Health safety and field strength exposure in ATDI tools

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Abstract

The rapid development of cellular communication systems all over the world has caused the appearance of many thousands of mobile telephone base stations. Installation of base station antennas has produced concerns about health and in some cases has resulted in litigation in court.
Independent research and measurements on electromagnetic fields in areas close to base stations was discussed, as well as a comparison of the level of exposure of local populations and current exposure limits.

This white paper addresses the problem of potential health risks of radiofrequency electromagnetic fields emitted by cellular networks (GSM, UMTS, WiMAX, Wifi…) in outdoor and indoor environments. This document is intended for radio-planner, technical director, project manager, authorities, expert responsible for population electromagnetic radiation safety, national regulators, scientists, government officials and industry representatives….

It focuses on international recommendation (IEEE standard 95.1-1-1999) related to the maximum permissible exposure for general public and it also provides methodologies of analysis of potential risk area inside a wireless mobile network. The suggested methodologies are divided into three topics:

- **Maximum permissible exposure area according to the international recommendation (ECC-1999/519) with ATDI tools.**
- **Calculation of the field strength exposure levels with ATDI tools.**
- **Permissible exposure analysis for indoor transmitters with ATDI tools.**

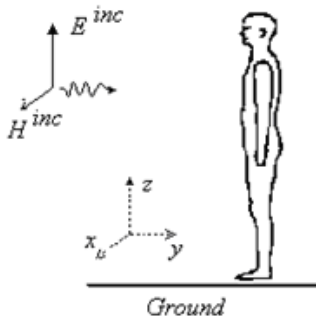
1. INTRODUCTION

The potential health risks of radiofrequency electromagnetic fields (RF EMFs) emitted by cellular networks (GSM, UMTS, Wifi…) are currently of considerable public interest. A very important issue is the requirement for coexistence between wireless equipment and people living around those types of transmitters.

In the last few years a noticeable acceleration in the activities related to the technical standards in the area of the human exposure of electromagnetic fields has been investigated at international, European and national levels. Notifications have been specified by the European Union to the regulation authorities and cellular operators in the Europe union community (IEEE standard 95.1-1-1999). The purpose of those recommendations was to take into account the potential health risk especially when the antennas used by the operators are located in urban areas (usually located on rooftops) and when they are close to sensitive areas like hospital, schools, people living near by the RF transmitters...
Today, the observance of existing EMF maximum permissible levels (standards) is mandatory for all base station equipment installations.

In order to assess the potential radiation hazard of the electromagnetic field around the base station, ATDI tools allow calculating:

- **The maximum permissible exposure (MPE) in a frequency range from 10kHz to 300GHz.**
- **The area of exposition risk where the field strength is higher than the acceptable level (in outdoor or indoor environment).**
- **All the EMF (electromagnetic fields) sources with different frequencies and different modulations.**
- **Full access to clear and accurate information about EMF emitting sources.**



2. MAXIMUM PERMISSIBLE EXPOSURE RECOMMENDATIONS

Existing national standards on electromagnetic radiation safety are based on the results of extensive research and consideration of any possible health risks. The recommendations about the maximum exposure level are depending on the countries and can be a subject of disputes between public lobbies and operators.

ATDI tools are based on the IEEE standard (95.1-1-1999). The IEE standard C95.1 is the current reference recommendation (US, EU) and it sets limits for human exposure to radio electromagnetic fields in the frequency range from 3 kHz to 300 GHz.

2.1. *Human hazard (ECC-1999/519)*

This part intends to outline a human hazard analysis with ATDI tools for public exposure.
The "***Spectrum/Human Hazard/ECC-1999/519***" function allows calculating the MPE (maximum permissible exposure). The calculation method is based on European Council Recommendation (1999/519/EC) and is calculated according to the following parameters:

- EIRP (W) transmitted by the BTS.
- Frequency (Mhz) transmitted by each station;
- The reference levels for each frequency.

