Interreg project WISE

(Wireless Safety for Employees)

Document: Measurement Equipment

V1.0

12th September 2012

Authors: Leen Verloock, Francis Goeminne, Emmeric Tanghe, Davy Gaillot, Martine Liénard, Wout Joseph

Lead participant: Ghent University
Partners: Ghent University, Université de Lille, Algemeen Stedelijk Ziekenhuis Aalst, SNCF - ASTI de Lille
Due date of document: 12th October 2012

Content

Abbreviations

DAB	Digital Audio Broadcasting
DECT	Digital Enhanced Cordless Telephony
DL	Downlink signal
FM	Frequency Modulation
GSM	Global System for Mobile Communications
PEM	Personal Exposure Meter
SA	Spectrum Analyzer
TETRA	Terrestrial Trunked Radio
TV	Television
UL	Uplink signal
UMTS	Universal Mobile Telecommunication System
WiFi	Wireless Fidelity 802.11
WiMAX	Worldwide Interoperability for Microwave Access

1 INTRODUCTION

This document summarizes the measurement equipment that will be used during the measurement campaigns performed in action 3 of the WISE project.
Two different types of measurements will be performed: exposure measurements to determine the electric-field values and propagation measurements to develop channel models dependent on the environment.

2 EXPOSURE MEASUREMENTS

Exposure measurements can be performed within a broad frequency range by using different types of equipment: broadband probes, frequency-selective equipment and personal exposure meters. In the following paragraphs the characteristics of the equipment are listed. All measurement equipment bought for this project are recently calibrated.

2.1 Broadband probes (100 kHz – 40 GHz)

Broadband probes can be used to locate the spot or area of maximum exposure. In Table 1, an overview is listed of the available broadband probes.

Equipment (manufacturer, type)	Probe	Frequency range	Dynamic range	Picture
Narda, NBM-550	EF-0391	100 kHz – 3 GHz	0.2 V/m – 320 V/m	Figure 1 (b)
	EF-0691	100 kHz – 6 GHz	0.35 V/m – 650 V/m	-
PMM, 8053	EP-330	100 kHz – 3 GHz	0.3 V/m – 300 V/m	Figure 1 (a)
	(Narda)Type 338	1 MHz – 40 GHz	0.8 V/m – 800 V/m	-

Table 1: Overview broadband probes

2.2 Smallband measurements (5 Hz – 26.5 GHz)

The setup of the smallband measurements consist of a spectrum analyser (SA) and a field probe or antenna. Dependent on the frequency range a proper spectrum analyser and field probe will be selected. The spectrum analyser is connected with the field probe, which is placed on a tripod on the position where we want to measure the field values.
In Table 2, an overview is listed of the available spectrum analyzers and Table 3 lists the field probes.

Equipment (manufacturer, type)	Frequency range	Picture
Rohde & Schwarz, FSL6	9 kHz – 6 GHz	Figure 3 (a)
Rohde & Schwarz, FSH8	9 kHz – 8 GHz	Figure 4 (a)
Rohde & Schwarz, FSEM30	20 Hz – 26.5 GHz	Figure 3 (b)

Table 2: Overview spectrum analyzers

Field probe (manufacturer, type)	Frequency range	Dynamic range	Picture
PMM, EHP-50C	5 Hz – 100 kHz	0.01 V/m – 100 kV/m 1 nT – 10 mT	Figure 2 (a)
Narda, EHP-200	9 kHz – 30 MHz	0.02 V/m – 1 kV/m 0.6 mA/m – 300 A/m	Figure 2 (b)
Rohde & Schwarz, TS-EMF Isotropic Antenna	30 MHz – 3 GHz	1 mV/m – 100 V/m	Figure 3 (a)
Austrian Research Centers Seibersdorf, PCD8250	80 MHz – 2.5 GHz	1 mV/m – 100 V/m	Figure 5 (a)
Rohde & Schwarz, 2 – 6 GHz probe	2 GHz – 6 GHz	2.5 mV/m – 200 V/m	Figure 5 (b)
Rohde & Schwarz, HF907OM	800 MHz – 26.5 GHz	Maximum input power 50 W to 10 W (CW)	Figure 3 (b)

Table 3: Overview field probes.

