

One Word 5G Mobile Network (Bath) Pilot

International Standards Organisation (ISO) Non-Compliance Report (NCR)
issued by Neil McDougall and Karen Churchill 27 September 2024

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1. NCR Form

Date: 26-9-24	Area of Incident: All Areas	Incident / NCR No: 001 – EMF – Iss
Project Ref: ONE WORD 5G MOBILE NETWORK PILOT	Decision Ref. E3501 5/12/2023	Quantity:
Description: OPEN 5G RAN	Identification No:	Sample Size:
Supplier:	Grn No: -	Reject Qty:
Order No:	Batch No: -	
Nature of Fault/Defect and Cause (refer to NCR Section 3, part 3.1 to 3.4)		
<p>1. The suitability of the equipment, installations and services when brought into use. The suitability is proven by identifying risk and assuring that no predictable harm results from deployment and future use. The scientific evidence issued in appendices 1, 2 & 3, identifies non-thermal risks from electromagnetic radiation (low intensity). These risks warrant the adoption of the precautionary principle, and its application to risk assessments re: human health, the health of other living organisms, and to the wider environment to assure the suitability of all EMR emitting equipment before use (parts 3.1, 3.2 and 3.3).</p> <p>2. The NCR raises vital questions concerning the functionality of ICNIRP guidelines used by the UK Health Security Agency (UKHSA) to avert the risks that EMR emitting equipment poses to human health and welfare (part 3.4).</p>		
Raised by: Neil McDougall		Date: 27 September 2024
Corrective/Preventive Action Required (refer to NCR Section 5 timescales)		
<p>1. Confirmation of intent to enact interim containment action to control and restrict exposure levels to prevent nuisance associated with identified risk, harm and hazard.</p> <p>2. The issue of all risk assessments undertaken on the non-thermal effects of EMR emissions released by equipment, installations or services operated by ISO/TL9000 compliant companies partnered or contracted with Bath & North East Somerset Council and One Word/Telet</p> <p>3. Issue of corrective action plans that will address the risks identified in this NCR to prevent any re-occurrence.</p>		
Suggested by: Neil McDougall and Karen Churchill		Date: 26 September 2024
<p>1. Confirmation of intent to enact interim containment action to control and restrict exposure levels to prevent nuisance associated with identified risk, harm and hazard.</p> <p>2. The issue of all risk assessments undertaken on the non-thermal effects of EMR emissions released by equipment, installations or services operated by ISO/TL9000 compliant companies partnered or contracted with ONE WORD/Telet.</p> <p>3. Issue of corrective action plans that will address the risks identified in this NCR to prevent any re-occurrence.</p>		
Deposition of Items		
	Return to Supplier/Replace with New Part	Scrap as Advised by Supplier
	Take Further Samples	x Arrange Tech change
	Accepted under restricted concession	Repair
Estimate Total Cost of this Incident / NCR £ unknown (All Costs should be included eg Time of all persons involved including staff, meeting time, etc)		
Signed	For QA	Date:
Signed	For manufacturing	Date:

2. Context

2.1 By issuing this ISO Non-Compliance Report (NCR) in accordance with ISO procedures to Bath & North East Somerset Council as an 'alert/ISO customer complaint', we placed the Council on notice that the NCR must be issued to ONE WORD/TELET, and through ONE Word/TELET or otherwise to any other ISO compliant authorised service supplier, currently partnered or contracted to use or develop electro-magnetic radiation (EMR) emitting equipment installations and services operated by, or in conjunction with Bath & North East Somerset Council and ONE WORD/TELET.

2.2 A five (5) day 'on notice' deadline is placed on Bath & North East Somerset Council to issue this NCR, as stated above.

2.3 The NCR is issued to ensure that EMR emitting equipment, installations and services are used only after the precautionary principle has been applied to ensure that all risks to human health and environmental impacts of EMR emitting technologies are addressed during 'test-to-pilot' stages and prior to subsequent deployments, in accordance with ISO standards that service providers/authorised service providers are obliged to comply with by contract.

2.4 That compliance must be assured beyond the issue of this NCR and secured in ways that invite and remain open to public scrutiny.

3. Reasons for the issue of the NCR

The reasons for raising the NCR are affirmed and justified, as below:

3.1 The suitability of the equipment, installations and services when brought into use.

3.1.1 All electro-magnetic radiation (EMR/radiofrequency electromagnetic radiation) emitting equipment, installations and services in use, or installed for future use under the contracts or public/private partnership arrangements initiated by Bath & North East Somerset Council and managed by ONE WORD/TELET, must be proven safe in relation to identifiable risk. This requires that available scientific evidence should be assessed carefully, and the precautionary principle must be applied where risk is uncertain.

3.1.2 Guidance on the precautionary principle in the UK context, was provided by the Interdepartmental Liaison Group on Risk Assessment (ILGRA)(footnote 1) which was established,

'to help secure coherence and consistency within and between policy and practice in risk assessment as undertaken by Government, and help disseminate and advance good practice'.

3.1.3 In 2023 the UK government published *'The Orange Book: Management*

of Risk Principles and Concepts' (2) reporting that,

'as with all aspects of good governance, the effectiveness of risk management depends on the individuals responsible for operating the systems put in place. Our risk culture must embrace openness, support transparency, welcome constructive challenge and promote collaboration, consultation and co-operation. We must invite scrutiny and embrace expertise to inform decision-making. We must also invest in the necessary capabilities and seek to continually learn from experience',

and founded upon the Government's,

'inherent role in protecting and assuring the public, which includes taking cost-effective action to reduce risk to a tolerable level and providing accurate and timely information about risks to the public' ('Integration', paragraph B5, page 15 .[9]). The 'Orange Book' affirms that,

'policy leads should take explicit steps to involve the public, understand what they are concerned about and why and communicate good information about risk that is targeted to the needs of the audiences involved. Government will:

- be open and transparent about its understanding of the nature of risks to the public and about the process it is following in handling them*
- seek wide involvement of those concerned in decision-making processes*
- act proportionately and consistently in dealing with risks to the public*
- base decisions for intervention on relevant evidence, including expert risk assessment*
- place responsibility for managing risks to those best able to control them'.*

(1) ILGRA, 'The Precautionary Principle: Policy and Application', Health and Safety Executive, 2002 see:

<https://www.hse.gov.uk/aboutus/meetings/committees/ilgra/index.htm>

3.1.4 Our checklist of risks that need to be managed in accordance with the 'Orange Book' principles and ISO compliance include elements of risk requiring prior informed consent by One Word trial volunteers:-

1. Possible biological, health and sensory effects, acute and long term, non-thermal and thermal effects.

2. Risks arising from the use of all handsets and their storage to include:

- distance to pinna during phone calls,
- duration limits for holding in the hand for media streaming,

- duration limits for holding in the hand for receiving and making phone calls,
- distance to body and duration limits for streaming and loudspeaker mode for phone calls,
- risks from storing devices in pockets, including breast pockets for women & trouser front pockets for men in both active and airplane mode,
- risks from storage in bodybags, backpacks and handbags in both active and airplane mode.

