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Recommendation

ITU-T K.83 (01/2024)

SERIES K: Protection against interference

Monitoring of electromagnetic field levels

Recommendation ITU-T K.83

Monitoring of electromagnetic field levels

Summary

Recommendation ITU-T K.83 gives guidance on how to make long-term measurements for the monitoring of electromagnetic fields (EMF) in the selected areas that are under public concern, in order to show that EMFs are under control and under the limits. The purpose of this Recommendation is to provide the general public, clear and easily available data concerning electromagnetic field levels in the form of results of continuous measurement.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
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1.1	ITU-T K.83 (2011) Amd. 1	2014-07-29	5	11.1002/1000/12224
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Keywords

EMF, EMF monitoring system.

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Introduction

Recommendation ITU-T K.83 presents the basis for the implementation of continuous measurement systems for electromagnetic emissions, in order to constitute a common practice at the international level for these types of continuous measurements.

Electromagnetic fields are imperceptible and unknown to the general public. This unawareness and imperceptibility generate distrust and rejection among the population, which can result in social conflicts and lead to delays in the deployment of new wireless technologies.

One solution to these problems can be the control of the electromagnetic emissions by taking measurements and having proper communication. Measurements turn emissions into something objective and, when presented to the public in an understandable format it helps diminish the unawareness and helplessness of the public.

The measurements of electromagnetic fields described in this Recommendation meet three requirements: must be objective, reliable, and continuous. The objectivity of the measurements is achieved whenever a public and/or independent body carries out the taking of the measurements and manages their publication. Reliability derives from compliance with international norms and standards regarding the measurement of electromagnetic fields and by an accredited calibration of the measuring equipment. The continuous taking of objective and reliable measurements (24/365) provides permanent monitoring of emissions and maximum transparency.

For years, in various parts of the world, broadband systems have been used for the continuous measurement of electromagnetic fields with satisfactory results, increasing citizens' confidence in governments and reducing their fear and ignorance regarding electromagnetic emissions. An alternative is the frequency selective measurement systems which should be applied to meet particular requirements. Other Recommendations, such as [b-ITU-T K.52], [b-ITU-T K.61] and [b-ITU-T K.70], provide guidance on measurement methods that can be used to achieve a compliance assessment as these are also effective approaches to reduce concerns that have been undertaken by some countries.

Recommendation ITU-T K.83

Monitoring of electromagnetic field levels

1 Scope

This Recommendation specifies the methods and characteristics of the monitoring system to be used for the continuous monitoring of electromagnetic fields emitted by radio transmitters, both in broadband and in frequency selective measurement systems, in order to assess the long-term exposure of people to electromagnetic fields in the band of 9 kHz-300 GHz.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.113] Recommendation ITU-T K.113 (2015), *Generation of radiofrequency electromagnetic field level maps*.

[EN 50413] BS EN 50413:2019, *Basic standard on measurement and calculation procedures for human exposure to electric, magnetic and electromagnetic fields (0 Hz – 300 GHz)*.

[IEC 62232] IEC 62232:2022, *Determination of RF field strength, power density and SAR in the vicinity of base stations for the purpose of evaluating human exposure*.

[IEC 62311] IEC 62311:2019, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)*.

[IEEE C95.3] IEEE C95.3-2021, *IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 300 GHz*.

[ISO/IEC Guide] ISO/IEC Guide 98-3:2008 – *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*.

3 Definitions

This Recommendation defines the following terms:

3.1 averaging time (tavg): Appropriate time over which exposure is averaged for purposes of determining compliance with the limits.

3.2 electric field strength (E): Magnitude of a field vector at a point that represents the force (F) on a small test charge (q) divided by the charge:

$$E = \frac{F}{q}$$

The electric field strength is expressed in units of volt per metre (V/m).

3.3 exposure: Exposure occurs whenever a person is exposed to electric, magnetic, or electromagnetic fields.

3.4 exposure ratio: The assessed exposure parameter at a specified location for each operating frequency of a radio source, expressed as the fraction of the related limit.

For assessments against reference levels [b-ICNIRP 1998]:

Between 9 kHz and 10 MHz:

$$ER = MAX\left[\left(\frac{E}{EL}\right),\left(\frac{H}{HL}\right)\right]$$

Between 100 kHz and 300 GHz:

$$ER = MAX\left[\left(\frac{E}{EL}\right)^2,\left(\frac{H}{HL}\right)^2\right]$$

or between 10 MHz and 300 GHz:

$$ER = \left(\frac{S}{SL}\right)$$

where:

ER is the exposure ratio at each operating frequency for the source

EL is the investigation E-field limit at frequency *f*

HL is the investigation H-field limit at frequency *f*

SL is the equivalent plane-wave power density limit at frequency *f*

E is the assessed E-field at frequency *f* for the source

H is the assessed H-field at frequency *f* for the source

S is the assessed equivalent plane-wave power density at frequency *f* for the source

f is each operating frequency of the source

ER is applicable to limits based on the national regulations, or if they are not defined in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) principles.

3.5 far-field region: Region of the field of an antenna where the radial field distribution is essentially dependent inversely on the distance from the antenna. In this region, the field has a predominantly plane-wave character, i.e., locally uniform distribution of electric field and magnetic field in planes transverse to the direction of propagation.

NOTE – In the far-field region, the vectors of the electric field *E* and the magnetic field *H* are perpendicular to each other, and the quotient between the value of the electric field strength *E* and the magnetic field strength *H* is constant and equals the impedance of free space Z_0.

3.6 impedance of free space: The impedance of free space Z_0 is defined as the square root of the free space permeability μ_0 divided by the permittivity of free space ε_0:

$$Z_0 = \sqrt{\frac{\mu_0}{\varepsilon_0}} \approx 120\pi \cdot \Omega \approx 377\Omega$$

3.7 linearity: Maximum deviation over the measurement range of the measured quantity from the closest linear reference curve defined over the range.

3.8 magnetic field strength (H): The magnitude of a field vector in a point that results in a force (*F*) on a charge *q* moving with the velocity *v*:

$$F = q(v \times \mu H)$$

The magnetic field strength is expressed in units of amperes per meter (A/m).

3.9 modulation: The process of modifying the amplitude, phase and/or frequency of a periodic waveform to convey information.

3.10 near-field region: Region generally in proximity to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character but vary considerably from point to point. The near-field region is further subdivided into the reactive near-field region, which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the radiating near-field region where the radiation field predominates over the reactive field but lacks substantial plane-wave character and is complex in structure.

3.11 permeability (μ): Magnetic permeability of a material is defined by the magnetic flux density *B* divided by the magnetic field strength *H*:

$$\mu = \frac{\left\|\vec{B}\right\|}{\left\|\vec{H}\right\|}$$

where μ is the permeability of the medium expressed in henry per metre (H/m).

3.12 permittivity (ε): Property of a dielectric material (e.g., biological tissue). In the case of an isotropic material, it is defined by the electrical flux density *D* divided by the electrical field strength *E*:

$$\varepsilon = \frac{\left\|\vec{D}\right\|}{\left\|\vec{E}\right\|}$$

The permittivity is expressed in units of farads per metre (F/m).

3.13 power density (S): Radiant power incident perpendicular to a surface, divided by the area of the surface. The power density is expressed in units of watt per square metre (W/m^2).

3.14 relevant source: A radio source which at a given measurement point, has an exposure ratio larger than 0.05.

3.15 root mean square (rms): Effective value or rms value obtained by taking the square root of the average of the square of the value of the periodic function taken throughout one period.

3.16 total exposure ratio (TER) [IEC 62232]: The total exposure ratio is the maximum value of the sum of exposure ratios of the equipment under test and all relevant sources over the frequency range 9 kHz to 300 GHz.

$$TER = ER_{EUT} + ER_{RS}$$

where:

ER_{EUT} is the assessed exposure ratio from the equipment under test

ER_{RS} is the assessed exposure ratio of all the relevant sources

3.17 unperturbed field: Field that exists in a space in the absence of a person or an object that could influence the field.

NOTE – The field measured or calculated with a person or object present may differ considerably.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BTS Base Station

CB Compliance Boundary

CDMA Code Division Multiple Access

DVB-T Digital Video Broadcasting – Terrestrial

EMF Electromagnetic Field

ER Exposure Ratio

LTE Long Term Evolution (4G)

NEP National EMF Portal

NR New Radio (5G)

RBW Resolution Bandwidth

RMS Root Mean Square

TER Total Exposure Ratio

TSP Telecom Service Provider

WCDMA Wideband CDMA

5 Conventions

None.

6 Physical quantities, units, and constants

The internationally accepted SI-units are used throughout this Recommendation.

Quantity	Symbol	Unit	Dimension
Current density	J	ampere per square metre	A/m^2
Electric field strength	E	volt per metre	V/m
Electric flux density	D	coulomb per square metre	C/m^2
Frequency	f	hertz	Hz
Magnetic field strength	H	ampere per metre	A/m
Magnetic flux density	B	tesla (Vs/m^2)	T
Permeability	μ	henry per metre	H/m
Permittivity	ε	farad per metre	F/m
Wavelength	λ	metre	m
Physical constant		***Magnitude***	
Speed of light in a vacuum	c	2'997 × 108 m/s	
Permittivity of free space	ε_0	$8'854 \times 10^{-12}$ F/m	
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ H/m	
Impedance of free space	Z_0	377 ohms (approx. 120 πΩ)	

7 General process

This Recommendation defines the methods that shall be used to determine the total exposure ratio (TER) over a certain period to perform a time dependent evaluation of EMF exposure. Two methods are recommended: using the frequency selective measurement or using the broadband measurement.

The frequency selective measurement procedure is based on [EN 50413] and [IEC 62311].

The broadband measuring method is based on [EN 50413] and [IEC 62311]. It allows obtaining the total radiation level in the form of electric field strength (E) in the frequency band of interest, averaged

over a certain period. If the measurement is performed in the near-field region, then the evaluation of the total radiation level for the magnetic field strength (H) is necessary.

This method is applicable in those cases where the total summation of the emissions of a said frequency band is required to be measured. It allows obtaining a rapid measure of the total emission level of the band at a low cost.

The broadband method should not be applied:

- If it is necessary to know the radiation levels by frequency.
- If the value given exceeds the minimum reference level in the frequency band to be measured.
- If the sensitivity of the equipment is not low enough to obtain a radiation value, but the legislation in force requires giving a radiation value.
- To measure frequencies under 100 kHz since the total summation of the emissions is not a valid method for these frequencies.

7.1 Description of the general method

The measurement is continuously and automatically carried out over the targeted frequency range operating in the considered area.

If the measurement is carried out within the reactive near field (distance < max (λ, D, $D^2/(4\lambda)$) – where λ is the wavelength and D is the maximum size of the antenna) of the relevant emitters (ER > 0.05), the validity of the measurement result should be justified by a detailed analysis.

NOTE – For a distance of 10 m, the conditions for radiating near field or far field are met for all emitters above 30 MHz.

The range for low frequency measurements is from 0 Hz up to 100 kHz and the range for high frequency measurements is from 100 kHz up to 300 GHz [EN 50413].

In the case of low frequency fields, electric (E) and magnetic (H) fields must be assessed separately.

In the case of high frequency fields and far-field conditions, either electric (E), magnetic (H) or power density (S) may be used for the assessment.

In the case of near-field conditions, both electric (E) and magnetic (H) field components must be assessed.

Figure 1 gives an overview of the procedure for a site.

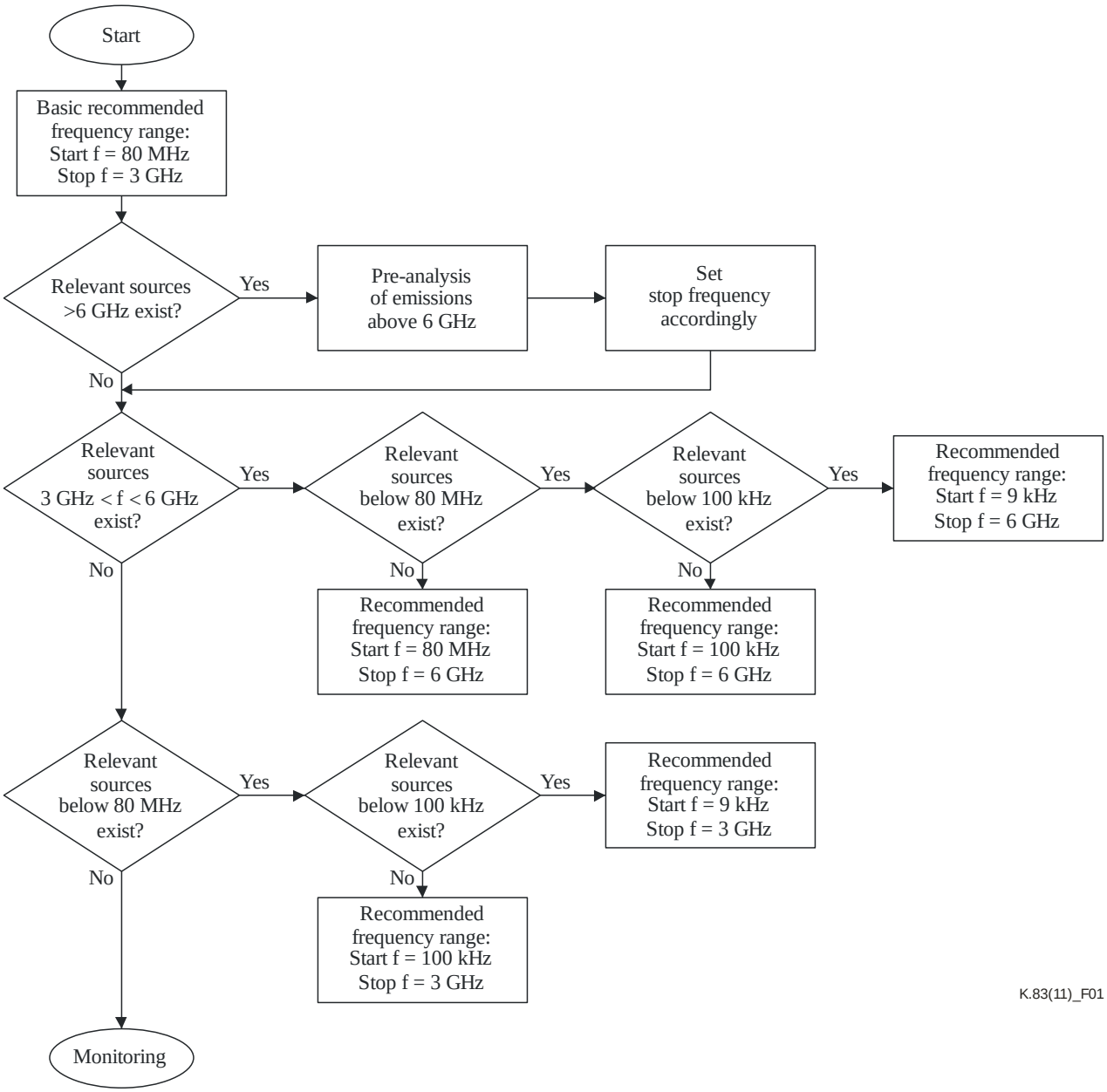


Figure 1 – Site evaluation procedure

7.2 Exposure limits

The limits for general public exposure specified in the national regulations, or if they do not exist in the ICNIRP, limits as well as conditions for simultaneous exposure to multiple frequency fields shall apply for the purposes of this Recommendation.

From such derived field strengths E_i, the TER for the complete frequency range is derived:

In the case of [b-ICNIRP 1998] guidelines, the total exposure ratio (TER) criteria refers to the electrical stimulation effects (a = 87 V/m); El is the frequency dependent limit):

$$\sum_{i=1\text{Hz}}^{1\text{MHz}} \frac{E_i}{El_i} + \sum_{i=1\text{MHz}}^{10\text{MHz}} \frac{E_i}{a} \leq 1$$

The total exposure criteria refers to the thermal effect circumstances ($c = 87/f^{1/2}$ V/m, *El* is the frequency dependent limit):

$$\sum_{i=9\text{kHz}}^{1\text{MHz}} \left(\frac{E_i}{c}\right)^2 + \sum_{i=1\text{MHz}}^{300\text{GHz}} \left(\frac{E_i}{El_i}\right)^2 \leq 1$$

8 Frequency selective measurement procedure

The measurement consists of repeated measurement cycles, each representing one measurement result. Each cycle consists of the steps according to Figure 2.

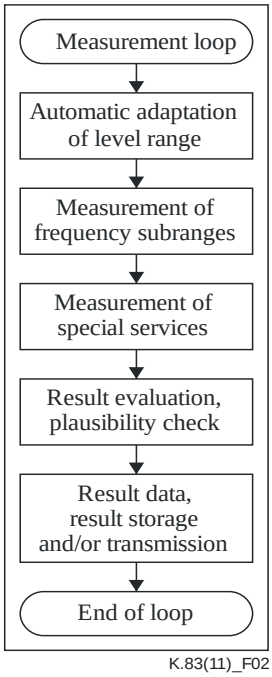


Figure 2 – Measurement loop

8.1 Frequency sub-ranges

The frequency range is divided into sub-ranges depending on the region.

For each sub-band, the maximum detectable level is at least the limit value. The minimum detectable level is required in case no emissions above the threshold value are present. It can be achieved with adopted settings of, e.g., attenuation, bandwidth. An instantaneous dynamic range of 60 dB must be achieved for each level setting. Another signal present in any other sub-range and bigger than 25% or at least 3 MHz off the measurement frequency must cause no overload or measurement error if its field strength is below the exposure limit.

8.2 Automatic level range determination

The parameters (e.g., attenuation, preamplifier) for each sub-range are adopted automatically during each cycle to achieve the best possible sensitivity without signal distortion due to overload (e.g., in preamplifiers, mixers) from other emitters in the same or other sub-bands.

8.3 Measurement of frequency bands

For each frequency band, the measurement should be done using a detector according to the national regulations. If there are no national regulations, then the RMS level should be used according to the ICNIRP guidelines. The measurement time for each band is chosen according to the typical time behaviour of the emitters. The measurement is repeated with increasing sensitivity (e.g., smaller

bandwidth) as long as no emission above and less than two emissions below the threshold are detected and the minimum detectable level is not reached. The noise floor of the measurement system is discriminated independent from the sensitivity setting and therefore not used as a measurement value.

8.4 Measurement of special services

Special services, e.g., broadband services such as wideband code division multiple access (WCDMA) and digital video broadcasting – terrestrial (DVB-T), signals with high crest factors and radar signals are measured with specific settings (at least zero span, measurement time and signal adopted bandwidth). Depending on the signal type, RMS or peak detector shall be used [IEC 62232].

A result value obtained here at a frequency f_0 replaces the swept measurement achieved in clause 8.3 in the frequency range $f_0 \pm ½$ resolution bandwidth (RBW).

An extrapolation of the field strength at maximum traffic of a cellular network is not carried out.

8.5 Result evaluation

Measurement result consists of values achieved according to clauses 8.2 and 8.3 that fulfil the criteria of clause 7.2 stored as relevant emissions and used for the TER calculation.

For a plausibility check and the detection of unusual transmissions (e.g., broadband interferers), bandwidth and field strength limits can be defined for every frequency band. If the emission is outside the limit, a warning is added for the operator. In case no limit is defined for a frequency range, or the measurement is not possible (e.g., insufficient S/N for determination of occupied bandwidth), the plausibility check is skipped for this frequency. The next measurement cycle is started independently from the plausibility check result.

NOTE – In case of automatic data transmission and central data management, the plausibility check can also be centralized.

As additional information date, time, actual measurement position, ambient temperature and humidity, system status and warnings are added to the measurement result.

This result is stored internally (offline evaluation) or transmitted automatically via a data link to a server (online evaluation).

8.6 Measurement equipment, general requirements

The measurement equipment consists of the following parts:

- Measurement probe.
- Frequency selective measuring instrument, which processes the signal from the probe and indicates the value of the EM field quantity.
- Measurement automation.
- Mechanical and protective housing.

The system parameters, as defined in this clause, are valid for the completely assembled unit as installed on site.

The measurement equipment shall be calibrated as a complete system at the measurement frequencies according to [IEC 62232]. The calibration shall take into account the high crest factor of some signals or combinations of signals.

8.7 Measurement probe

Isotropic measurement shall be used to determine the field value used to assess the human exposure. The isotropy shall be analysed according to [IEC 62232], and the isotropy deviation shall be less than 2.5 dB in the frequency range up to 3 GHz and less than 3.5 dB for 3 to 6 GHz. In the extended frequency range 3 to 6 GHz and above, the isotropy may increase to 3.5 dB.

The measurement is carried out at a height of concern (typically 1.5 m above floor level). If the frequency range is split into more than one probe, field probes below 130 MHz may be mounted within a height range of 1.3 m to 1.7 m.