2.2. *Calculation method with ATDI tools*

- The following formula is applied, merging all received field strengths from all transmitted frequencies:

$$\sum_{i=100\ kHz}^{1\ MHz} \left(\frac{E_i}{c}\right)^2 + \sum_{i>1\ MHz}^{300\ GHz} \left(\frac{E_i}{E_{L,i}}\right)^2 \leq 1$$

Where:
Ei is the electric field strength at frequency i;
EL,i is the electric field reference level. Please refer to Appendix for details of calculations.

The result is a map with two levels:
0 = No risk.
255 = Risk for the public.

Figure 1: Maximum permissible exposure for a GSM 900MHz base station (3 sectors) on a building in PARIS (EIRP=1.5kW)

3. FIELD STRENGHT EXPOSURE CALCULATION WITH ATDI tools

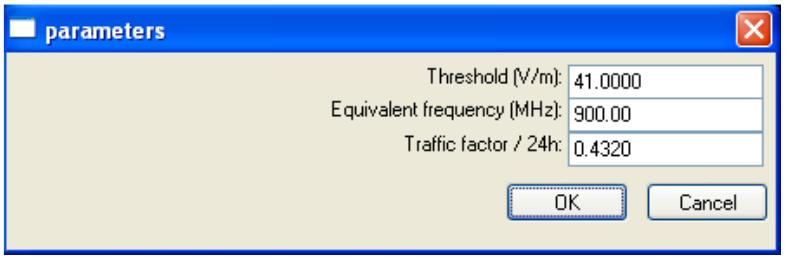
The "***Spectrum/Human hazard/Field strength exposure***" function allows calculating the field strength exposure of the public.
This function is based on the publication 2002-775 (03/05/2002) referring to the 1999/519/CE Recommendation from the European Union Council from 12th July 1999 regarding public exposure and electromagnetic field strengths (from 3 KHz to 300 GHz).

For exposure in controlled environments (duration of exposure is defined) higher field strength are admissible. With this function, ATDI tools can make the distinction between exposed population, duration of exposure and frequencies.

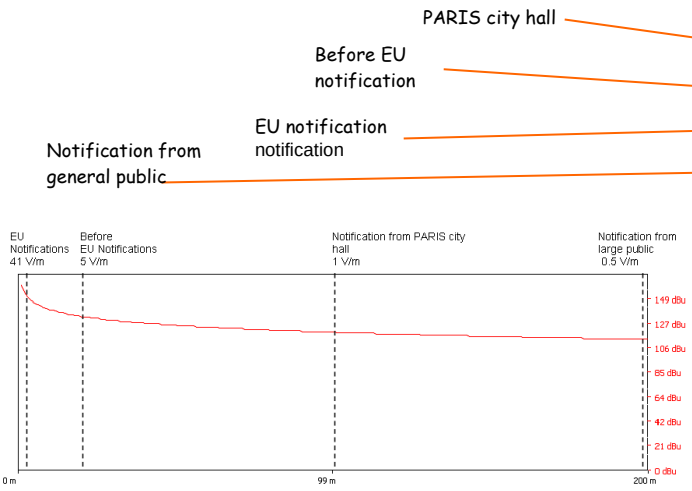
The analysis is done according to those parameters:

- Threshold (V/m).
- Equivalent frequency (MHz).
- Traffic factor/24h: Ratio between the mean effective exposure levels measured on 24 hour and the maximum theoretical field strength level.

NOTE: The method of calculation is defined in the APPENDIX.
The result of the calculation is the area where the field strength (V/m) >= Threshold (V/m).