3. Risks from nighttime use and storage of devices including distance from head and body.

4. Risks from pre-existing health conditions. Information should be made available to prospective volunteers on any additional risk that they may endure if they intend to participate in the trial, prior to them volunteering to do so.

5. Risks arising from pacemakers and other medical devices, and metal within and on the surface of the body.

6. Risks to vulnerable people through unconditional exclusion of volunteers who would be exposed to avoidable harm, injury and nuisance. This may include children, the elderly and those with electrohypersensitivity (EHS) based on overt criteria drawn from evidence of established adverse health effects properly developed through ISO compliance and Bath&NES Council's regulatory obligations if the Council intends to proceed with the trial.

7. Risks from variable and varying frequency and power output from the small cells and hand held devices. Technical information must be provided to volunteers about restrictions placed upon the frequencies and the power of equipment.

(2) See *ORANGE BOOK*

https://assets.publishing.service.gov.uk/media/6453acadc33b460012f5e6b8/HMT_Orange_Book_May_2023.pdf

3.1.5 Our checklist includes conditions that need to be applied to protect residents and workers within the small cell trial locality:

1. Residents living within the trial locality should screening for vulnerabilities including pre-existing conditions, metal implants and Electrohypersensitivity (EHS).

2. Setback to prevent avoidable harm, injury and nuisance - minimal permitted setback distances between antennas and residential dwellings/working spaces must be determined for occupants including vulnerable groups.

3. Technical information must be provided to workers and residents on restrictions placed upon the frequencies and the power of equipment by One Word.

3.1.6 Our checklist includes the visiting public:

1. What information about risk will be made available to the public who will be inside the radiation testing zones temporarily?

3.1.7 Further environmental risks that need to be addressed - animals, insects and flora:

1. What provision will be made for domestic animals in residential properties adjacent to small cell trial equipment?

2. What advice on pet welfare will be supplied to pet owners?

3. Which parks, recreational areas and open spaces are identified as potentially being affected by EMR exposures arising from the proposed trial?

4. What information about risk to wildlife will be provided to authorities responsible for biodiversity on these sites within trial localities?

5. How will the risks to indoor plants in line of site of the radiation be assessed?

3.1.8 Our checklist includes conditions that apply through the phases of the trial:

1. Radiation 'hotspots' are risk factors, and should identified and monitored pre-trial, during the trial, and post-trial.

2. What methods will be used to measure variations in levels of resulting exposure to the volunteers, residents, visitors and domestic animals?

3. What methods for monitoring public health will be used during the proposed trial and post-trial?

4. What health questionnaire standard will be utilised?

5. What medical/veterinary support will be available to all three categories of those at risk of harm, injury and nuisance?

6. How will pre-trial, trial and post-trial monitoring be structured?

3.1.9 Scientific evidence of risk arising from EMR/radiofrequency electromagnetic radiation emitted from telecommunication systems, and in particular all proposed 5G systems, are attached from the sources listed in Section 4 below, as Appendix 1, 2 and 3.

3.2 The consequent requirement for a full investigation into major Health & Safety issues associated with EMR/radiofrequent electromagnetic radiation emitting equipment used, or installed for

future use under the contracts or public/private partnership arrangements initiated by Bath & North East Somerset Council and managed by ONE WORD/TELET.

3.2.1 This requires carrying out and making available to the public, appropriate, independent risk assessments and impact assessments on all equipment, installations and services from a human health and safety perspective.

3.2.2 This requirement dovetails with the ONE WORD/TELET commitment to the effect that,

'risk assessments will be actioned at the start, regularly during the course of the project and when any relevant changes are made which may include technical changes to networks and systems, changes in procedure or new threat information',

made at the head of page 4 of Appendix 1 filed to accompany the B&NES Council decision (ERP Ref E3501, 5 December 2023), link:

<https://democracy.bathnes.gov.uk/mgIssueHistoryHome.aspx?IIId=38190&PlanId=929&RPID=0>

3.3 The consequent requirement for a full investigation into Major Environmental issues associated with EMR/radiofrequent electromagnetic radiation emitting equipment used, or installed for future use under the contracts or public/private partnership arrangements initiated by Bath & North East Somerset Council and managed by ONE WORD/TELET.

3.3.1 Significant evidence issued through Appendix 2, paragraphs 17 to 20 concerns the risk that EMR poses to wildlife, insects and the wider environment. Reference: F. 'Environmental exposure to RF radiation' **Assumption 13)** *There is no concern for environmental effects of RF radiation or for effects on wildlife or household pets',* and in Appendix 3, more generally.

3.3.2 This requires ISO compliant service or equipment operators and/or suppliers carrying out and making available to the public, appropriate, independent risk assessments and impact assessments on all equipment, installations and services from a public health and environmental protection perspective.

3.4 The NCR raises vital questions concerning the functionality of ICNIRP guidelines used by the UK Health Security Agency (UKHSA) to avert the risks that EMR emitting equipment poses to human health and welfare.

3.4.1 The functionality of ICNIRP guidelines was raised in the statement made on behalf of the US Environmental Protection Agency in July 2002, as quoted below (2)



JUL 16 2002

OFFICE OF
AIR AND RADIATION

"The FCC's current exposure guidelines, as well as those of the Institute of Electrical and Electronics Engineers (IEEE) and the International Commission on Non-ionizing Radiation Protection, are thermally based, and do not apply to chronic non-thermal exposure situations. They are believed to protect against injury that may be caused by acute exposures that result in tissue heating or electric shock and burn."