The size of each probe should be smaller than 150 mm. Interaction between the probes, radome and the measurement equipment shall be taken into account for isotropy, sensitivity and measurement uncertainty evaluation.

If active probes are used, 1 dB compression point must be higher than the measurement range.

8.8 Measurement instrument

The measurement range of the instrumentation is required to be in accordance with the field strengths to be measured. The sensitivity should be sufficient to determine the lowest level, to be measured within the accuracy at that level, as stated by the instrument's manufacturer. By a preselector, strong emissions in other frequency bands are suppressed. Preamplifiers shall be used only after the preselector to avoid unrecognized overload effects. The frequency range of the measuring equipment should be sufficient to cover the frequencies of the EM field sources to be characterized.

For the measurement of special services, the radio bandwidth should cover 10 Hz to 10 MHz, including channel filters for typical services, e.g., WCDMA, DVB-T, long term evolution (4G) (LTE), new radio (5G) (NR).

8.9 Measurement control

The measurement control shall monitor the system status. In case of a detected interruption in the measurement procedure, the system shall recover on its own, start the measurement cycle again and send out a warning. The results of the interrupted measurement cycle are deleted and the results of completed cycles stay valid. In case of a detected hardware failure, the measurement is set to invalid.

8.10 Mechanical and protective housing

The measuring equipment shall be appropriate to the environmental conditions (e.g., temperature, humidity, wind speed, vibration) to be expected during the monitoring period at the measurement site.

9 Broadband measurement procedure

9.1 Measuring equipment

To take the broadband measurement, the instrument to be used consists of an equipment that has a broadband probe and measures the electromagnetic field. This equipment will consist of:

- Broadband probe.
- Measurement instrument, which processes the signal from the probe and provides the measurement of the field strength.
- Protection.

It is essential that the measuring equipment must provide the RMS (*root mean square*) value of the electric field strength to compare the levels measured with the exposure limits.

The measuring equipment should be calibrated as a whole, and the said calibration should be registered.

9.2 Measurement probe

The broadband probe provides an independent measurement of the frequency, which integrates all of the emissions in the desired frequency band. One must use a broadband probe that covers the band of interest. This probe must be isotropic, and the isotropic deviation must be less than 2.5 dB for frequencies up to 3 GHz, and less than 3.5 dB for higher frequencies. Each one of the three field components must be measured possibly at the same time to have a correct total field result. Besides, the probe must have a dynamic range adapted to the levels that one wants to measure.

The deviation of the measurement due to the variation of the response of the probe with the frequency must be less than ±3 dB for the interest frequency band.

The catchment area of the probe should be sufficiently separated from the readout unit through a high impedance connection and low permittivity materials that minimize the interaction between the field and the connection circuitry.

9.3 Measurement instrument

The function of the measurement instrument is to calculate the field level based on the information given by the probe. The sensitivity of the equipment must be sufficient to discriminate the minimum desired field level with adequate precision. Similarly, the dynamic range of the equipment should be adapted to the measurements to be taken.

The probe and the measurement instrument as a whole should provide the RMS (*root mean square*) value of the field strength.

Besides, the measurement instrument should manage the automation of the measurements for them to be continuous, with the sampling and the defined average periods. A sampling rate of at least one second is recommended and the average period should be six minutes, as specified by [b-ICNIRP 1998], and it should be continuous or "sliding" over time, to avoid losing data, as specified by [IEEE C95.3]. It should have an adequate storage capacity for measurements, which in any case should exceed one week.

It is also responsible for monitoring the status of the system, generating alarms in case of any anomaly in the operation.

9.4 Protection

The measuring equipment should be adapted to environmental conditions (temperature, humidity, rainfall, wind, etc.) that can be expected at the location point. To this end, we will employ a properly conditioned mechanical protection.

9.5 Measurement method

The procedure to be followed is:

9.5.1 Selection of the probe

Firstly, it is important to correctly choose the measurement probe, so that it should adapt to both the frequency margin and the necessary dynamic range of the field strength.

Probes offer absolute field values, without frequency information. It will be necessary to compare the obtained value, which is the total strength field of all the spectral components in the bandwidth to be measured, with the minimum value of the exposure limit. It is interesting to observe that the bandwidth of the probe should be adjusted as closely as possible to the bandwidth to be measured, so that the minimum exposure limit coincides with that of the frequencies that we want to measure.

9.5.2 Selection of the measurement site

The measurement should be taken at a height of concern (typically 1.5 m above the floor level). Thus, the measuring equipment should be located so that the catchment area of the probe is located at that height.

The measurement point should be chosen so that it represents the highest level of exposure that a person may be subjected to, taking into account all the possible sources of emissions. This maximum can be determined either empirically through a quick scan with a field measuring equipment, or by a calculation of the theoretical propagation from nearby transmitting antennas. It is important to keep the probe away from metal surfaces (several times the diameter of the probe) to avoid coupling effects that would distort the measurement.

The measured field value must correspond to the "undisturbed" field. This means, all possible influences of assembling on the field should be minimized. To this end, the equipment should be assembled on a non-conductive support, with low permittivity, and any possible metallic fittings should be far enough from the probe. Besides, one should take all the necessary measures so that while measuring any moving object or person may not approach the equipment.

9.5.3 Automatic taking of the measurements

The equipment should operate autonomously once it is put into operation. The same equipment will manage the taking of the measurements and its automation so that the measurements will be continuous and uninterrupted.

Field measurements should be an average of duration to be defined by the national regulations, or six minutes should be used according to the [b-ICNIRP 1998] guidelines. Each measurement should be stored in the equipment memory, pending to be recovered by the system manager.

9.6 Measurement of exposure to multiple sources or frequencies

Exposure to a single frequency is an ideal case. The most general case is that of the exposure to various sources or a single source with various frequencies. Considering this general case, it can, however, be easily proved mathematically that if the value measured by the equipment does not exceed the most restrictive exposure limit in the frequency band to be measured, then the contributions at different frequencies will also be below the said limit, since:

$$E_{tot} = \sqrt{\sum_{i=1}^{n} E_i^2}$$

10 Uncertainty

The uncertainties shall be estimated in compliance with methods described in [EN 50413], [IEC 62232], and [ISO/IEC Guide]. The contributions to the total uncertainty of the measurement can be obtained through the appropriate measurements performed on the equipment, or according to the manufacturer's specifications that can be taken as tolerances with the rectangular distribution.

The expanded uncertainty with a confidence interval of 95% [EN 50413], [IEC 62232], and [ISO/IEC Guide] shall not exceed 4 dB.

The contributions of each component of uncertainty shall be registered with their name, probability distribution, sensitivity coefficient and uncertainty value. The results shall be recorded in a table as described in Table 1. The combined uncertainty shall then be evaluated according to the following formula:

$$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$$

where c_i is the weighting coefficient (sensitivity coefficient). The expanded uncertainty shall be evaluated using a confidence interval of 95%. The coverage factor to be employed is 1.96, which is provided by the confidence interval of 95% for a near-normal distribution, typical in most measurements.

Table 1 gives a practical guideline to set up an uncertainty budget for EMF measurements.

There may be other uncertainties, which are not listed, and some of the listed uncertainties may not be present or may not be significant in the overall assessment.

Table 1 – Uncertainty assessment

Error sources	Description	Uncertainty value % uv_i	Probability distribution	Divisor k_i	c_i	Standard uncertainty % $u_i = uv_i/k_i$
Measurement equipment						
Calibration	[IEC 62232]		Normal	1 or k	1	
Isotropy	[IEC 62232]		Normal	1 or k	1	
Linearity	[IEC 62232]		Rectangular	$\sqrt{3}$	1	
Measurement device			Normal	1 or k	1	
Noise			Normal	1	1	
Mismatch	[IEC 62232]		U-shape	$\sqrt{2}$	1	
Influence of temperature and humidity on the measurement equipment	[IEC 62232]		Rectangular	$\sqrt{3}$	1	
Environmental parameters						
Perturbation by environment			Rectangular	$\sqrt{3}$	1	
Influence of the body	[IEC 62232]		Rectangular			
Post-processing						
Spatial averaging	[IEC 62232]		Rectangular	$\sqrt{3}$	1	
Combined standard uncertainty			$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$			
Expanded uncertainty (confidence interval of 95%)			Normal			$u_e = 1.96 \cdot u_c$

11 Report on the measurement results

As stated in the introduction, taking measurements is as important as the correct communication of the results to solve public concerns about electromagnetic radiation.

Therefore, when communicating the results of the measurements taken, the following aspects should be taken into account:

- Comprehensibility: Results should be clear and comprehensible for the general public, without excessive technicalities. It is important to show the results compared with the applicable limit values.

- Accessibility: Results should be published on the Internet, and access to them should be easy for the general public; that is to say, the link should be accessed from home pages and not from the inside pages of a website with a difficult access.
- Details: All the possible information about how the measurements are taken should be provided:
  - measurement location (by its geographical positioning on a map [ITU-T K.113]),
  - description of the measurement site,
  - date and time,
  - description of the measurement method: broadband, frequency selective, average time, position of the probe, etc.,
  - identify the measurement equipment,
  - record the calibration details for any instrumentation used,
  - identify who has done the assessment,
  - record when and where the assessment was performed,
  - record the relevant sources considered and associated parameters,
  - include the value of the parameters used in the assessment and any assumptions made,
  - record the results of the total exposure ratio measurements.

Appendix I

Links to the official websites with results of the EMF monitoring

(This appendix does not form an integral part of this Recommendation.)

As an example, Tables I.1 and I.2 contain an alphabetical list of the links to the official websites of the regulatory agencies in which the information with results of the EMF monitoring are presented. Table I.3 lists the links to the official websites of the regulatory agencies where results of EMF measurements are presented.

Table I.1 – Links to the websites with results of EMF monitoring (Governments)

Country	Institution	Website	Contact details
Argentine Republic	Universidad Nacional de La Plata	https://itma-cem.unlp.edu.ar	Calle 50 esq 115 Piso 3 (1900) La Plata, Argentina Telephone: 542 214 236 609 E-mail: monitorcem@cespi.unlp.edu.ar
Republic of Colombia	ANE (Agencia Nacional del Espectro) – National spectrum agency of Colombia	http://smrni.ane.gov.co/es/public/colombia/	Calle 93 # 17-45 Floor 4. Bogotá D.C. Postal code: 110221 Telephone: 57 16 000 030 E-mail: contactenos@ane.gov.co
Republic of El Salvador	ITU pilot project, SIGET (Superintendencia General de Electricidad y Telecomunicaciones)	http://rni.siget.gob.sv/ http://www.siget.gob.sv/rni http://www.siget.gob.sv/rni/cartas/	Sexta décima Calle Poniente y 37Av. Sur #2001, Col. Flor Blanca, San Salvador, El Salvador Telephone: 503 22 574 438 E-mail: info@siget.gob.sv
Federal Republic of Germany	Federal network agency. Fourteen monitoring stations available on request and relocated after three months.	https://www.bundesnetzagentur.de/DE/Fachthemen/Telekommunikation/Technik/EMF/start.html	Bundesnetzagentur Section 414 Postfach 80 01 D-55 003 Mainz E-mail: monitoring@bnetza.de
Hungary	National media and communications authority (NMIA)	http://emirpub-prod.nmhh.hu/pubrendszer-web/eszmog/meresiAdatok.jhtml	
Italy	ARPAE (Regional agency for the prevention, environment and energy)	https://www.arpae.it/ Campi elettromagnetici — Arpae Emilia-Romagna	Via Po, 5 – 40139 – Bologna (Bologna) Telephone: 05 16 223 811
State of Israel	Israel ministry of environmental protection	קרינה בתדרי רדיו | המשרד להגנת הסביבה (www.gov.il)	Israel ministry of environmental protection https://www.gov.il/he/departments/ministry_of_environmental_protection/govil-landing-page

Table I.1 – Links to the websites with results of EMF monitoring (Governments)

Country	Institution	Website	Contact details
Republic of Korea	Korea communications agency	http://118.37.76.251:9080/download.htm this application is available for mobile phones.	760, Bitgaram-ro, Naju-si, Jeollanam-do, Korea Telephone: 82-61-350-1604 Mobile: 821 088 600 845 E-mail: geo0707@kca.kr
Republic of Panama	Autoridad Nacional de los Servicios Públicos, ASEP (Public services national authority)	http://170.82.247.23/es/public/asep-panama/	0816-01235, Zona 5 Panamá. Telephone: 50 75 084 500 E-mail: atencionalusuario@asep.gob.pa
Republic of Poland	Instytut Telekomunikacji – Państwowy Instytut Badawczy	https://si2pem.gov.pl/	ul. Szachowa 1 04-894 Warszawa Telephone: 48 225 128 100 E-mail: info@itl.waw.pl
Romania	ANCOM http://www.ancom.org.ro	http://www.monitor-emf.ro/en/map/	2 Delea Noua Street Bucharest 3, Postal Code 030925, Bucharest, Romania Telephone: 03 72 845 845 (Free) Line: 08 00 855 855 E-mail: sesizare@ancom.org.ro
Spain – Catalonia	Generalitat de Catalunya (Telecommunication and information technologies centre)	Governança radioelèctrica. Departament de la Presidència (gencat.cat)	Ministry of the Presidency (gencat.cat) Carrer de Salvador Espriu, 45-51 08908 L'Hospitalet de Llobregat Telephone: 935 574 000
Turkey	Bilgi Teknolojileri ve İletişim Kurumu (Information and communication technologies authority, ICTA)	https://www.btk.gov.tr/olcum-takip-sistemi with sub-page: https://www.turkiye.gov.tr/baz-istasyonlari (NOTE – Access is restricted to Turkish ID holders)	Bilgi Teknolojileri ve İletişim Kurumu Eskişehir Yolu 10. Km No: 276 Posta Kodu: 06 530 Çankaya / Ankara Telephone: 03 122 947 200 https://www.btk.gov.tr/iletisim
Eastern Republic of Uruguay	URSEC (Communication services regulatory unit)	http://201.217.159.117:8085/gmap/index.html	www.ursec.gub.uy
Republic of Serbia	Regulatory agency for electronic communications and postal services	http://emf.ratel.rs/eng/index	RATEL Palmotićeva 2, 11103 Belgrade, Republic of Serbia Telephone: 01 13 242 673 E-mail: ratel@ratel.rs

Table I.2 – Links to the websites with results of EMF monitoring (non-Government)

Country	Institution	Website	Contact details
Andorra	Andorra telecom	https://www.andorratelecom.com/en/corporate-social-responsibility	Andorra Telecom – Contact
France & Belgium	Observatoire des Ondes (Exem)	https://www.observatoiredesondes.com/fr/carte-des-ondes/	EXEM, 39 Avenue Crampel 31400 Toulouse Telephone: 330 561 629 636
Greece	Mobile radiocommunications laboratory of the National Technical University of Athens (NTUA) and the radiocommunications laboratory of the Aristotle University of Thessaloniki	http://www.pedion24.gr/en/results_en.jsp	Mail address: Mobile Radiocommunicarion Lab 9, Iroon Polytechniou Str GR15773, Zografou campus Athens, Greece Telephone: 302 107 724 196 E-mail: pedion24@mobile.ntua.gr Fax: 302 107 723 851
Spain	Vitoria-Gasteiz city council	https://www.vitoria-gasteiz.org/wb021/was/contenidoAction.do?lang=en&locale=en&idioma=en&uid=_6a6e93ad_11a9a62c81b__7fd7	Ayuntamiento de Vitoria-Gasteiz Plaza España 1, 01001 Vitoria-Gasteiz. informacion@vitoria-gasteiz.org
Confederation of Switzerland	Cantons of Uri, Schwyz, Obwalden, Nidwalden, Luzern and Zug	http://e-smogmessung.ch/i4Def.aspx?tabindex=0&tabid=437	

Table I.3 – Links to websites with other EMF results (not monitoring)

Country	Institution	Website	Contact details
Federative Republic of Brazil	ANATEL	https://informacoes.anatel.gov.br/paineis/espectro-e-orbita/mapa-de-exposicao-a-campos-eletromagneticos	National telecommunication agency SAUS Q. 6 Bloco E 10º Andar Brasilia – DF – Brazil. Zip code 70070-940. Takeshi Ikeda espectro@anatel.gov.br / figf@anatel.gov.br
France	Agence Nationale des Fréquences	https://www.cartoradio.fr	Agence Nationale des Fréquences 78 avenue du Général de Gaulle 94704 Maisons-Alfort. https://www.anfr.fr/contact-anfr
Ireland	Commission for communications regulation (ComReg)	http://www.comreg.ie/licensing_and_services/nir.554.444.html *(Sample of sites measured yearly since. Initially 400 sites in 2003-04 and down to 40 sites in 2012.)*	Commission for communications regulation, One dockland central, Guild street, Dublin, D01 E4X0 Email: consumerline@comreg.ie
Spain	Ministry of economic affairs and digital transformation (Secretaría de Estado de Telecomunicaciones e Infraestructuras digitales)	https://geoportal.minetur.gob.es/VCTEL/vcne.do	P.º de la Castellana, 162. 28046 – Madrid Telephone: 34 912 582 852
United Kingdom of Great Britain and Northern Ireland	OFCOM	https://www.ofcom.org.uk/phones-telecoms-and-internet/coverage/mobile-operational-enquiries/audit-info	

Appendix II

Examples of the existing websites with EMF monitoring results[1]

(This appendix does not form an integral part of this Recommendation.)

This appendix gives examples of the results presented in the websites dedicated to EMF monitoring.

II.1 EMF monitoring system in Serbia

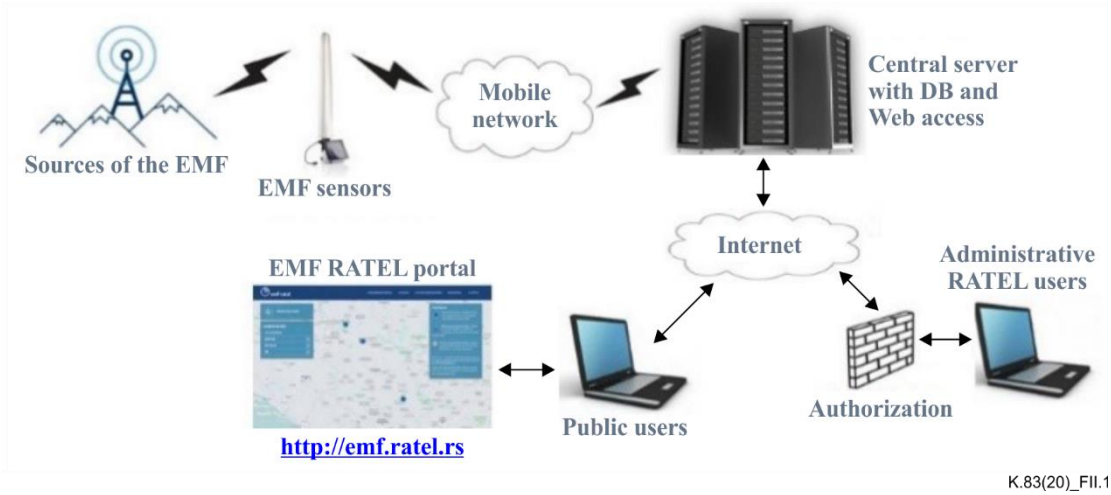


Figure II.1 – RATEL EMF monitoring system overview

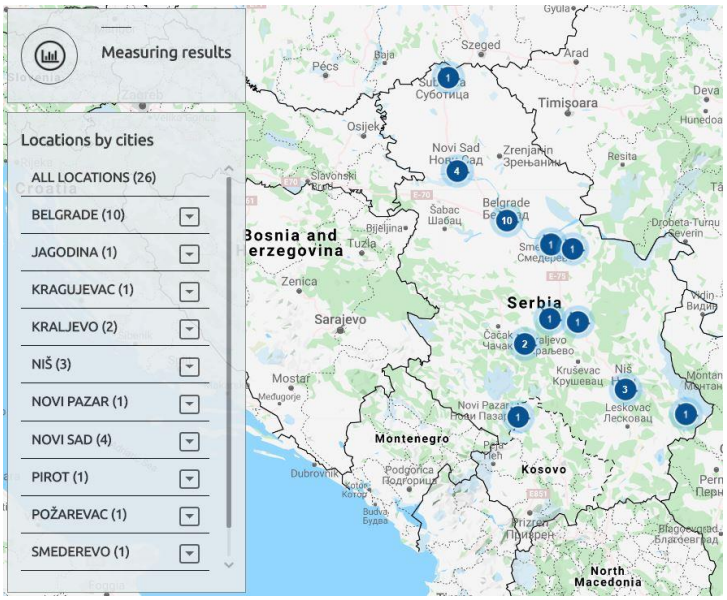


Figure II.2 – Measuring stations' positions on the interactive map

[1] The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

Figure II.3 – Student dormitory "4.april", Belgrade – Field and exposure levels

II.2 EMF monitoring system in Korea (Republic of)