EU notification	Before EU notification	Notification from PARIS city hall	Notification from general public
41 V/m	5 V/m (*)	1 V/m (*)	0.5 V/m (*)
GREEN	Red	PINK	BLUE



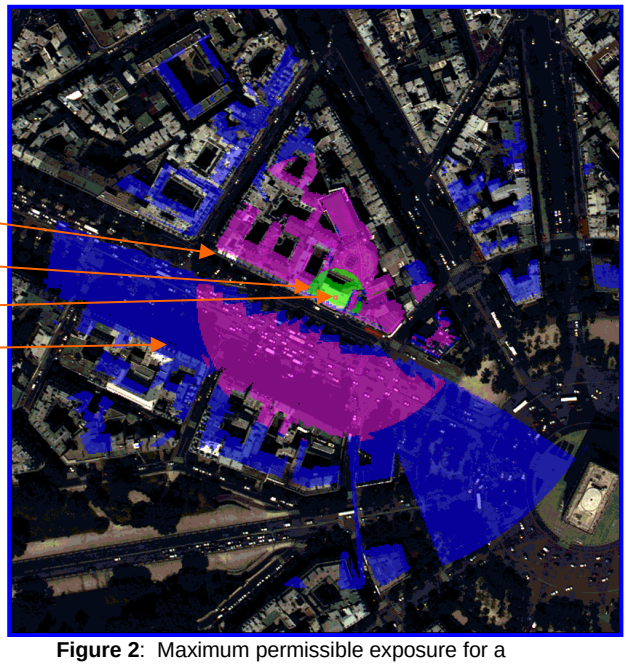


Figure 2: Maximum permissible exposure for a GSM 900MHz base station located on a rooftop in Paris (EIRP=300W)

4. INDOOR PERMISSIVE EXPOSURE WITH ATDI tools

In order to take into account the antennas installed inside an indoor environment (Airports, stations, business center, tunnels, schools…) where the risk of exposure is important, ATDI tools incorporates Indoor network functions for WiFi and cellular applications (repeaters, micro cell…). It integrates specific coverage analysis functions in order to perform the indoor field strength exposure including W-LAN (WiFi, 802.11-b).

The building data can be manually extracted using ATDI tools from a **basic digitized floor plan.** Based upon the material crossed (walls in concrete, separators in brick on the same floor...) standard or manual attenuations can be applied, as well as attenuation when a ceiling/floor is crossed.