2.3 Personal exposure meters (88 MHz – 5.85 GHz)

Personal exposure meters (PEM) or exposimeters are available to assess the electric-field levels in twelve or fourteen fixed frequency bands (FM, DAB, TETRA, TV, GSM900 UL, GSM900 DL, GSM1800 UL, GSM1800 DL, DECT, UMTS UL, UMTS DL, WiFi 2G, WiMax, WiFi 5G) in the frequency range of 88 MHz up to 5.85 GHz. Table 4 lists the different exposimeters.

Equipment (manufacturer, type)	Frequency range	Frequency bands	Dynamic range	Picture
Satimo, EME Spy 120	88 MHz – 2.5 GHz	12	0.05 V/m – 5 V/m	Figure 1 (a)
Satimo, EME Spy 140	88 MHz – 5.85 GHz	14	0.005 V/m – 5 V/m	Figure 3 (a)

Table 4: Overview exposimeters.

2.4 Pictures of equipment for exposure measurements

(a)

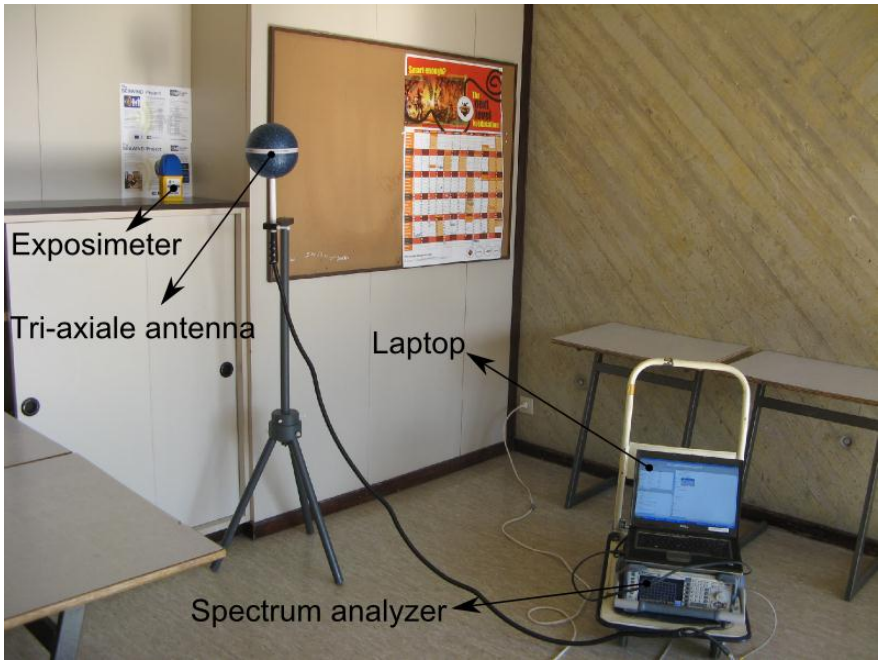
(b)

Figure 1:Picture with indication of exposimeter EME Spy 120 and broadband probe PMM 8053 –EP330 (a), and broadband probe Narda NBM-550 – EF0391 (b).

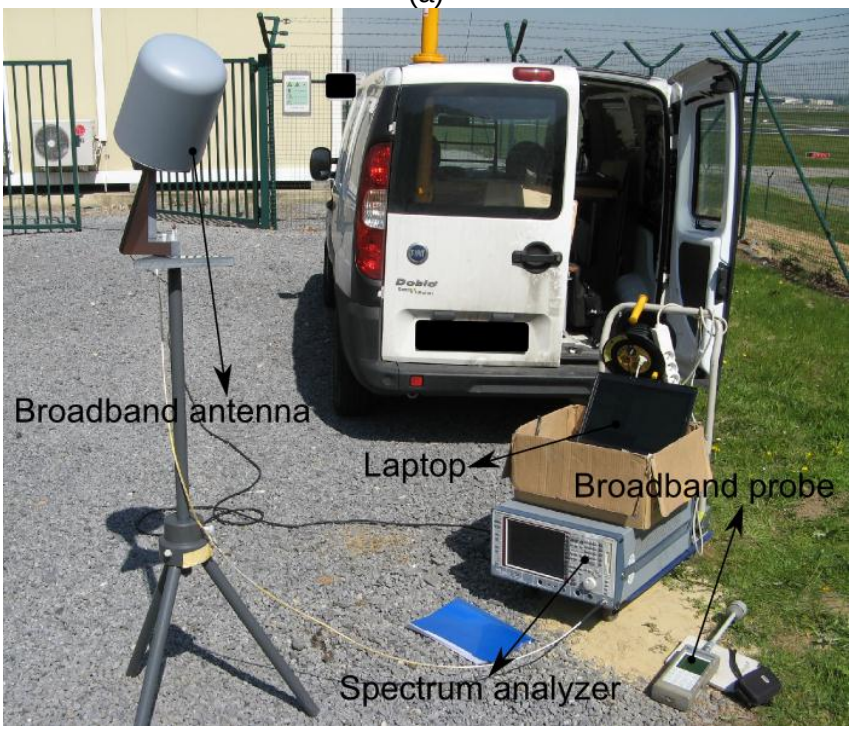
(a)