"The exposure guidelines did not consider information that addresses non-thermal, prolonged exposures, i.e., chronic/prolonged, low-level (non-thermal) exposures."

"The FCC's exposure guidelines are considered protective of effects arising from a thermal mechanism but not from all possible mechanisms. Therefore the generalization by many that the guidelines protect human beings from harm by any or all mechanisms is not justified."

Sincerely,

Norbert Hankin
Center for Science and Risk Assessment
Radiation Protection Division

3.4.2 The statement reinforces the conclusion that the safety of EMR exposure at ICNIRP guideline levels, is opinion based on a narrowly defined paradigm of potential harm.

Evidence used to challenge the reliability of ICNIRP guidelines can be classified into three types:

- i) evidence that confirms the validity of the opinion that the thermal effects of EMR at guideline levels are safe,
- ii) evidence that demonstrates that the non-thermal effects of EMR at guideline levels are safe,

and,

- iii) evidence that demonstrates that the non-thermal effects of EMR below guideline levels are unsafe.

3.4.3 Evidence outlined in Section 4, and presented in the attached appendices, undermines the validity of the ICNIRP guidelines on the dangers to human health created by exposure to electromagnetic radiation, as the evidence is category iii) evidence.

4. Evidence of Health and Environmental risk

4.1 Scientific evidence of risk arising from electro-magnetic radiation (EMR) emitted from telecommunication systems, and proposed 5G systems, are

attached to this NCR from three contemporary and overlapping sources. The the **International Commission on the Biological Effects of Electromagnetic Fields** (ICBE-EMF) paper Appendix 2 provides the overlap, as it is cited in both Appendix 1 and 3.

Appendix 1: *'Why electrohypersensitivity (EHS) is a biologically expected reaction to radiation'*.

Appendix 2: *'Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G'*.

(2) the full letter is available at:

<https://ehtrust.org/wp-content/uploads/4c0f61dc30c3d6bb27d90f53a57c616e.pdf>

and,

Appendix 3: *'Environmental Health Trust Comments on the National Telecommunication and Information Administration National Spectrum Strategy submitted to the Office of Spectrum Management National Telecommunications and Information Administration U.S. Department of Commerce'*.

5. Stated timescales for action on the NCR

5.1 Under ISO procedure we require compliance with the stated timescales for action on this major Non-Compliance Report issued to protect against health and environmental non-thermal impacts of EMR emissions, as identified in the submitted evidence, through:

First: confirmation of intent to enact interim containment action to control and restrict exposure levels to prevent nuisance associated with identified risk, harm and hazard, within five (5) days of the receipt of this NCR by **ONE WORD/TELET**, through collaboration with all ISO compliant companies partnered or contracted to deliver services or equipment intended to be utilised in the Bath Open RAN 5G trial,

Second: the issue of all risk assessments undertaken on the non-thermal effects of EMR emissions released by equipment, installations or services intended to be operated by ISO compliant companies partnered or contracted with **ONE WORD/TELET**, within fourteen (14) days of their receipt of this NCR,

and,

Third: the issue of corrective action plans that will address the risks identified in this NCR to prevent any occurrence, within thirty (30) days of receipt.

5.2 These staged responses, and the stated timescales for the completion of the three stages, are deemed reasonable to accord with good practice for ISO/TL 9000 compliance, commencing after the five (5) day 'on-notice' deadline for Bath & North East Somerset Council to issue the NCR to **ONE WORD/TELET** who contractually under good business practice are obliged to trigger the requisite ISO risk assessments and reporting systems that ISO compliant companies engage through governance procedures embedded in contracts as partners or contracted suppliers for the Bath Open RAN 5G trial, as stated in paragraphs 2.1 and 2.2 of Section 2 'Context', above.

5.3 An extension beyond the thirty (30) day deadline for the completion of the third stage, as above, and for the issue of corrective action plans, must be sought and accepted by us as the complainants to conclude this NCR.

5.4 To allow us to establish that relevant ISO procedures are being applied by to conclude this NCR, all companies should issue to **ONE WORD/TELET** immediately on notice, copies of the relevant ISO procedures that they will apply to address the NCR.

5.5 Documents so issued, must be made available by **ONE WORD/TELET** to us as the complainants, and then made available to the public similarly on request. Additionally, any deficiency in the availability of ISO/TL 9000 documentation required to assess the adequacy of any response to the NCR must be rectified by extending our right, and the rights of the public, to reasonable access to additional documents that must be supplied in response to further requests.

6. Quality Management System ISO requirements

6.1 ISO 9001 (Quality) and the equivalent TL 9000

6.1.1 Partnership agreements and contracts between Bath and North East Somerset Council and authorised service providers that lead to the installation and use of EMR emitting equipment, installations and services, require **ONE WORD/TELET** and participating ISO compliant companies to:

- i) document the scope of their Quality Management System (QMS),
- ii) produce and maintain a Quality Policy (QP) that serves defined quality objectives,
and,
- iii) document the processes that are critical to the performance of the QMS.

The QMS and the QP should be maintained in compliance with ISO 9001 (Quality), or the equivalent TL 9000 (as an ICT-specific quality management standard based on ISO 9001), ISO 14001 (Environment), and OHSAS 18001 (Health & Safety)(3).

6.1.2 The TL 9000 Rev. 6.0 ICT QMS Requirement standard was intended to be released in conjunction with the ISO 9001:2015 revision(4 see page 12, below), and a TL 9000 QMS Requirements Handbook '*The ICT Quality Management System Performance Excellence through Global ICT Quality*' (Point Release 6.1) was issued in late 2017.

(3) Primary sources are '*ISO 9000 Quality Systems Handbook*', Hoyle D, Elsevier 2006, and '*ISO 140001 Implementation Manual*', Wood G, Aurrichio P, and Yturri J, McGraw-Hill, 1998.

6.1.3 The maintenance of ISO/TL 9000 QMS should be an express, or an implied term of the contracts and agreements that bind together so that all aspects of services provision by companies claiming compliance are, at all times, made subject to operational QMS's.

6.1.4 Cases of unresolved ambiguity and uncertainty regarding the operation of QMS, must result in the disclosure of relevant quality procedures and processes.

