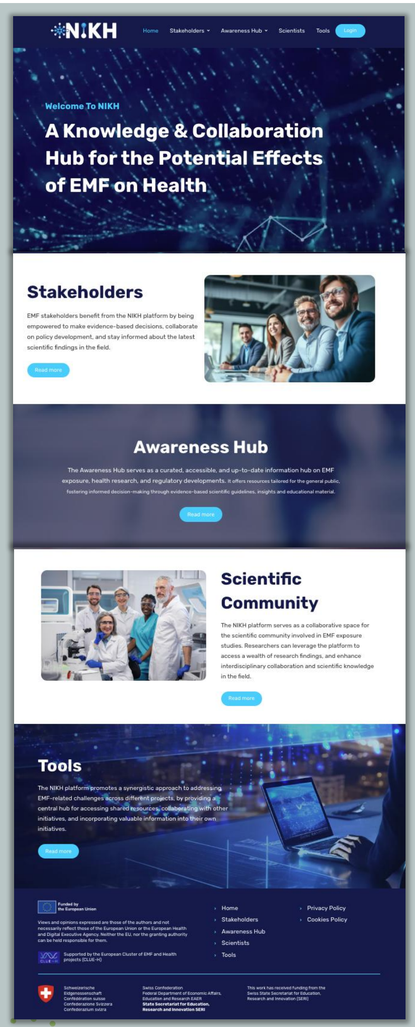


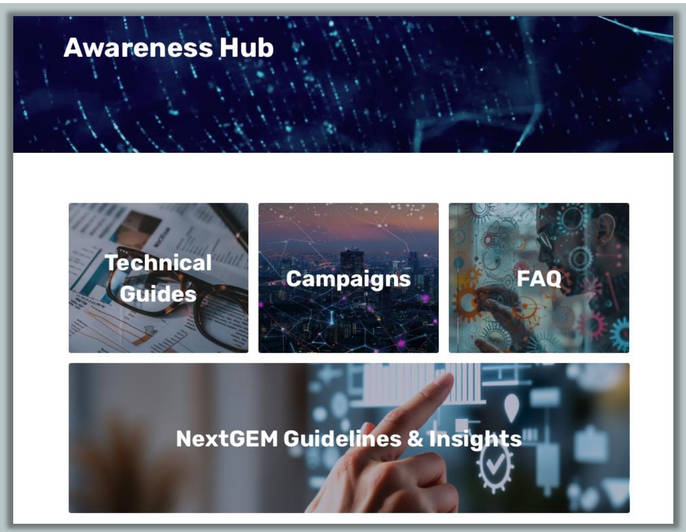
Scope

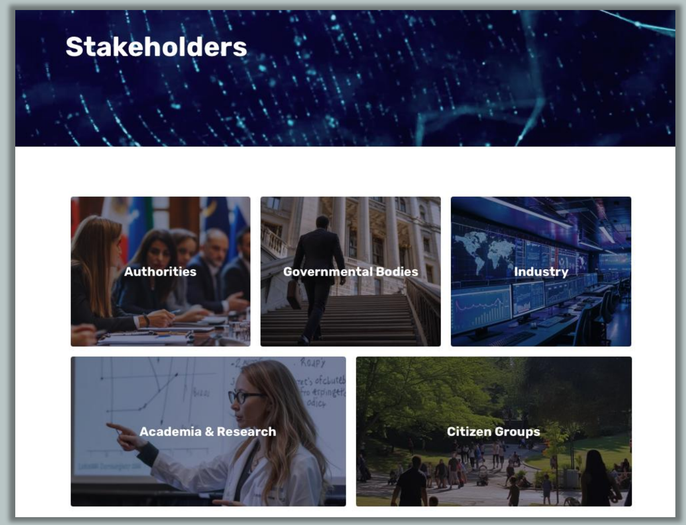
- Open platform designed for collecting, assessing and populating research outputs
- Connection with worldwide literature databases
- Data exchanged within health data space
- Stakeholders dashboard for accessing evidence, risks and communicating findings
- Collection of International/European guidelines and relevant stakeholders on EMF and Health
- Used for NextGEM and CLUE-H results
- Security, reliability trustworthiness and GDPR compliance

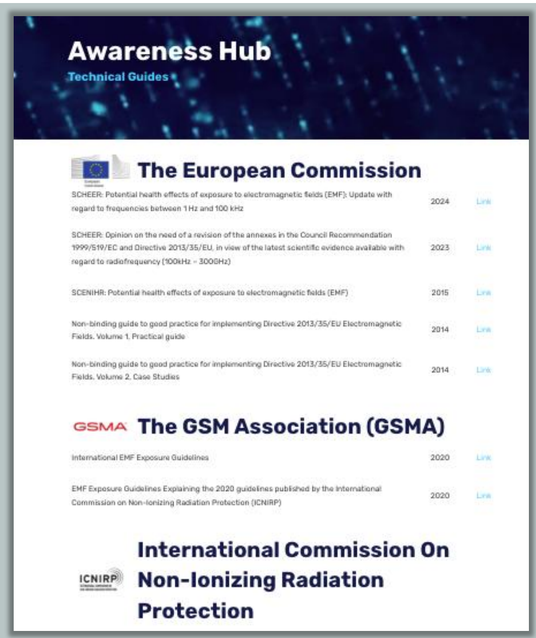
NextGEM

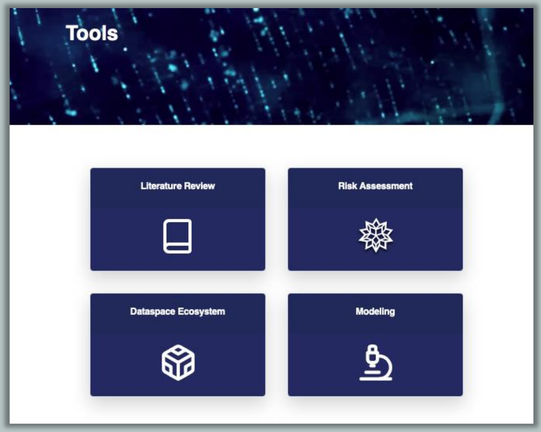
NextGEM Innovation and Knowledge Hub (NIKH)