(b)

Figure 2:Picture with indication of EHP-50C in combination with PMM 8053 (a), and EHP-200 (b).



(a)



(b)

Figure 3: Picture with indication of exposimeter EME Spy 140, tri-axiale antenna (TS-EMF Isotropic Antenna), spectrum analyzer (FSL6) and laptop (a), and broadband antenna (HF907OM), spectrum analyzer (FSEM30), broadband probe (PMM 8053 – EP330) and laptop (b).

Figure 4:Picture of handheld spectrum analyzer FSH8.

(a)

(b)

Figure 5:Picture with indication of conical dipole antenna (PCD8250) (a) and broadband antenna (2 GHz – 6 GHz probe) (b).

3 PROPAGATION MEASUREMENTS

The measurement equipment for wireless propagation consists of a transmitting and a receiving part. In contrast to the exposure measurements, we transmit our own wireless signal during the propagation measurements. Both transmitter and receiver possess a broadband antenna that can be moved in a horizontal plane by means of a rail system with stepper motors.

What follows are a few practical considerations concerning the use of this equipment:

- At all times during measurements, the transmitter and the receiver will be interconnected by two cables. One cable is need for remote control of the rail system at the receiver, while the other cable is needed for time synchronization between transmitter and receiver. Both cables are fragile and should not be trodden on or driven over.
- The equipment is capable of wideband measurements over several GHz. However, most commonly measurements will be done in a smaller frequency band of a few 100 MHz centered around 3 GHz. This is to not interfere with existing wireless infrastructure and for this infrastructure to not interfere with our measurements.

Propagation measurements can be performed within a broad frequency range by using different types of equipment: broadband antennas, and frequency-selective equipment. In the following paragraphs the characteristics of the equipment are listed.

3.1 Broadband Antennas

Broadband antennas are used jointly with a frequency spectrum analyzer or vectorial network analyzer to measure the frequency response of the propagation scenario with various field orientations. The available antennas are listed in Table 5 and displayed in Figure 6.

Equipment (manufacturer, type)	**Reference**	**Frequency range**	**Gain**	**Picture**
ETS LINDGREN, Horn antenna	3117	1 GHz – 18 GHz	3 dBi – 13 dBi	Figure 6(a)
	3164-05	2 GHz – 18 GHz	6 dBi – 14 dBi	Figure 6(b)
AH Systems, Horn antenna	SAS-571	700 MHz – 18 GHz	1.4 dBi – 15 dBi	Figure 6(c)
EMCO, Horn antenna	3115	1 GHz – 18 GHz	4 dBi – 16 dBi	Figure 6(d)
Schwarzbeck, Log-Periodic	VUSLP 9111	230 MHz – 2.8 GHz	4 dBi – 8 dBi	Figure 6(e)
Electro-Metrics, Biconal	EM-6116	2 GHz – 10 GHz	±1 dBi	Figure 6(f)