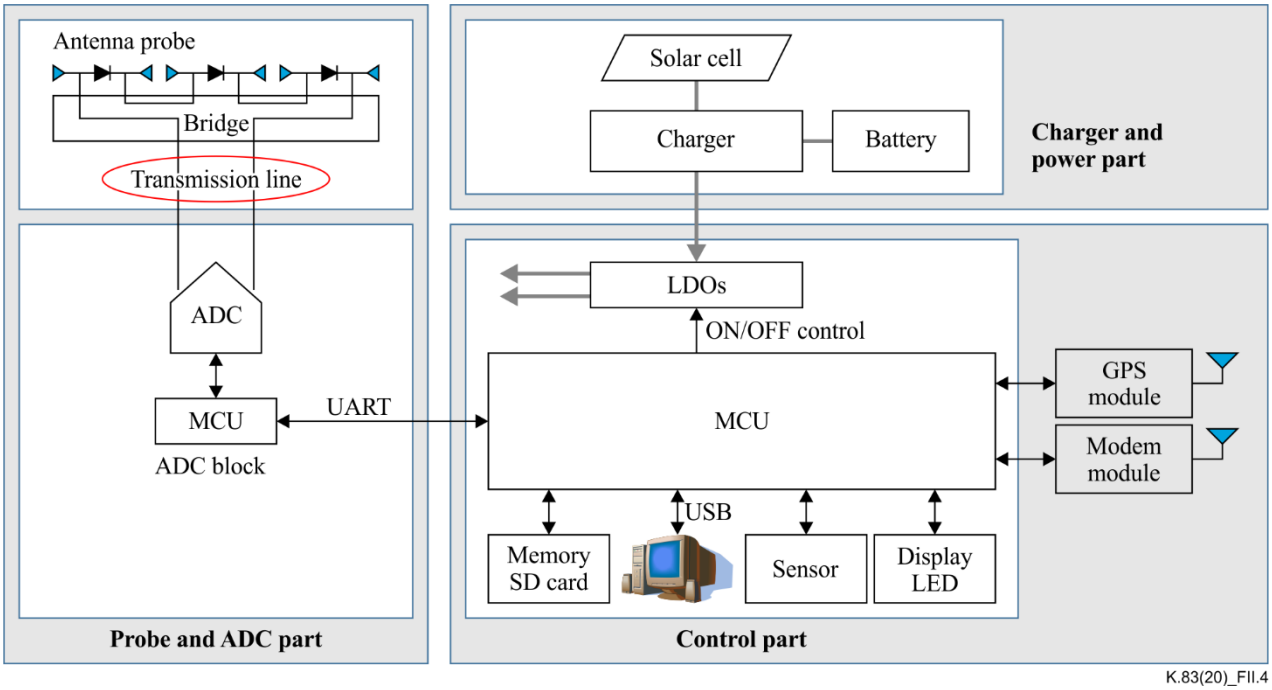


Figure II.4 – Broadband EMF area monitor block diagram

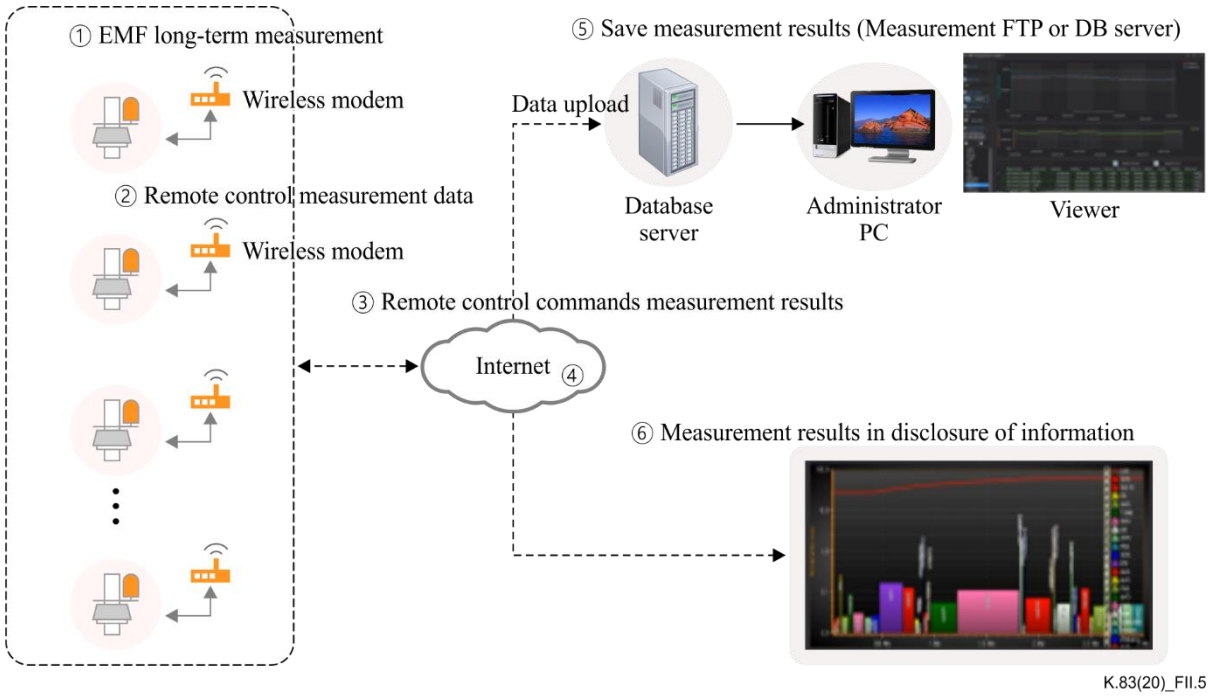


Figure II.5 – Frequency selective EMF area monitoring architecture system

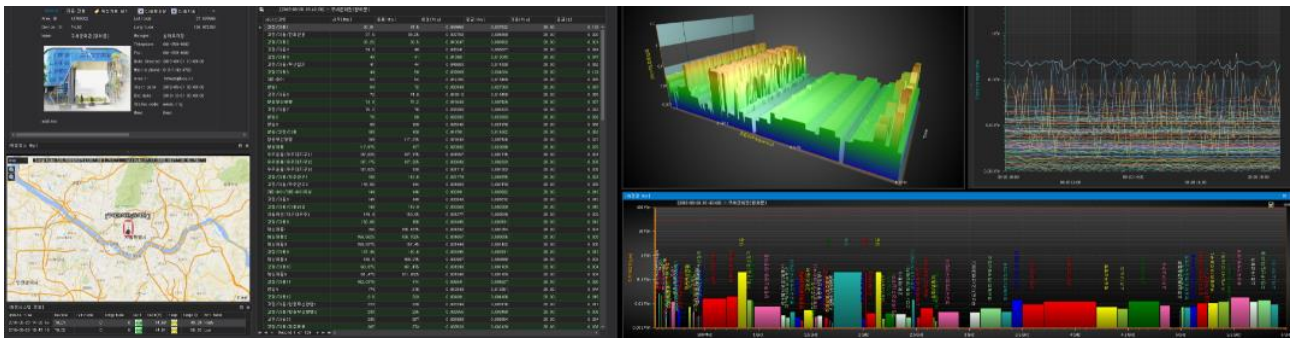


Figure II.6 – Frequency selective EMF monitoring analysis (Korea KCA)

II.3 EMF monitoring system in Panama

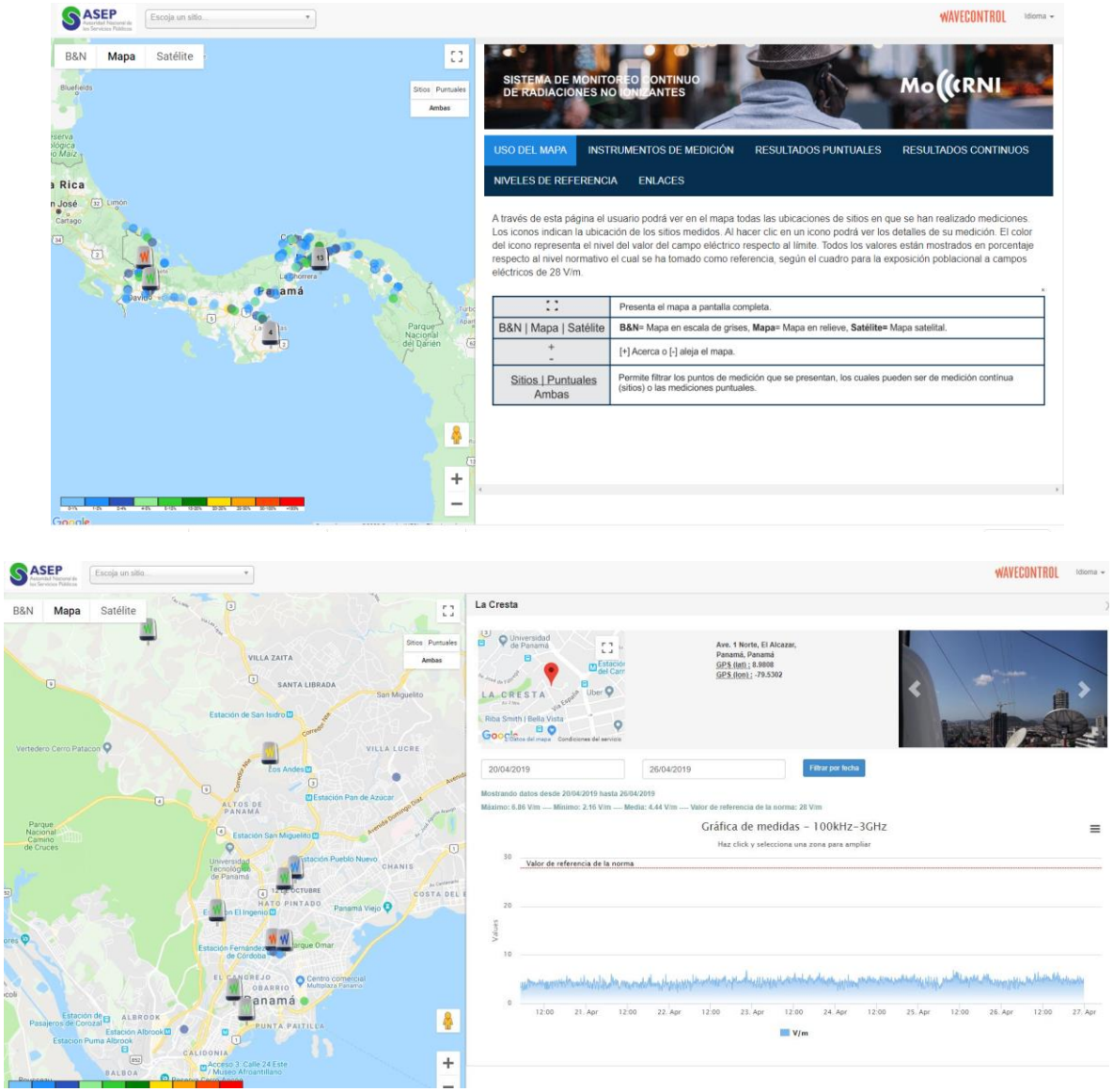


Figure II.7 – EMF monitoring system in Panama[2]

2 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

II.4 EMF monitoring system in Uruguay

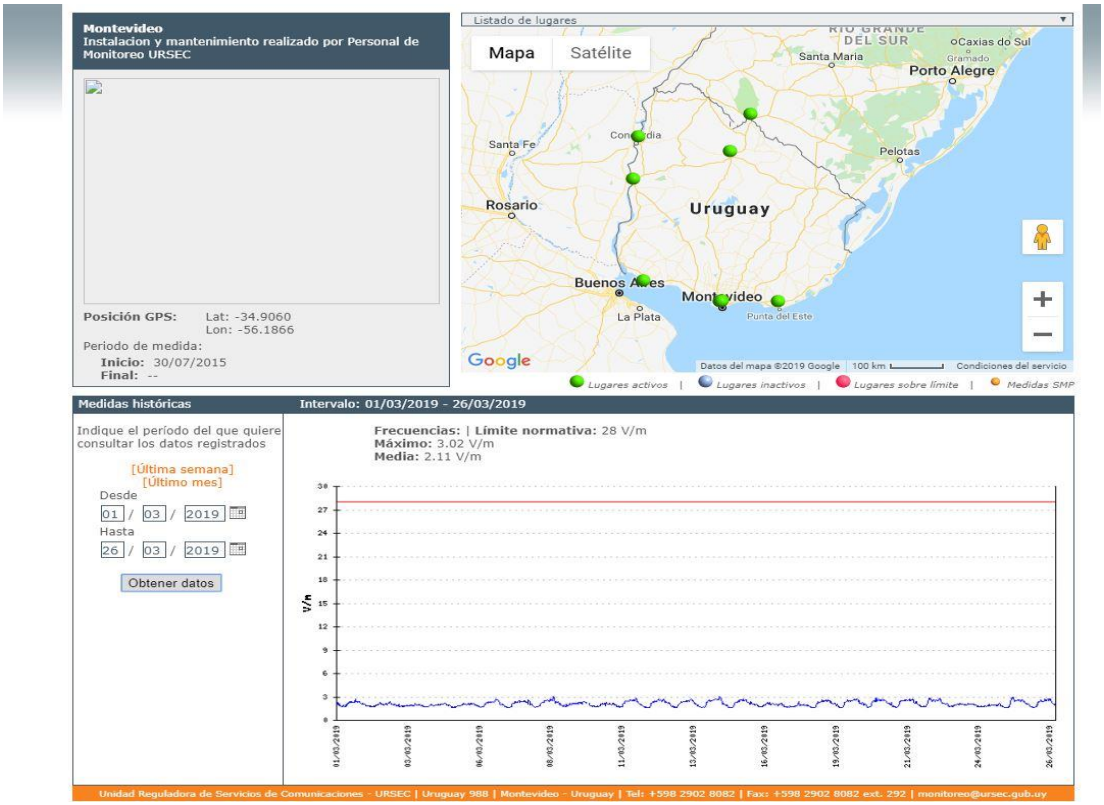


Figure II.8 – EMF monitoring system in Uruguay[3]

3 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

II.5 EMF monitoring system in Colombia

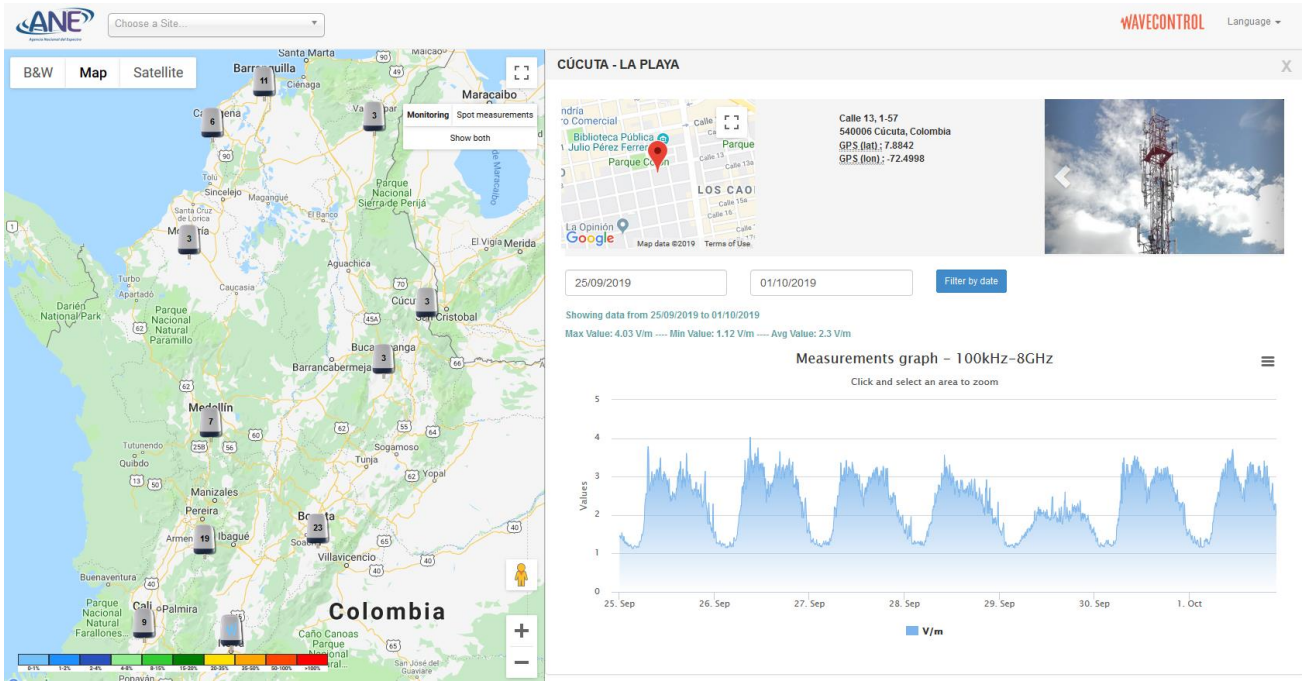


Figure II.9 – EMF monitoring system in Colombia[4]

