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ASSESSING TRANSPARENCY OF ELECTROMAGNETIC FIELD EXPOSURE DATA IN THE CONTEXT OF INFORMATION SECURITY AND DIGITAL GOVERNANCE

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Abstract: *The expansion of 4G/5G wireless networks has brought significant benefits, but also new challenges related to information security, driven by misinformation and declining public trust. In this context, transparency of data on electromagnetic field (EMF) exposure becomes essential for effective risk communication and evidence-based public policies. This paper analyzes the Monitor EMF platform, managed by ANCOM, from the perspective of its alignment with the requirements of the NIS2 Directive and data-driven digital governance. The results indicate that clear and accessible presentation of EMF data can reduce misinterpretations and contribute to increased public trust, thereby supporting societal resilience within the European digital context.*

Keywords: *EMF, electromagnetic field; information security; digital governance; NIS2 Directive; public trust.*

1. INTRODUCTION

The rapid deployment of 4G/5G networks has intensified public concerns regarding electromagnetic field (EMF) exposure, amplified by misinformation and limited interpretability of technical data. As a result, EMF issues increasingly intersect with information security, public trust, and digital governance. Although several European countries operate EMF monitoring platforms, many focus primarily on publishing measurements without sufficient contextualization for meaningful public understanding.

This paper advances a security-oriented perspective on EMF transparency by proposing operational transparency indicators, integrating quantitative data with normative context, and comparatively evaluating the Romanian Monitor EMF platform against selected European initiatives. By positioning EMF transparency as a mechanism for mitigating information-related and societal risks, the study contributes to an underexplored dimension of EMF monitoring research.

2. METHODOLOGY

The study conducts a comparative analysis of selected European EMF monitoring platforms based on predefined transparency indicators capturing technical and socio-informational dimensions of public data communication, including update frequency, spatial granularity, normative contextualization, traceability, and visual clarity. The Monitor EMF platform is examined as a case study to evaluate how transparency mechanisms support public trust and information resilience within a digital governance framework.

3. INFORMATION

3.1 Institutional transparency in monitoring electromagnetic field exposure

Transparency of electromagnetic field (EMF) exposure data has become a central component of digital governance and responsible risk communication. As telecommunications infrastructures expand and public sensitivity increases, accessible and normatively contextualized EMF information is essential for

correct interpretation. Beyond regulatory compliance, transparency shapes public perception, mitigates misinformation, and strengthens societal resilience.

Effective transparency requires more than publishing numerical values; it involves contextualization relative to legal limits, measurement traceability, and clear visual tools for non-expert audiences [1], [2]. To evaluate institutional transparency, this study applies a structured set of indicators integrating technical and socio-informational dimensions of EMF data communication.

Table 1

EMF transparency indicators for public trust

Indicator	Description (concise)	Impact on trust
Free public access	Online EMF data, freely available, no authentication required	Enables direct verification
Frequent updates	Real-time or daily data updates	Indicates continuous monitoring
Normative contextualization	Reporting relative to ICNIRP limits (%) and regulated units	Facilitates correct interpretation
Traceability	Location, date, time, and measurement source	Enhances credibility
Visual indicators	Maps, charts, and color codes	Improves risk understanding

Source: adapted by the authors based on [1], [2]

Operationally, transparency indicators can be quantified through parameters such as update frequency, spatial granularity, and usability features, including percentage-based reporting and color-coded visualization. These elements reduce information asymmetry and enhance information resilience by improving accessibility and interpretability.

When EMF data are accessible, verifiable, and clearly contextualized, public confidence in institutional monitoring increases. Empirical evidence shows that transparent and well-structured data presentation positively influences trust, even when perceived risk remains stable [1]. Thus, availability and interpretability of information are as significant as measured values themselves, supporting accountability, informed dialogue, and institutional legitimacy within digital governance frameworks. The interaction between authorities, experts, and the public is illustrated in Fig. 1.