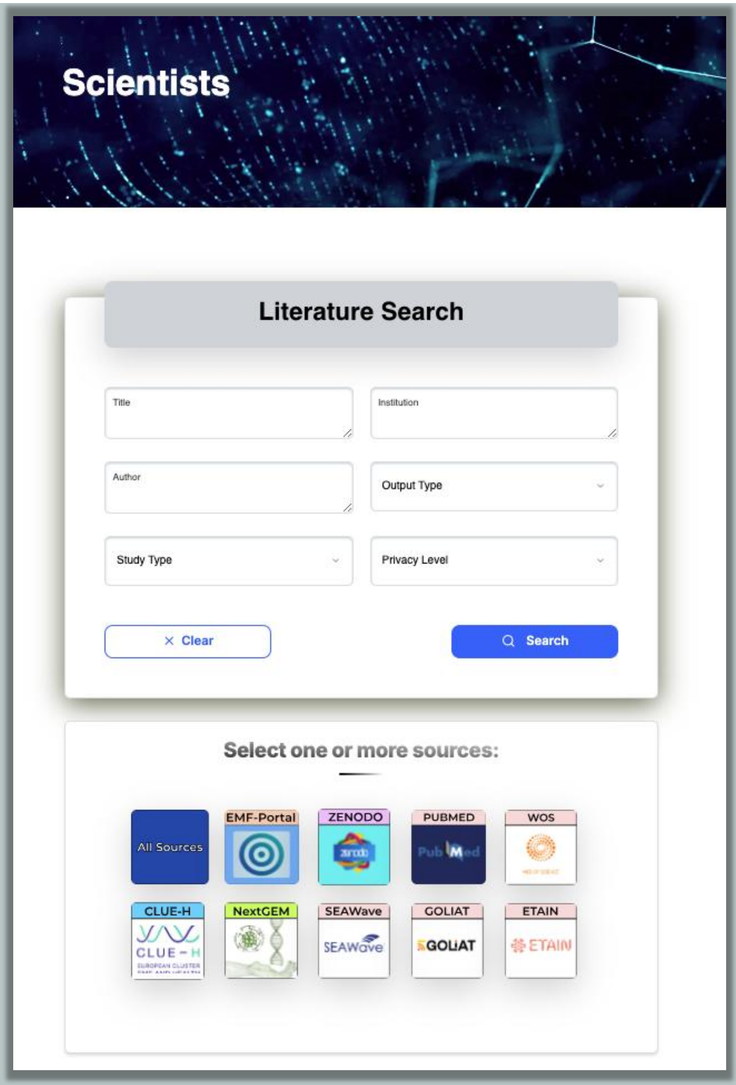






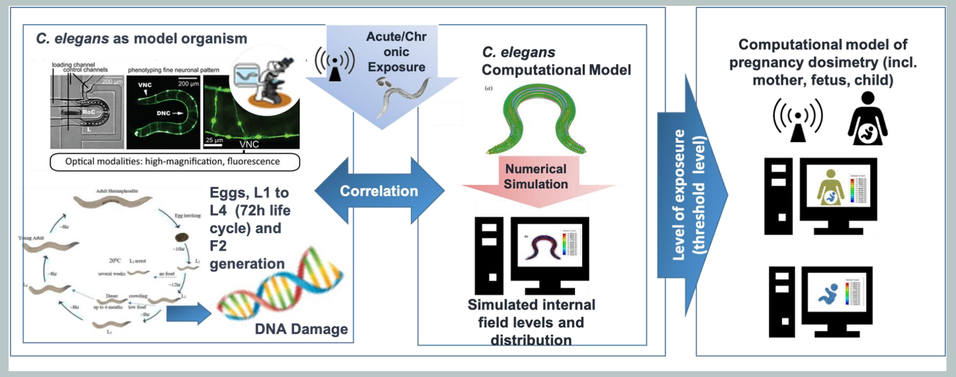




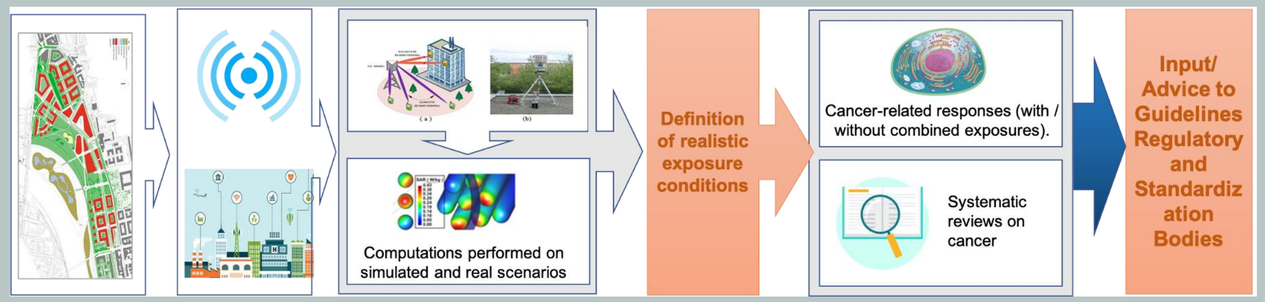


Case studies

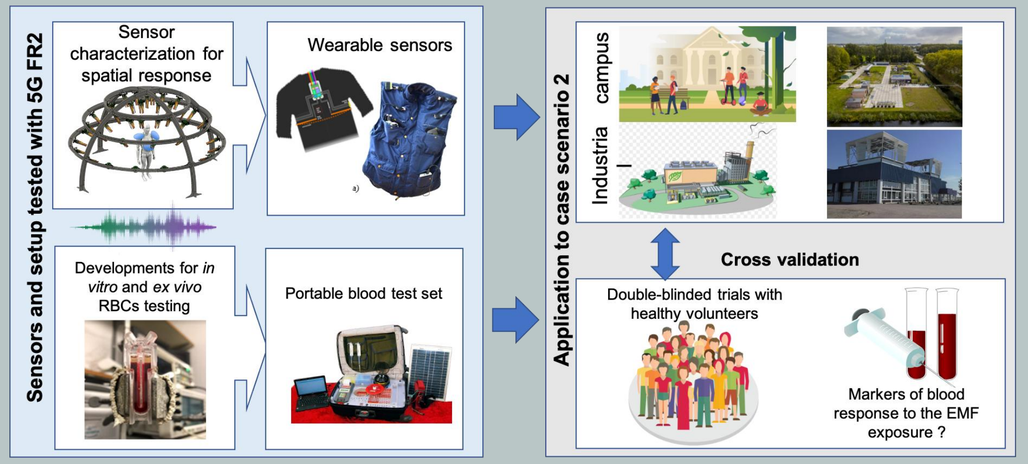
Case Study 1 - Potential effects of indoor levels of RF exposure of vulnerable people on reproduction and development



Case Study 2 - Optimised outdoor urban planning and 5G design architecture for public awareness on cancer-related health hazards



Case Study 3 - Health effects of exposure to mmWave EMF in indoor & outdoor environments



NextGEM

NextGEM case study process

Model- and sensor-based technologies for exposure monitoring

Experimental approaches for assessing biological and health-related effects of EMF

Hazard and risk assessment

Literature

Case Study 1
Potential effects of indoor levels of RF exposure of vulnerable people on reproduction and development

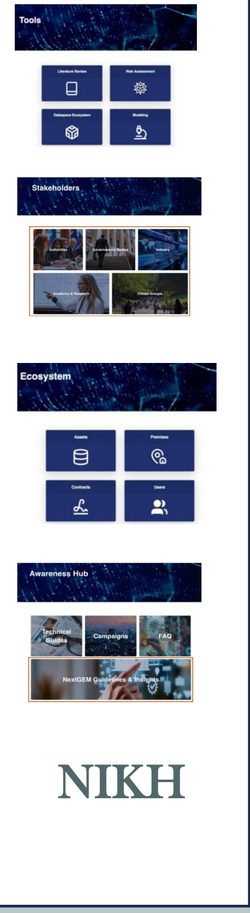
Case Study 2
Optimised outdoor urban planning and 5G design architecture and investigations for public awareness on cancer-related health hazards

Case Study 3
Health effects of exposure to mmWave EMF in indoor and outdoor environments

Guidelines

Risk Assessment

Publications



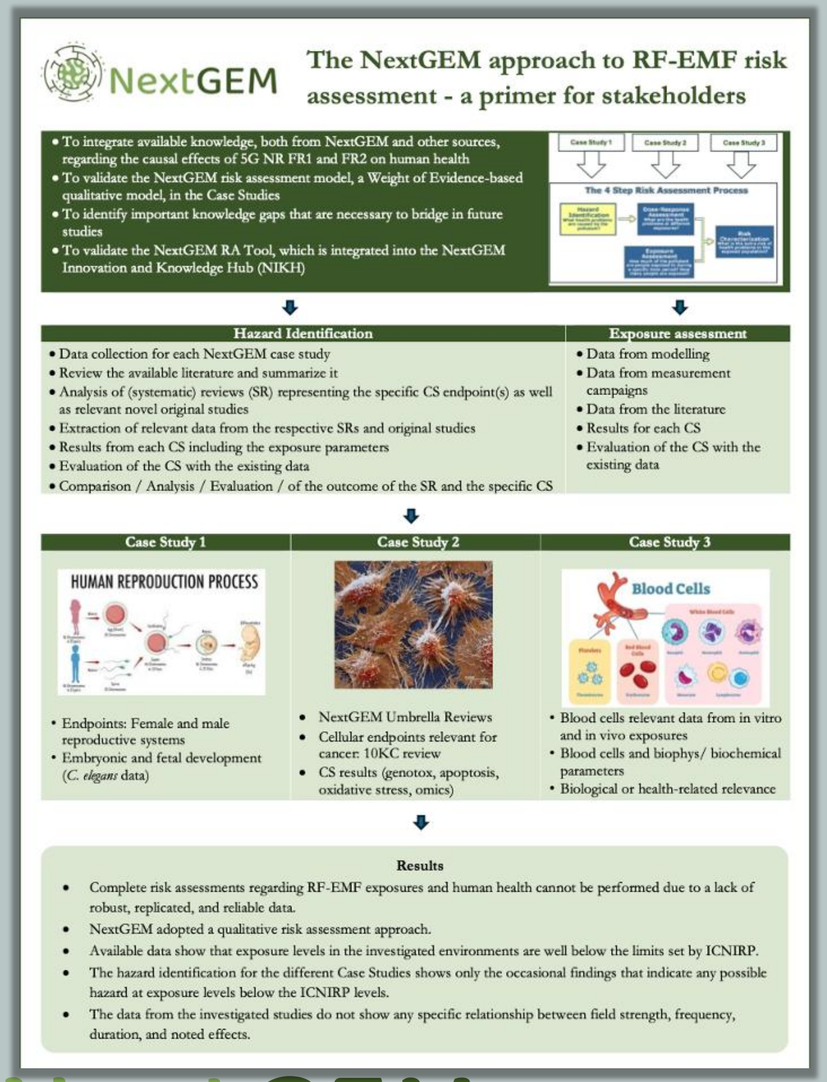
NIKH

NextGEM

Overall risk assessment

Line of Evidence	Results in NextGEM	Health endpoint	Weight of evidence NextGEM	Weight of evidence from the literature	Risk assessment
Epidemiology	Umbrella reviews: Near field exposure Far field exposure	Cancer	Uncertain weight of evidence	Uncertain weight of evidence	Low risk
Human experiments	Buccal cells: Heavy exposure user Low exposure user	Cancer	No suitable evidence available	No suitable evidence available	Low risk
Ex vivo	Blood cell investigations	Blood cell status/ mechanisms	No suitable evidence available	No suitable evidence available	Low risk
In vivo	*C. elegans*	Development, Reproduction	Strong weight of evidence for the absence of an effect	Strong weight of evidence for the absence of an effect	Low risk
In vitro	Different experimental endpoints (ROS, micronuclei, apoptosis, cell cycle progression, epigenetics, genomics)	Cancer, Development Reproduction	Strong weight of evidence for the absence of an effect	Uncertain weight of evidence	Low risk
In silico	Dosimetry	Development Reproduction	Strong weight of evidence for the absence of an effect	Strong weight of evidence for the absence of an effect	Low risk

NextGEM approach to RF-EMF risk assessment



NextGEM

The NextGEM approach to RF-EMF risk assessment - a primer for stakeholders

- To integrate available knowledge, both from NextGEM and other sources, regarding the causal effects of 5G NR FR1 and FR2 on human health
- To validate the NextGEM risk assessment model, a Weight of Evidence-based qualitative model, in the Case Studies
- To identify important knowledge gaps that are necessary to bridge in future studies
- To validate the NextGEM RA Tool, which is integrated into the NextGEM Innovation and Knowledge Hub (NIKH)

Case Study 1 | Case Study 2 | Case Study 3

The 4 Step Risk Assessment Process

Hazard Identification

- Data collection for each NextGEM case study
- Review the available literature and summarize it
- Analysis of (systematic) reviews (SR) representing the specific CS endpoint(s) as well as relevant novel original studies
- Extraction of relevant data from the respective SRs and original studies
- Results from each CS including the exposure parameters
- Evaluation of the CS with the existing data
- Comparison / Analysis / Evaluation / of the outcome of the SR and the specific CS

Exposure assessment

- Data from modelling
- Data from measurement campaigns
- Data from the literature
- Results for each CS
- Evaluation of the CS with the existing data

Case Study 1

HUMAN REPRODUCTION PROCESS

- Endpoints: Female and male reproductive systems
- Embryonic and fetal development (*C. elegans* data)

Case Study 2

- NextGEM Umbrella Reviews
- Cellular endpoints relevant for cancer: 10KC review
- CS results (genotox, apoptosis, oxidative stress, omics)

Case Study 3

Blood Cells

- Blood cells relevant data from in vitro and in vivo exposures
- Blood cells and biophys/ biochemical parameters
- Biological or health-related relevance

Results

- Complete risk assessments regarding RF-EMF exposures and human health cannot be performed due to a lack of robust, replicated, and reliable data.
- NextGEM adopted a qualitative risk assessment approach.
- Available data show that exposure levels in the investigated environments are well below the limits set by ICNIRP.
- The hazard identification for the different Case Studies shows only the occasional findings that indicate any possible hazard at exposure levels below the ICNIRP levels.
- The data from the investigated studies do not show any specific relationship between field strength, frequency, duration, and noted effects.