II.6 EMF monitoring system in France

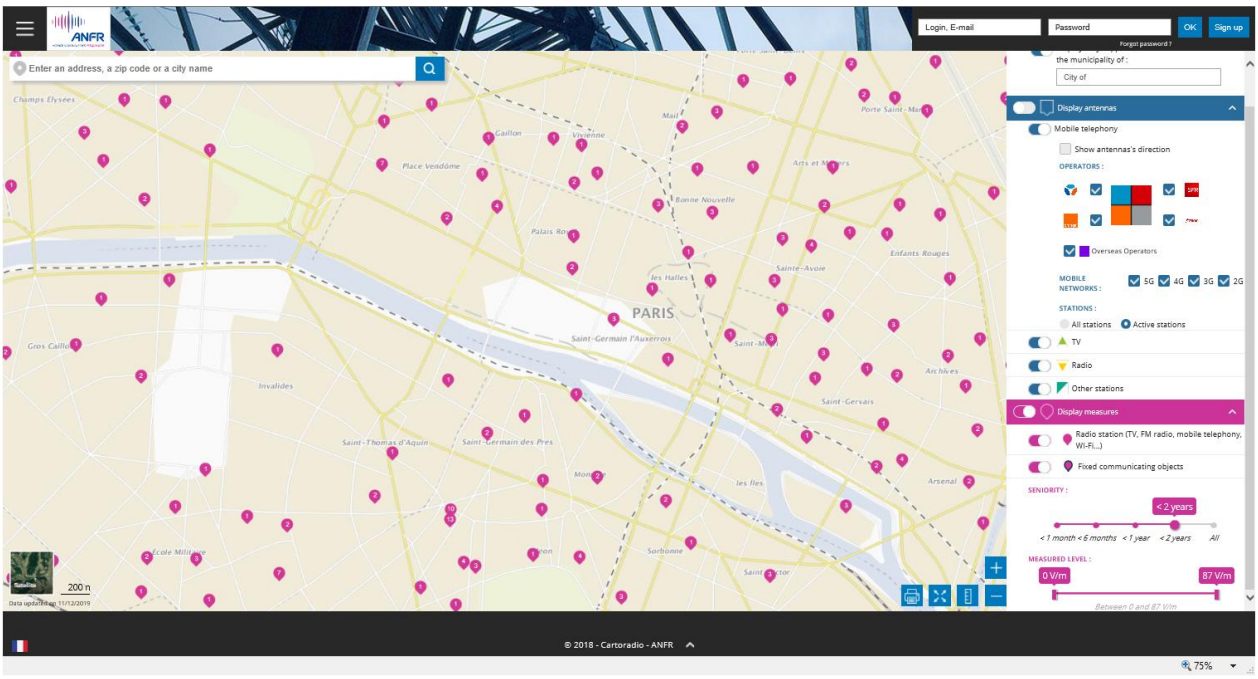


Figure II.10 – Screen with the location of the mobile base stations

4 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

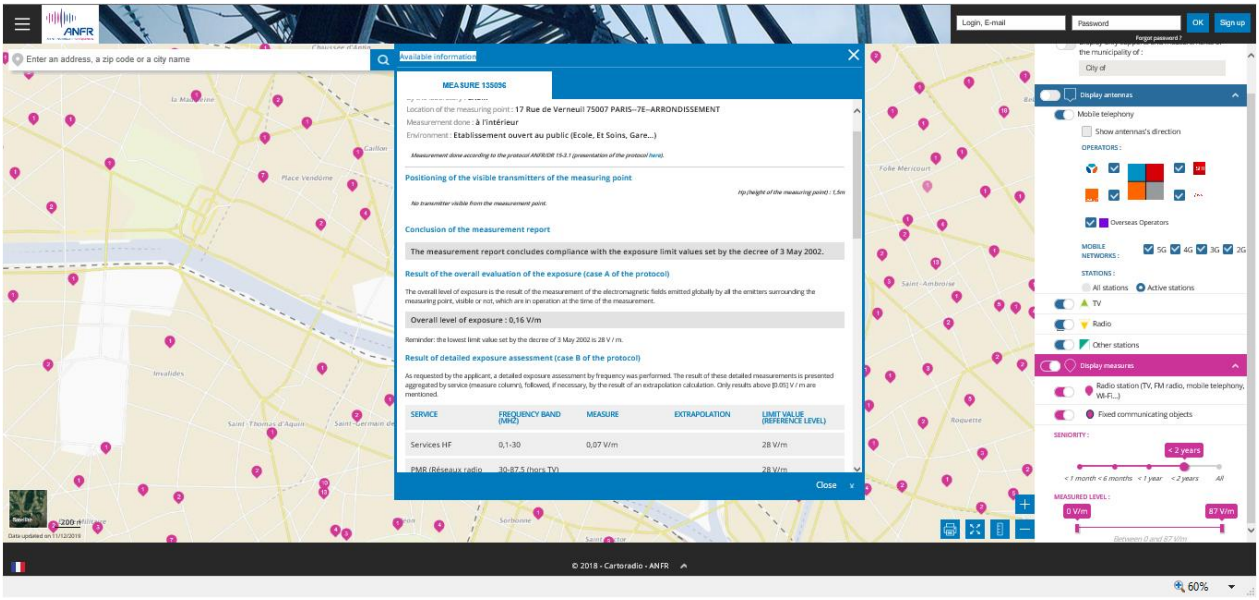


Figure II.11 – Example of the menu

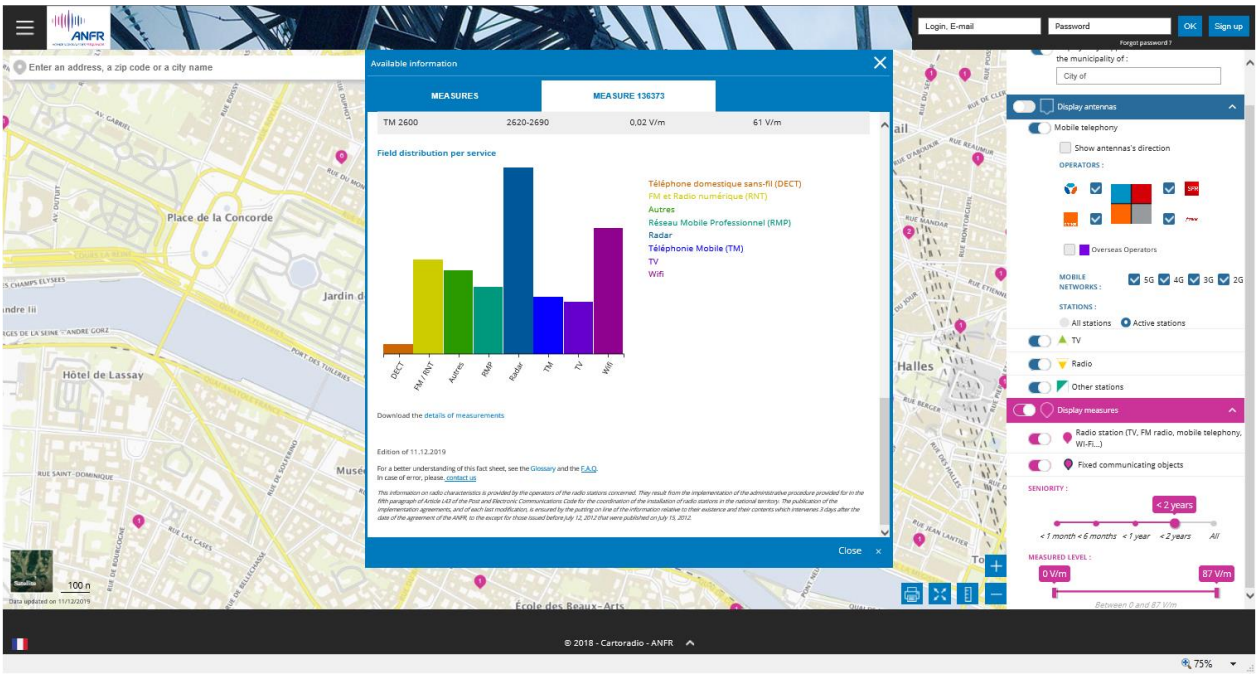


Figure II.12 – Example of the results of the EMF monitoring

II.7 EMF monitoring system in Greece

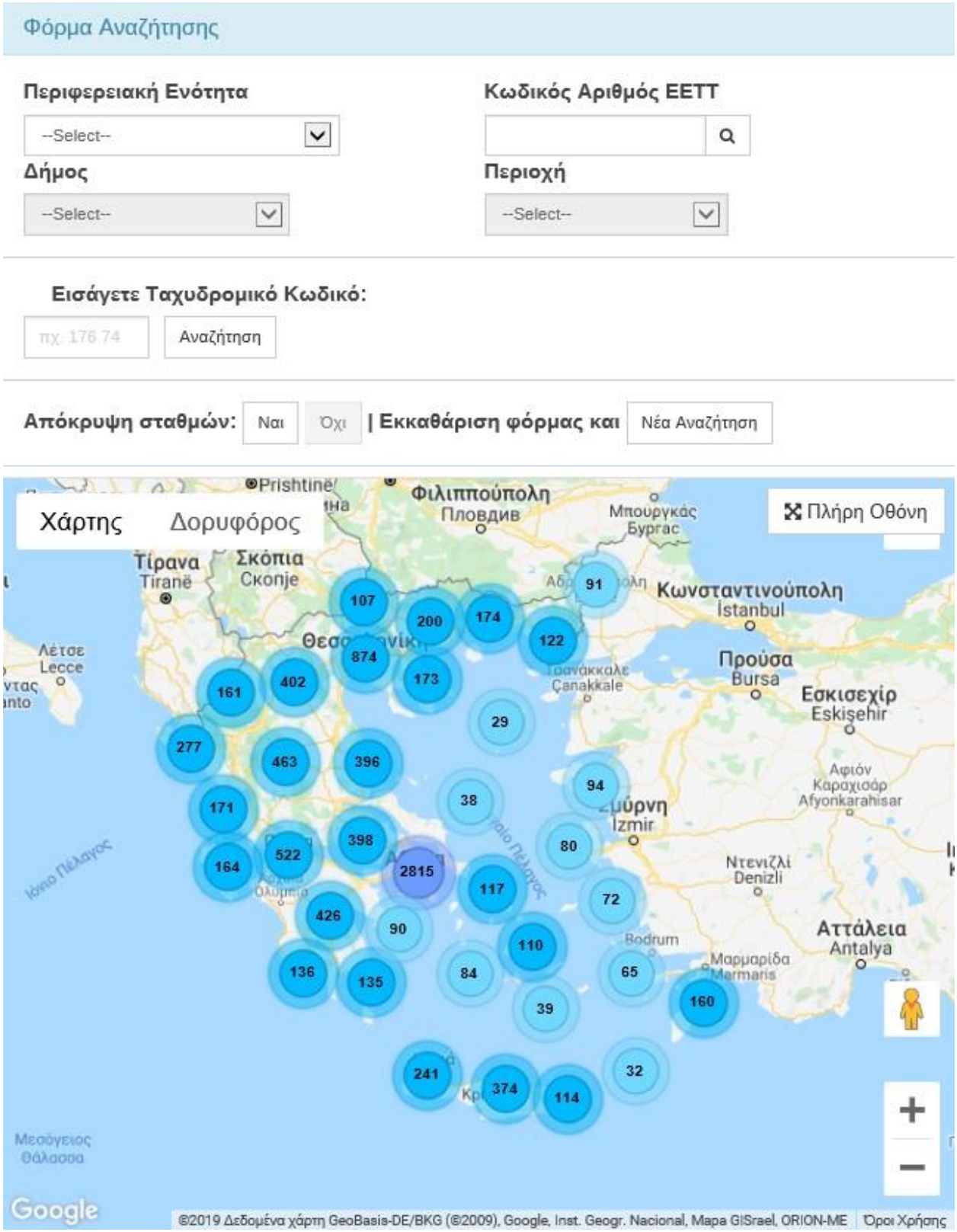


Figure II.13 – In situ measurement results available to the public[5]

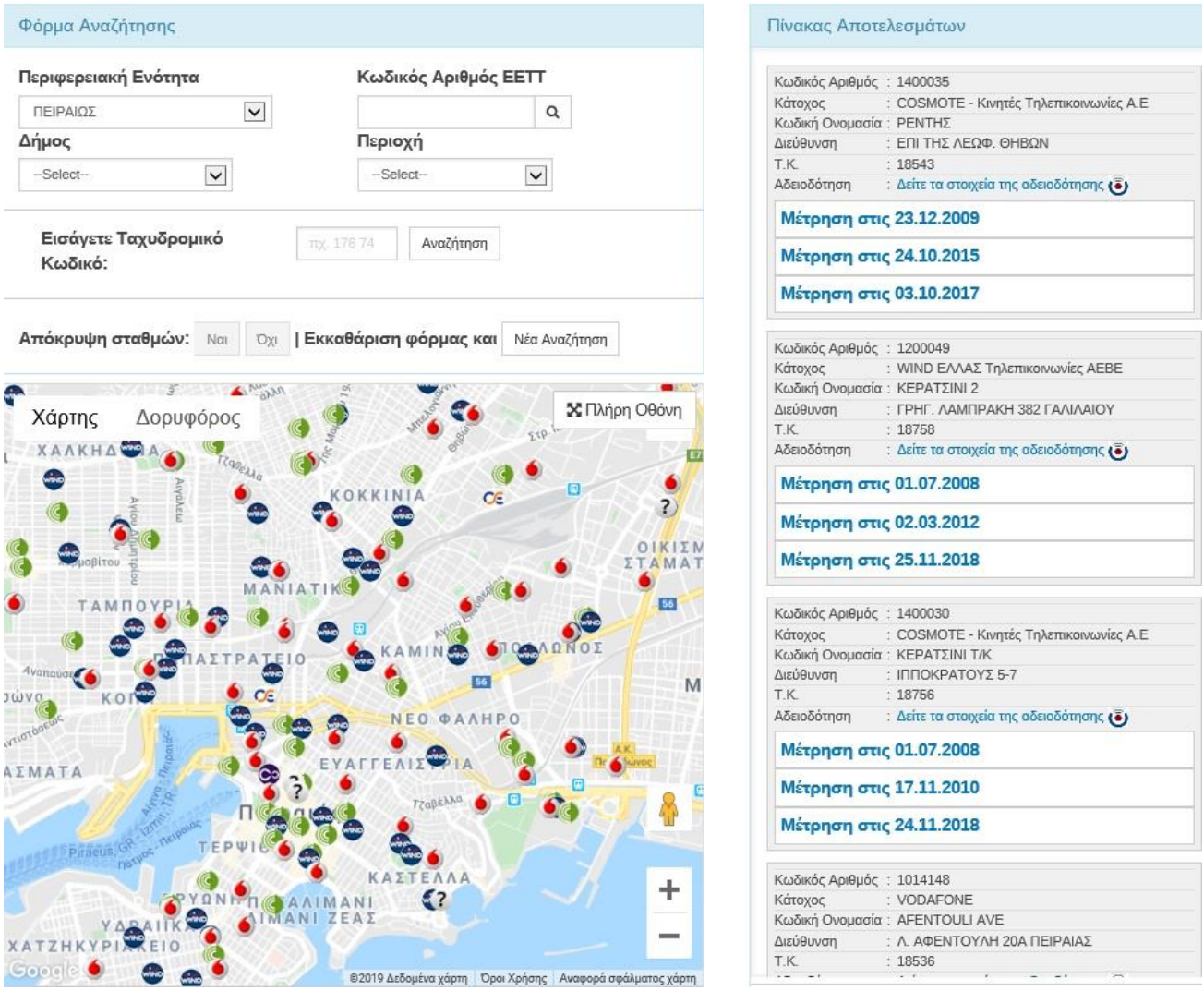


Figure II.14 – Map with location of the EMF sources

5 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

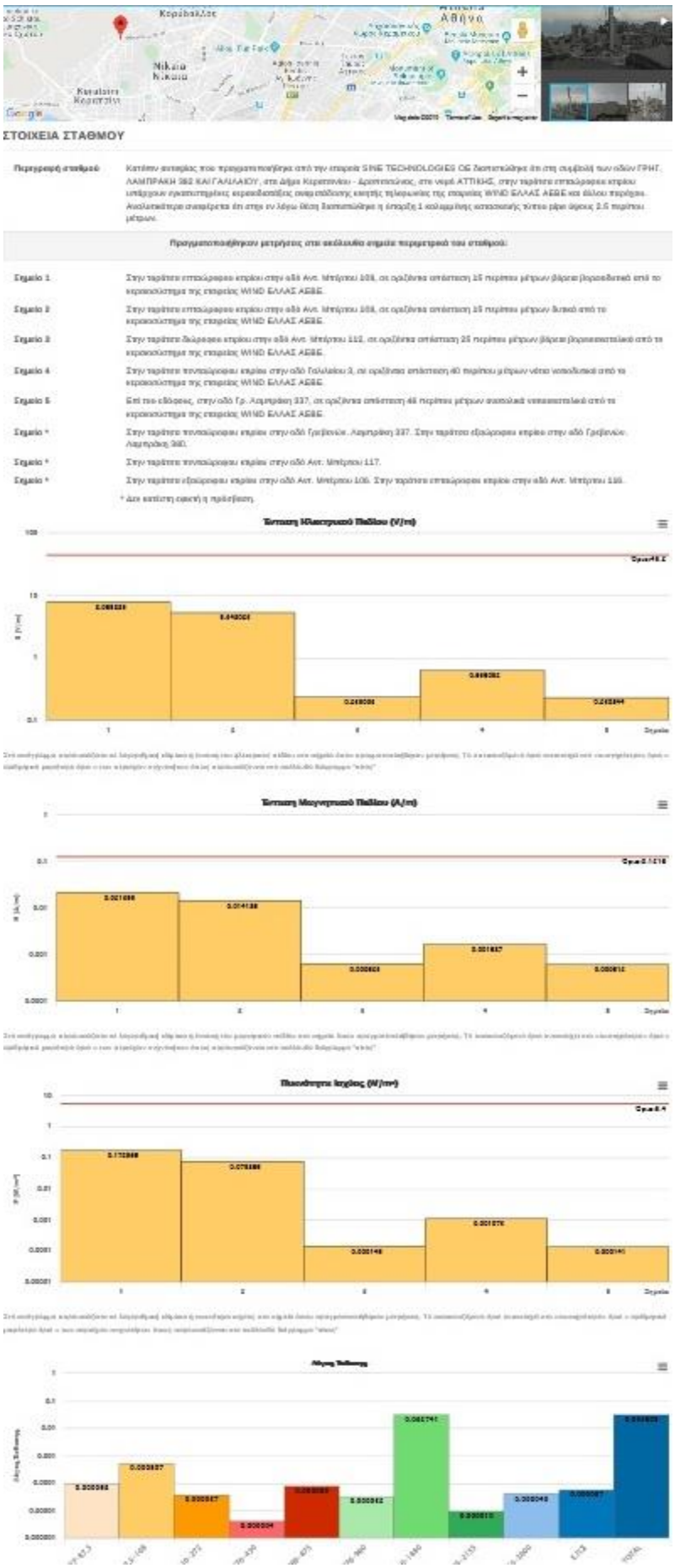


Figure II.15 – Results of EMF monitoring

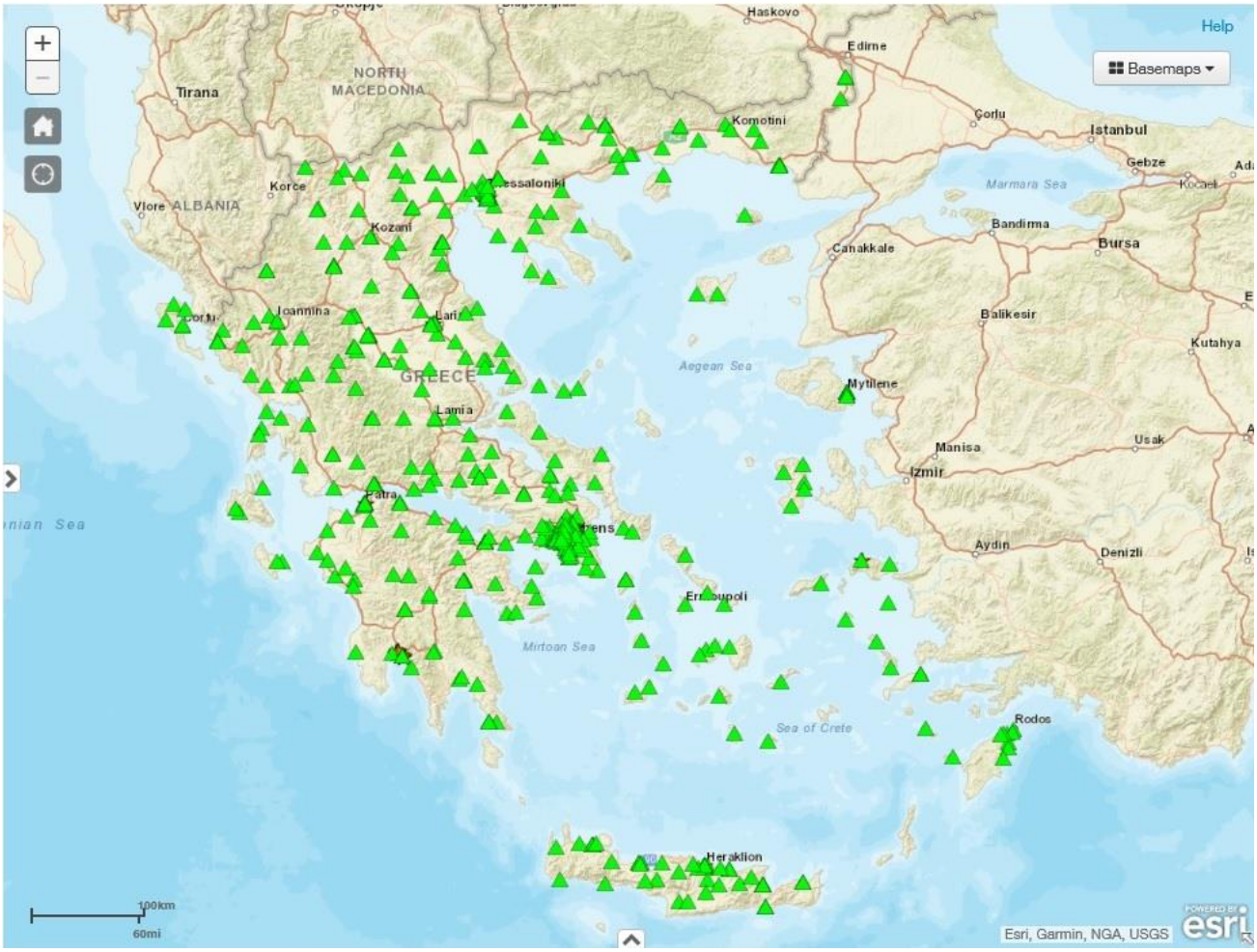


Figure II.16 – Location of the EMF measurement points[6]

6 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

Depot of Palaio Faliro Municipality

Station Location

Station Photos

Station Information	
Address	**Sokratous kai Ag. Petrou**
Municipality	**Palaiou Falirou**
Prefecture	**Notiou Tomea Athinon**
Active since	**22-09-2015 08:02:30**
Last update	**12-12-2019**
Measurement files captured by handheld device	Click here

Electric Field Strength			
Frequency Bands (MHz)	**Frequency Band Limit (V/m)***	**Average Value (V/m)**	**Peak Value (V/m)**
Broadband Zone	21.7	0.69	0.77
EGSM-900	31.8	0.11	0.12
EGSM-1800	45.1	0.14	0.17
UMTS	47.2	0.13	0.16