6.1.5 Central to Quality Management under ISO 9001, and the TL 9000 equivalent, are the control of non-conformance of products or services supplied by service suppliers, or authorised service providers. Control of non-compliance should be matched with a long-term managerial commitment to the continued improvement of products and services by the elimination of an re-occurrence of non-compliance.

6.1.6 The importance of health and safety risks, and the risks of environmental harm highlighted in the evidence submitted with this NCR, necessitates the control of non-conforming products/services and re-occurrence risks for the duration of all contracts and public/private partnership agreements.

6.1.7 ISO 9001 and the TL 9000 equivalent compliant QMS, require a documented procedure for addressing the NCR is enacted through a process that draws together the following steps, or their equivalent to define the requirements for:

- i) evaluating the need for action to ensure that nonconformities do not recur,
- ii) determining and implementing corrective action,
- iii) recording the results of actions taken, and, the ISO compliant

organisation/s will seek,

iv) to eliminate the cause of potential nonconformities to prevent their occurrence, through actions that are appropriate in relation to the effects of the potential problems,

v) to utilise documented procedures for determining potential nonconformities and their causes,

(4) 'Nokia leads industry initiative addressing the cost of poor quality', Monique Herbert, Nokia Blog, 30th April 2015

<https://www.nokia.com/blog/nokia-leads-industry-initiative-addressing-cost-poor-quality>

and,

vi) to record any requirement for evaluating the need for action to prevent the future occurrence of nonconformities.

The QMS requires the enactment of procedures for preventing occurrences of nonconformities by:

vii) determining, implementing and recording preventative action

viii) recording the results of preventative action

and,

ix) for reviewing and recording preventative actions.

6.2 ISO 14001 (Environment)

6.2.1 The ISO mandates the compliant service provider/authorised service provider to operate an Environment Management System (EMS), founded on an Environmental Policy (EP) committed to the prevention of pollution and to enact continual improvement to minimise adverse effects persistently.

6.2.2 The EP has to be,

'appropriate to the nature, scale and the environmental impacts of the organisations activities, products and services'.

6.2.3 The EMS implements the EP as,

'part of the overall management system that includes organisational structure, planning activities, responsibilities, actions, procedures, process, and resources for developing, implementing, achieving, reviewing, and maintaining the

environmental policy'.

6.2.4 ISO 14001 requires the service providers (in parallel with ISO 9001) to,

'establish and maintain procedures for defining responsibility and authority for handling and investigating non-conformances, for taking action to mitigate any environmental impacts, and for initiating and completing corrective and preventative action'.

6.2.5 Further,

'the corrective or preventative action taken to eliminate the causes of non-conformances should be appropriate to the magnitudes of the problems encountered',

and,

'the standard requires the organization to make changes to procedures, as necessary, as a result of corrective and preventative action'.

6.2.6 Types of environmental non-conformances might include:

i) activities or operations that do not support the EP,

ii) significant environmental impacts that have not been defined,

iii) views of interested parties that were not considered when setting objectives and targets,

and,

iv) relevant external communications that are not documented.

6.3 OHSAS 18001 (Health Occurrence & Safety)

6.3.1 The OHSAS defines,

'the requirements for establishing, implementing and operating the Occupational Health and Safety Management System (OHSMS)',

and compatibility with ISO 9001 (Quality) and ISO 14001 (Environment) standards are intended to facilitate,

'the design, implement and operate an integrated quality, environmental and occupational health and safety management system'.

6.3.2 The OHSMS,

'is a framework that allows an organisation to consistently identify and control its health and safety risks, reduce the potential for accidents, help achieve compliance with health and safety legislation and continually improve its performances'.

6.3.3 The Health and Safety at Work Act 1994 implies the need for risk assessment under the general duties of employers to their employees. These duties are extended by section 3 of the Act to anybody affected by activities of the employer including contractors, visitors, customers and members of the public.

6.3.4 Hazard identification, risk assessment, and risk control are paramount to the operation of the OHSMS.

6.3.5 Checking and corrective action, and all relevant process and procedures triggered by a NCR in ways that are compatible with the tripartite ISO systems, are required to eliminate the actual or potential causes of accidents, incidents and non-conformances.

7. Conclusion

7.1 The NCR is specific to contracts, agreements and public/private partnerships initiated by Bath & North East Somerset Council that are managed by **ONE WORD/TELET**, and it is accompanied with appropriate scientific evidence (appendices 1, 2 and 3), issued as a crucial part of the alert/ISO customer complaint to serve the public interest.

7.2 Please deal with this submission in compliance with the stated timescales for action on this significant Non-Compliance Report (Section 5, paragraphs 5.1, 5.2 and 5.3 above), issued with the intent of protecting the public from non-thermal effects of EMR emissions, as identified in the submitted evidence (as below).

7.3 A mechanism for releasing relevant documentation to us via **ONE WORD/TELET** is proposed (in Section 5, paragraphs 5.4 and 5.5 above), and we will seek the name of a nominated person at **ONE WORD/TELET** to co-ordinate this mechanism.

8. Appendices to the NCR

Appendix 1: *'Why electrohypersensitivity (EHS) is a biologically expected reaction to radiation'.*

Appendix 2: *'Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G'.*

and,

Appendix 3: *'Environmental Health Trust Comments on the National Telecommunication and Information Administration National Spectrum Strategy submitted to the Office of Spectrum Management National Telecommunications and Information Administration U.S. Department of Commerce'.*

Neil McDougall/Karen Churchill

Date: 26 September 2024

8.1. Appendix 1 *'Why electrohypersensitivity (EHS) is a biologically expected reaction to radiation', by Peter Hensinger and Bernd I. Budzinsk*

<https://ehtrust.org/why-electrohypersensitivity-ehs-is-a-biologically-expected-reaction-to-harmful-radiation/>

Previously issued to Mr Godfrey 17 July 2024

8.2. Appendix 2 *'Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G' International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), Environmental Health, 21, Article number: 92 (2022) (reproducing for particular attention Section D Assumptions 7 and 8, and Section F Environmental exposure to RF Radiation Assumption 13, and Section G 5G(5th Generation Wireless) Assumption 14, below).*

<https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00900-9>

D. Individual variations in exposure and sensitivity to RF-EMF

- **Assumption 7)** *There are no differences among individuals, including children, in the absorption of RF-EMF and susceptibility to this radiation.*

1. Differences between children and adults regarding the absorption of radio frequency electromagnetic fields when mobile phones are operated close to the head have been demonstrated and widely documented [[132](#),[133](#),[134](#),[135](#),[136](#),[137](#)]. The main factors accounting for these dissimilar absorption rates include differences in anatomy, tissue dielectric properties, and physiology. Through finite-difference time-domain (FDTD) simulations, employing detailed computational anthropomorphic models, it is possible to find differences relating to anatomy and to dimensions of the head.