Results

Qualitative RF-EMF risk-assessment model developed for cancer, reproduction/development and blood-cell outcomes.

Risk assessment indicated that 5G RF exposure at existing low levels appears to pose no or very low risks for the general population.

Evidence and systematic reviews used to strengthen RF-EMF governance and policy recommendations.

Identified limitations preventing robust quantitative risk assessment.

NextGEM

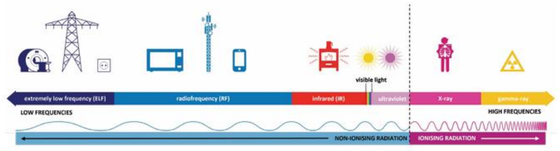
NextGEM guidelines and recommendations

NextGEM

GENERAL INFORMATION ABOUT RF-EMFS

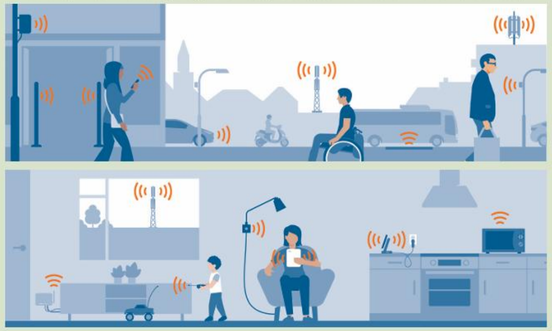
WHAT ARE EMFs?

Electromagnetic fields (***EMF***) result from sources that emit ***electric*** and/or ***magnetic energy***. Electromagnetic energy moves from a ***source*** through space like waves. These moving waves are also called ***fields***. These ***waves*** have different ***wavelengths*** and ***frequencies***. Low frequency EMF have a long wavelength and high frequency EMF have a short wavelength. The different types of EMF together form the electromagnetic spectrum, which is shown in the figure below. The figure also shows common applications of the different types of EMF.



WHERE ARE THE RF-EMFS?

This document is about radiofrequency EMFs (***RF-EMFs***). These are used in many different everyday services and devices. Nowadays, it is possible to have an internet connection and make phone calls almost everywhere. Therefore, a large and widespread telecommunication network is necessary.



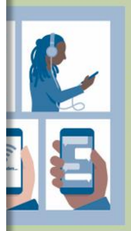
...OUT EXPOSURE AND HEALTH?

...damage molecules ...F-EMF do not dam... ...refore ***non-ionising***. ...ength and distance, ...a ***biological effect***. ...as some organs are ...f field strengths are ...***tive health effects***.



...***ts*** and regulation are ...ific research. Health ... and continue to be ... no proof of harm to ... been found.

...UCE YOUR EXPOSURE?



Some people want to reduce their exposure to RF-EMF. This is possible through the following measures:

- Use wired devices (keyboard, internet).
- Use device less or for a shorter amount of time.
- Do not use devices when there is a poor connection.
- Use a device with a lower SAR-value.
- Do not hold devices close to the body when it is making a connection.
- Use texting instead of voice calling.
- Increase the distance to devices (like the Wi-Fi router).

DISCLAIMER

Funded by the European Union under Grant Agreement no. 101057527. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency. Neither the European Union nor the granting authority can be held responsible for them

About NextGEM

NextGEM aims to ensure the safety of EU citizens by developing frameworks for monitoring and assessing EMF exposure. The project's goal is to generate health-relevant scientific knowledge, create tools for risk assessment, and establish a Knowledge Hub for data storage and accessibility, particularly for policymakers and the scientific community.

NextGEM

Funded by the European Union

...OPYRIGHT MESSAGE

NextGEM Consortium. This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both. Reproduction is authorised provided the source is acknowledged.

NextGEM

HOW TO COMMUNICATE ABOUT RF-EMF

This factsheet provides a concise overview of recommendations for communicating about RF-EMF.

A more comprehensive overview is provided in the document Practical tools for communicating about radiofrequency electromagnetic fields [1].

PROVIDE CLEAR, ACCURATE, AND RELIABLE INFORMATION

To effectively disseminate technical information, it is recommended to:

- Explain the following technical aspects:
  - What RF-EMF are and the ubiquitous presence
  - How RF-EMF differ from ionising radiation
  - Biological and potential health effects
  - Exposure levels and patterns
- Leave out technical details that impede understandability.
- Clarify how risks are assessed:
  - Research methods and evaluation of the evidence
  - Clarify how exposure limits are determined
  - Reflect on the current state of knowledge and acknowledge scientific uncertainty



ENGAGE WITH AND TAILOR INFORMATION TO AUDIENCES



Two-way risk communication requires:

- In depth knowledge of the different target audiences.
  - Adequately and regularly identify audiences
  - Consult representatives of audiences with diverse different backgrounds and opinions
- To take questions and concerns seriously.
  - By active and empathic listening
  - By committing to helping people
- Selection of information that is relevant for audiences.
  - Determine core messages, based on the specific information needs
  - Refer to more comprehensive sources for those seeking more information





[3] Freepik

...SE ACCESSIBILITY AND REACH

...lity and reach, consider the following suggestions:

- ...mmunication expertise
- ...munication experts for (risk) information dissemination
- ...s and invest in training for professionals
- ...s and channels
- ...udience and to ensure information is obtained more
- ...d & layered approach to minimise information overload
- ...plex information with accessible summaries or
- ...s to improve the findability of information
- ...formal and informal settings
- ...l (informal) information sessions to effectively address ...ncerns
- ...t of contact to address questions and concerns, and for ...rganisations



...FACILITATE STAKEHOLDER DIALOGUE



[4] Freepik

For effective consultation and proactive involvement of stakeholders, it is suggested to:

- Create regular opportunities for dialogue.
  - Initialise dialogue at the earliest opportunity, far before decision-making
  - Improve inter-organisational collaboration and referral in general
- Commit to being a trustworthy and reliable source and partner in dialogue.
  - Acknowledge limited knowledge
  - Be honest, patient, transparent, and accountable
  - Report relevant information in early stages and keep stakeholders informed

...w.nextgem.eu/

...com/

...GE

...This deliverable ...published work ...ated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation, or both. Reproduction is authorised provided the source is acknowledged.

DISCLAIMER

Funded by the European Union under Grant Agreement no. 101057527. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.

About NextGEM

NextGEM aims to ensure the safety of EU citizens by developing frameworks for monitoring and assessing EMF exposure. Visit NextGEM website in: https://www.nextgem.eu

NextGEM

Funded by the European Union

NextGEM

Future directions

Modeling	Personalised computational for emerging technologies, scenarios, and populations, including 6G/FR3.
Sensor Devices	Advance 6G/FR3 exposure assessment through low-cost sensing devices, OTA measurements, and modelling.
Exposure Monitoring	Long-term 5G/6G exposure monitoring through harmonised measurements and modelling.
Experimental Studies	Expand FR2/FR3 studies on molecular, epigenetic, and environmental effects for in vivo and in vitro studies
Human Studies	Expand human FR2 studies through larger cohorts and broader exposure and biological assessments.

Umbrella Reviews	Strengthen URs with robust methods, standardized protocols, high-quality SRs for reliable risk assessment
SOPs	Harmonise methods, protocols, data practices in multi-centre, bio, and evidence-synthesis research on 5G/6G
Risk Assessment	Update risk assessments with emerging evidence while strengthening quantitative assessment and governance.
NIKH Platform	Further develop and validate the NIKH platform, update awareness hub, expand dataspace, integrate AI

6G Networks

6GSNS

Co-funded by the European Union

6G OPTIMUS — Optimized 6G-enabled IoT networks for unlicensed operations in the computing continuum

6G-CARE — 6G-enabled Connected and Autonomous Response for eHealth

NextGEM

THANK YOU



NextGEM

Dr Nikolaos Petroulakis NextGEM Project Coordinator npetro@ics.forth.gr

www.nextgem.eu nextgem-project/ @NextGEM_eu

This work is part of the European Union's Horizon Europe research and innovation programme under grant agreement No 101057527 (NextGEM). Funded by the European Union. Views and opinions expressed are however those of the authors only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

Twenty years of EMF research monitoring: what has been learned?



Dr Sarah Driessen
EMF-Portal Project Head -
RWTH Aachen, Germany

Copyright notice:
Some images in this presentation have been blurred to respect copyright restrictions.

UNIKLINIK RWTH AACHEN
Institute for Occupational,
Social and Environmental Medicine

femu
Research Center for Bioelectro-
magnetic Interaction

20 Years of EMF Research Monitoring

Dr. rer. nat. Sarah Driessen

Brussels, 13 October 2026,
EMF-Forum 2026

Growing concerns about health risks from exposure to non-ionizing radiation following the use of tracking radars during World War II



Source: mobileradar





Source: Wikipedia

Related research in the USA and the former Soviet Union led to development of first limit values

1950er

- Foundation of Forschungsstelle für Elektropathologie (FfE) („Research Center of Electropathology“)
  - Initial focus: investigation of electric injuries
  - From the ’70s: investigation of the effects of electric and magnetic fields



1955

1965

1979

Foundation of the International Radiation Protection Association (IRPA)



1955

1965

1979

Wertheimer and Leeper: Association between childhood leukaemia and distance between homes and high-voltage power lines



Source: muehlviertel110kv



Original Contributions

1955

1965

1979

1979

Foundation of the International Commission on Non-Ionizing Radiation Protection (ICNIRP)

