Training Course on Conformity and Interoperability,
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Speed up your compliance

SAR
Specific absorption rate

Presented by: Karim Loukil & Kaïs Siala
Kaim.wakil@cert.mincom.tn
Kais.siala@cert.mincom.tn

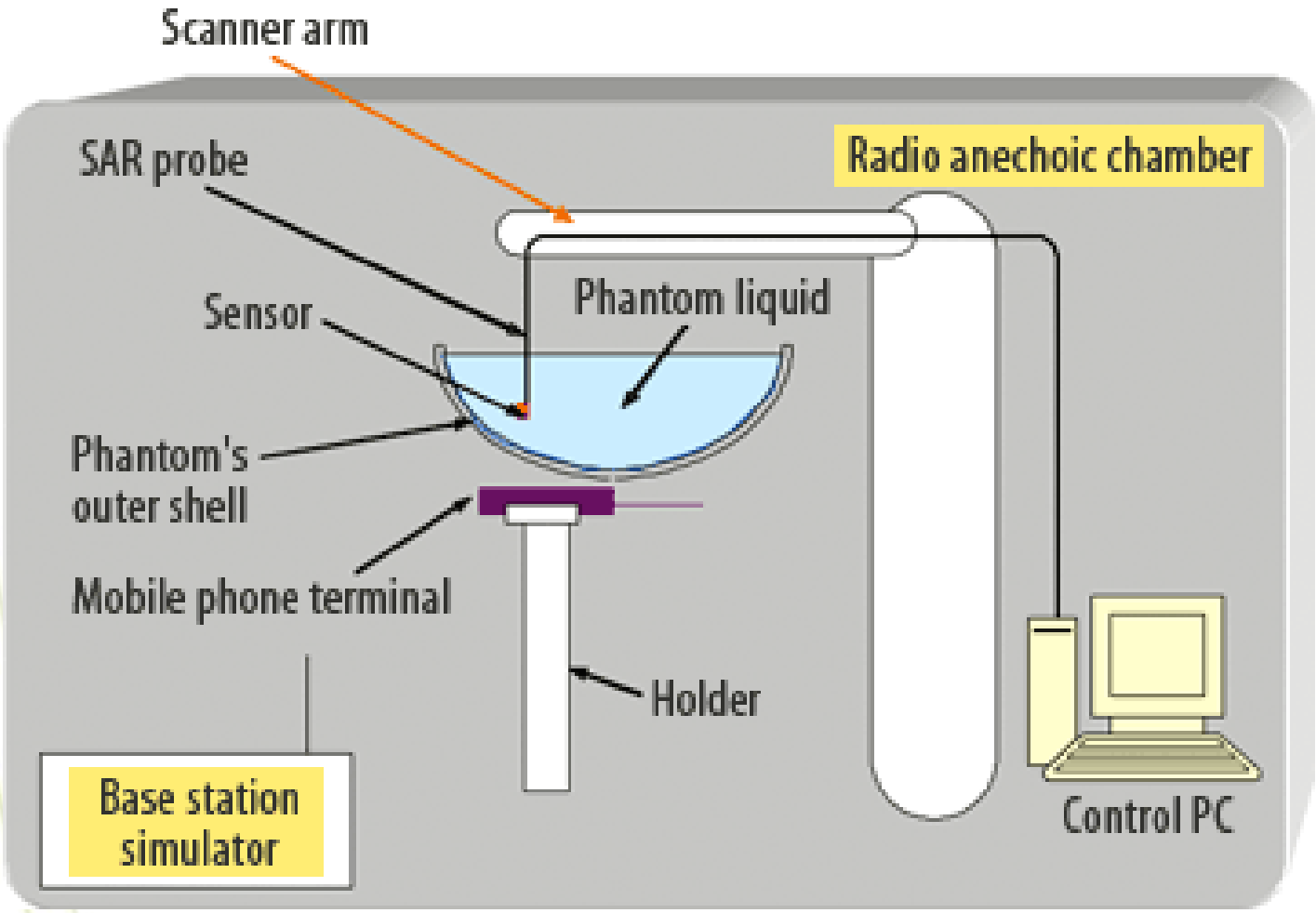
What is specific absorption rate (SAR)?