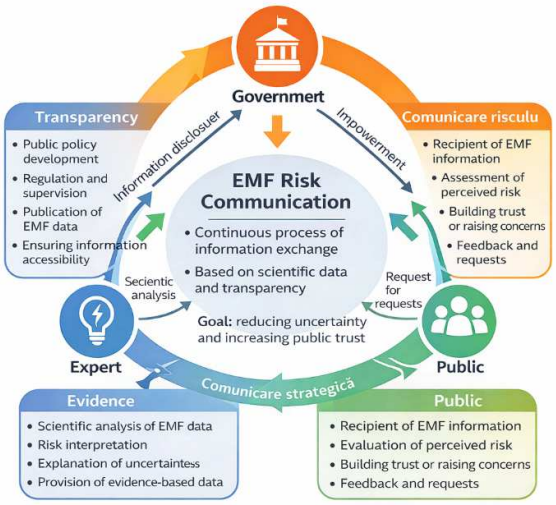


Fig. 1. Conceptual model of EMF risk communication between government, experts, and the public.
Source: adapted by the authors based on [1]

Within this framework, authorities define the regulatory context and publish EMF data, experts provide scientific interpretation, and the public receives and evaluates the information. This bidirectional exchange, grounded in transparency and data-driven communication, reduces uncertainty and strengthens trust in wireless technologies.

Effective transparency requires reporting EMF measurements relative to ICNIRP legal limits. Expressing exposure levels as percentages of admissible thresholds enables non-expert users to quickly assess their significance and distinguish negligible from potentially relevant values [3]. Table 2 illustrates this contextualized reporting approach.

Table 2

Example of EMF value contextualization in the 2110–2170 MHz band

Parameter	Measured value	ICNIRP limit	Percentage of limit	Interpretation
Electric field strength	1.2 V/m	61 V/m	2%	Very low level
Power density	0.02 W/m²	10 W/m²	0.2%	Negligible exposure

Source: adapted by the authors based on ANCOM [5]

This approach makes complex technical data accessible to the general public, reducing unwarranted alarm and supporting effective risk communication by translating measurements into contextualized information aligned with regulatory limits and public understanding.

Visual tools such as interactive maps, charts, and color-coded scales further enhance interpretability, as shown in Fig. 2, by enabling rapid identification of exposure levels, spatial distribution, and their evolution over time without requiring technical expertise.

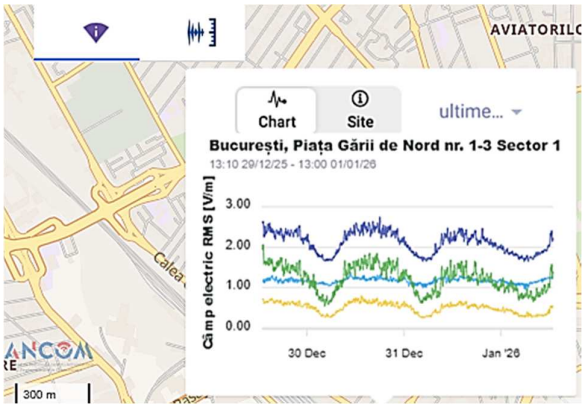


Fig. 2. Example of an interactive map for electromagnetic field monitoring.
Source: Monitor EMF [5]

At the European level, population safety with respect to EMF exposure is regulated through Council Recommendation 1999/519/EC[7], which remains the EU reference framework and is based on ICNIRP scientific guidelines [3]. Although ICNIRP updated its guidelines in 2020, this Recommendation continues to serve as the common normative benchmark applied by EU Member States for public exposure limits.

In Romania, these European provisions have been transposed through Order of the Minister of Public Health No. 1193/2006, ensuring a uniform level of protection and enabling EMF measurements to be reported against harmonized legal limits across the European Union. This regulatory alignment supports result comparability and coherent risk communication.

EMF exposure monitoring and public information dissemination are carried out by ANCOM through networks of fixed sensors and mobile measurement campaigns, in accordance with European methodologies. Measurement results are published on the Monitor EMF platform via an interactive map, indicating values below legal limits and providing contextual information for public interpretation [5].

The regulatory framework also provides for institutional cooperation and information-on-demand mechanisms. Telecommunications operators supply technical data, while ANCOM collaborates with public health authorities in data interpretation, thereby enhancing information credibility and ensuring consistent communication to the population [4].

3.2 The Monitor EMF Platform as a case study

The Monitor EMF platform is a national system operated by the National Authority for Management and Regulation in Communications (ANCOM) for monitoring and publicly reporting electromagnetic field (EMF) levels generated by major radio sources, including mobile communication networks (2G–5G), broadcasting services, and Wi-Fi systems. It is referenced as a relevant national example aligned with European practices on EMF transparency and population exposure monitoring [5], [6].

