

Introduction to the Measurement of Non- ionizing Radiation

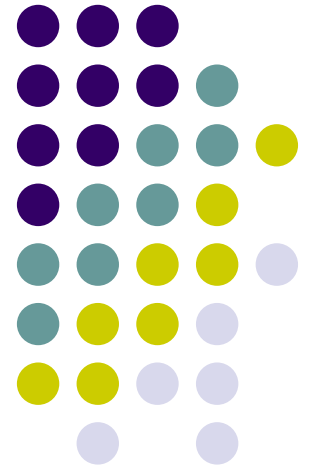


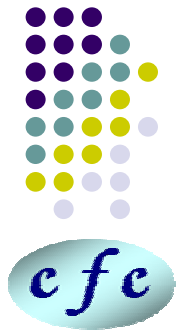
***CONSULTORA FEDERAL DE
COMUNICACIONES (CFC)***

– ARGENTINA –

Alfredo Debattista

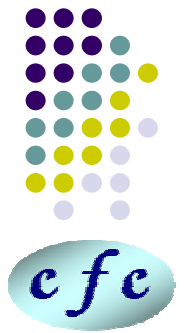
19 June 2006 – Lima, Peru





Basic information about CFC

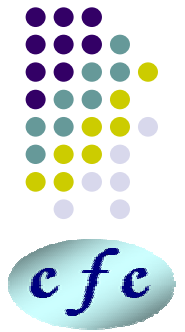
- Created only recently but making a major contribution
- Its members contribute the value added:
 - Public and private telecommunications sector
 - Technical and management profiles
 - Great experience vis-à-vis the Radio Spectrum and Non-ionizing Radiation
- Focuses on providing comprehensive advisory services, not only for technical matters but also with regard to regulatory issues and procedures, for government agencies and private companies



What do we offer?

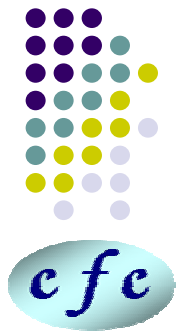
- Comprehensive advisory services with regard to Non-ionizing Radiation (NIR)
- Methodology for measuring NIR
- Consciousness raising and mitigation of the possible effects of NIR
- Development of regulations for municipal districts and government bodies
- Development of protocols for measuring NIR, based on international recommendations and standards

Case Study: Situation in Argentina



- Concerns of the population and users of communications equipment (Mobile Telephony)
- “Activity” of municipal districts and provincial governments
- Political will vs. practical implementation
- Risk of overlapping regulation
- Examples:
 - Río Gallegos (Santa Cruz)
 - San Fernando de Catamarca
 - Rosario (Santa Fé)
 - Ciudad Autónoma de Buenos Aires
 - Province of Buenos Aires

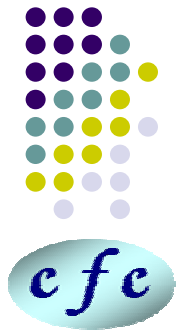
Argentina's Regulatory Framework



- Follows international parameters (ICNIRP, WHO, IEEE, FCC)
- Resolution N° 202/1995 – National Ministry of Health and Social Action
- Resolution N° 530/2000 – National Communications Secretariat
- Resolution N° 269/2002 – National Communications Committee (CNC) *[Withdrawn]*
- Resolution N° 117/2003 – CNC *[Withdrawn]*
- Resolution N° 3690/2004 – CNC *[In Force]*

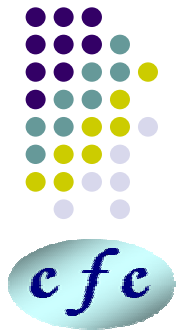
Note: *Communications Secretariat is the Implementing Agency
CNC is the Oversight Body*

Standardizing NIR concepts



- **NON-IONIZING RADIATION (NIR):** Radiation across the electromagnetic spectrum that does not have sufficient energy to ionize matter
- **ELECTRIC FIELD STRENGTH (E):** The magnitude of the electric field vector expressed in V/m
- **MAGNETIC FIELD STRENGTH (H):** The magnitude of the magnetic field vector expressed in A/m
- **POWER DENSITY (S):** Power per unit area normal to the direction of propagation, expressed in mW/cm²
- **EMISSION:** Radiation produced by a single radiofrequency source
- **INMISION:** Radiation resulting from the contribution of all radiofrequency sources whose fields are present in the place
- **EXPOSURE:** A situation in which people are subjected to electrical, magnetic or electromagnetic fields, or to contact or induced currents associated with electromagnetic fields of radiofrequencies
- **POPULATION OR NON-CONTROLLED EXPOSURE:** Situations in which the general public may be exposed or in which people exposed in the course of their work may not have been warned of the potential exposure and may not be able to control it