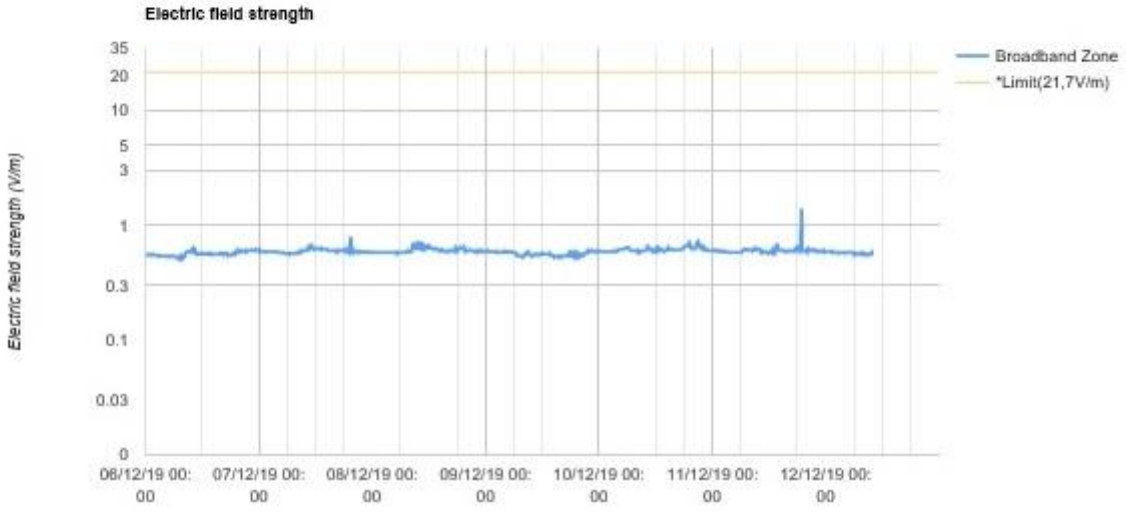


Figure II.17 – Results of the EMF measurement

II.8 EMF monitoring system in Italy

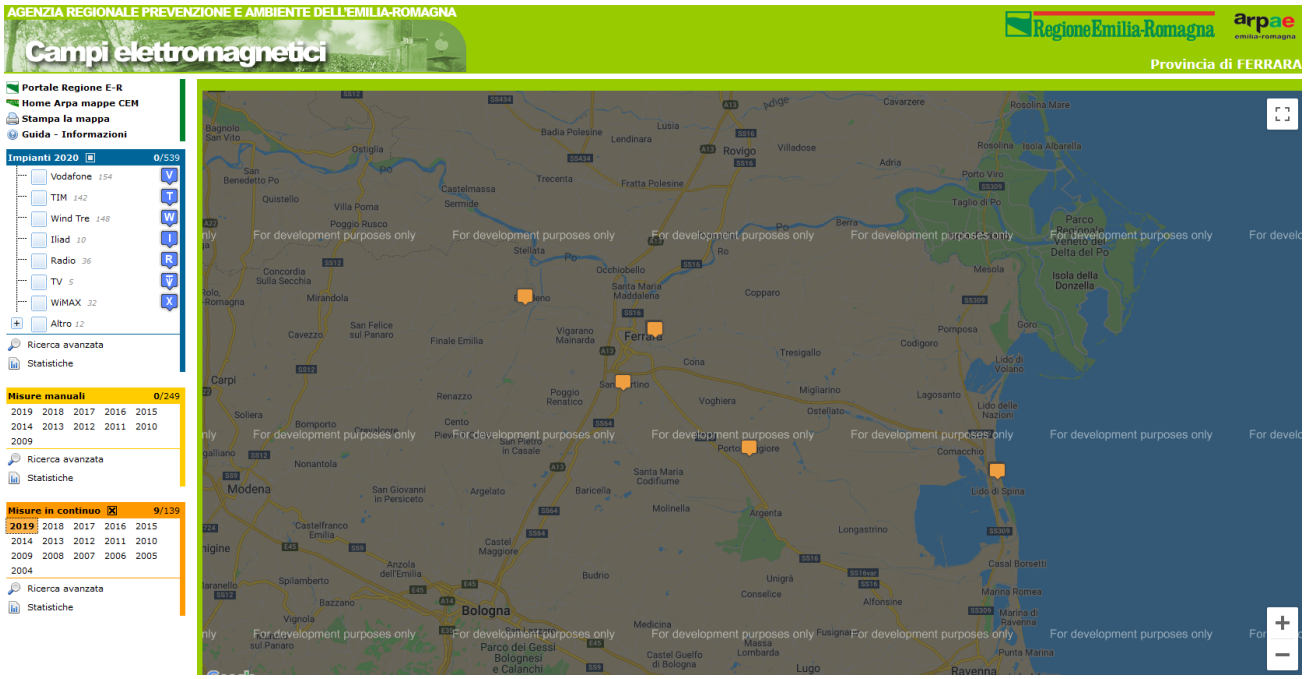


Figure II.18 – Main page of the system

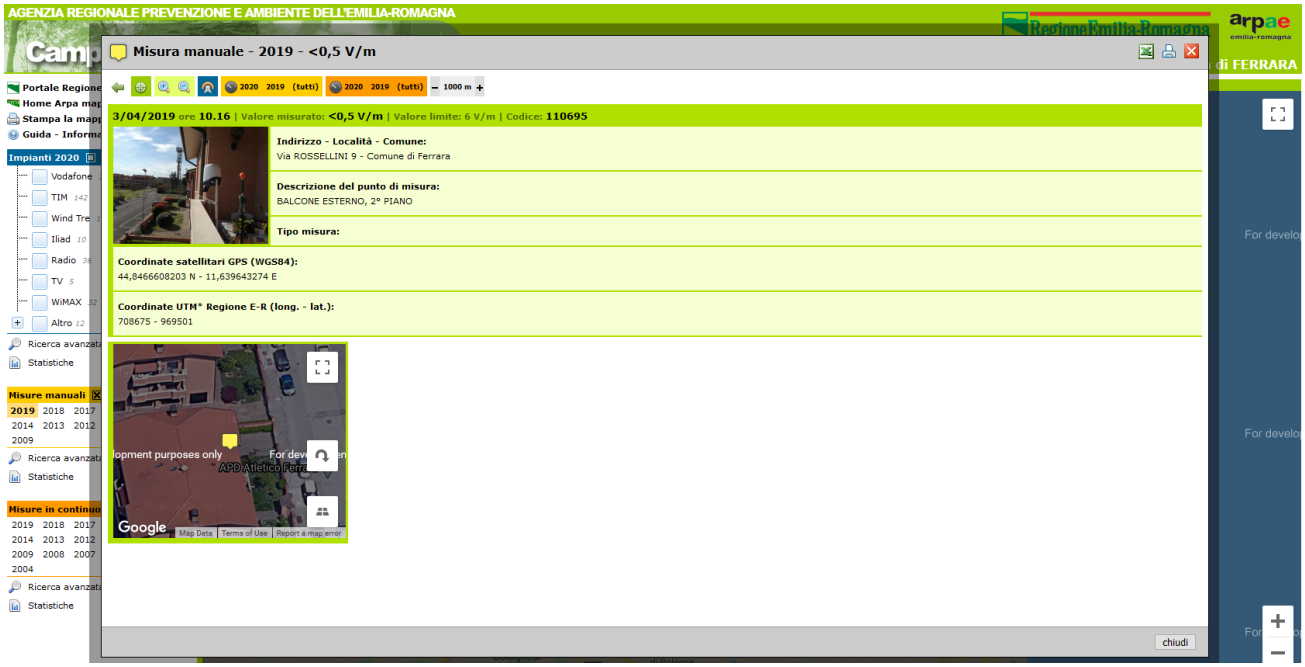


Figure II.19 – Example of the result of the measurement

II.9 EMF monitoring system in Catalonia (Spain)

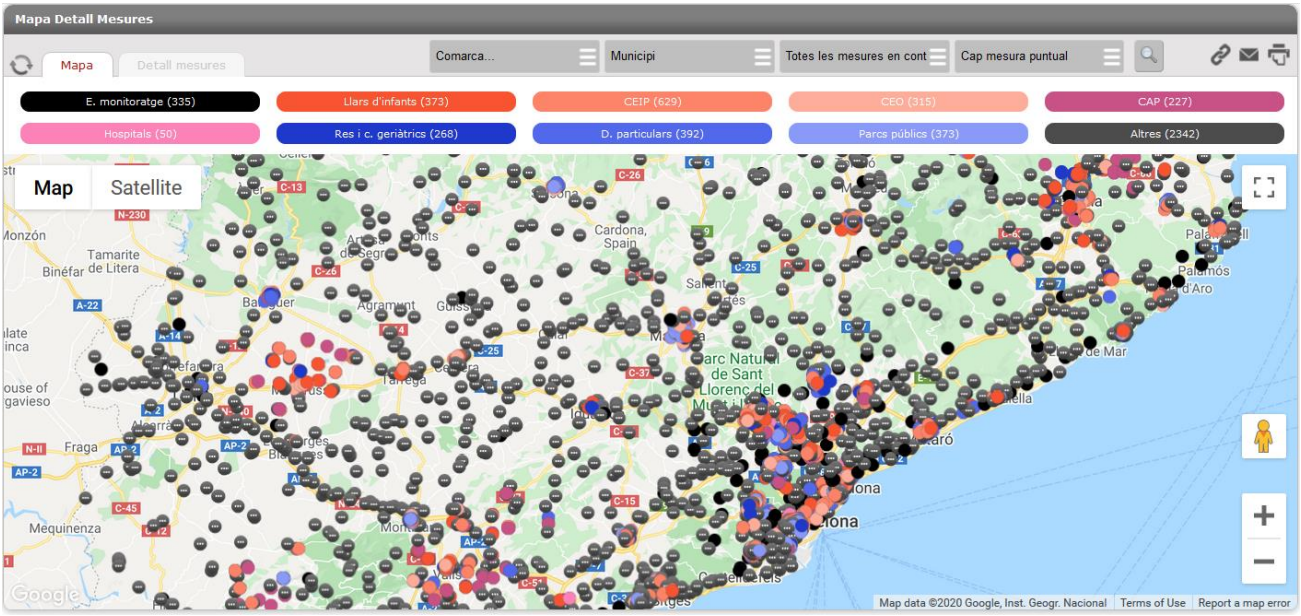


Figure II.20 – Main page of the system

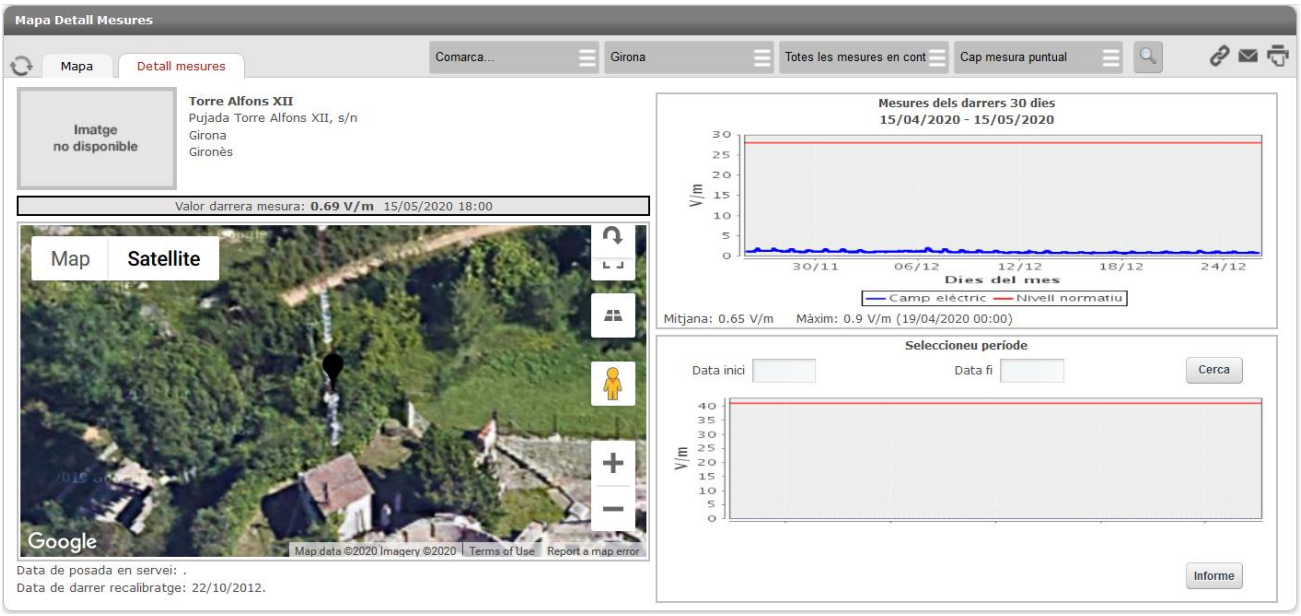


Figure II.21 – Example of the result of measurement

II.10 EMF monitoring system in Poland

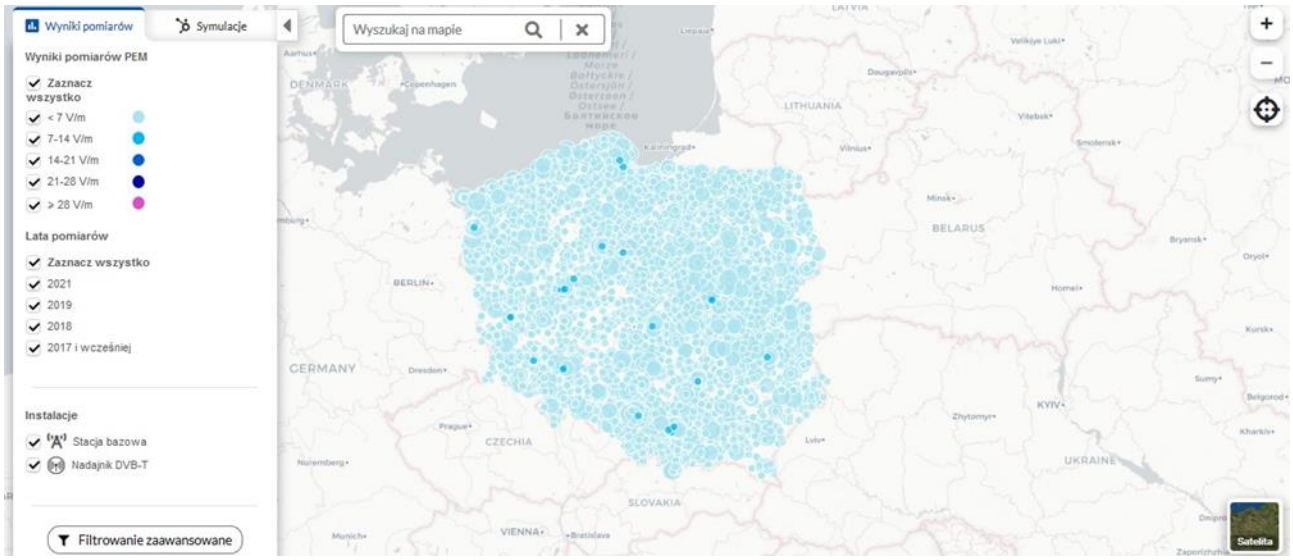


Figure II.22 – Main page of the system[7]

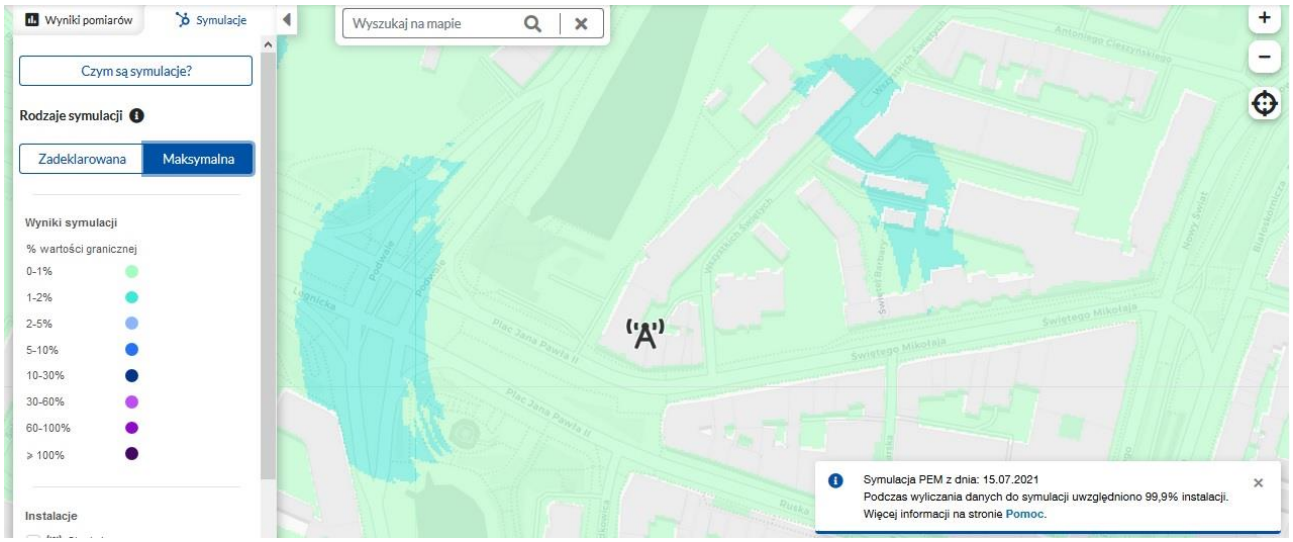


Figure II.23 – Example of the result of simulations of the FR EMF distribution

[7] The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

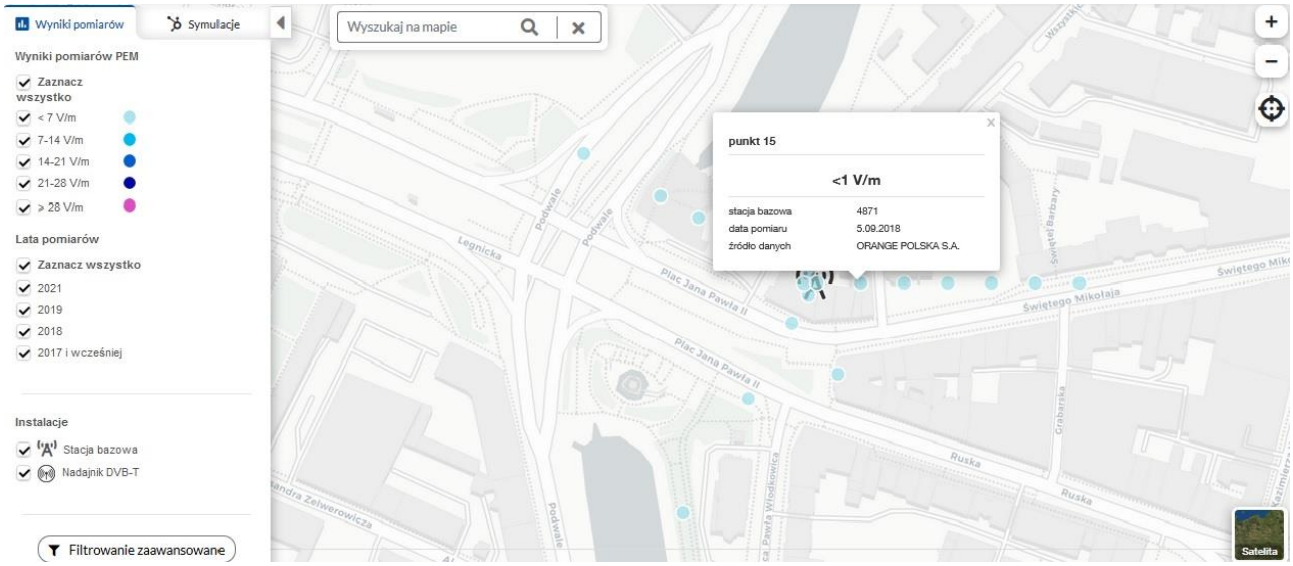


Figure II.24 – Example of the result of measurement

Appendix III

EMF monitoring and information platforms

(This appendix does not form an integral part of this Recommendation.)

III.1 System in Korea

III.1.1 Introduction

This appendix specifies the concept and method of an EMF exposure information platform to enhance general public awareness of EMF exposure status and usage data for the EMF related professional.

It provides technical system level guidance on how to provide EMF exposure level information for selected areas that are of interest to the general public. The purpose of this platform is to enable consistency of management by national regulators of EMF under their control and the national limits, and for providing EMF related data to professionals for the improvement of EMF policy and research.

III.1.2 EMF monitoring platform concept

The concept of an EMF information platform for the general public and its usage by experts is depicted in Figure III.1.