Table 5: Overview broadband antennas

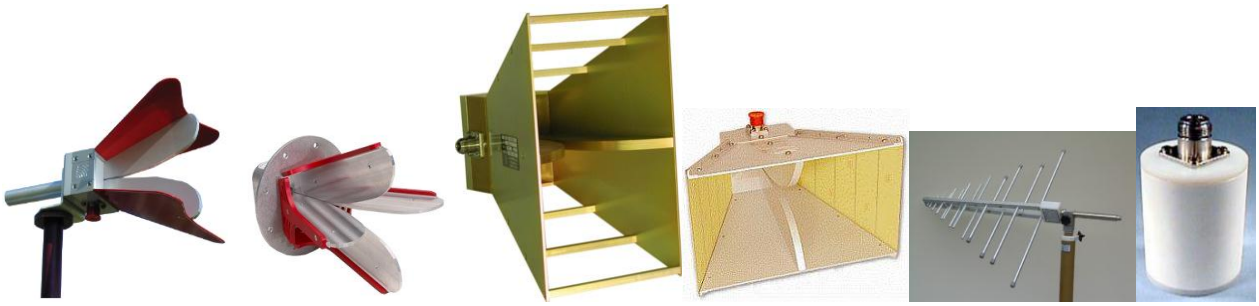


Figure 6: Broadband antennas (a) 3117, (b) 3164-05, (c) SAS-541, (d) 3115, (e) VUSLP 9111, (f) EM-6116.

3.2 Spectrum Analyzer and Vectorial Network Analyzer

The Spectrum Analyzer and Vectorial Network Analyzer are supplementary frequency-selective equipments used for propagation measurements. The spectrum analyzer identifies occupied frequency bands and gain whereas the Vectorial Network Analyzer (VNA) characterizes the complex frequency response for a given band between single or multiple antennas/polarizations. Table 6 presents the specifications of the two equipments.

Manufacturer	Equipment Type	Frequency range	Picture
Agilent	Spectrum Analyzer E4445A	9 kHz – 13.2 GHz	Figure 7(a)
Agilent	VNA E5071C	9 kHz – 8.5 GHz	Figure 7(b)

Table 6: Overview of the Analyzers

Figure 7: (a) Agilent E4445A Spectrum Analyzer, (b) Agilent E5071C VNA

3.3 MIMO (Multiple Input – Multiple Output) Radio Channel Measurement Setup

The Lille 1 setup consists includes 2 identical home-made battery-operated (optional) automated XY tables which allow the motion of the transmitting antenna only (MISO – Multiple Input Single Output), receiving antenna only (SIMO – Single Input Multiple Output), or both antennas (MIMO – Multiple Input Single Output). The tables occupy ~ 1 m^3 and are wheeled (Figure 8). The transmitting or receiving antenna can be either on a table or tripod depending upon the chosen measurement configuration.

The frequency response is measured with the E5071C 4-port vectorial network analyzer. A ~ 500 m fiber optics grants large distances between the transmitter and receiver via an optic/RF link (Figure 8(b)). The setup also comprises a power amplifier at the transmitter side (Figure 8(b)) and low-noise amplifiers (Figure 7(b)) at the receiving side to increase the quality of the radio link.