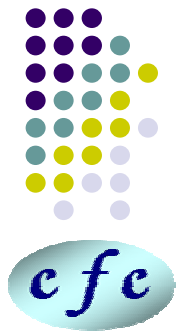
Maximum Permitted Values for Argentina



- Table of maximum permitted exposure levels for the population, for the different frequencies, pursuant to Resolution N° 202/95 of the National Ministry of Health and Social Action

Electric Field E (V/m)	Magnetic Field H (A/m)		

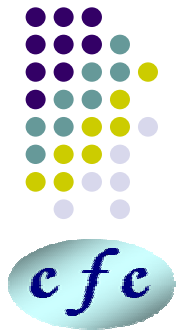
Note: Levels similar to those established by the ICNIRP



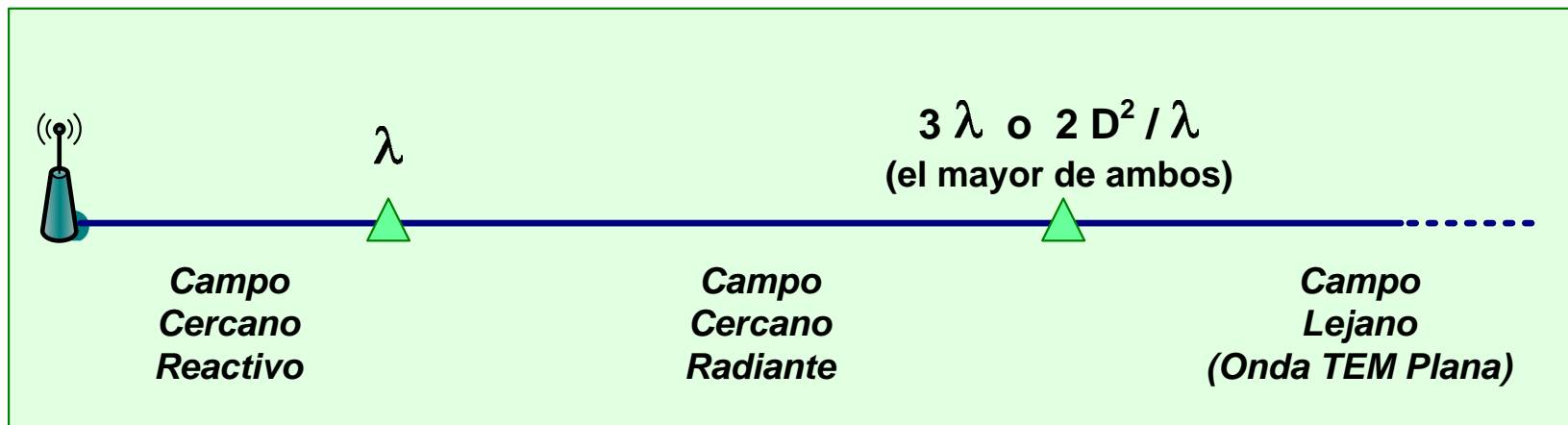
Regulation Systems

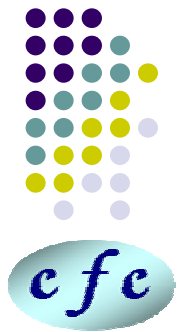
- Predictive Method (theoretical calculation)
- Method of Measurement (practical development)
- Combination of the two methods:
 - Fans vs. Critics
 - Methods of Application, which depend on:
 - ⇒ Types of radiofrequency sources
 - ⇒ Density of the number of sources, for measurement purposes
 - ⇒ Strength and frequency bands of the sources involved
 - ⇒ Location of the sources involved
 - ⇒ Political definition in the regulation system

Regulation Systems



- If Far Field is considered → evaluation of NIR values by calculation, based on Prediction Method
- If the Maximum Permitted Exposure (MPEs) limits are exceeded → the Measurement Method is used