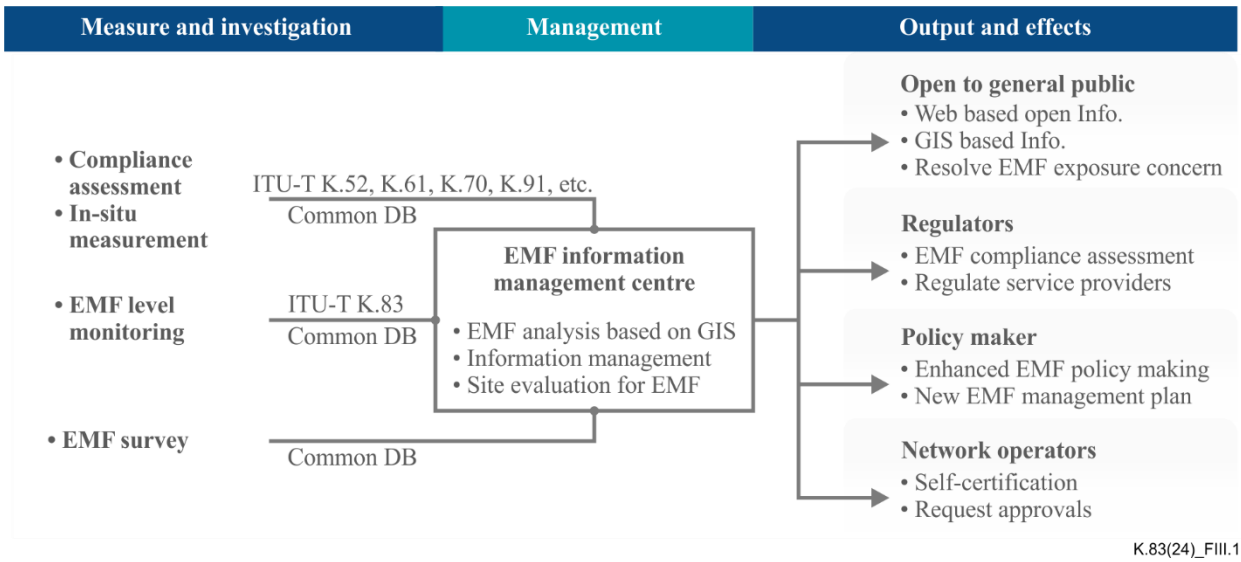


Figure III.1 – Concept of EMF information platform

All EMF related information collected and delivered to the information platform is open to various people as indicated in Figure III.1. The concept of an EMF information platform provides a user interface based on geographic information system (GIS) for an easy understanding and convenient access by the general public, industry, researchers and policy makers. All measured and collected data need to be in a common database format in order to be handled by the open platform. The platform has two types of data handling: the evaluated result and the measured raw data, which can be made accessible to professionals via an open application programming interface (API).

The detailed platform architecture consists of data collection, data classification, standard database, interactive system and data transaction with a user interface component. To avoid the difficulty of direct access to the platform server, a local database (DB) can be used, which would be synchronized with the common DB in the platform system. The general public can access the

system using a smartphone application (app) or web-based user interface (UI), or a dedicated UI for professionals.

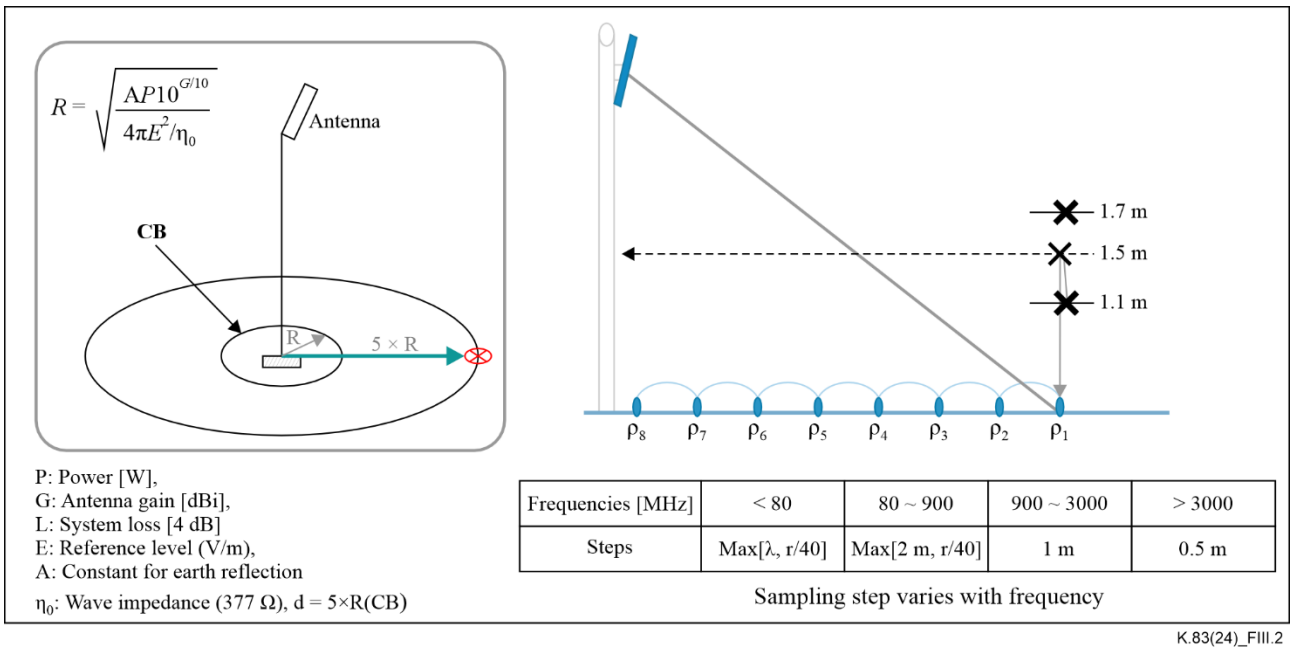
III.1.3 Data collection of RF EMF

III.1.3.1 Compliance assessment

– Measurement starting point: 5 times the distance from compliance boundary (CB);

– Step measurement at 1.5 m from the starting point to the antenna and 1.1 m, 1.5 m, 1.7 m at the maximum strength point (see Figure III.2);

  • sampling step varies with frequency, from the measurement starting point (5 × CB) to the nearest point accessible to the general public.



Frequencies [MHz]	< 80	80 ~ 900	900 ~ 3000	> 3000
Steps	Max[λ, r/40]	Max[2 m, r/40]	1 m	0.5 m

Figure III.2 – Example of Korea EMF compliance assessment

III.1.4 Broadband EMF area monitoring

See example in Figure III.3.

This Recommendation defines the methods that shall be used to determine the total exposure ratio (TER) over a certain period to perform a time-dependent evaluation of EMF exposure. The measurement is continuously and automatically carried out over the frequency range from 100 kHz to 3 GHz. Installation height is 1.5 m from the floor level.

The average measurements time is 6 minutes according to the national guideline. The measured data shall be transferred to a designated server or personal computer (PC) via wireless modem every day, or at another defined time interval.

The measurement equipment consists of:

– broadband probe based on diode detection;

– signal processing and system control unit;

– GPS and wireless communication module;

– solar power system and system protection.

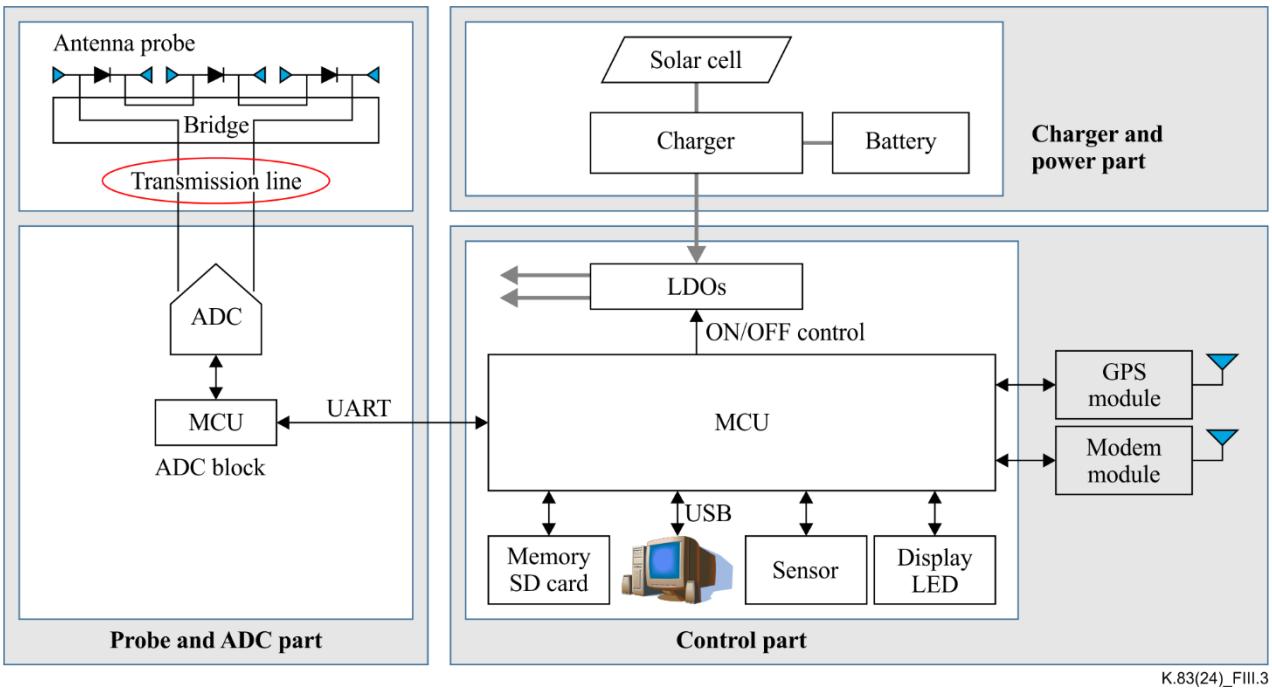


Figure III.3 – Example of broadband EMF area monitor block diagram

The measured data is the rms value of the electric field (see Figure III.4). This probe is tri-axial isotropic. The sampling rate is 1 second and the measurement interval is 6 minutes, as recommended in this Recommendation. The various sources are all measured with the broadband area monitor, but without identifying each source frequency. It is designed with Schottky diode detector generally. The result of broadband monitoring is the electric field strength variation along with time.

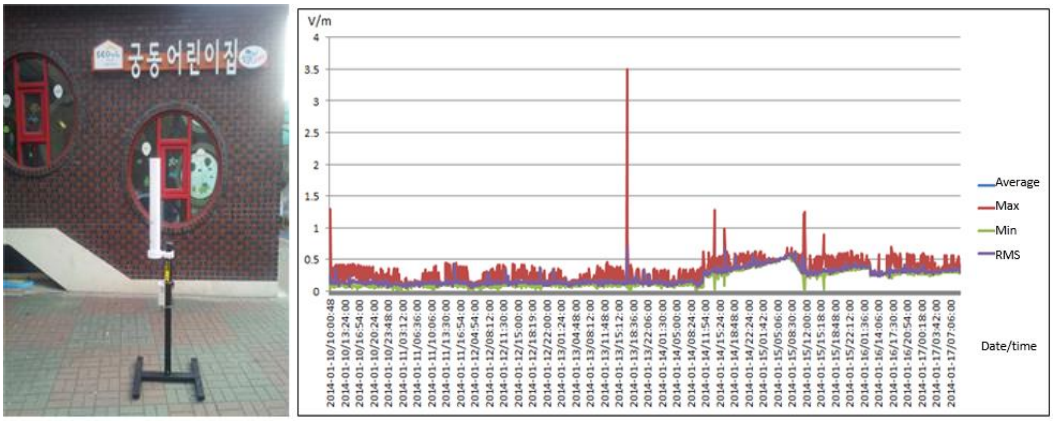


Figure III.4 – Example result of broadband EMF monitoring survey

The long-term measurement result is shown with location-based EMF monitor over time. The daily, weekly, monthly and yearly based statistics results are shown on the web or app on the smartphone.

III.1.5 Frequency selective EMF area monitoring

See Figures III.5 and III.6.

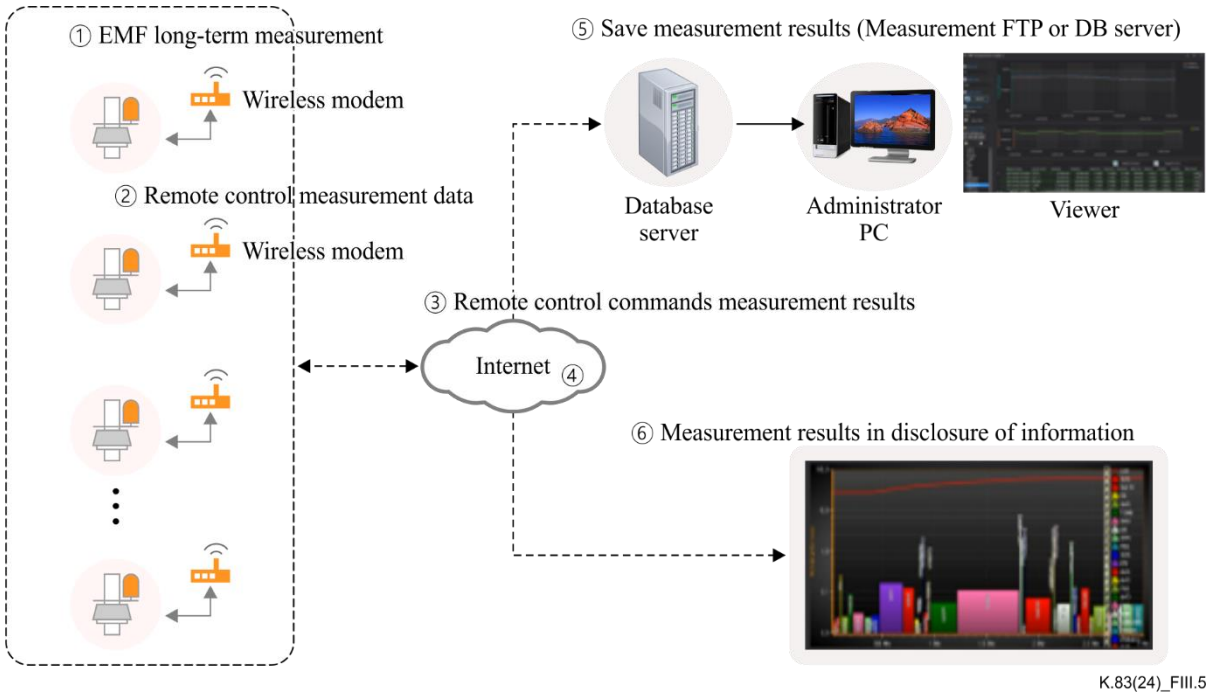


Figure III.5 – Concept of frequency selective EMF area monitoring

The frequency selective EMF area monitoring can be distributed at local sites of interest, measuring EMF strength continuously and sending data to the server via wireless modem. The results show each EMF strength value and percentage of limit for all frequency subranges in the chart with graphic results and level of variation over time (1, 2, 6, 15-minute intervals) for daily, weekly, monthly, yearly variation results.

The measurement equipment consists of the following parts:

– tri-axial isotropic probe;

– frequency selective measuring instrument, which processes the signal from the probe and indicates the value of the EM field quantity;

– measurement automation with GPS;

– mechanical and protective housing with solar power system.

The frequency subrange is the frequency bandwidth list or table in the instrument. The frequency ranges are listed as FM, TV, TRS, GSM, CDMA, WCDMA, LTE, Wi-Fi, etc., as an example.

The parameters (e.g., attenuation, preamplifier) for each subrange are adopted automatically during each cycle to achieve best possible sensitivity without signal distortion due to overload (e.g., in preamplifiers, mixers) from other emitters in the same or other sub bands.

The built-in spectrum analyser has a frequency range from 100 kHz to 6 GHz based on fast Fourier transform (FFT) scanning. The instrument has GPS for the location information, wireless modem to transmit the data to the server, and alarms for security, system status and over limit.

The measurement result consists of values obtained according to the measurement method and frequency subranges that fulfil the criteria as defined by the user, and which are stored as relevant emissions that are used for the TER calculation. As additional information, date, time, actual measurement position, ambient temperature and system status and warnings are added to the measurement results. This result is stored internally (offline evaluation) or transmitted automatically via data link to a server (online evaluation).

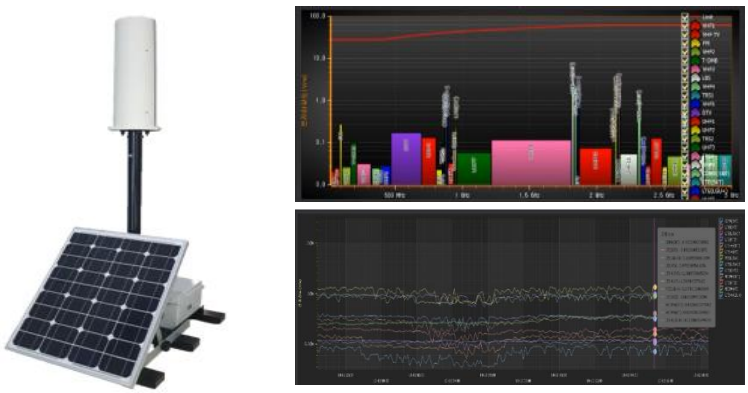


Figure III.6 – Example of frequency selective EMF area monitor with AGOS SDSM6000

III.1.6 EMF area scanning with vehicle

The EMF area scanning procedure starts with the measurement set-up and scenario, including scanning area and frequency subranges, as well as the target scanning area along with all loads as possible (see Figure III.7). The measured spectrum and electric field strength data is recorded at each coordinate and mapping on the commercial map. The measured results are expressed with colour dots that show electric field intensity.

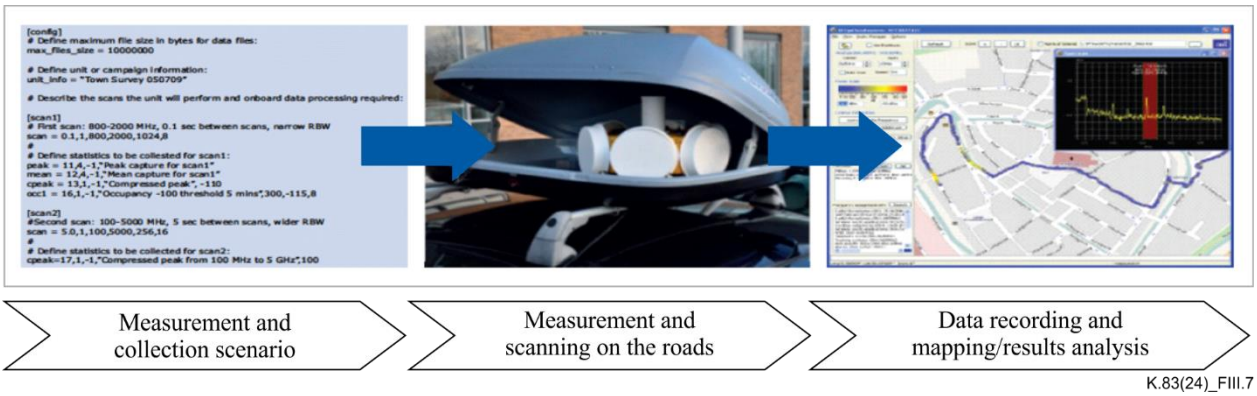


Figure III.7 – EMF area scanning process

For each sub-band, the maximum detectable level is at least the limit value. The minimum detectable level is required in case no emissions above the threshold value are present. It can be achieved with adopted settings of e.g., attenuation, bandwidth. An instantaneous dynamic range of 60 dB must be achieved for each level setting. Any other signal present in any other subrange and bigger than 25% or at least 3 MHz off the measurement frequency, must cause no overload or measurement error, if its field strength is below the exposure limit.

Scanned and measured data need to be uploaded to the DB server for area analysis with huge amount of data. This database needs to be built for the measured electric field strength to generate analysis of exposure ratio and power density based on geographic information.

The measurement equipment consists of the following parts (see Figure III.8):

– measurement probe;
– frequency selective measuring instrument, which processes the signal from the probe and indicates the value of the EM field quantity;
– measurement automation;
– mechanical and protective housing.