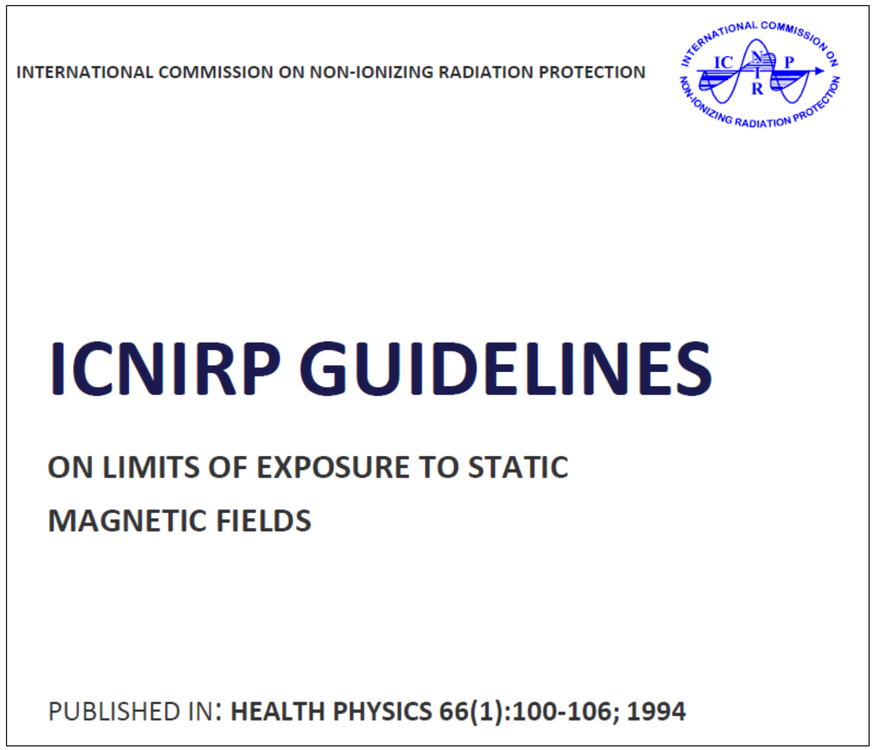
1992

Launch of mobile cellular networks of the second generation (2G/GSM)



1994

Publication of the first ICNIRP Guidelines

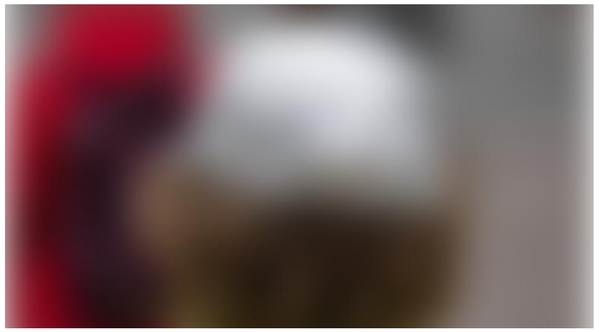


1990

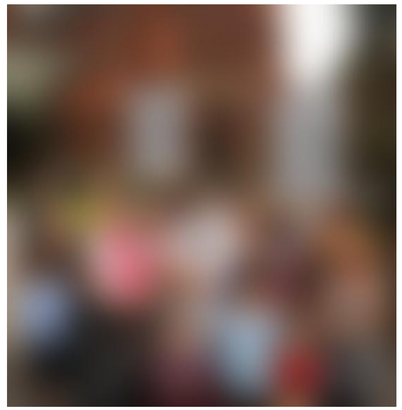
1992

1994

Growing public concern, particularly regarding radiofrequency EMFs from cellular networks



Source: Frankfurter Rundschau, dpa



Source: Your Local Guardian/ Martin George

1990er

- Emergence of many activist groups and the politicization of the issue in many countries



Source: Arbeit&Wirtschaft

- Launch of new research projects (including the Fifth European Research Framework Program)

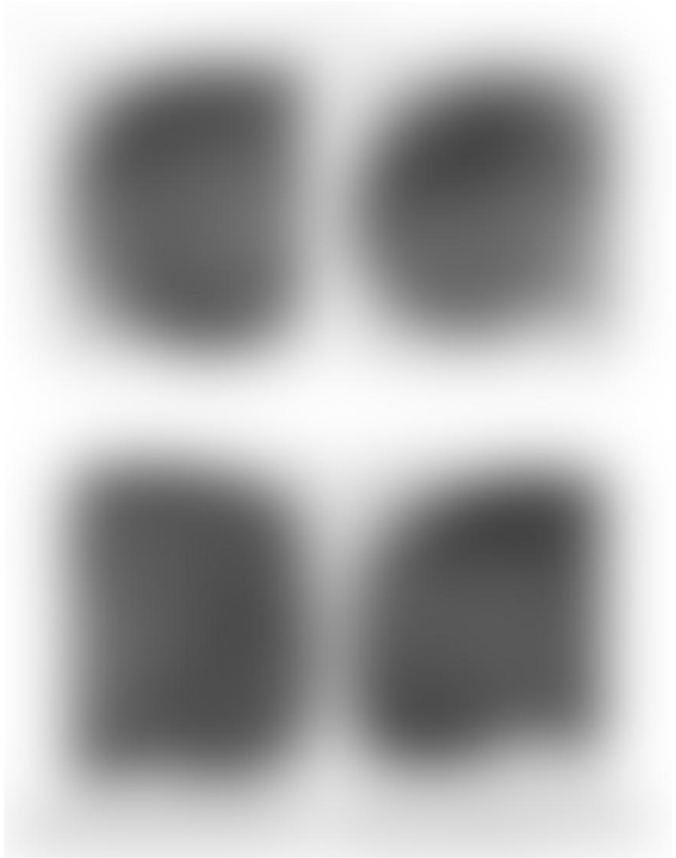
1990er

Salford studies

→ Studies on the effects of microwave exposure on blood-brain barrier permeability in rats

→ Results were subject of intense debate; numerous methodological limitations

→ Results could not be replicated



1990er

Von Klitzing study

→ Effects of pulsed EMF (150 MHz) on EEG

→ Significant impact on the alpha wave EEG below the limits

→ Health-related relevance unclear

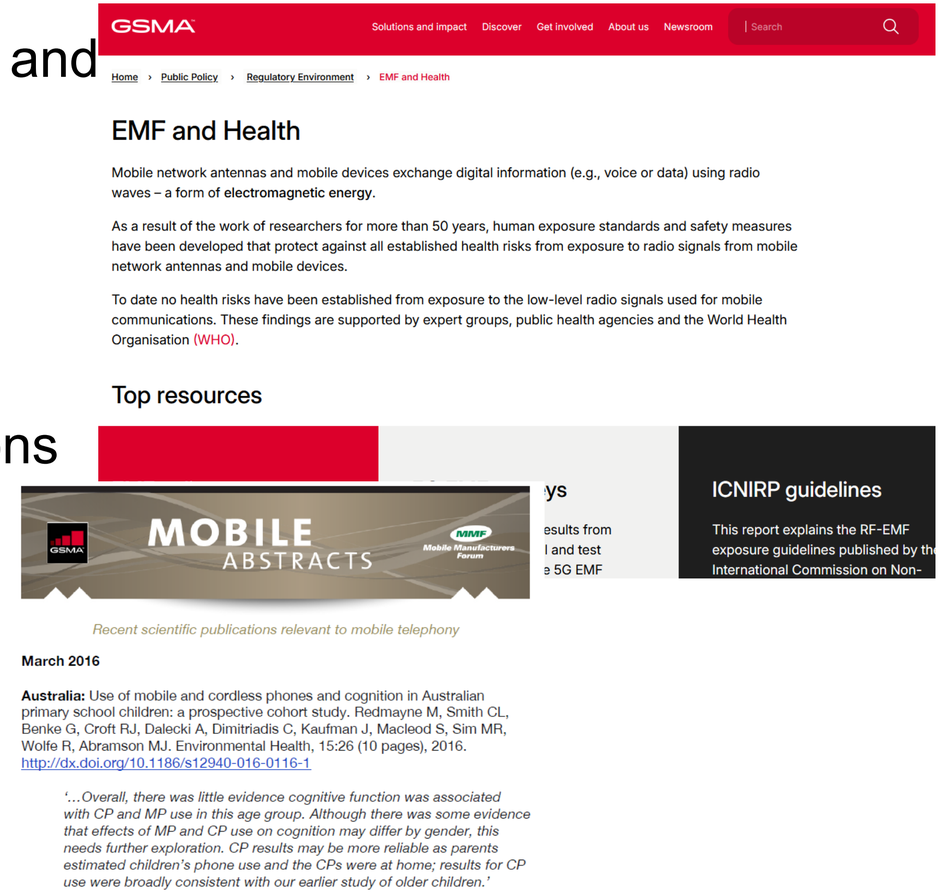
1995

GSMA

→ Set up a group called “EMC and Bioeffects Review Committee (EBRC)”

→ To evaluate environmental safety and potential biological effects of mobile communications

→ To provide information and literature surveys



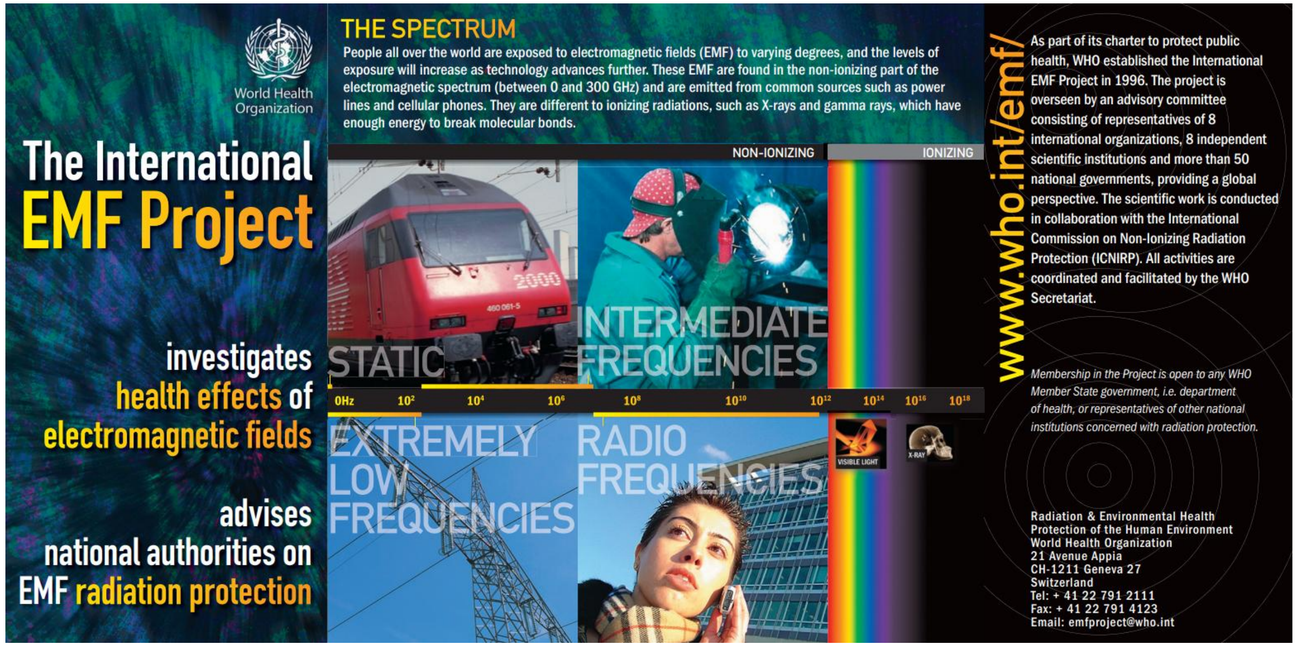
1995

Foundation of the Forum Mobilkommunikation (FMK; „Forum Mobile Communication“), Austria