2. Since EMF penetration into human tissues can be in the order of a few centimetres, depending on the wavelength, the inner tissues in the brain clearly will receive a significantly higher dose in the smaller heads of children compared to adults, despite the total absorption and the peak spatial SAR (psSAR) calculated across the whole head varying by smaller amounts [[132](#),[133](#),[138](#)]. Fernández et al. [[136](#)] estimated that the cell phone radiation psSAR in the hippocampus was 30-fold higher in children compared to adults, while the psSAR in the eyes was 5-fold higher in children; these differences were due largely to closer proximity to the cell phone antennas. The thinner dimensions of children's skulls also contribute to this difference [[135](#)], resulting in a psSAR around 2-fold higher in children's brains [[134](#),[135](#),[136](#), [137](#),[139](#)] compared to adults.

3. Additionally, tissues of young mammals have higher conductivity and electrical permittivity than those of mature animals [[140](#)]. This also contributes to greater EMF penetration and absorption, resulting in further increases in the psSAR. The psSAR in the skull bone marrow of children was estimated to increase by 10-fold due to higher conductivity in this tissue [[137](#)]. Distance between the mobile device and the body tissues is important in characterizing tissue dosimetry. The National Agency ANFR of France recently released cell phone SAR test data for 450 cell phones. Ten gram psSARs increased by 10–30% for each millimeter of proximal placement of the cell phone to the planar body phantom (<http://data.anfr.fr/explore/dataset/das-telephonie-mobile/?disjunctive.marque&disjunctive.modele&sort=marque>). **problem**

4. Finally, it is important to note that simulations of tissue dosimetry consider only the physical parameters of the tissues; they do not consider biological processes occurring in living tissues. While children are growing, developing organs and multi-organ systems are more susceptible to adverse effects of environmental agents; finite-difference time-domain (FDTD) simulations do not address differences in organ or system susceptibility for exposures occurring during child development.

- **Assumption 8)** *There are no differences among individuals in their sensitivity to RF radiation-induced health effects.*

5. All life is “electrosensitive” to some degree as physiological processes are dependent on both subtle and substantial electromagnetic interactions at every level, from the molecular to the systemic. Responses to multiple types of electromagnetic exposure reveal that there is a far broader range of EMF

sensitivity than previously assumed, and subgroups of extremely hypersensitive subjects exist [[141](#),[142](#),[143](#),[144](#),[145](#),[146](#),[147](#),[148](#),[149](#),[150](#),[151](#)].

6. Given the adverse health effects noted in Assumption #1, including cardiomyopathy, carcinogenicity and neurological effects, the acute, conscious symptoms manifesting in some individuals should not be unexpected. The term currently and most frequently used within the medical profession to describe those who are acutely, symptomatically sensitive to non-ionizing radiation exposures is Electromagnetic Hypersensitivity (EHS).

7. EHS is a multisystem, physical response characterized by awareness and/or symptoms triggered by EMF exposures. Common symptoms include (but are not limited to) headaches, dizziness, sleep disturbance, heart palpitations, tinnitus, skin rashes, visual disturbance, sensory disturbance, and mood disturbance [[152](#),[153](#)]. These symptoms are reported in response to even extremely low intensity (orders of magnitude below current safety levels) EMFs of multiple types (in terms of frequency, intensity and waveforms). Commonly noticed triggers of frequent and persistent EHS symptoms are pulse-modulated RF emissions, modulated at extremely low frequencies. Common triggering sources include mobile phones, DECT cordless landlines, Wi-Fi/Bluetooth-enabled computers, Wi-Fi routers, smart meters, base station antennas, and household electrical items. EMF avoidance/mitigation is found to be the most effective way to reduce symptoms [[154](#)].

8. Guidelines for EHS diagnosis and management have also been peer-reviewed and concur that the mainstay of medical management is avoidance of anthropogenic electromagnetic fields [[152](#),[155](#),[156](#)]. Case histories detailing clinical presentations, EMF measurements and mitigation are also published [[157](#)], and biomarkers including elevated markers of oxidative stress, inflammatory markers and changes in cerebral blood flow continue to be explored [[152](#)].

9. EHS has been proven to be a physical response under blinded conditions [[145](#),[151](#),[158](#),[159](#)] and, in addition to these studies, acute EMF-induced changes in cognition, behaviour, and physiology reactions have been observed in studies involving animals [[27](#),[30](#),[160](#),[161](#),[162](#),[163](#),[164](#),[165](#),[166](#),[167](#),[168](#),[169](#),[170](#),[171](#),[172](#)]; plus further references under Assumption 13), which cannot be biased by media-cultivated fears. These studies provide further evidence which invalidates the nocebo response (physical symptoms induced by fear) as causal regarding symptoms.

10. It should not be expected that all provocation studies will reliably demonstrate adverse reactions; however, suggestions that the nocebo response may cause EHS symptoms were claimed from provocation studies which failed to show a relationship between the EMF exposure and the reported symptoms [[173](#)]. The failures of these studies are explainable given the very poor methodology in the majority of them. There were failures to account for a multitude of essential factors that must be tailored to the individual, such as variable symptom onset and offset, the necessity for adequate washout

periods, specificity of trigger frequencies and intensities, requirement for complete EMF hygiene during sham exposures, requirement for life-like exposures (e.g., pulse-modulated information-carrying waves), etc. For example, it has been shown that various frequency channels from GSM/UMTS mobile phones affect the same human cells differently [174,175,176,177]. Similarly, EHS has been shown to be frequency dependent [151]. As noted above, meaningful provocation studies need to take into consideration multiple physical parameters of exposure, including frequency, modulation, duration of exposure, and time after exposure [155]; however, most provocation studies that have failed to establish causative connection between RFR exposure and EHS symptoms [173] used only one or two conditions with short-term exposures.