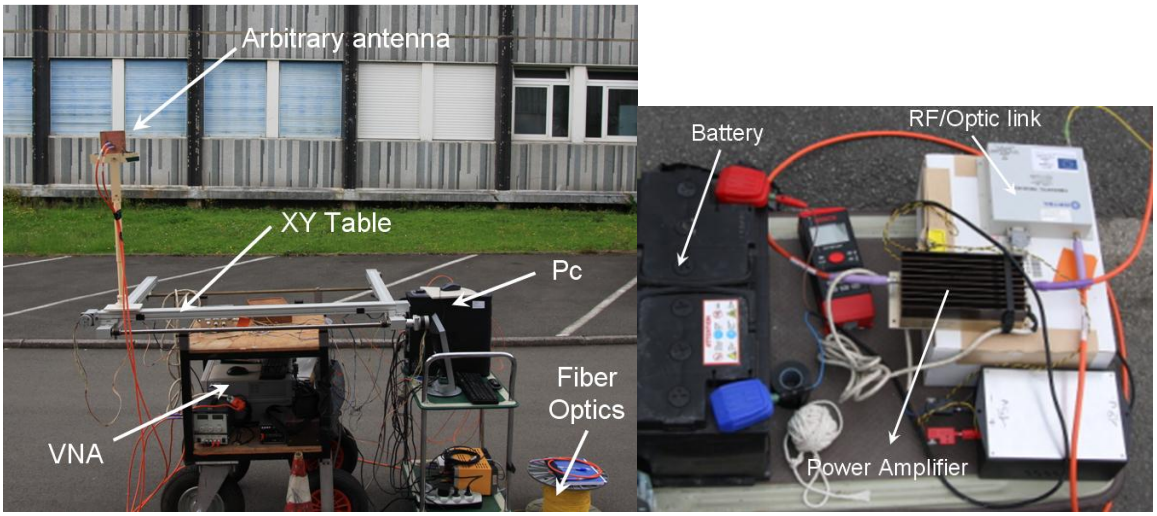
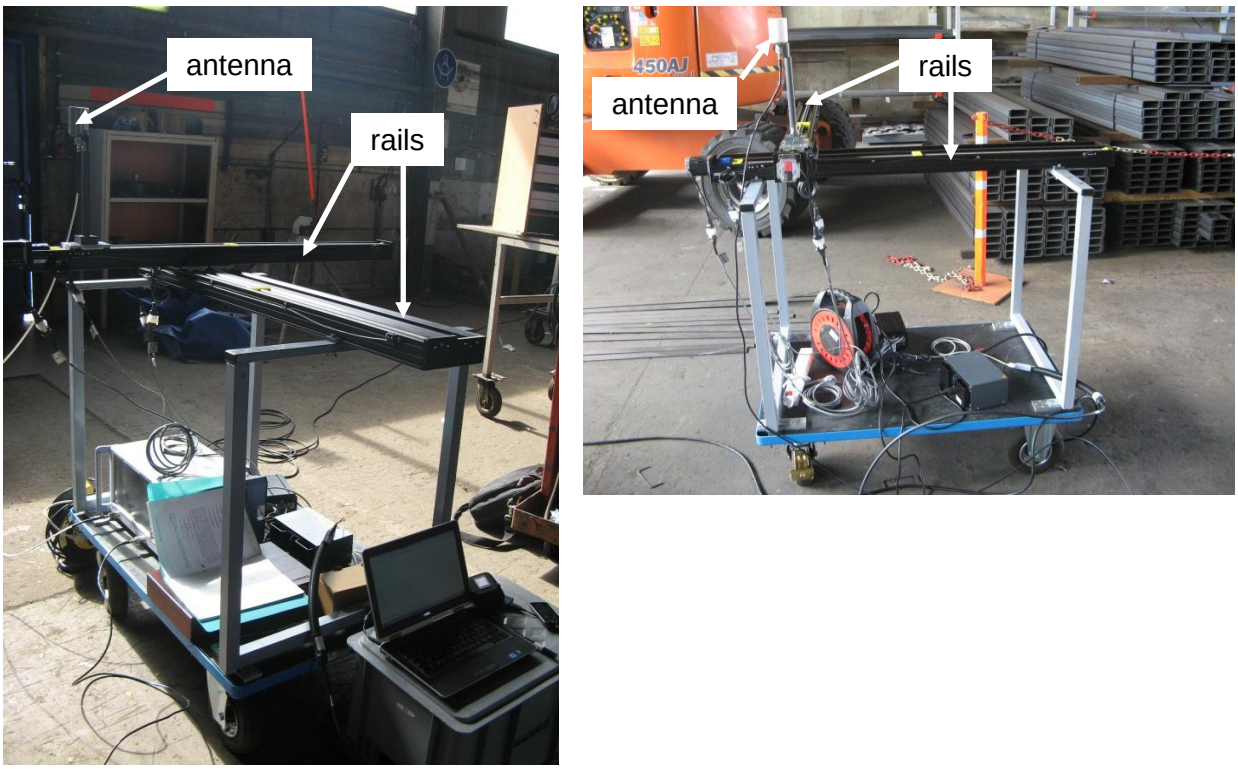


Figure 8: Propagation Measurement Setup (a) Automated XY table with PC controller, VNA, fiber optics, and receiving antenna. (b) Battery, Power Amplifier and RF/Optic link.

The University of Ghent system presents similar characteristics and can employ the same equipment. Transmitter and receiver are identical in size: 1.4 m (length) x 1.4 m (width) x 1.5 m (height). Fig. 9 shows the transmitter and the receiver.



(a) (b)

Figure 9: Measurement equipment for wireless propagation, transmitter (a) and receiver (b)