FORUM MOBILKOMMUNIKATION

1996

Foundation of the EMF-Project (WHO)



1996

Repacholi study



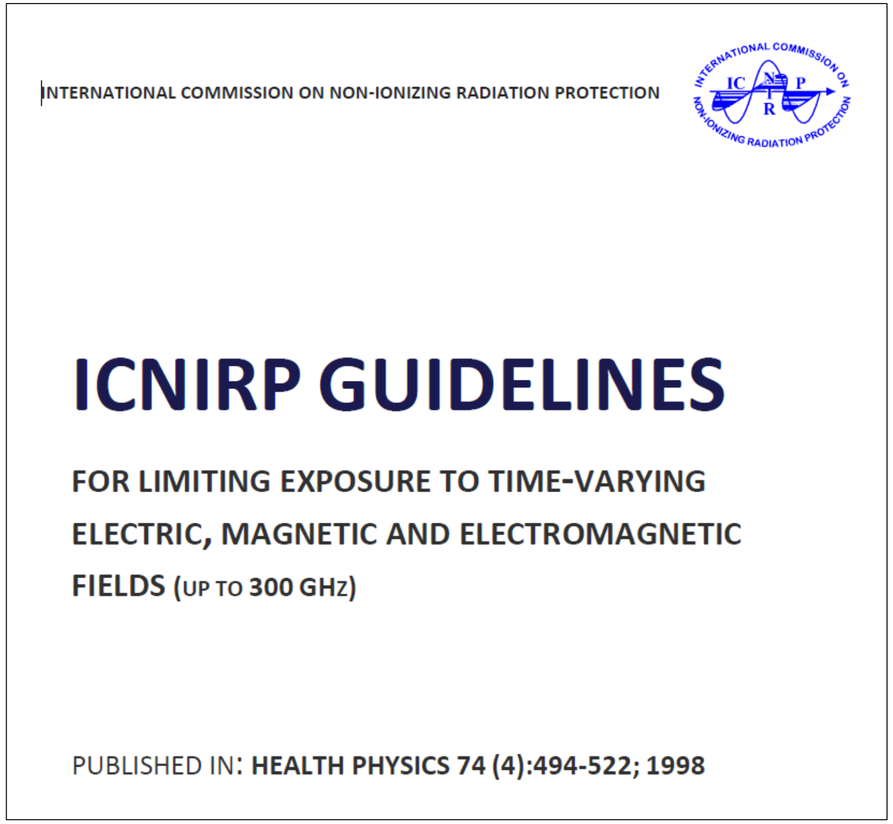
→ Risk of lymphoma in genetically modified mice exposed to GSM significantly higher than in control group

→ Study received a great deal of attention and prompted numerous comments

→ Results could not be replicated

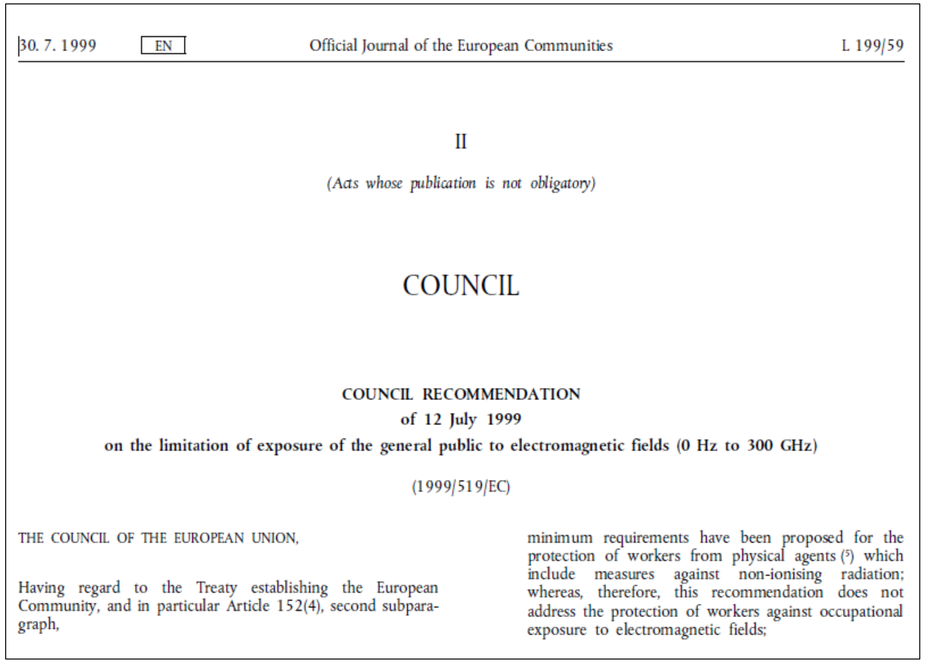
1996 1997 1998

Publication of ICNIRP Guideline



1996 1997 1998

EU Council recommendation on the limitation of exposure to EMF



30. 7. 1999 EN Official Journal of the European Communities L 199/59

II

(Acts whose publication is not obligatory)

COUNCIL

COUNCIL RECOMMENDATION
of 12 July 1999
on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)

(1999/519/EC)

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 152(4), second subparagraph,

minimum requirements have been proposed for the protection of workers from physical agents (5) which include measures against non-ionising radiation; whereas, therefore, this recommendation does not address the protection of workers against occupational exposure to electromagnetic fields;

1999 2000 2002

Hardell studies

→ Studies find associations between cell phone/DECT exposure and brain tumors

→ Due to methodological flaws, studies are subject of intense debate

→ Results could not be confirmed by other researchers



1999 2000er 2002

Foundation Swiss Research Foundation for Electricity and Mobile Communication (CH)

FSM | Forschungsstiftung
Strom und Mobilkommunikation
FSM | Swiss Research Foundation for
Electricity and Mobile Communication

Start of the German Mobile Telecommunication Research Programme (funding of 54 projects, 17 Mio. €)



1999 2000 2002

IARC classification of magnetic fields



Overall evaluation

Extremely low-frequency magnetic fields are *possibly carcinogenic to humans (Group 2B)*.

Static electric and magnetic fields and extremely low-frequency electric fields are *not classifiable as to their carcinogenicity to humans (Group 3)*.

1999

2000

2002

Launch of third-generation (3G/UMTS) mobile networks



Source: Telefónica

2004

2005

2009

Naila study

- Study conducted by physicians on cancer incidence and proximity to a cell tower→ patients living in close proximity have a 2.3-fold higher risk of cancer compared to patients farther away
- Study attracted a great deal of attention and has prompted numerous comments





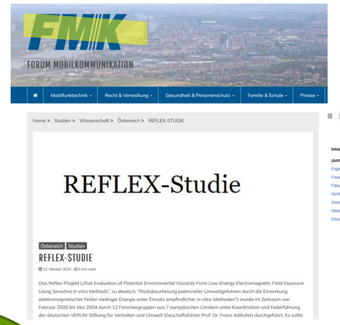


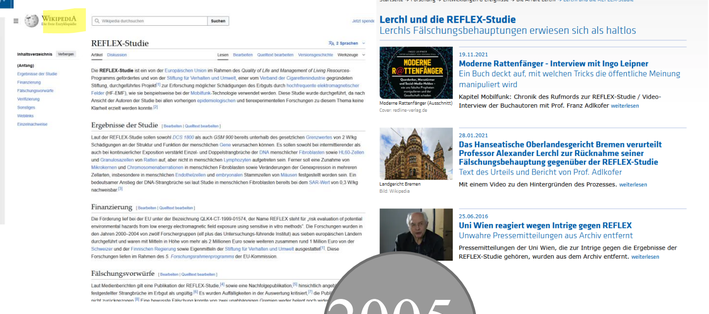
Source: MMW-Fortschr. Med. Nr. 3/2006 (148. Jg.)