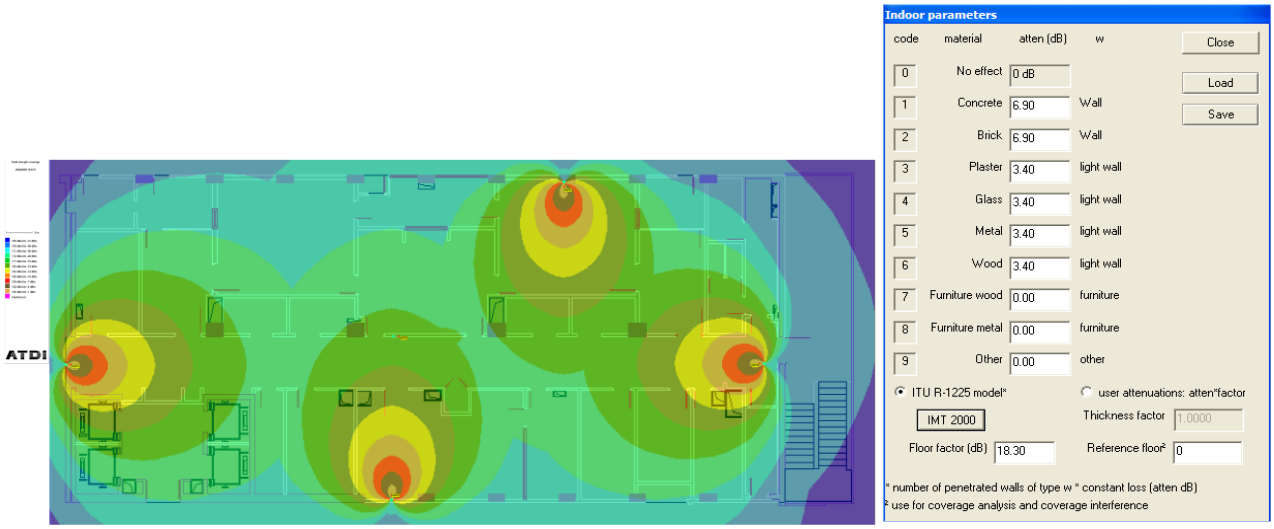


Figure 3: Threshold coverage for Wifi indoor stations

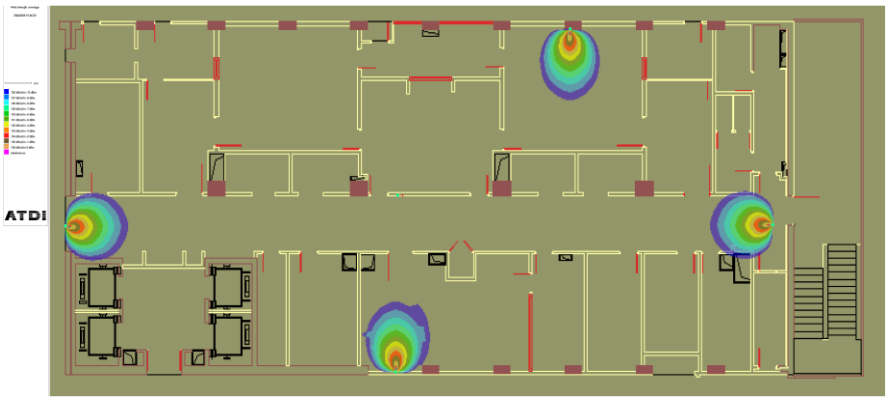


Figure 4: Field strength exposure ≥ 1 V/m for Wifi indoor stations

Figure 5: Indoor parameters for the Attenuation per material.

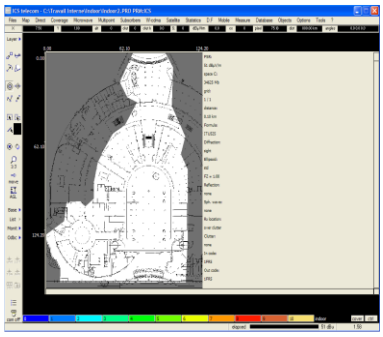


Figure 6: Basic digital floor plan In ATDI tools

5. 3D PERMISSIVE EXPOSURE WITH ATDI tools

In some cases, the antenna can be turned directly into the building. In this case, it is quite difficult to estimate the height at which the maximum radiation is produced. ATDI tools provides functions to calculate the distribution of radiation in the space **Draw rectangle/3D coverage**