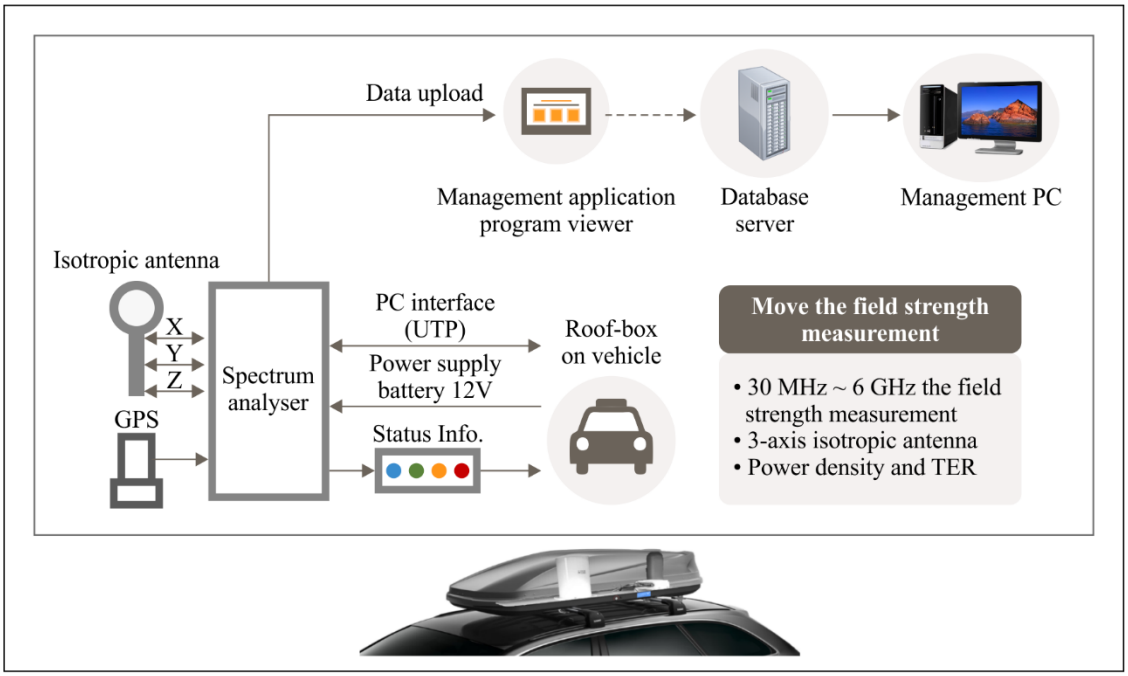


Figure III.8 – Example of EMF area scanning system

For the EMF mobile measurement, all measuring parts need to be installed in the roof-box on the vehicle to protect against outside environmental impacts such as dust, rain and vibration. The measurement and scanning control shall monitor the system status and measuring status with auto script which be made in scanning scenario automatically. The measured data shall be saved to the internal memory with every 1 second GPS interval.

Each measured pixel is a small square area which can be decided with vehicle moving speed and GPS data update rate. Thus, 1 degree of coordinate is the basic resolution unit of the scanning data. The size of the pixel is 24.6 m for the longitude and 30.8 m for the latitude in grid mapping.

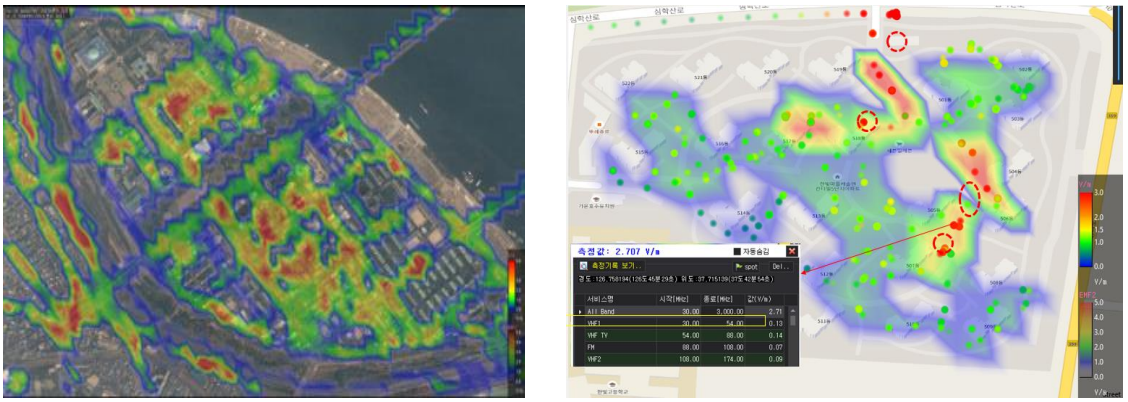


Figure III.9 – Example of GIS-based scanning results

Mapping data shows the high points of electric field strength or power density. In the picture at the right of Figure III.9, the red dots are wireless repeaters or mobile base stations.

III.1.7 Information platform for the general public and experts

Web based information

See case in Figure III.10.

All possible information about how the measurements are taken is provided:

– measurement location (by its geographical positioning on a map);
– description of the measurement site;
– date and time;
– description of the measurement method: broadband, frequency selective, average time, position of the probe, etc;
– identification of the measurement equipment;
– record of calibration details for any instruments used;
– identification of who has done the assessment;
– record of when and where the assessment was performed;
– record of the relevant sources considered and associated parameters.

GIS based interface method

The current measuring device shows all the information of the related system and the results of EMF strength values in the area of interest. Measured points are also shown using various charts that include daily, weekly, monthly, yearly based results statistics.

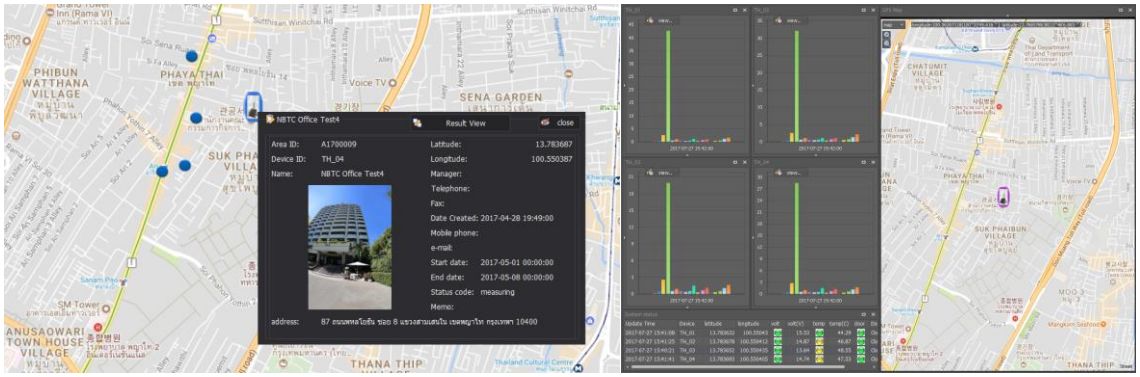
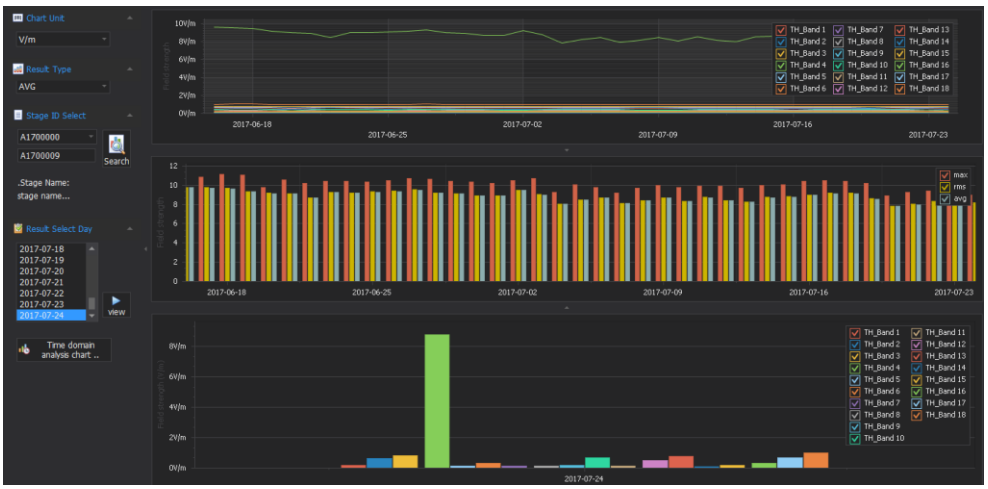


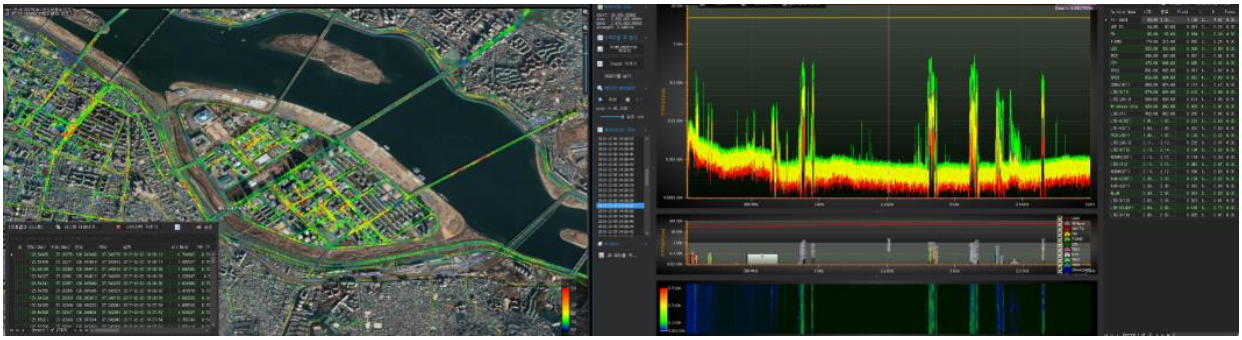
Figure III.10 – Web-based general public access view (Thailand NBTC & Korea: KCA)

Statistics analysis

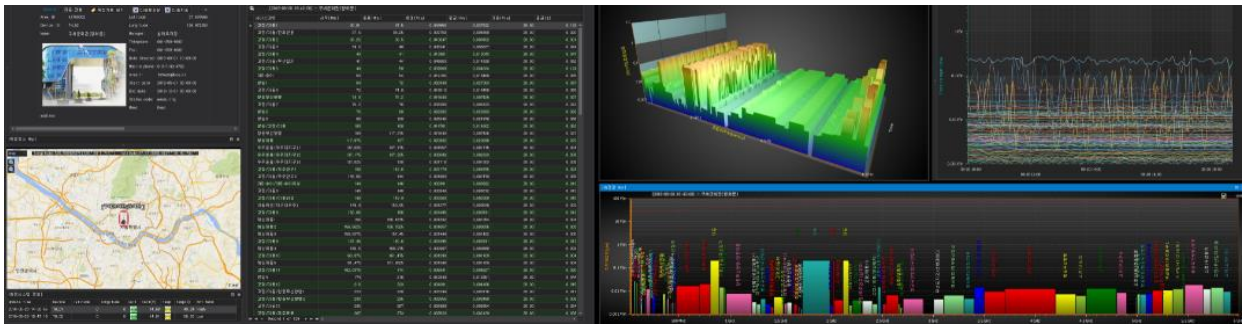
The results are provided as the time chart, bar chart, each frequency subranges chart for better understanding to general public. See Figure III.11.



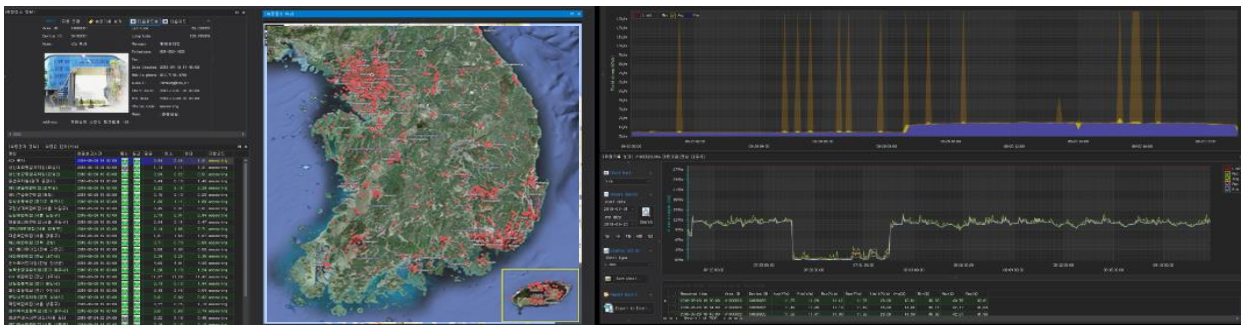
(a) EMF time variation analysis (Thailand NBTC & Korea: KCA)



(b) EMF area scanning result analysis (Korea Communication Agency)



(c) Frequency selective EMF monitoring analysis (Korea Communication Agency)



(d) National wide management analysis (Korea Communication Agency)

Figure III.11 – Example of views of the analysis results

III.2 System in India

III.2.1 Electromagnetic field from mobile communications base stations – Monitoring, compliance and public awareness mechanism

Approach for making a sustainable compliance tool for the current regulations prescribed by the Government of India.

This clause describes an approach that was taken to make compliance of the EMF emission exposure norms more robust and sustainable. This has helped in creating transparency and accountability for all stakeholders i.e., the government, service provider and the general public.

III.2.2 Introduction

A web-based portal called Tarang Sanchar hosts a central database which serves as a common repository for all the cellular base stations, along with their geolocation, deployed in India. This database and the associated web-portal serves a number of purposes which facilitate adherence to the EMF exposure norms in India. It provides a platform for the telecom service providers to ensure compliance to EMF exposure norms through self-certification of their telecom installations, and also to the Government for record-keeping and assessment of this self-certification data related to compliance of EMF exposure norms. It further offers the general public a transparent medium to understand the EMF exposure norms where they can also check the status of EMF exposure compliance of a telecom site in their vicinity. The general public can also request a measurement of EMF exposure from the government at a location of their choice by placing a request on this portal. Tarang Sanchar has been aimed to facilitate awareness, reduce distrust and rejection caused by imperceptibility and low understanding of EMF exposure among the population, which ultimately results in social conflicts and leads to delays in the deployment of new wireless technologies. It has further streamlined the EMF exposure compliance process through adoption of environment friendly, modern, efficient and cost saving processes.

As Tarang Sanchar has digitized the conformance process of EMF exposure norms and is used for online submission of self-certificates with respect to all cellular base stations, it always carries updated information of all the base stations and ensures track of EMF compliance at all times. The portal, thus offers a simple and convenient means to the government as well as telecom service providers for access to any kind of database/information about telecom site compliance to EMF exposure norms.

III.2.3 Background

The EMF norms for exposure adopted in India are $1/10^{th}$ of ICNIRP Standard. TEC, the technical wing of Department of Telecommunications, Government of India has published a test procedure document for compliance to EMF exposure norms which is used by service providers for self-certification as well as audit and monitoring by the field units of the Government.

This test procedure is based on [b-ITU-T K.52], [b-ITU-T K.61], and [b-ITU-T K.100].

The main aim of the test procedure is to ensure the compliance of base station to EMF exposure norms. Key highlights are:

III.2.3.1 All existing base stations to be compliant to EMF exposure as per 1/10th value of ICNIRP.

III.2.3.2 Self-certification to be submitted to the government.

III.2.3.3 Field surveys and certification to be renewed on a biennial basis.

III.2.3.4 All new base station sites to start emitting only after a self-certificate is submitted.

III.2.3.5 The concerned field units of the government to conduct up to a certain defined percentage of random audit of all base stations.

III.2.3.6 Provision for penalty in case of non-compliance to the EMF exposure norms of the government.

III.2.3.7 In the event of any change / upgrade (pertaining only to change in antenna, antenna height, electrical/mechanical tilt, azimuth, increase in TRX channels) of the base station (BTS), fresh self-certification may be required.

III.2.3.8 In order to ensure co-ordination and shared responsibility of the service providers with respect to conformance to EMF exposure norms, the concept of responsibility of service providers at shared sites has been prescribed:

a) A shared site may be defined as having:
   i. Responsibility for EMF multiple towers on the same or different plots within 20 m radius.
   ii. Multiple roof top poles on a BTS site/adjacent building within 20 meter radius.

b) Compliance of shared site shall lie with all the participating telecom service providers (TSPs).

c) Placement of signage at shared site will also be joint responsibility of all the participating TSPs.

d) For self-certification of shared sites, participating TSPs will also separately issue self-certification of their individual BTS.

e) In case of overall non-compliance of shared site, penalty shall be imposed on all participating TSPs.

The test procedure for compliance to EMF exposure norms is revised by the government from time to time to incorporate changes related to EMF measurement with respect to different mobile technologies as per the latest ITU standards like [b-ITU K.52], [b-ITU-T K.61], [b-ITU-T K.100] and [IEC 62232]. The current Test Procedure applicable is at https://tec.gov.in/pdf/TSTP/TEC%2013019_2021EMF%20Std.pdf .

III.2.4 Concerns of stakeholders in the EMF compliance procedure

III.2.4.1 Multiplicity of TSPs, lack of a common platform enabling them to share 100% of the data of standalone and also the shared sites, standardized documentation.

III.2.4.2 Timely sharing of data amongst TSPs was a major challenge resulting in delayed submission of self-certificates. Required considerable efforts, paperwork and duplication of reporting requirements.

III.2.4.3 Need to mitigate public concerns against compliance to EMF exposure norms. Creation of common platform for public information relating to EMF exposure.

III.2.4.4 Need for a standardized online process pan India to be followed by all TSPs and field units of the Government to monitor and enforce compliance to EMF exposure norms.

III.2.5 Solution: Web-based portal for EMF compliance, monitoring and public awareness

Implementation of the concept of shared responsibility by all TSPs to ensure compliance to EMF norms at the shared sites it was realized that the TSPs were facing considerable problem in sharing all the data amongst them due to the size and scale of the procedural requirements of sharing data particularly on shared sites. In terms of scale this required the data of more than 1,700,000 base stations (as of the date of publication) of all the public and private telecom TSPs spread all over the country to be collated.

The scale and volume of the exercise can be judged pictorially from the map given below. The map (see Figure III.12) below depicts the vast population in India that the telecom TSPs need to cover. India is divided into 22 telecom circles. The map amply highlights that each of the telecom circles is equivalent to the population of a country in the world and hence needs to be treated in that manner, which is a massive task. For example, How big is Uttar Pradesh, India's most populous state? One

way of answering the question is to take its total area: 95,000 square miles (246,000 sq. km). Another way is to think of it as a country (e.g., Brazil).

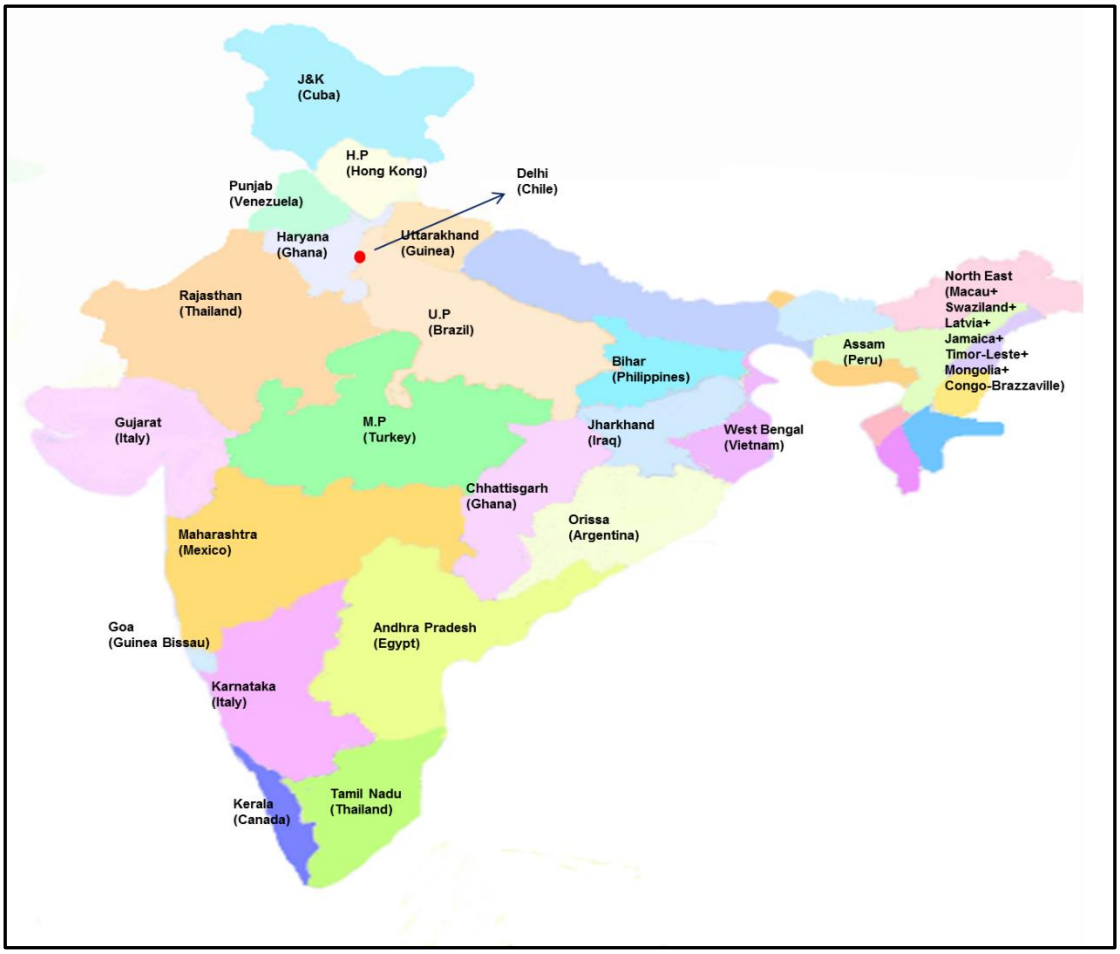


Figure III.12 – Comparison of Indian states with countries of equivalent population[8]

Source: http://www.economist.com/content/indian-summary

A complete online, standardized, common platform which is convenient for use by all three segments – Public, TSPs and the Government. This enables paperless documentation and uses digital certification for authentication and submission of self-certificates, for ensuring compliance to EMF exposure norms, that are auditable.