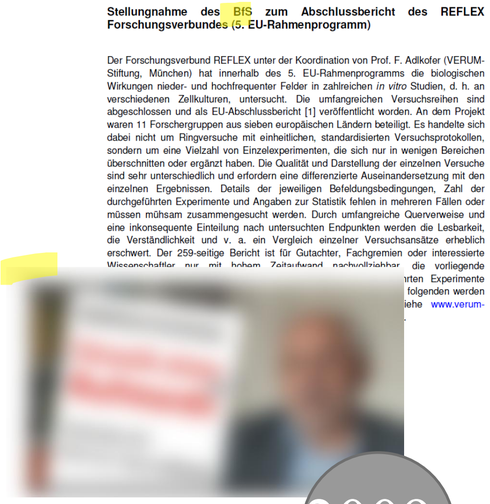
2004 2005 2009

REFLEX study:

- EU funded joint project
- 11 groups from 7 European countries under the leadership of the German VERUM Foundation (Prof. Adlkofer)
- Study on effects of low- and radiofrequency EMFs on various cell cultures regarding potential carcinogenic mechanisms
- University of Vienna and Benjamin Franklin University Hospital Berlin report genotoxic effects






Stellungnahme des BfS zum Abschlussbericht des REFLEX Forschungsverbundes (5. EU-Rahmenprogramm)

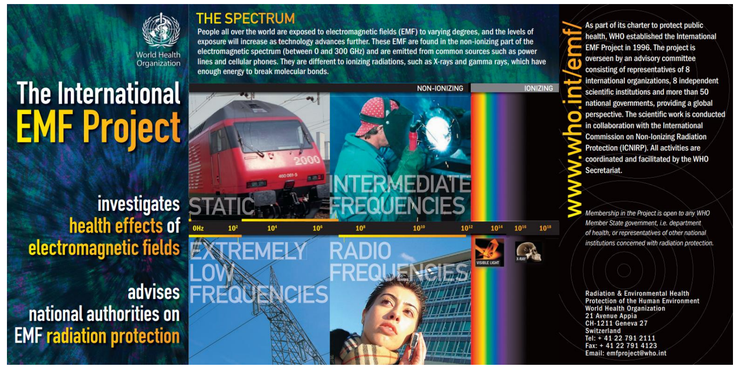
Der Forschungsverbund REFLEX unter der Koordination von Prof. F. Adlkofer (VERUM-Stiftung, München) hat innerhalb des 5. EU-Rahmenprogramms die biologischen Wirkungen nieder- und hochfrequenter Felder in zahlreichen *in vitro* Studien, d. h. an verschiedenen Zellkulturen, untersucht. Die umfangreichen Versuchsreihen sind abgeschlossen und als EU-Abschlussbericht [1] veröffentlicht worden. An dem Projekt waren 11 Forschergruppen aus sieben europäischen Ländern beteiligt. Es handelte sich dabei nicht um Ringversuche mit einheitlichen, standardisierten Versuchsprotokollen, sondern um eine Vielzahl von Einzelexperimenten, die sich nur in wenigen Bereichen überschnitten oder ergänzt haben. Die Qualität und Darstellung der einzelnen Versuche sind sehr unterschiedlich und erfordern eine differenzierte Auseinandersetzung mit den einzelnen Ergebnissen. Details der jeweiligen Befeldungsbedingungen, Zahl der durchgeführten Experimente und Angaben zur Statistik fehlen in mehreren Fällen oder müssen mühsam zusammengesucht werden. Durch umfangreiche Querverweise und eine inkonsequente Einteilung nach untersuchten Endpunkten werden die Lesbarkeit, die Verständlichkeit und v. a. ein Vergleich einzelner Versuchsansätze erheblich erschwert. Der 259-seitige Bericht ist für Gutachter, Fachgremien oder interessierte Wissenschaftler nur mit hohem Zeitaufwand nachvollziehbar, die vorliegende [illegible] Experimente [illegible] folgenden werden [illegible] siehe www.verum-

2004

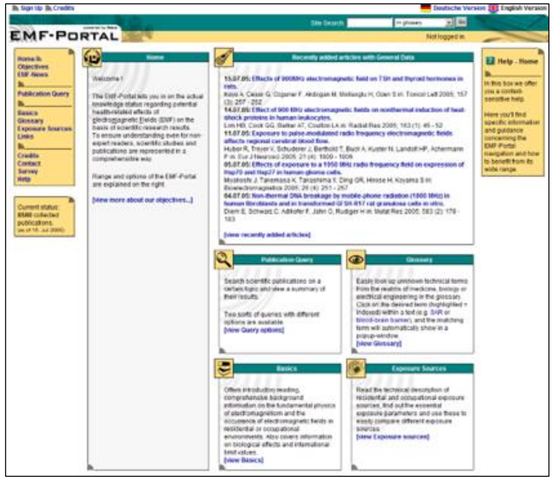
2005

2009

WHO extends EMF project



Launch of EMF-Portal



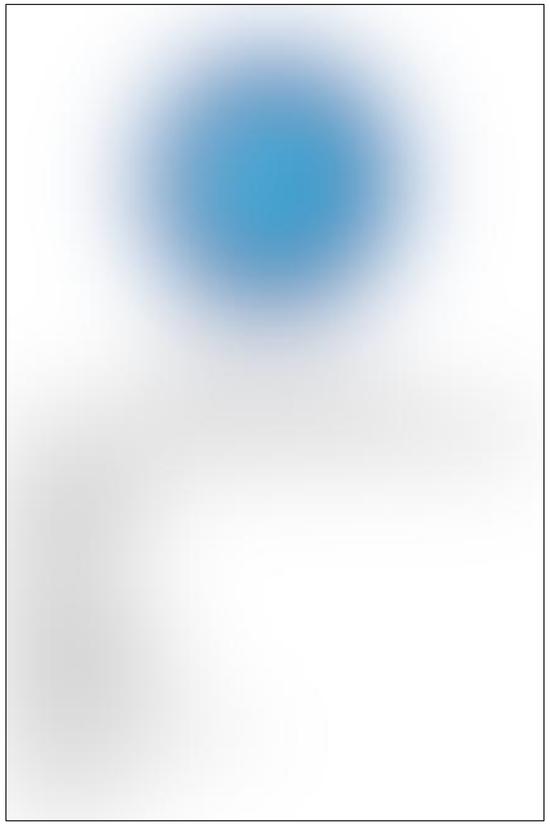
Source: EMF-Portal

2004

2005

2007

Bioinitiative Report



→ Report on health effects of EMFs from power lines and mobile devices

→ Published online without peer review by a group of 14 scientists and health policy experts

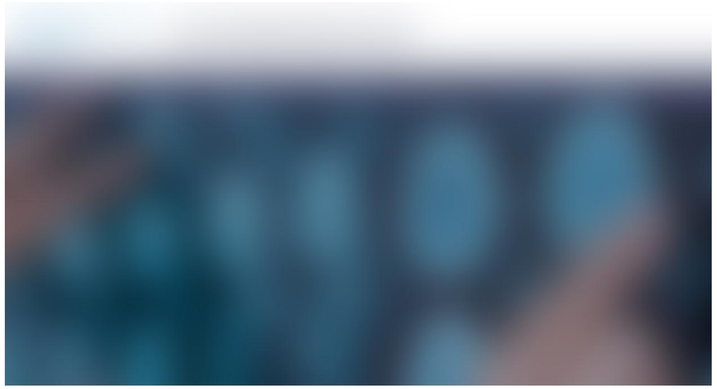
→ Heavily criticized by many government agencies for its lack of balance (https://en.wikipedia.org/wiki/Bioinitiative_Report)

2005 2007 2010

Launch of LTE mobile networks (in Germany)

Publication of Interphone study

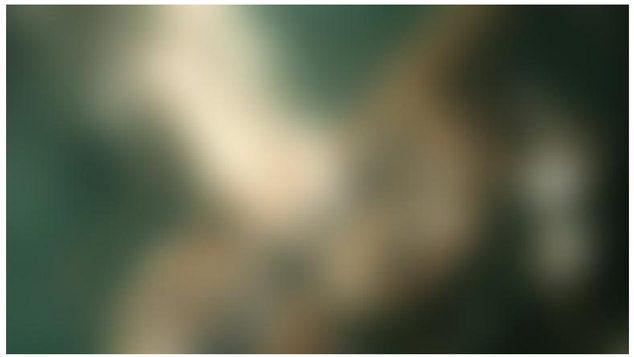
- 13 countries involved
- Patients included:
  - 2,765 with glioma
  - 2,425 with meningioma
  - 1,121 with acoustic neuroma
  - 109 with parotid gland tumors
  - 7,658 controls



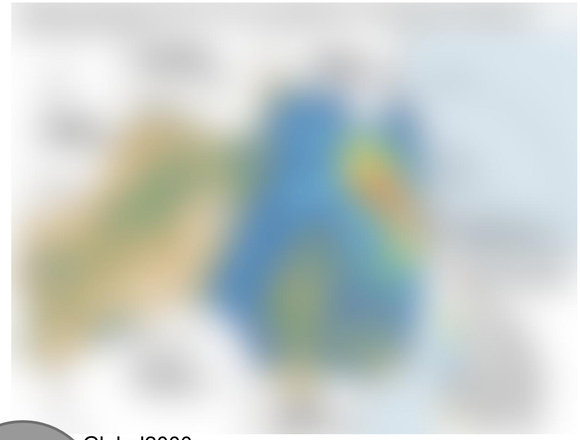
→ Data showed an increased risk of gliomas and acoustic neuromas among the group with the longest total call duration (≥ 1640 h)

2010 2011 2012

Accident at the Fukushima Nuclear Power Plant

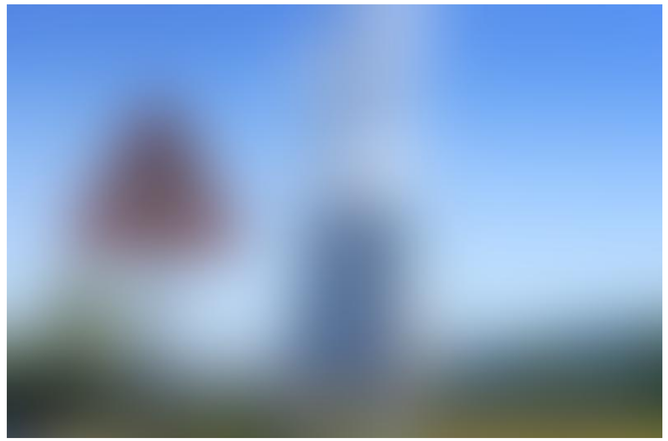


Source: Deutschlandfunk



Global2000

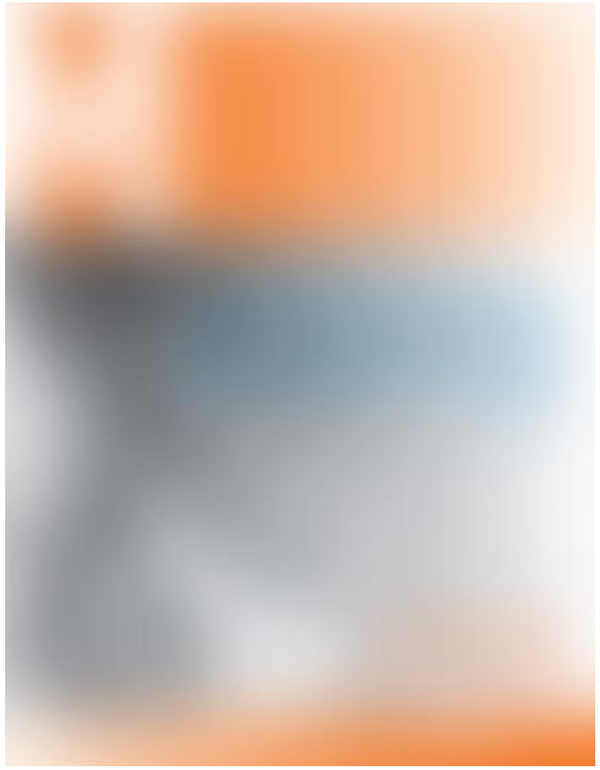
Resolution on the Phase-Out of Nuclear Power in Germany