EMF measurement results are publicly accessible through an interactive online map, where values are presented relative to legal exposure limits defined by European Union recommendations and ICNIRP guidelines [5], [7]. This contextualized visualization supports correct interpretation of exposure levels and effective risk communication, contributing to public trust in regulatory institutions [8].

Currently, the platform provides visual access to EMF data via maps and graphical representations, while machine-readable open datasets (e.g., CSV or API access) are not publicly available. Although this may limit independent data reuse, it does not undermine transparency for public communication, as the platform is primarily designed to support understanding and trust among non-expert users.

The core objective of Monitor EMF is continuous monitoring of EMF levels in areas of

public interest, verification of compliance with legal limits, and enhancement of institutional

transparency, particularly in the context of 5G deployment. By publishing data in real time or near real time, the platform reduces information asymmetry between authorities, operators, and citizens.

From a functional perspective, Monitor EMF offers map-based visualization, automatic comparison with legal thresholds, access to historical measurements, and analysis of temporal trends. Its modular and scalable architecture, aligned with ITU and CEPT recommendations, ensures interoperability and long-term adaptability [6], [9], [10]. The system architecture is illustrated in Fig. 3.

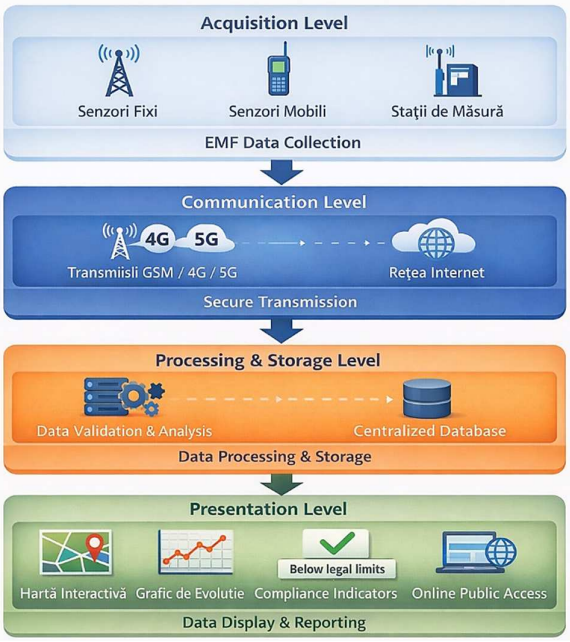


Fig. 3. General architecture of the Monitor EMF platform.
Source: adapted by the authors based on [5]

The data acquisition layer combines fixed, mobile, portable, and SAR-based measurement solutions, in compliance with IEC and ECC requirements [9], [11]. Representative examples of monitoring equipment supporting continuous and selective EMF measurements are illustrated in Fig. 4.

The communication layer ensures secure transmission of EMF data via Ethernet and cellular networks, enabling autonomous monitoring and remote sensor configuration. Processing and storage are handled by centralized servers that support data validation, analysis, and archiving in accordance with ICNIRP and CEPT standards [7], [9].

The presentation layer provides public access through a web-based GIS interface with charts and summary reports, facilitating clear EMF risk communication and supporting broader digital governance objectives [8].

The main categories of equipment used within the Monitor EMF platform, together with their frequency ranges and operational roles, are summarized in Table 3.



Fig. 4. Fixed broadband EMF monitoring station (a) and mobile EMF measurement stations (b).
Source: adapted by the authors [5]

Table 3

Equipment used within the Monitor EMF platform

Equipment type	Model / frequency range	Main role
Portable equipment	NARDA SRM-3006 (9 kHz – 6 GHz)	Targeted campaigns, selective measurements
Fixed EMF stations	NARDA AMB-8059 (100 kHz – 7 GHz)	Continuous 24/7 monitoring
Mobile / selective stations	In accordance with ITU-T K.83	Temporary measurements and band-specific analyses
SAR laboratory	Electromagnetic Compatibility Testing Laboratory (LICETER)	SAR evaluation for radio terminals

Source: adapted by the authors based on [5]

By integrating continuous broadband monitoring, frequency-selective measurements, mobile campaigns, and SAR evaluations, the Monitor EMF platform generates comprehensive data for compliance verification, trend analysis, and cumulative exposure

assessment. In the context of 5G expansion and growing public attention, the system is evolving through network extension and technological modernization, strengthening its role as a transparency and trust-building instrument.