Prediction Method

- Mono-Antenna Site Case
- Equations only valid for calculations in the far field, but can be used to predict the worse case

$$r = \sqrt{\frac{PRA * 1,64 * 2.56 * F^2}{4 * \pi * S}}$$

$$r = \sqrt{\frac{PIRE * 2.56 * F^2}{4 * \pi * S}}$$

S: Maximum Power Density (MPD) [W/m²]

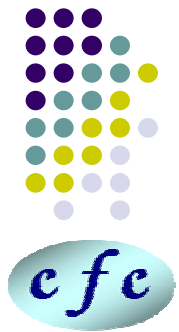
PRA & PIRE: antenna power [W]

F: attenuation of radiation for a certain angle of incidence in the vertical plane (F=1, worse case)

2.56: empirical reflection factor (reflected fields added in phase with direct incident field - 60%)

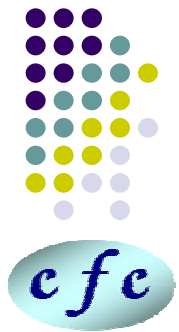
r: distance from the antenna [m]

- If the distance from the antenna to all points to which the general public have access is $\geq r$, it is not necessary to verify the site by means of measurements



Method of Measurement

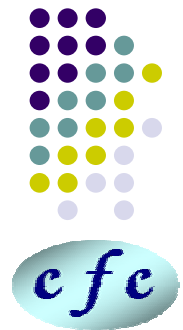
- Determine the place to be measured
- Inspect the place chosen and determine the radiofrequency sources, types of emission, characteristics of irradiation and surrounding environment
- Determine the method of measurement (reactive or radiant near fields, far field)
- Determine tools and probes to be used in the measurement process
- Measurement protocol to be applied
- Define the points to be measured, based on the protocol chosen and the points where the greatest risk exists (ext. / int.)
- Perform the measurements and prepare reports



Method of Measurement

- **Near Field** → measure E, H or both (must comply with MPE limits imposed)
- **Far Field** → measure E or H and obtain S [$S = E^2/Z_0 = H^2 \cdot Z_0$] (must comply with MPE limits imposed)
- Sequence:
 - Measure **imission**. If strictest MPE is exceeded, then measure the **emission** of each station
- Imission: use of broadband instruments (non-tuneable electromagnetic radiation detectors), with isotropic E and H measurement probes
- Emission: use of narrowband instruments (field intensity meters, tuneable spectrum analyzers, etc.), with antennae suitable for measurement frequency ranges
- All instruments, antennae and probes must have a calibration certificate (manufacturer or laboratory accredited in country of origin).
- Record the value of the measurement, plus the uncertainties specified (manufacturer), plus the error of the method used.

Models of Probes and Equipment



- Broadband probes

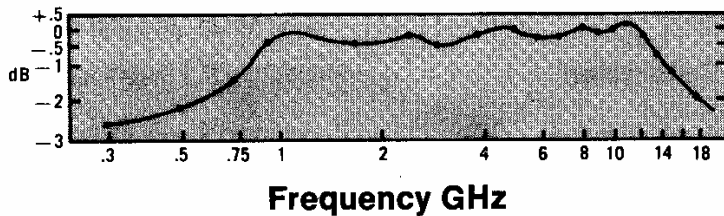


Fig. 4. Typical frequency response characteristics

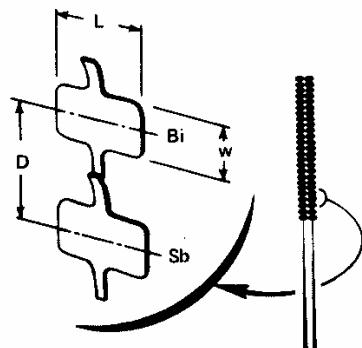


Fig. 5. Antenna probe element with the distributed thermocouple film elements. Tapered film leads reduce interaction between leads and elements. Geometry in the section view determines C_2 .