Source: bpd

2010 2011 2012

IARC classification of radiofrequency fields



6.3 Overall evaluation

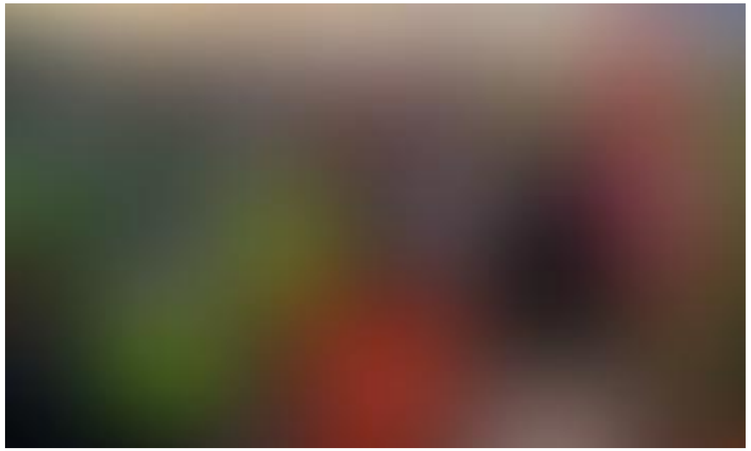
Radiofrequency electromagnetic fields are *possibly carcinogenic to humans (Group 2B).*

2013

2014

2015

Growing public concern regarding ELF magnetic fields from power lines, at least in Germany



Source: n-land

2013

2014

2017

Start of research program
„Radiation Protection in the Process of Power Grid Expansion“
of the BfS (Federal Office for Radiation Protection)



Source: Bundesamt für Strahlenschutz/
Federal Office for Radiation Protection

2017

NTP study

- Clear evidence of exposure (GSM, CDMA)-related occurence of heart tumors (malignant schwannoma) in male rats
- Some evidence for the occurrence of brain tumors and diseases of the adrenal medulla in male rats
- Validation studies doi:10.1093/toxsci/kfag002 and doi:10.1093/toxsci/kfag001



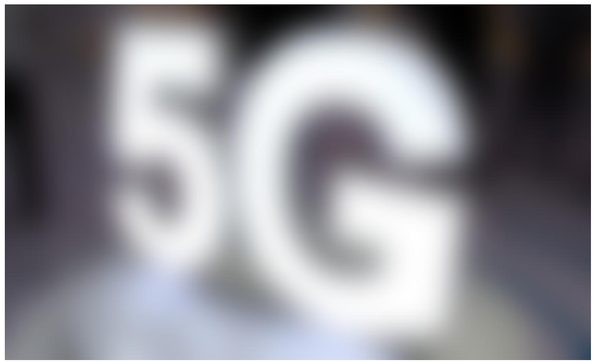




Source: National Toxicology Program (NTP)

2018 2019 2020

Auction of 5G frequencies



Source: tagesschau

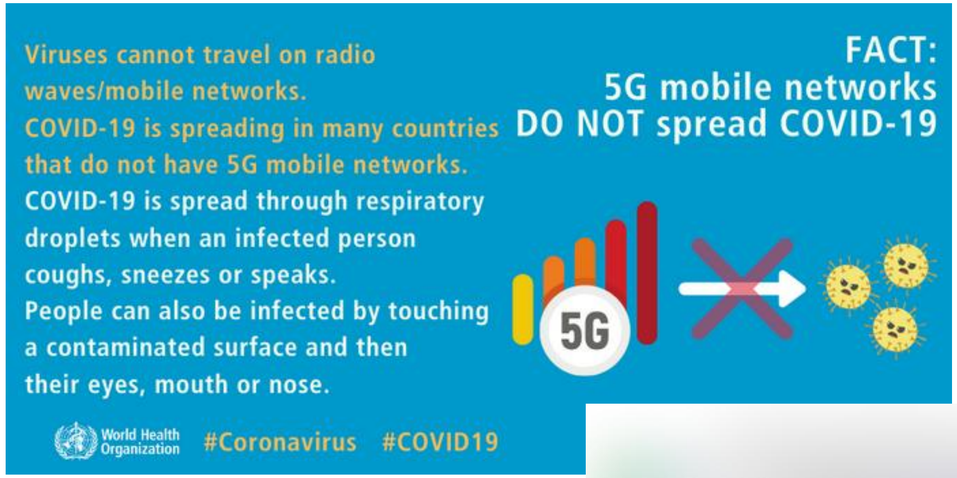
Numerous protests against 5G

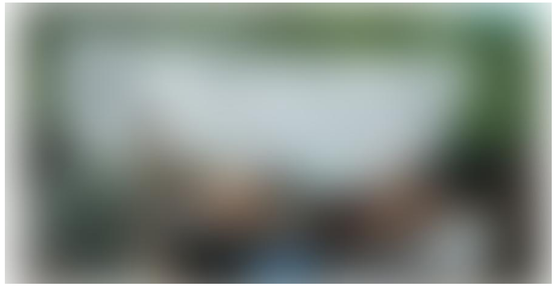


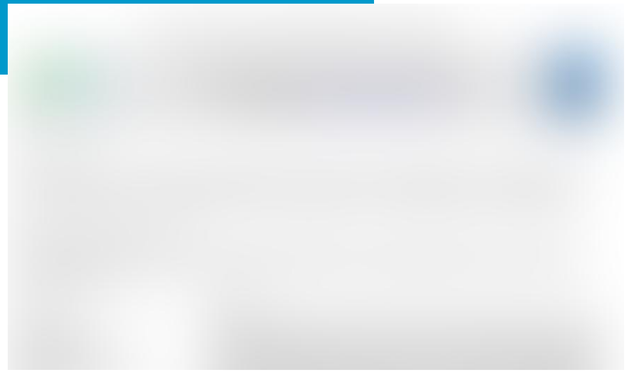
Source: euronews

2018 2019 2020

Corona pandemic





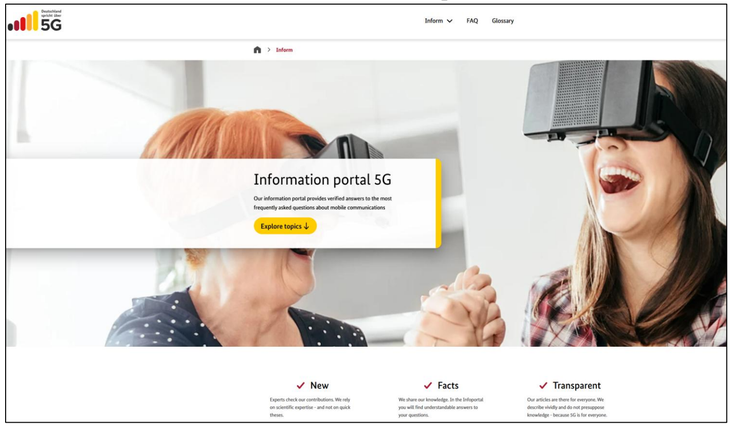


2018

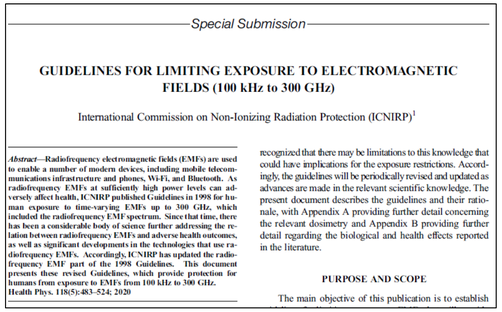
2019

2020

„Information portal 5G “



New ICNIRP Guideline



Special Submission

GUIDELINES FOR LIMITING EXPOSURE TO ELECTROMAGNETIC FIELDS (100 kHz to 300 GHz)

International Commission on Non-Ionizing Radiation Protection (ICNIRP)[1]

Abstract—**Radiofrequency electromagnetic fields (EMFs) are used to enable a number of modern devices, including mobile telecommunications infrastructure and phones, Wi-Fi, and Bluetooth. As radiofrequency EMFs at sufficiently high power levels can adversely affect health, ICNIRP published Guidelines in 1998 for human exposure to time-varying EMFs up to 300 GHz, which included the radiofrequency EMF spectrum. Since that time, there has been a considerable body of science further addressing the relation between radiofrequency EMFs and adverse health outcomes, as well as significant developments in the technologies that use radiofrequency EMFs. Accordingly, ICNIRP has updated the radiofrequency EMF part of the 1998 Guidelines. This document presents these revised Guidelines, which provide protection for humans from exposure to EMFs from 100 kHz to 300 GHz.**
Health Phys. 118(5):483–524; 2020

recognized that there may be limitations to this knowledge that could have implications for the exposure restrictions. Accordingly, the guidelines will be periodically revised and updated as advances are made in the relevant scientific knowledge. The present document describes the guidelines and their rationale, with Appendix A providing further detail concerning the relevant dosimetry and Appendix B providing further detail regarding the biological and health effects reported in the literature.