Similar EMF monitoring initiatives operate across Europe, including Cartoradio (France), BNetzA databases (Germany), and ARPA regional networks in Italy [6], [10], as summarized in Table 4.

Table 4

Comparison of european EMF Monitoring platforms

Country	Platform	Main characteristics
Romania	Monitor EMF (ANCOM)	Continuous monitoring, fixed sensors, real-time public data
France	Cartoradio (ANFR)	Spot measurements and numerical modeling
Germany	EMF Database (BNetzA)	Pre-deployment compliance assessments
Italy	ARPA networks	Regional monitoring, detailed reports
Spain	Regional platforms	Periodic reporting, limited monitoring

Source: compiled by the authors based on public information provided by ANCOM, BEREC, ICNIRP, and CEPT [4]–[6], [9], [10]

In addition to the platforms discussed above, several European initiatives provide public access to EMF exposure data through online visualization tools. These include Greece's National Observatory of Electromagnetic Fields (NOEF), with public visualization via the Pedion24 platform, as well as the France–Belgium Observatoire des ondes network operated by EXEM in cooperation with ANFR. Similar to the Romanian Monitor EMF platform, these initiatives primarily offer visual access to EMF data, whereas Serbia's RATEL platform represents the only identified European example providing EMF measurements as true open data, including machine-readable and exportable datasets, enabling independent reuse and advanced data-driven analysis.

Compared to other European initiatives, Monitor EMF stands out through continuous monitoring based on a dense network of fixed sensors and the integrated use of fixed, mobile, portable, and SAR measurements. Unlike platforms focused mainly on compliance or isolated measurements, it is designed to inform the public and address recent technological developments, particularly 5G deployment [5], [6].

EMF indicators used within the Monitor EMF platform

The Monitor EMF platform uses a concise set of standardized technical indicators to ensure scientific rigor and public accessibility, aligned with ICNIRP guidelines [7], ECC Recommendation (02)04 [9], and regulatory transparency requirements [5]. Table 5 summarizes these indicators and their role in supporting transparency.

Table 5

EMF indicators published on the Monitor EMF platform and their role in transparency

EMF indicator	Unit	Operational description (concise)	Role in transparency
Electric field strength (E)	V/m	RMS value, standard-averaged	Scientific basis, comparability
Power density (S)	W/m²	Parameter derived from E	Intuitive understanding of exposure
Percentage of ICNIRP limit	%	Ratio between measured value and legal limit	Rapid risk assessment
ICNIRP reference level	V/m, W/m²	Maximum EU-admissible limit	Clear normative context
Temporal marker	Date, time	Measurement moment or interval	Time analysis, credibility
Geographic location	GIS / address	Map-based positioning	Spatial correlation of exposure

Source: adapted by the authors based on [3], [9]

Transparency is ensured by expressing EMF measurements as percentages of ICNIRP limits, enabling rapid assessment and supporting data traceability [5], [7]. Accessibility is further enhanced through intuitive visual tools, such as color-coded representations and frequency-band differentiation (3G–5G).

The interactive GIS map serves as a key accessibility tool, enabling the correlation of EMF levels with locations of public interest and supporting the analysis of spatial and temporal

exposure patterns without requiring advanced technical expertise. By integrating these visual elements, the Monitor EMF platform translates complex measurements into effective public information, contributing to misinformation reduction and the strengthening of public trust.

3.3 Impact on information and social security

The analysis demonstrates that the transparent and systematic publication of data on population exposure to electromagnetic fields (EMF) plays a significant role in strengthening information and social security, particularly in the context of the accelerated deployment of advanced wireless technologies such as 4G and 5G. When clear, accessible, and verifiable information is lacking, public perceptions of EMF-related risks tend to be amplified by uncertainty and misinformation. In this regard, open access to EMF data, clearly reported relative to legal limits and presented in an easily interpretable format, contributes to reducing social anxiety and stabilizing public perception of actual exposure levels.

The Monitor EMF platform represents a relevant example of good practice, demonstrating an institutional commitment to continuous, objective, and transparent EMF monitoring. Publishing data within a normative framework aligned with international standards strengthens the legitimacy of regulatory authorities and reinforces public trust in the management of technological risks. Furthermore, the platform provides an official factual reference that can be used to verify alarmist or unfounded claims related to EMF and 5G technologies, thereby limiting the spread of misinformation.