11. There are many issues with the nocebo response as a cause of EHS, not least of which is also the absence of the required temporal link. For the nocebo response to be the cause of EHS, awareness and concern of negative health impacts from EMFs must precede symptoms. But, in the majority of EHS persons this is not the case [178]. As public risk communication improves, this will no longer be verifiable; however, this has been importantly observed at the only point in time when it could have been – prior to generalized awareness of health detriments from non-ionizing radiation (NIR).

12. While recognizing that some vulnerable groups may be more susceptible to effects of NIR exposure, ICNIRP [179] acknowledged that their guidelines may not safely accommodate these sensitive subgroups:

"Different groups in a population may have differences in their ability to tolerate a particular NIR [Non-Ionizing Radiation] exposure. For example, children, the elderly, and some chronically ill people might have a lower tolerance for one or more forms of NIR exposure than the rest of the population. Under such circumstances, it may be useful or necessary to develop separate guideline levels for different groups within the general population, but it may be more effective to adjust the guidelines for the general population to include such groups. Some guidelines may still not provide adequate protection for certain sensitive individuals nor for normal individuals exposed concomitantly to other agents, which may exacerbate the effect of the NIR exposure, an example being individuals with photosensitivity".

13. In 2020, ICNIRP [23] also noted that biological effects are not easily discernible from adverse health effects, and that their guidelines:

"...are not intended to protect against biological effects as such (when compensatory mechanisms are overwhelmed or exhausted), unless there is also an associated adverse health effect. However, it is not always easy to draw a clear distinction between biological and adverse health effects, and indeed this can vary depending on individual susceptibility to specific situations. An example is sensory effects from nonionizing radiation exposures under certain

circumstances, such as a tingling sensation resulting from peripheral nerve stimulation by electric or magnetic fields; magnetophosphenes (light flickering sensations in the periphery of the visual field) resulting from stimulation of the retina by electric fields induced by exposure to low-frequency magnetic fields; and microwave hearing resulting from thermoelastic waves due to expansion of soft tissues in the head which travel via bone conduction to the inner ear. Such perceptions may sometimes lead to discomfort and annoyance. ICNIRP does not consider discomfort and annoyance to be adverse health effects by themselves, but, in some cases, annoyance may lead to adverse health effects by compromising well-being. The exposure circumstances under which discomfort and annoyance occur vary between individuals”.

14. Trivializing “discomfort” which is the pre-cursor to pain is not in keeping with WHO recommendations quoted by the same ICNIRP [23] document: *“Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.”*

15. Discomfort is a sign that an organism is experiencing something which is compromising optimal health and although in some cases this can be trivial and reversible, in other cases it may not be reversed. There is an extremely broad range of both pain tolerance and also of pain perception among humans, and to achieve meaningful preventative health care, “discomfort” must be taken seriously and mitigated whenever possible. This is especially true in this case where symptoms such as headaches are being reported in response to mobile phone exposures at the same time as increased brain tumor risk is noted from those same exposures (see Assumption 6).

16. In reality, people with EHS are reporting far more serious health disruption than “discomfort” or “annoyance” and in some cases these symptoms are disabling [180,181]. Increasingly, EHS is being recognized as a disability by national courts in France, Sweden, and Spain, which amplifies the requirement for safety guidelines that are deliberately accommodating to this more susceptible group [180].

F. Environmental exposure to RF radiation

Assumption 13) *There is no concern for environmental effects of RF radiation or for effects on wildlife or household pets.*

17. While background levels of RF-EMF are increasing in the environment, including rural remote areas [189], neither the FCC nor the ICNIRP take into consideration effects of this radiation on wildlife. The constant movement of most wildlife species in and out of varying artificial EMF can result in high exposures near communication structures, especially for flying species such as birds and insects. There is a substantial amount of scientific literature on the disrupting effects of RFR on wildlife (e.g., [190,191,192,193,194,195,196,197,198,199,200,201,202,203,204,205,206]).

18. Many nonhuman species use Earth's geomagnetic fields for activities such as orientation and seasonal migration, food finding, mating, nest and den building [190]. For example, migratory bird species [191, 192], honeybees [193], bats [194], fish [195,196,197], and numerous other species sense Earth's magnetic fields with specialized sensory receptors. Mechanisms likely involved in magneto-reception include magnetic induction of weak electric signals in specialized sensory receptors [198], magneto-mechanical interactions with the iron-based crystal magnetite [194], and/or free-radical interactions with cryptochrome photoreceptors [191, 192]. Each of these sensing processes shows extreme sensitivity to low intensity changes in electromagnetic fields. For a fuller description of the mechanisms by which non-human species use magneto-reception to perform essential life activities see Levitt et al. [190].

19. The following studies represent a few of the many examples of the disrupting effects of low-level exposures to RF-EMF on magneto-reception and the natural behavior of wildlife. Oscillating magnetic fields have been reported to disrupt the ability of migratory birds to orient and navigate in Earth's geomagnetic field [199,200,201,202]. Garden warblers became disoriented by exposure to a weak oscillating magnetic field of 1.403 MHz at an intensity as low as 2–3 nT [200]. The orientation of European robins that use Earth's magnetic field for compass orientation was completely disrupted by exposure to electromagnetic noise in the frequency range of 50 kHz to 5 MHz or a broadband noise-modulated ELF covering the range ~ 2 kHz to ~ 9 MHz [199, 201]. RFR in the low MHz range (7.0 MHz of 480 nT or 1.315 MHz of 15 nT) has been shown to disable the magneto-reception avian compass as long as the exposure was present [202].

20. In addition to effects on migratory birds, Landler et al. [203] found that exposure to a low-level magnetic field (1.43 MHz at an intensity of 30–52 nT) disrupted the natural orientation of juvenile turtles hatched on land. GSM-modulated 900 MHz RF radiation caused ants to lose their visual and olfactory memory for finding food [166]. Navigational abilities of trout were reduced when reared under conditions in which magnetic fields were spatially distorted [204].

21. Activities of honeybees are also disrupted by exposure to RF radiation. GSM-modulated cell phone radiation (900 MHz) caused a reduction in egg laying by queen bees and depletion of beehive pollen and honey counts [205]. GSM-modulated cell phone radiation (900 MHz) reduced hatching and altered pupal development of honey queen bee larvae [206].