PURPOSE AND SCOPE

The main objective of this publication is to establish

2018

2019

2020

Foundation “International Commission on the Biological Effects of Electromagnetic Fields”

ICBE–EMF
INTERNATIONAL COMMISSION ON THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

2021

2022

2023

Start „EU Research Cluster CLUE- H"

ETAIN

NextGEM

GOLiAT

SEAWave

WHO systematic reviews on health-related effects of radiofrequency EMF exposure



2021

2022

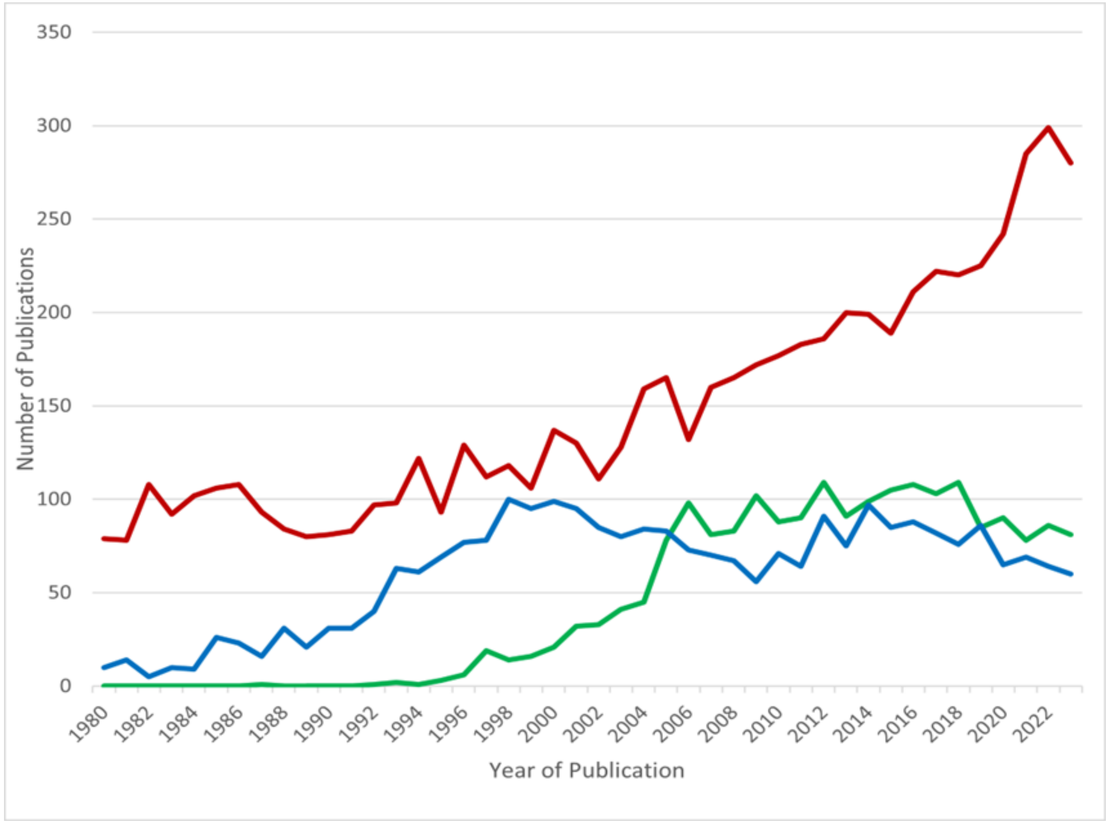
2023

SCHEER = Scientific Committee on Health, Environmental and Emerging Risks:
→ no moderate or strong level of evidence for adverse health effects resulting from chronic or acute RF EMF exposure from existing technology at levels below the limits



2021 2022 2023

Trends in scientific research in the past 40 years



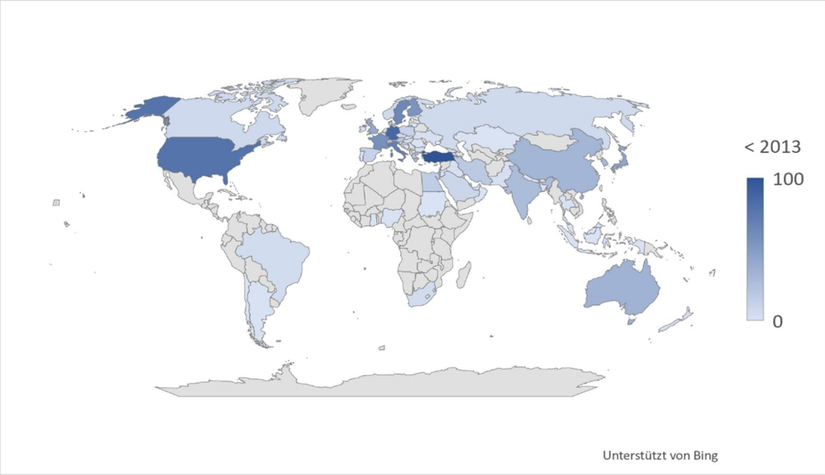
-- mobile communications (n=2,007); cutpoint 2013
-- power frequency (n=2,677); cutpoint 2006
(only experimental and epidemiological studies considered)

--- remaining studies

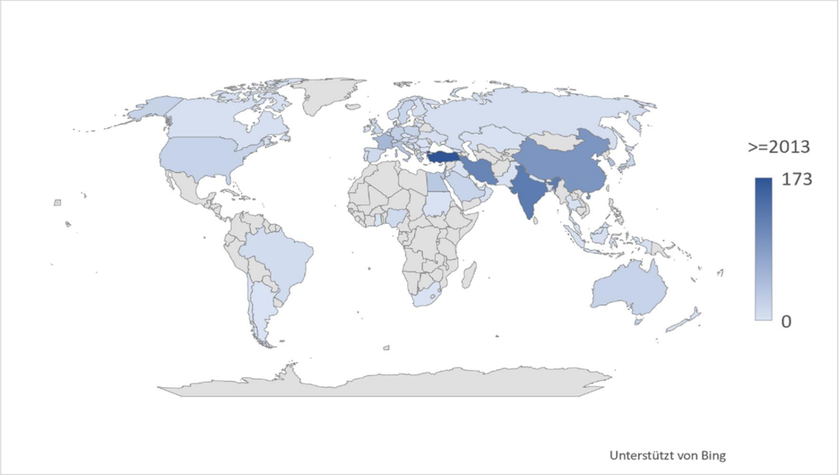
2024

Geospatial analysis (mobile communications)

2000-2012



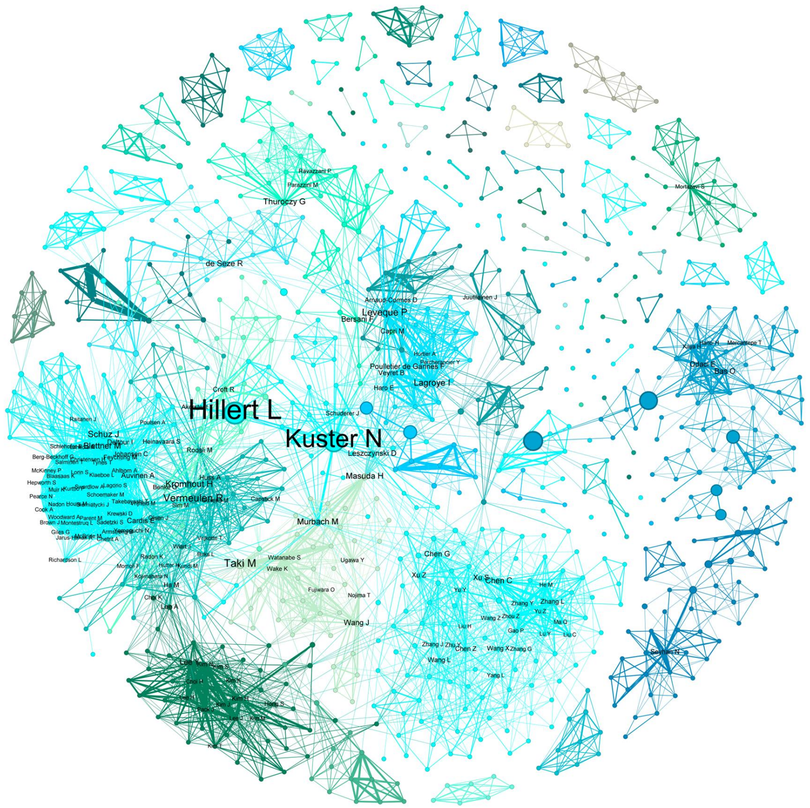
2013-2023



Top 10 countries contributing 63% of the publications:
Türkiye, India, Iran, China, Germany, France, Italy, the USA, Sweden and South Korea

2024

Co-authors network (mobile communications)



- 5,952 unique authors
- 67.7% of the authors with only 1 publication
- 134 authors (2.3%) with ≥ 10 articles

2024

Co-author network using Gephi Version 0.10.1 [Bastian M, Heymann S, Jacomy M (2009). Gephi: an open source software for exploring and manipulating networks. International AAAI Conference on Weblogs and Social Media]

Summary (I)

- A great deal of research has been conducted over the past 40 years
- Numerous studies have shown effects below the limits but weaknesses in the studies have led to intense discussions
- 20 years ago: 'problematic' studies were discussed more extensively, and replication studies were conducted more frequently; today, this only happens in isolated cases
- Biological and health-related effects exceeding the limits are widely accepted, whereas those below the limits are still being discussed

Summary (II)

- Radiofrequency/mobile communication: research and information campaigns have a very broad international reach
- Low frequency: funded more on a project basis and considered more of a national “problem”
- Over time, two groups have emerged:
  - Scientists who are less concerned regarding potential adverse effects below limits: ICNIRP
  - Scientists who are more concerned: Bioinitiative Group and the International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF)
- Recurring Patterns: New technologies are introduced, followed by protests, citizens' initiatives, information campaigns, and research
- Funding has declined sharply over the years in Germany (as in many other countries)

Thank you for your attention

20 years of EMF research monitoring: what has been learned?



Dr Sarah Driessen
EMF-Portal Project Head –
RWTH Aachen, Germany



Dr Nikolaos Petroulakis
NextGEM Coordinator - Institute of Computer Science, Foundation for Research and Technology-Hellas (FORTH-ICS), Greece



Davide Colombi
Ericsson (Sweden)
GSMA EMF and Health Delegate



DI Manfred Ruttner
A1 Telekom Austria
GSMA EMF and Health
Deputy Chair

Summary and conclusions