- Invisible electromagnetic waves can be absorbed by human or animal bodies;
- the specific absorption rate (SAR) is a numerical expression of these absorbed waves.
- SAR refers to the amount of radio wave energy absorbed in unit mass of human body (1kg or 1g); units are W/kg or mW/g.

Meaning of specific absorption rate (SAR)

- When the human body is exposed to low frequency (1Hz-100KHz) electromagnetic waves, the current induced in the body irritates the nerves.
- Exposure to high frequency (100KHz-10GHz) electromagnetic waves causes a heating reaction which increases body temperature.
- Electromagnetic waves emitted by mobile phones are of high frequency, thus capable of body temperature increase;
- such heat reactions are expressed quantitatively by the specific absorption rate (SAR).

SAR measurements



SAR measurment

SAR standards

Test configuration	Standard	Lower frequency	Upper frequency
Against the head	EN50361	300 MHz	3 GHz
Against the head	IEEE 1528	300 MHz	3 GHz
Against the head	IEC 62209 Part 1	300 MHz	3 GHz
Head and Flat phantom	IEC 62209 Part 2	30MHz	6GHz
Head and Flat phantom	IEEE 1528.X	30MHz	6GHz

SAR & SAR Limits (1)

Specific absorption rate or SAR is the time derivative of the incremental energy (dW) absorbed by or dissipated in an incremental mass (dm) contained in a volume (dV) of a given density (r):

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

SAR & SAR Limits (2)

SAR should be considered an “absorbed dose rate” and is related to electric fields at a point by:

$$SAR = \frac{\sigma |E|^2}{\rho}$$

Where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m^3)

E = rms electric field strength (V/m)

The SAR Measurement System

- According to IEC 62209 Para 5.1:
- “The test shall be performed using a miniature probe that is automatically positioned to measure the internal E-field distribution in a phantom model representing the human head exposed to the electromagnetic fields produced by wireless devices.
- From the measured E-field values, the SAR distribution and the maximum mass averaged SAR value shall be calculated.”