Thus, a need was felt to have an exhaustive and comprehensive database of all the cellular base stations being deployed by the Telecom service providers in order to have better accuracy, timely sharing of information related to operational parameters of base stations amongst TSPs and eliminating other in-efficiencies of self-certificate submission and procedures for EMF exposure compliance requirements.

8 The designations employed and the presentation of material of maps included in this appendix do not imply the expression of any opinion whatsoever on the part of ITU and of the Secretariat of the ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

The entire telecom service provider industry along with the Government prepared a proper scope of work (SoW) to achieve the objectives through a web portal incorporating the regulatory processes and technical procedures prescribed by the government and accordingly the portal, which was named Tarang Sanchar, was implemented.

The broad highlights of the Tarang Sanchar Portal are:

a) A common database that holds pan-India base station site portfolio based on data provided by the TSPs.

b) Each TSP has exclusive control on site tenancies and RF technical parameters.

c) There are workflows for ensuring site EMF compliance through site surveys, broadband/frequency selective measurement tests.

d) New sites and site upgrades are streamlined by the Portal to achieve higher efficiencies and exploit synergies of a common database.

e) Significant reduction in the efforts and costs spent on compliance individually by each operator.

f) Standardized paperless implementation.

III.2.6 EMF exposure calculation

The basis of this calculation is [b-ITU-T K.61] and the government guidelines which are prescribed in the government's test procedure document . This provides guidance on:

a) Defines a set of reference antenna parameters or antenna types. These categories can be customized to the types of emitters used for the particular application.

b) Defines a set of accessibility conditions. These categories depend on the accessibility of various areas in the proximity of the emitter to people. These categories can be customized to the most commonly occurring installation environment for the particular service or application.

c) For each combination of reference antenna parameters and accessibility condition, determine the threshold *EIRP*. This threshold *EIRP*, which will be denoted as $EIRP_{th}$, is the value that corresponds to the exposure limit for the power density or field from the reference antenna for the accessibility condition. The formulae for calculation of $EIRP_{th}$ have been referred from the ITU-T recommendations and have been suitably adapted to incorporate the 1/10-th of ICNIRP EMF exposure limits.

d) For each site, an installation belongs to the normally compliant class, if the following criterion is fulfilled:

$$\sum_i \frac{EIRP_i}{EIRP_{th,i}} \leq 1$$

e) where $EIRP_i$ is the temporal averaged radiated power of the antenna at a particular frequency *i*, and EIRPth,i is the *EIRP* threshold relevant to the particular antenna parameters and accessibility conditions.

III.2.7 Architecture of the Tarang Sanchar portal

IIII.2.7.1 The Tarang Sanchar portal has been designed to have three different role-based interfaces. One for the general public to be informed of the EMF norms and the compliance status of telecom base station sites near them, second for the telecom service providers to manage the submission of self-certificates for compliance to EMF exposure norms, and third for the government for assessing and auditing the self-certificates and ensuring compliance to EMF exposure norms.

III.2.7.2 There is a public interface of the portal, which is hosted in a cloud. The common database-based stakeholder portal interface is hosted in a data centre. A dedicated and daily-twice updated database is used for the public interface.

III.2.7.3 For general public, the public window of the Tarang Sanchar portal offers the latest news and research articles that are related to EMF exposure. In addition, a user-friendly Google map-based site finder feature that works on pin code or street name-based search and show towers and their EMF compliance status.

III.2.7.4 For the field units of the DoT, the portal offers user accounts for accessing Site Finder, Send a Query and EMF Report Viewer/Bulk Download features. Site Finder feature offered to the government will include additional options like searching on an TSPs or infra provider's site Id. A unique BTS identity has been devised to indicate comprehensively the BTS features. Development of Tarang Sanchar has necessitated for the standardization of a unique numbering system for each BTS and its associated certifications.

The coding is as below, which is an aggregation of ten different parameters:

- LSA/SSA/IP ID/IP Site No./SP/RF Band/Technology/SP BTS No./ToS/DDMMYYYY.
- LSA: Licensed service area
- SSA: Secondary switching area
- IP: Infrastructure provider
- SP: Service provider, other than TSP and ISP
- RF: Radio frequency
- ToS: Type of submission

III.2.7.5 For the TSPs, the approach followed by the portal will be:

a. Site master database will be created
b. All tenancies will be registered
c. Site RF Parameters by BTS are configured for each tenant
d. All Self certificates, broadband and selective frequency reports are mapped and loaded into the database
e. Create a picture pack album for a site
f. $EIRP_{th}$ calculations are run on all sites

III.2.7.6 The functionality for the TSPs would include:

g. Add a New Site
h. Search Site Database
i. View Site Database
j. Register as Anchor
k. Tenant Register as Shared Tenant (Upgradation)
l. Remove a Tenancy
m. View Sites on GIS
n. Edit Site Details
o. Downloadable Reports of Site Database
p. Manage Site Database
q. Version Controlled Site Master Database
r. Support What-If Analysis
s. 20 m Adjacent Tower Situation

III.2.8 Web-view of the Tarang Sanchar portal

III.2.8.1 The Tarang Sanchar portal has three primary modules to address the needs of different segment of users viz. public, government and the telecom service providers (TSPs).

III.2.8.2 Public interface module: Given below is the home page of the public portal, where people can get information related to EMF through FAQs, research articles, Government initiatives, etc. People can also locate towers in their area by entering details. (see Figure III.13). The EMF portal has been designed to provide a public interface for viewing the EMF compliance status of any mobile towers in India. Public can also request for testing of EMF emission against payment of requisite fee. Details of sites recently tested by the field units of the government are also displayed to the public.

Figure III.13 – Public window: Homepage

III.2.8.3 Once a person enters the details of the location, where they want to check the EMF exposure levels, 47hey can see the map with the towers marked in that area. By clicking on the site, they want to check, a box will open with certain technical details of the TSPs present on the site. It also shows whether the site is EMF compliant or not (see Figure III.14 and Figure III.15). Additional information about the site can also be requested. This information will be mailed in the format shown in Figure III.15.

III.2.8.4 As a major transparency measure, any citizen who is interested in the measurement of EMF levels of any site, can request them by clicking on the link "*Would you like to request for measurement*" in the e-mail sent to him/her. A nominal fee is to be paid online through *Bharat Kosh* portal. The tests will be conducted by field units of the government, and the test report will be sent to the requester who can also access the portal to get updates on the status of his request.

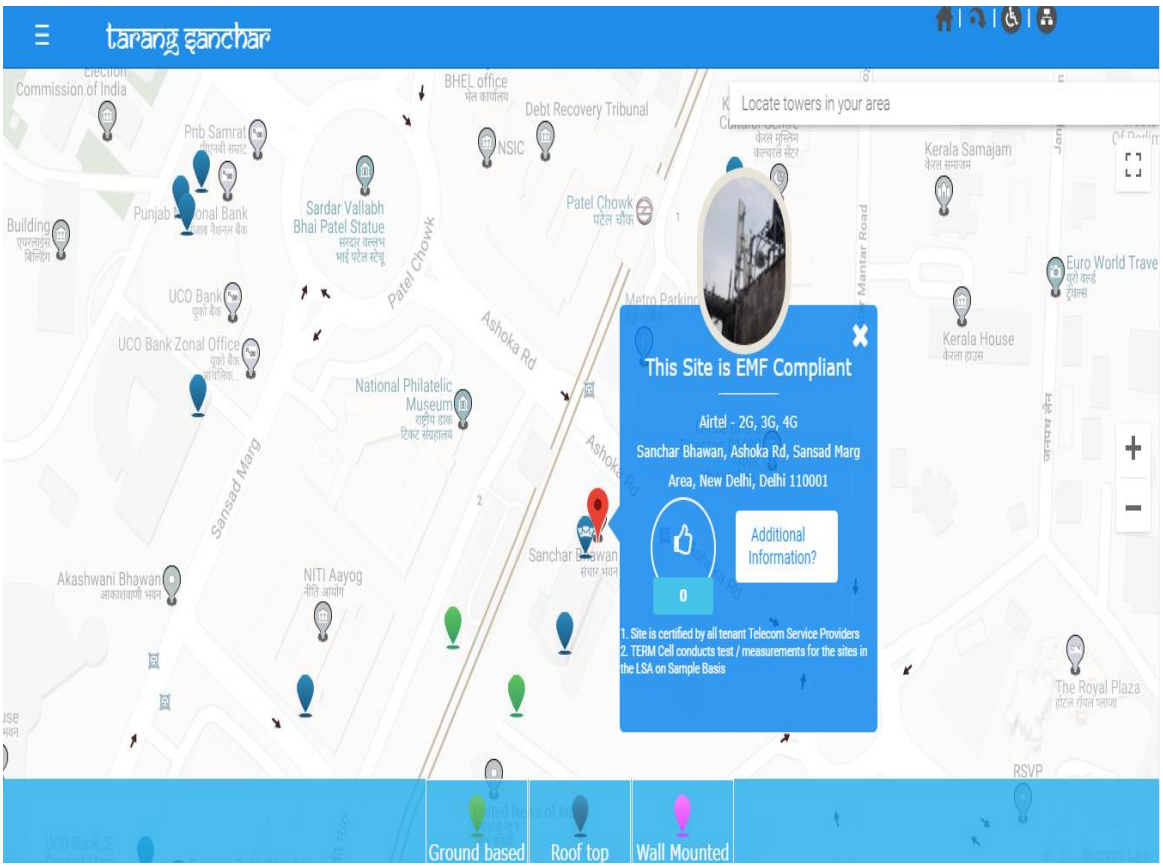


Figure III.14 – Public window: EMF site search and compliance details

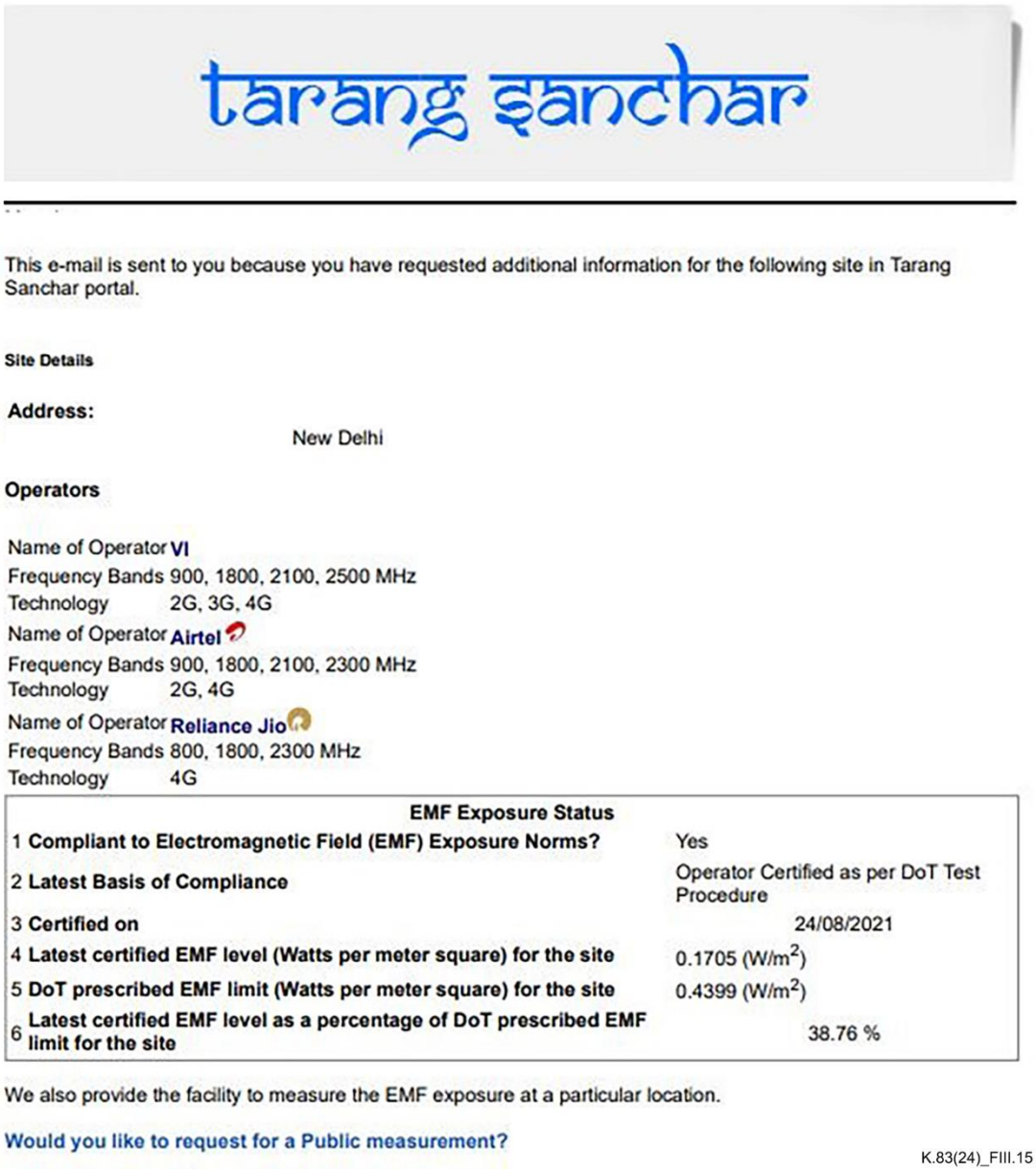


Figure III.15 – Public window: Additional information emailer

III.2.9 Telecom service provider window

The TSPs will get a login for their section in the National EMF Portal (NEP) where they can see the details of all their sites and also the details of the TSPs sharing the same site. However, changes can be made only on the data of that particular operator. Log-in ID, password management controls, have been incorporated to enable only the authorised person of the respective TSP to update data for the BTS, new sites, upgrades/changes and generation of digitally signed self-certificate for submission to the government (see Figure III.16). Portal enables online submission of site data, generation and submission of certification through step-by-step process for ensuring EMF regulatory compliance. With one common platform in place, test reports are standardized to ensure better regulatory compliance. It will also help in reducing huge amounts of paperwork involved.

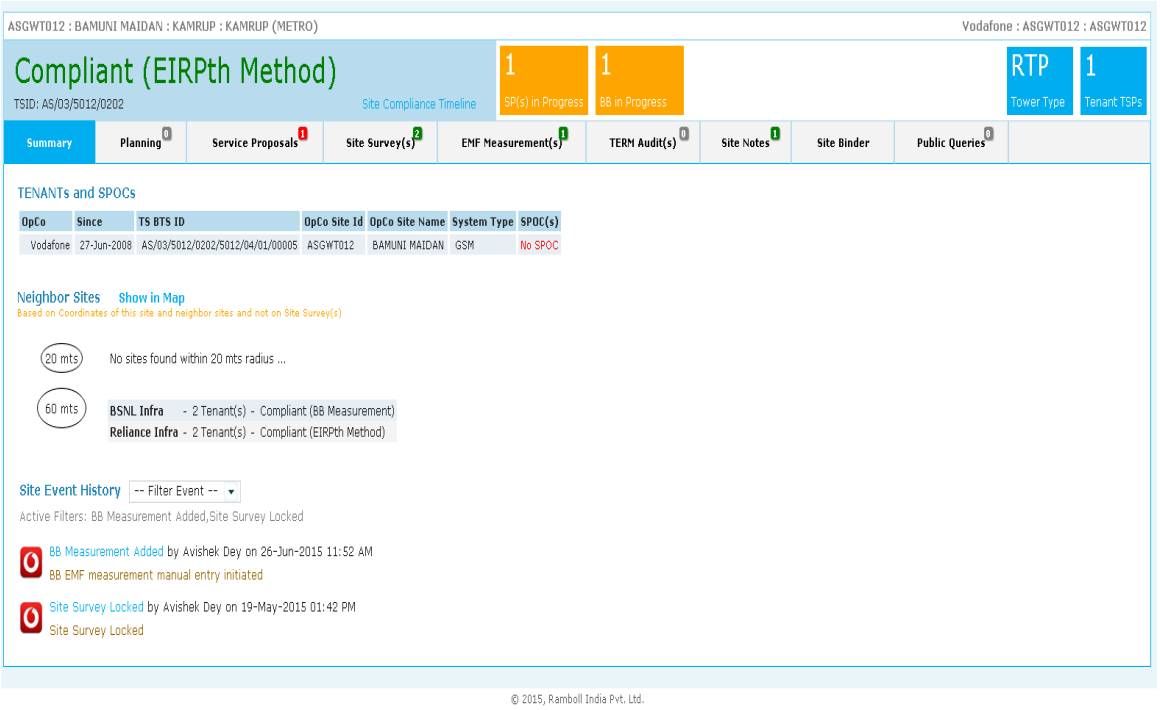


Figure III.16 – Sample of telecom service provider window

III.2.10 Field unit of the government window

Log-in ID, password management controls, have been incorporated to enable only the authorized person of the respective field unit to validate/audit data for the BTS, new sites, upgrades/changes and digitally signed self-certificate submitted by telecom service providers. They can issue digitally signed audit certificates using the portal for the sites tested by them (see Figure III.17). The field units can access the portal to view, monitor and audit EMF compliance online. Portal will also help them by providing access to timely intimation on up-gradation of sites, data mining, report generation and issuance of physical audit certificates. The portal facilitates a method of maintenance of end-to-end records of EMF emission through paperless processing, retention of records, their timely update and search.

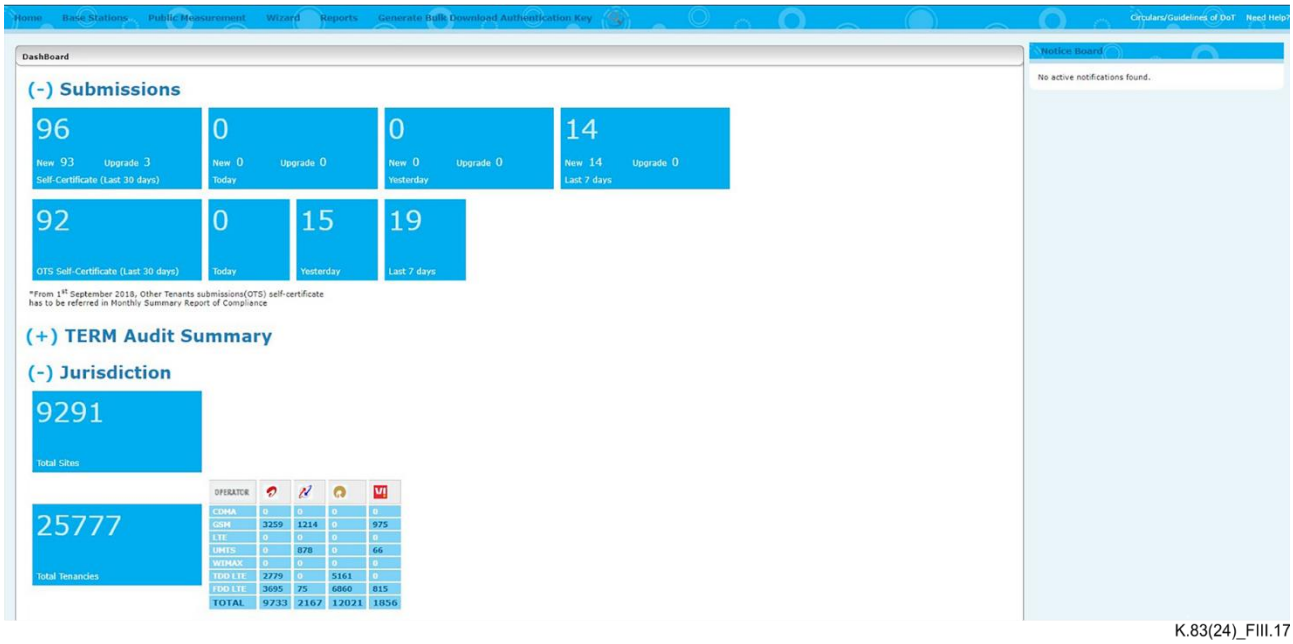


Figure III.17 – Field unit of the government window

III.2.11 Conclusion

III.2.11.1 A common collaborative platform is made available for entire end to end process of compliance to EMF exposure norms. Tarang Sanchar has facilitated digital record-keeping, paperless processing, standardized reporting and documentation, and retention of records with respect to compliance to EMF exposure norms for the entire telecom network of the country.

III.2.11.2 The Government and the TSPs believe that by having access to more information related to EMF through the Tarang Sanchar portal, which allows them to see compliance to EMF exposure norms on telecom sites, the general public will be more confident and their apprehensions will be mitigated.

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