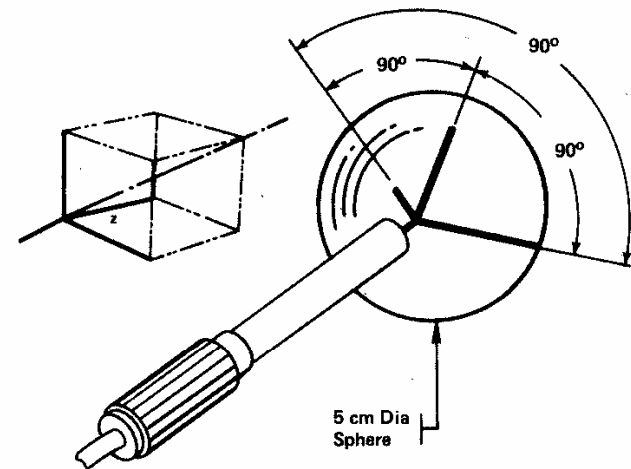


Fig. 6. Relationship of the three mutually orthogonal probe elements. Probe elements are contained within a 5-cm sphere.

Models of Probes and Equipment



- Commercial instruments and probes for measuring radiofrequency



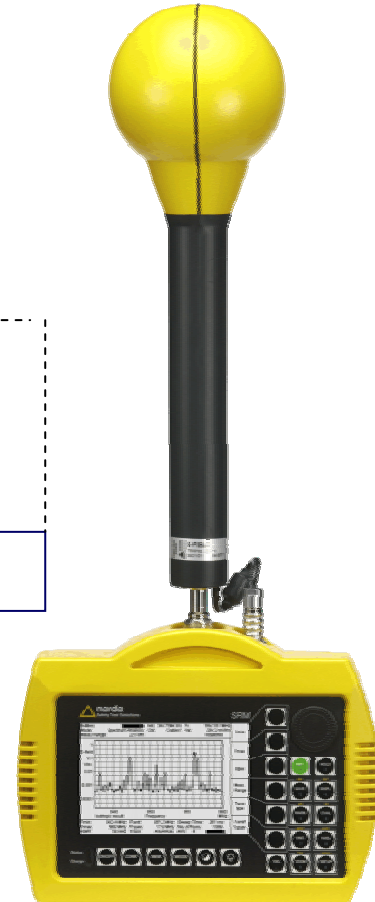
Interchangeable antennae for measuring E or H field (Isotropic)