22. The lack of consideration of chronic low-level RF radiation exposure on wildlife could result in dangerously disruptive effects on fragile ecosystems and on the behavior and survival of species that have long existed in Earth's natural environment.

G. 5G (5th generation wireless)

Assumption 14) *No health effects data are needed for exposures to 5G;*

safety is assumed because penetration is limited to the skin ("minimal body penetration").

23. Fifth generation (5G) wireless communication systems are being deployed worldwide to provide higher data transfer rates with shorter lag times between massive numbers of connected wireless devices. To provide faster transfer of large amounts of data (up to 20 gigabits per second peak data rates), the frequency range for 5G includes millimeter waves (30 to 300 GHz), in addition to carrier frequencies as low as 600 MHz. Extremely high frequency millimeter waves (MMW) that transmit large amounts of data to user devices are directed into narrow beams by line-of-sight transmission with beamforming antennas.

24. Because millimeter waves do not penetrate solid structures such as building materials, hills, foliage, etc., and travel only short distances (a few hundred meters), denser networks of base-stations with massive Multiple Input/Multiple Output (MIMO) transmitters and receivers in millions of small cell towers are being installed on structures such as utility poles. These features can lead to much closer proximity between humans and radiation-emitting antennas, and thereby change individual peak and average exposures to RFR.

25. For a 5G frequency of 26 GHz, EMF absorption is very superficial, which means that for typical human skin, more than 86% of the incident power is absorbed within the first millimeter. The skin penetration depth was computed as 1 mm based on the electrical conductivity of the skin and its electrical permittivity [5, 207]. This is expected to bring the SAR in this tissue well above the recommended limits ([208], and Additional file 2: Appendix 2). This is also expected to be harmful to very small species, such as birds and other small animals (e.g., insects) [209]. It is often claimed that because of its shallow penetration, exposure to high frequency 5G radiation is safe, and that the only effect is tissue heating [210]. However, this view ignores the deeper penetration of the ELF components of modulated RF signals, which are rated on the basis of heat alone, as well as the effects of short bursts of heat from pulsed signals [211, 212]. Within the first 1 mm of skin, cells divide to renew the stratum corneum (a consideration for skin cancer), and nerve endings in the dermis are situated within 0.6 mm (eyelids) to 3 mm (feet) of the surface (a consideration for neurological effects). Ultraviolet light, which exerts its action at a penetration depth of less than 0.1 mm [213, 214] is a recognized cause of skin cancer [87].

26. The higher the frequency of electromagnetic waves, the shorter the wavelength and the shallower the penetration of energy into exposed people or animals. For example, penetration depth in the human body is about 8 mm at 6 GHz and 0.92 mm at 30 GHz [5]. Because of the minimal depth of energy absorption at frequencies above 6 GHz, the FCC and ICNIRP have based exposure limits on power density instead of on SAR levels. The FCC [3] proposed a general localized power density exposure limit of 4 mW/cm² averaged over 1 cm² and not to exceed 30 minutes for 5G services up to 3000 GHz for the general population, claiming that this exposure is consistent with the peak spatial-average SAR of 1.6 W/kg averaged over any 1 g of tissue

at 6 GHz. ICNIRP's [5] exposure limits for 5G are an absorbed power density of 200 W/m² (0.2 W/cm²) averaged over 4 cm² and a 6-minute interval for frequencies up to 30 GHz, and 400 W/m² (0.4 mW/cm²) averaged over 1 cm² and a 6-minute interval for frequencies of 30 GHz to 300 GHz.

27. Because of its minimal penetration, exposure to 5G radiation results in higher energy intensity on the skin and other directly-exposed body parts, such as the eye cornea or lens. However, the skin, which is the largest organ in the human body, provides important functions such as acting as a protective physical and immunological barrier against mechanical injury, infection by pathogenic microorganisms, and entry of toxic substances. In addition, skin cancers, including basal cell carcinomas and squamous cell carcinomas, are the most prevalent human cancers, while melanomas are highly metastatic and increasing in prevalence. Although the high incidence of skin cancers are largely attributed to exposure to ultraviolet light, no studies have been reported on the effects of 5G radiation on (i) the skin's ability to provide protection from pathogenic microorganisms, (ii) the possible exacerbation of other skin diseases, (iii) promotion of sunlight-induced skin cancers, or (iv) initiation of skin cancer by itself. Information is also lacking on the effects of 5G radiation on nervous and immune systems which are also exposed even by the shallower penetration of MMW.

28. Another important factor is the maximum bandwidth with 5G radiation, which is up to 100 MHz in the frequency range of 450 MHz to 6 GHz, and up to 400 MHz in the ranges from 24 GHz to 52 GHz, compared to previous types of mobile communication where bandwidth is limited to 20 MHz. Because many studies indicated frequency-dependent, non-thermal RF effects from mobile communication RFR [43, 177] and for MMW effects [215, 216], the possibility of effective frequency windows for biological effects would increase with the increased bandwidth of 5G radiation.

29. Another consideration for effects of 5G exposures on human health is that radiation pulses created by extremely fast data transmission rates have the potential to generate bursts of energy that can travel much deeper than predicted by conventional models [217, 218]. Neufeld and Kuster [105] showed that repetitive pulses of data in bursts with short exposures to 5G can cause localized temperature spikes in the skin leading to permanent tissue damage even when the average power density values were within ICNIRP's acceptable safety limits. The authors urged the setting of new thermal safety standards to address the kind of health risks possible with 5G technology:

"The FIFTH generation of wireless communication technology (5G) promises to facilitate transmission at data rates up to a factor of 100 times higher than 4G. For that purpose, higher frequencies (including millimetre-wave bands), broadband modulation schemes, and thus faster signals with steeper rise and fall times will be employed, potentially in combination with pulsed operation for time domain multiple access...The thresholds for frequencies above 10 MHz set in current exposure guidelines (ICNIRP 1998, IEEE 2005, 2010) are intended to limit tissue heating. However, short

pulses can lead to important temperature oscillations, which may be further exacerbated at high frequencies (>10 GHz, fundamental to 5G), where the shallow penetration depth leads to intense surface heating and a steep, rapid rise in temperature...”.