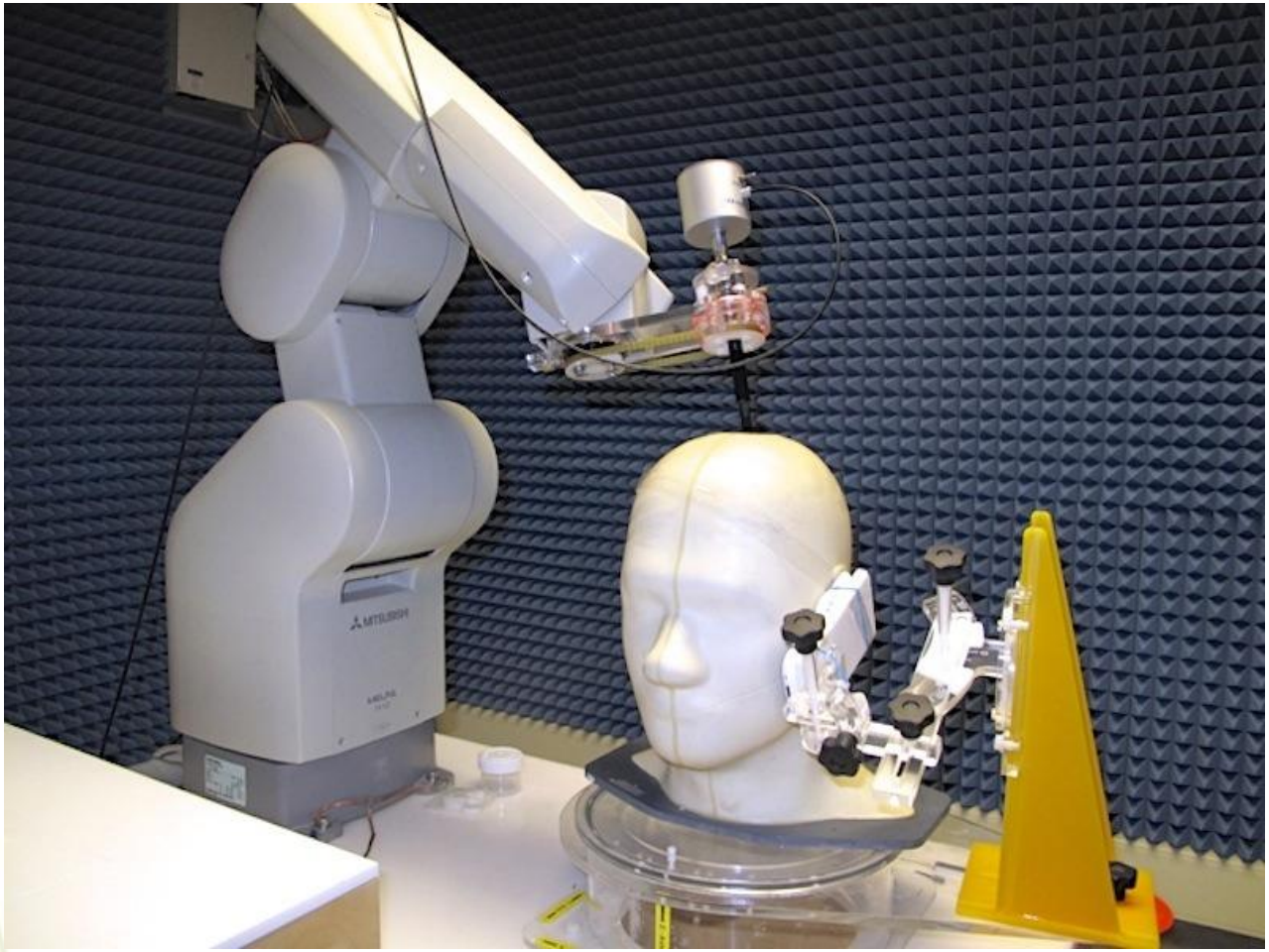
Test systems

- Test systems should also include components for positioning the equipment under test and aligning the scanning system;
  - for measuring the dielectric properties of the tissue simulant liquid;
  - and for checking and validating the measurement accuracy.

Phantom Requirements

- Two types of phantoms.
- For testing a wireless device that is held against the head at the user's ear, a Specific Anthropomorphic Mannequin (SAM) phantom is required.
- For systems validation and for testing body mounted or hand held devices (not held next to the user's ear), a flat phantom is required.
- Flat phantoms vary is size and construction based on the test frequencies of the DUT.