A representative illustrative example can be considered in the context of coordinated misinformation narratives claiming that the activation of new 5G base stations has led to “dangerous radiation levels” in residential areas. In such a scenario, publicly accessible EMF measurements reported as percentages of legally admissible limits allow citizens, journalists, and local authorities to independently verify these claims. By providing objective, normatively contextualized data, the Monitor EMF platform acts as a counter-narrative mechanism, reducing the effectiveness of hybrid threats targeting public trust and contributing to cognitive security by enabling informed, evidence-based risk assessment.

In this context, open EMF data function as a mechanism of information resilience. Consequently, the Monitor EMF platform goes beyond the role of a purely technical monitoring tool and emerges as a strategic element of digital governance and societal security. Its contribution lies not in preventing cybersecurity incidents per se, but in mitigating information-related and social risks associated with emerging technologies, with direct relevance for public policy, institutional credibility, and risk management in the digital era.

3.4 Implications for cybersecurity and digital governance (alignment with EU regulations)

Although exposure to electromagnetic fields does not, in itself, constitute a cybersecurity incident, the transparency mechanisms analyzed in this study address information-related and social risks associated with public perception, misinformation, and the erosion of trust. These dimensions are increasingly integrated into the European approach to digital security, particularly in the context of the NIS2 Directive, which promotes a systemic view of digital resilience.

Within this framework, the Monitor EMF platform goes beyond the role of a purely technical measurement instrument and emerges as a data-driven digital governance tool. By providing official, verifiable, and normatively contextualized information, the platform contributes to reducing information uncertainty and countering misinterpretations related to 4G and 5G technologies, in line with the objectives set out in the EU Cybersecurity Strategy for the Digital Decade [12].

a) *Transparency as an information resilience measure*

In the logic of European Union policies, cybersecurity extends beyond the protection of IT infrastructures and includes the dimension of information resilience, defined as the ability of public institutions to deliver credible, accessible,

and verifiable information within an appropriate timeframe. The systematic publication of EMF indicators (electric field strength – V/m, power density – W/m², percentage of the legal limit), together with geographic localization and temporal markers, provides the public with objective and reproducible reference points for assessing exposure levels. This mechanism reduces the vulnerability of the information space to alarmist narratives and supports EU objectives related to trust-building and the integration of security-by-design principles into the digital ecosystem [13].

b) *Contributions to risk governance for essential infrastructures (NIS2)*

In relation to the NIS2 Directive, the Monitor EMF platform can be positioned as a supporting instrument for risk management and institutional communication in essential sectors such as public administration, healthcare, and digital infrastructures. Although EMF exposure does not represent a cybersecurity incident per se, transparency mechanisms contribute to mitigating hybrid risks associated with trust crises and misinformation campaigns that may affect institutional functioning and the societal acceptance of emerging technologies. This approach is consistent with the core principles of NIS2, which emphasize prevention, governance, accountability, and the maintenance of a high common level of security [13].

Table 6 summarizes the relationship between EMF transparency features and key NIS2 principles.

Table 6

Mapping EMF transparency features to NIS2 principles

EMF transparency feature	Primary role	Supported NIS2 principle
Public availability of EMF data	Reduction of information asymmetry	Governance
Reporting as a percentage of legal limits	Prevention of misinterpretation	Prevention
Measurement traceability	Institutional clarity and responsibility	Accountability

Source: adapted by the authors [12], [13]

c) *Trust and institutional assurance within the European Framework (Cybersecurity Act)*

From the perspective of the Cybersecurity Act, which strengthens the role of ENISA and the European framework for trust and assurance in cybersecurity, Monitor EMF supports an equivalent outcome in the sphere of public communication. Through standardization, traceability, and coherent reporting, the platform contributes to building an institutional trust framework based on verifiable data. Although the Act primarily targets the certification of ICT products and services, its underlying principle remains applicable: public trust is reinforced through robust and transparent institutional mechanisms, not through unsubstantiated claims [14].