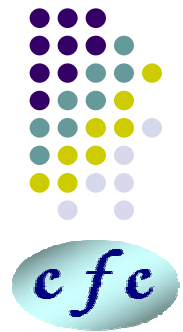
Non-tuneable



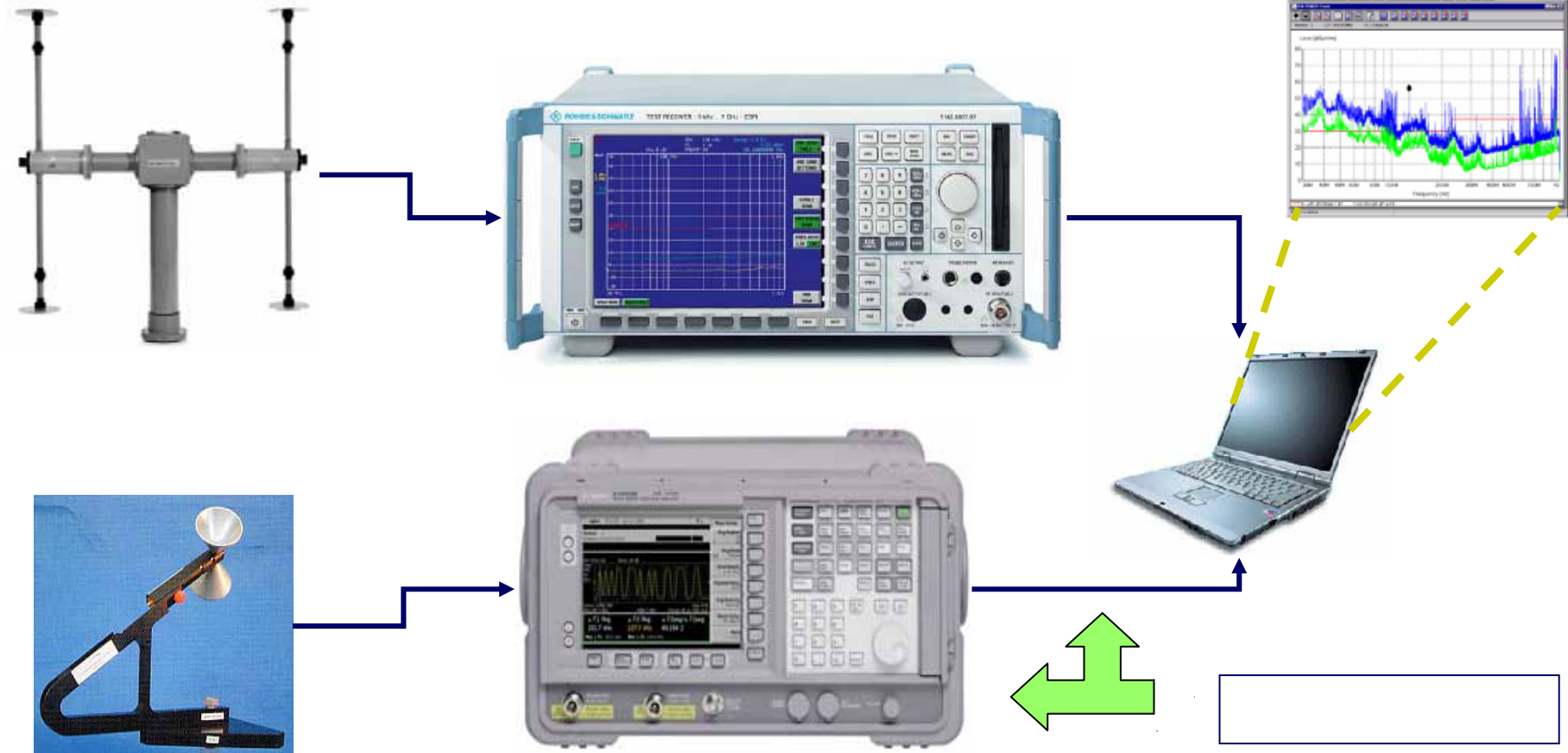
Tuneable



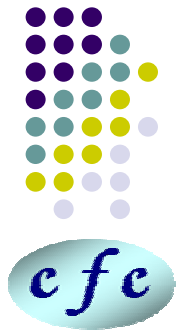
Models of Probes and Equipment



- Commercial instruments and antennae for measuring narrowband radiofrequency



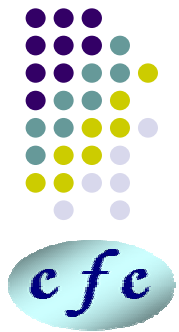
Measurement Protocol (Arg.)



- Applicable to radioelectric radiocommunications stations and radiobroadcasting stations (from 300 kHz to 100 GHz); not exempt on account of prediction method or exceptional conditions.
- Points of measurement:
 - Omni-directional systems:
 - ⇒ a minimum of 16 points
 - Directional systems:
 - ⇒ a minimum of 4 points in direction of max. propagation
 - ⇒ 12 remaining points according to charact. of radiation lobe

Note: More points may be included.
Measured at peak time (of traffic or strength emitted)

Measurement Protocol (Arg.)



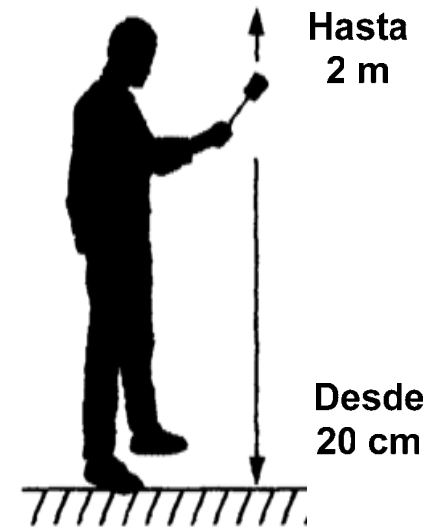
- **Inmision:**

- Sweep of peak value measurements [PV] (E, H or S) at the point of measurement

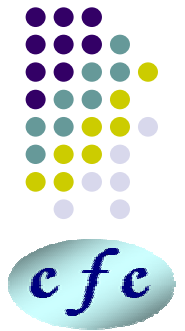
- ⇒ If maximum PV $\leq 50\%$ strictest MPE
→ that value is recorded
- ⇒ If maximum PV $> 50\%$ MPE → time-averaged measurement

- Time-averaged measurement:

- ⇒ Selection of 5 heights (separated by 20 cm and ≤ 2 m)
- ⇒ Measurement of components of E, H or S
- ⇒ At each height: time-averaging for 6 minutes. Record value and height.