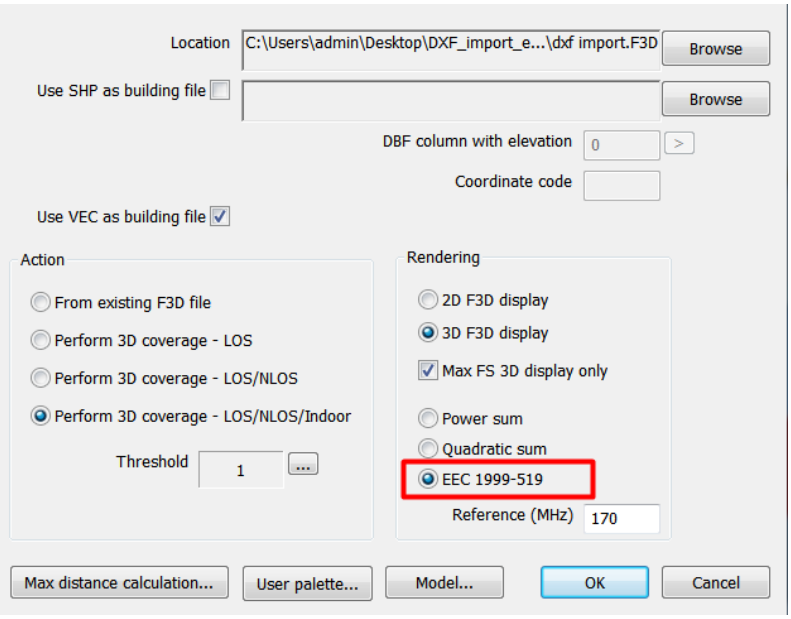


Figure 7: 3D coverage calculation options

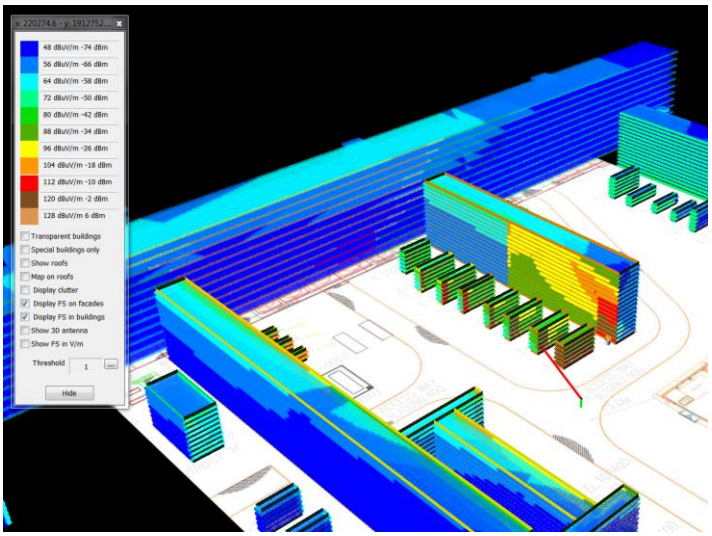


Figure 8: 3D view of Field strength

This tool provides possibility to analyze emissions on facades and inside of buildings.

6. APPENDIX

Calculation method for field strength exposure

Principle:

This function is based on the publication 2002-775 (03/05/2002) referring to the 1999/519/CE Recommendation from the European Union Council from the 12th of July 1999 regarding public exposure to electromagnetic field strengths (from 0 Hz to 300 GHz).
The result is a map with two levels:
0 = No risk.
255 = Risk for the public.

Method of calculation:

This function displays on the map electrical fields (V/m) greater or equal to the predefined threshold given in V/m.

Calculation method:

The electrical field in V/m is equal to: basic field in V/m (per channel) * (Ei/Eiq).

The parameter "Ei" is calculated as follows:

- If (transmitting frequency >=10 and transmitting frequency <=400), Ei=28
- If (transmitting frequency >400 and transmitting frequency <=2000), Ei=1.375*(transmitting frequency)^0.5
- iIf (transmitting frequency >2000), Ei=61

The parameter "Eiq" is calculated as follows:

- If (equivalent frequency >=10 and equivalent frequency <=400), Eiq=28
- If (equivalent frequency >400 and equivalent frequency <=2000),Eiq=1.375*(equivalent frequency)^0.5.
- If (equivalent frequency >2000), Eiq=61.

NOTE:

1. These formulas are given in the EEC-1999/519 recommendation.
2. All the fields are summed using a integer quadratic sum.
3. The resulting field strength is equal to: Summed field * Traffic factor (V/m).

"Traffic factor" corresponds to the ratio between the mean effective exposure level measured on 24 hours and the maximum theoretical field strength level.

The Following table illustrates the Reference levels for EME fields for Public exposure.

Table 2

Reference levels for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz, unperturbed rms values)

Frequency range	E-field strength (V/m)	H-field strength (A/m)	B-field (μT)	Equivalent plane wave power density S_{eq} (W/m²)
0-1 Hz	—	$3,2 \times 10^4$	4×10^4	—
1-8 Hz	10 000	$3,2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8-25 Hz	10 000	4 000/f	5 000/f	—
0,025-0,8 kHz	250/f	4/f	5/f	—
0,8-3 kHz	250/f	5	6,25	—
3-150 kHz	87	5	6,25	—
0,15-1 MHz	87	0,73/f	0,92/f	—
1-10 MHz	$87/f^{1/2}$	0,73/f	0,92/f	—
10-400 MHz	28	0,073	0,092	2
400-2 000 MHz	$1,375\ f^{1/2}$	$0,0037\ f^{1/2}$	$0,0046\ f^{1/2}$	f/200
2-300 GHz	61	0,16	0,20	10

COUNCIL RECOMMENDATION of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (1999/519/EC)