d) *Transparency versus open data in data-driven governance*

The publication of EMF data and public access to measurement results are aligned with European principles on transparency and the reuse of public sector information, with the aim of increasing visibility and facilitating independent analyses conducted by researchers, non-governmental organizations, or the media [15]. However, it is important to clarify that the Monitor EMF platform currently ensures transparency primarily through public visualization and normative contextualization, without providing fully reusable EMF datasets in machine-readable formats (such as CSV files or API access). Consequently, its contribution is mainly situated at the level of public information and trust-building, rather than full compliance with open data reuse principles.

e) *Transferability to emerging technologies and global security policies*

As a governance model, the proposed set of indicators and the mode of information presentation—measured data, legal contextualization, and traceability—are transferable to other domains characterized by high public sensitivity, such as smart city infrastructures, urban IoT systems, environmental monitoring, or the assessment of exposure to other physical factors. From a global security perspective, the main contribution lies in highlighting that transparency platforms can reduce information-related and social risks which, in contexts of polarization and

coordinated misinformation, may escalate into institutional vulnerabilities.

4. DISCUSSION

Limitations. The assessment of social and information-related impacts presented in this study is intentionally indirect and focuses on the analysis of transparency mechanisms, data accessibility, and normative contextualization of EMF exposure information. The absence of surveys or direct measurements of public perception represents a deliberate methodological choice, rather than a weakness of the research design. This approach was adopted in order to concentrate on institutional transparency and data presentation practices as foundational elements of information security and digital governance, independently of context-specific or culturally variable perception metrics.

At the same time, the quantitative analysis relies on aggregated public data and compliance indicators, which limits observational granularity and does not capture fine-scale variations related to specific locations, short time intervals, or localized network changes. From an ethical perspective, this methodological choice also reflects a cautious approach to EMF risk communication, recognizing that poorly contextualized or sensationalized data collection may inadvertently amplify public anxiety. Responsible communication, based on verified institutional data, therefore remains an essential consideration when addressing EMF-related societal concerns.

Future work. Future research may build upon the proposed framework by extending the analysis in several complementary directions. These include: (i) defining statistically representative samples of locations and time periods to improve spatial and temporal resolution; (ii) integrating advanced quantitative indicators, such as percentiles, daily variability, or comparative analyses conducted before and after the deployment of new wireless technologies; and (iii) directly assessing the relationship between transparency and public trust through surveys, interviews, or controlled risk communication experiments.

Such extensions would enable a more precise quantification of the links between transparency practices, misinformation mitigation, and the strengthening of societal resilience, while preserving the ethical and institutional perspective that underpins the present study.

5. CONCLUSION

The analysis demonstrates that transparency of electromagnetic field exposure data goes beyond the role of simple public information, making a meaningful contribution to reducing information security risks associated with modern communications infrastructures. Platforms that provide accessible, normatively contextualized, and clearly explained data help mitigate misperceptions and strengthen public trust in wireless technologies.

The results of this study indicate that integrating quantifiable EMF indicators with coherent communication mechanisms transforms monitoring platforms from technical compliance tools into effective instruments of societal resilience.

The comparative analysis with similar European initiatives confirms the alignment of the Monitor EMF platform with international best practices and highlights its potential for further expansion and harmonization within European policy frameworks.

The proposed methodology is reproducible and adaptable at both national and regional levels, offering a practical framework for assessing the impact of EMF data transparency on information security, digital governance, and public trust in the context of emerging technologies.

Furthermore, the analytical framework is transferable and can be applied to other domains characterized by high public sensitivity, such as smart city infrastructures, urban IoT systems, environmental monitoring, or the assessment of exposure to other physical factors, thereby supporting data-driven digital governance.

6. ACKNOWLEDGMENT

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Evaluarea transparenței datelor privind expunerea la câmpuri electromagnetice în contextul securității informaționale și al guvernanței digitale

Rezumat: Extinderea rețelelor wireless 4G/5G a adus beneficii semnificative, dar și noi provocări legate de securitatea informațională, alimentate de dezinformare și de lipsa încrederii publice. În acest context, transparența datelor privind expunerea la câmpuri electromagnetice (EMF) devine esențială pentru comunicarea riscului și pentru politici publice eficiente. Lucrarea analizează platforma Monitor EMF, administrată de ANCOM, din perspectiva alinierii la cerințele Directivei NIS2 și ale guvernanței digitale bazate pe date. Rezultatele arată că prezentarea clară și accesibilă a datelor EMF poate reduce interpretările eronate și poate contribui la creșterea încrederii publice, susținând reziliența societală în contextul digital european**.**

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