Measurement Protocol (Arg.)



- **Emission:**

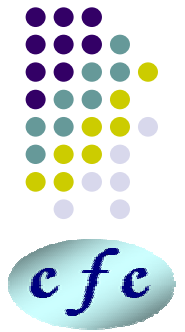
- Evaluation of individual contributions from each of the sources emitting NIR
- Points to be measured: those where the strictest MPEs were exceeded
- Use of narrowband instruments, with linear polarization antennae (with calibration certificate)
- Optional measurement methods:

- Measurement of the 3 orthogonal components (x, y, z):

$$E^2 = E_x^2 + E_y^2 + E_z^2 \quad \circ \quad H^2 = H_x^2 + H_y^2 + H_z^2$$

- Point antenna in direction of strongest signal

Continuous Monitoring



- The methods evaluated are for use in specific cases or repeatedly, but over long periods of time.
- There are new measurement models, based on continuous detection (7 x 24) of potentially hazardous zones, with data published on the Internet, to which citizens have free access.
- Advantages:
 - Population: has objective data, 24 hours a day, showing that the radiation values are below the maximums permitted.
 - Municipal districts: their residents know that an extensive network is in place for monitoring electromagnetic radiation
 - Service Providers: reduces the perception that their base stations are dangerous or a cause for concern.

Continuous Monitoring

- Conceptual Approach:



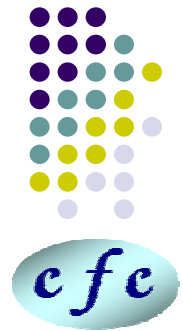
- Commercial Systems:

- CPqD

- Narda

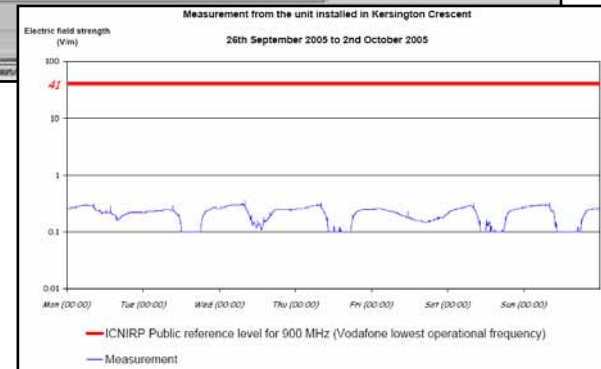
- Wave Control

Commercial Models

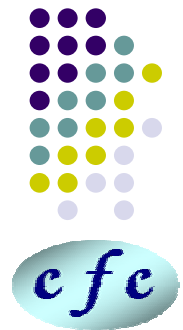


- Monitoring System

- Measurements of broadband (from 5 Hz to 40 GHz, with different probes)
- Use of isotropic probes
- Cellular signal discrimination vs. other sources EMF
- Storing of peak values, AVG, RMS (up to 18 months)
- Follow-up to measurement EMF
- Communication of data, alerts and configurations in a programmable way
- Outdoor and Indoor installation



Commercial Models

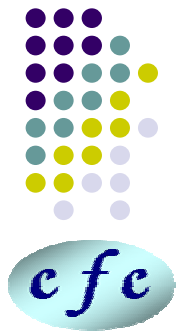


- **Monitoring System**

- **Permanent real time measurement at the field level**
- **Use of isotropic probe**
- **Regular averaging of the measurements**
- **Memorization of maximum values by periods**
- **Programmable threshold of level of alert**
- **Margin of measurement: 0.2-45V/m**
- **Wireless transfer of data to control center**



Conclusions



1. There is no conclusive evidence that the predefined levels of NIR affect the population...
2. ... but nor does evidence exist to prove that there are no effects when people are exposed to it for long periods
3. The issue continues to be studied (WHO, ICNIRP, etc.)
4. The first priority of our work should be prevention
5. It is worth defining and measuring the “hot points”
6. Repetitive, regular measurement methods to generate a statistical base (Maps of radiation - protected areas)
7. Balance between technological resources and human health (comfort and present society vs. prehistoric age)

We can help you with the last 4 points

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– Thank you very much –

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