30. Areas of uncertainty and health concerns with 5G radiation include potential increase in skin cancer rates with (or possibly without) co-exposure to sunlight, exacerbation of skin diseases, greater susceptibility to pathogenic microorganisms, corneal damage or early development of cataracts, testicular effects, and possible resonant-enhanced absorption due to skin structures [219].

31. One of the complex technical challenges in relation to human exposure to 5G millimeter waves is that the unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation are not well understood [220].

32. Although MMW are almost completely absorbed within 1–2 mm in biologically-equivalent tissues, their effects may penetrate deeper in a live human body possibly by affecting signal transduction pathways. Thus, there are too many uncertainties with exposure to 5G to support an assumption of safety without adequate health effects data.

33. There are no adequate studies on health effects from short-term or long-term exposures to 5G radiation in animal models or in humans.

Appendix 3. 'Environmental Health Trust Comments on the National Telecommunication and Information Administration National Spectrum Strategy submitted to the Office of Spectrum Management National Telecommunications and Information Administration U.S. Department of Commerce', filed 2 January 2024, (reproducing paragraphs 4 and 5, with footnotes as below)

<https://www.ntia.gov/sites/default/files/environmental-health-trust-written-input.pdf>

The Federal Communication Commission's RF human exposure limits remain almost entirely unchanged since 1996 and they are designed only to protect against heating effects of short term exposures, not biological impacts from long term exposure.³ An ever growing body of scientific evidence documents adverse effects from RF radiation at exposure levels well below FCC limits⁴ with research findings that include **cancer**, the induction of **oxidative stress**, **epigenetic effects**, impacts to **neurotransmitters**, **memory**, **brain development** and damage to the **immune**, **endocrine**, **hematological** and **reproductive system**. Further, studies have found impacts to **tree canopy**, **plant growth**, **pollinator health** and the **orientation, migration and breeding of wildlife**.⁵ The science clearly indicates that wireless networks create harmful interference in humans as well as flora and fauna.

A study by U.S. Army and Air Force Research Laboratories found that high

powered pulsed microwave exposures could reach the same threshold pressures of explosive blast brain and football head impact injuries even at levels considered “safe” and compliant with current FCC RF limits.⁶

footnotes 3

Lin, J. C. (2023). [Incongruities in recently revised radiofrequency exposure guidelines and standards](#). *Environmental Research*, 222, 115369; International Commission on the Biological Effects of Electromagnetic Fields (ICBE-EMF), (2022).

<https://www.sciencedirect.com/science/article/abs/pii/S0013935123001615?via%3Dihub>

[Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G.](#)

Environ Health. Oct 18;21(1):92;

<https://ehjournal.biomedcentral.com/articles/10.1186/s12940-022-00900-9>

Lopez I, Rivera M, Feliz N, Maestu C. (2022) [It is mandatory to review environmental radiofrequency electromagnetic field measurement protocols and exposure regulations: An opinion article](#). *Front. Public Health*, 24 October;

<https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.992645/full>

Davis, D., Birnbaum, L., Ben-Ishai, P., Taylor, H., Sears, M., Butler, T., & Scarato, T. (2023). [Wireless technologies, non-ionizing electromagnetic fields and children: Identifying and reducing health risks](#). *Current Problems in Pediatric and Adolescent Health Care*, 53(2), 101374.

<https://www.sciencedirect.com/science/article/abs/pii/S0013935118303475>

footnotes 4

Belpomme, D., Hardell, L., Belyaev, I., Burgio, E., & Carpenter, D. O. (2018). [Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective](#). *Environmental Pollution*, 242, 643–658;

<https://www.sciencedirect.com/science/article/abs/pii/S0269749118310157?via%3Dihub>

McCredde, J. E., Cook, N., Weller, S., & Leach, V. (2022). [Wireless technology](#)

is an environmental stressor requiring new understanding and approaches in health care. *Frontiers in Public Health*, 10;

<https://www.frontiersin.org/journals/public-health/articles/10.3389/fpubh.2022.986315/full>

Miller, A. B., Morgan, L. L., Udasin, I., & Davis, D. L. (2018). [Cancer epidemiology update, following the 2011 IARC evaluation of radiofrequency electromagnetic fields \(Monograph 102\)](#). *Environmental Research*, 167, 673–683.

<https://www.sciencedirect.com/science/article/abs/pii/S0013935118303475>

footnotes 5

Levitt, B. B., Lai, H. C., & Manville, A. M. (2022b). [Effects of non-ionizing electromagnetic fields on flora and fauna, Part 2 impacts: How species interact with natural and man-made EMF](#). *Reviews on Environmental Health*, 37(3), 327–406;

<https://www.degruyter.com/document/doi/10.1515/reveh-2021-0050/html>

Thill A, Cammaerts MC, Balmori A. [Biological effects of electromagnetic fields on insects: a systematic review and meta-analysis](#). *Rev Environ Health*. 2023 Nov 23

<https://www.degruyter.com/document/doi/10.1515/reveh-2023-0072/html>

footnotes 6

A. M. Dagro, J. W. Wilkerson, T. P. Thomas, B. T. Kalinosky, and J. A. Payne, [“Computational modeling investigation of pulsed high peak power microwaves and the potential for traumatic brain injury,”](#) *Sci. Adv.*, vol. 7, no. 44, pp. 1–10, Oct. 2021, doi: 10.1126/sciadv. abd8405. “Nevertheless, the simulations here have shown that exceptionally intense HPM exposures with incident power densities greater than 1.5×10^6 mW/cm² (at short pulse durations) may generate intracranial stresses that are similar ($\pm \sim 20$ to 200 kPa) in comparison to typical TBI events (sports, vehicle accidents, ballistic impact, etc.). For sufficiently short microwave pulse durations ($< \tau_c$), large tensile stresses are created in the deep regions of the brain...While the peak power densities used within this simulation study are large, they are achievable with known microwave hardware. For example, to produce a power density of 1×10^6 mW/cm² at 25 m away from a 40-dBi antenna, a microwave source would require approximately 8 MW of power per pulse. This is within the capabilities of some commercial and military systems, and we therefore consider this as a relevant approximation for the simulations here. However, we also consider some more extreme conditions in the final analysis summary for scaling purposes against known mechanical TBI thresholds.”

<https://www.science.org/doi/10.1126/sciadv.abd8405>

See also Lin, J. C. (2023). [A Paradigm Shift?](#) IEEE Microw.

<https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10314707>

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