Head phantom



Body phantom

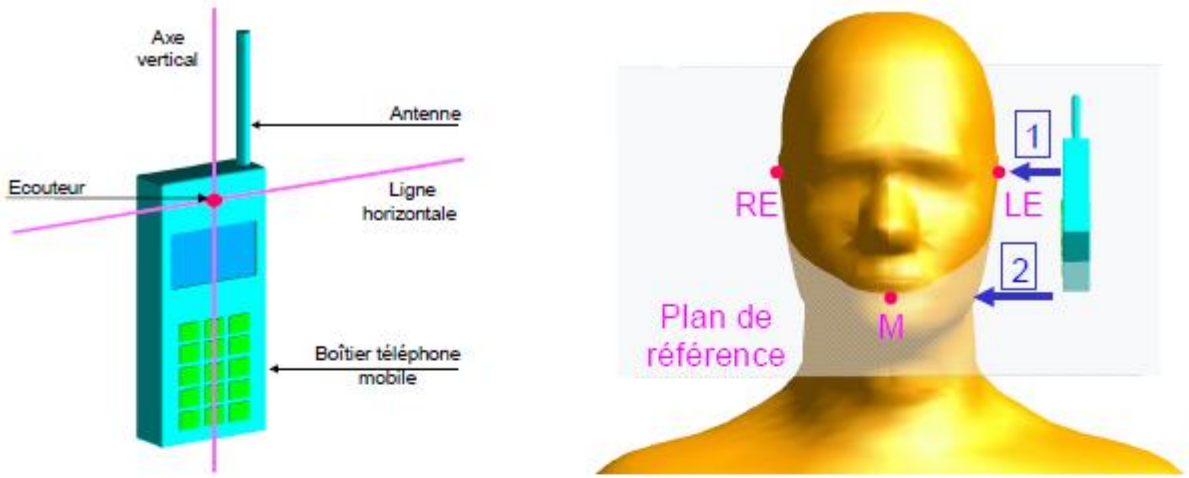
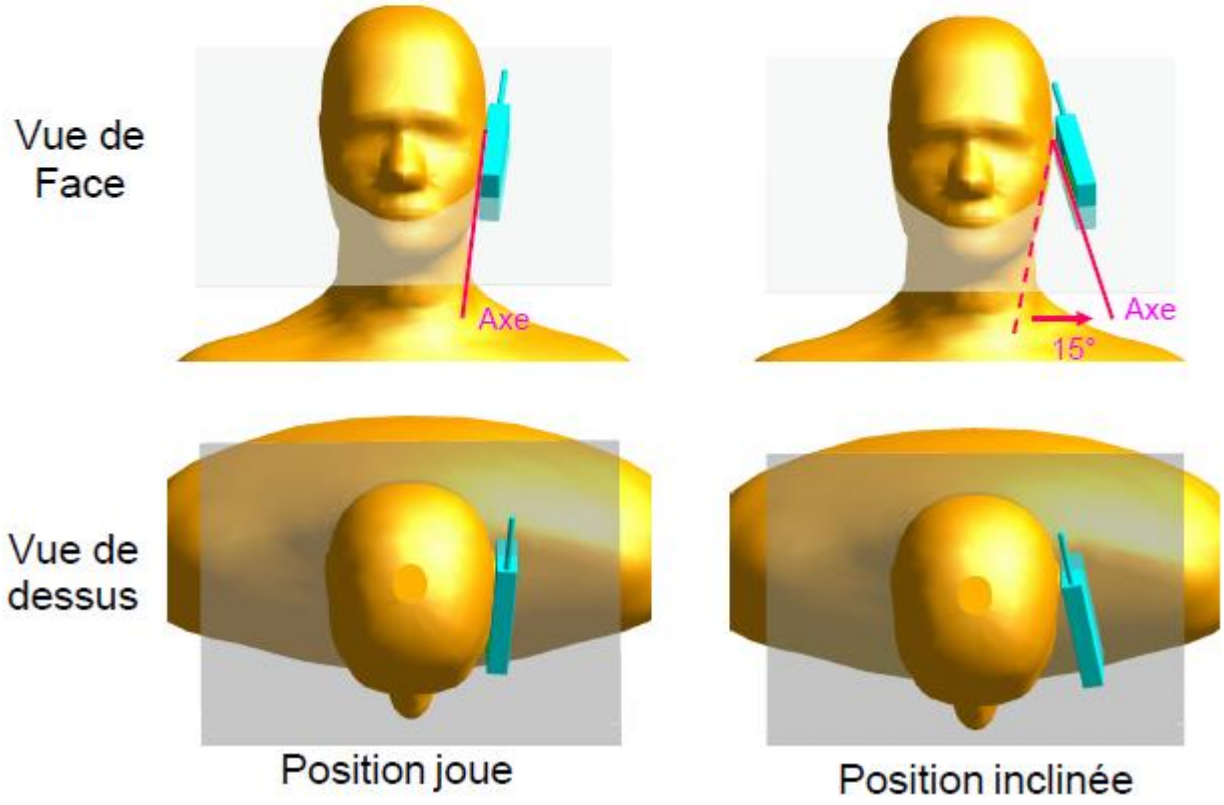


Figure 2 – Définition des lignes et points de référence, sur le téléphone et sur le fantôme et position initiale



Calibration of SAR probes

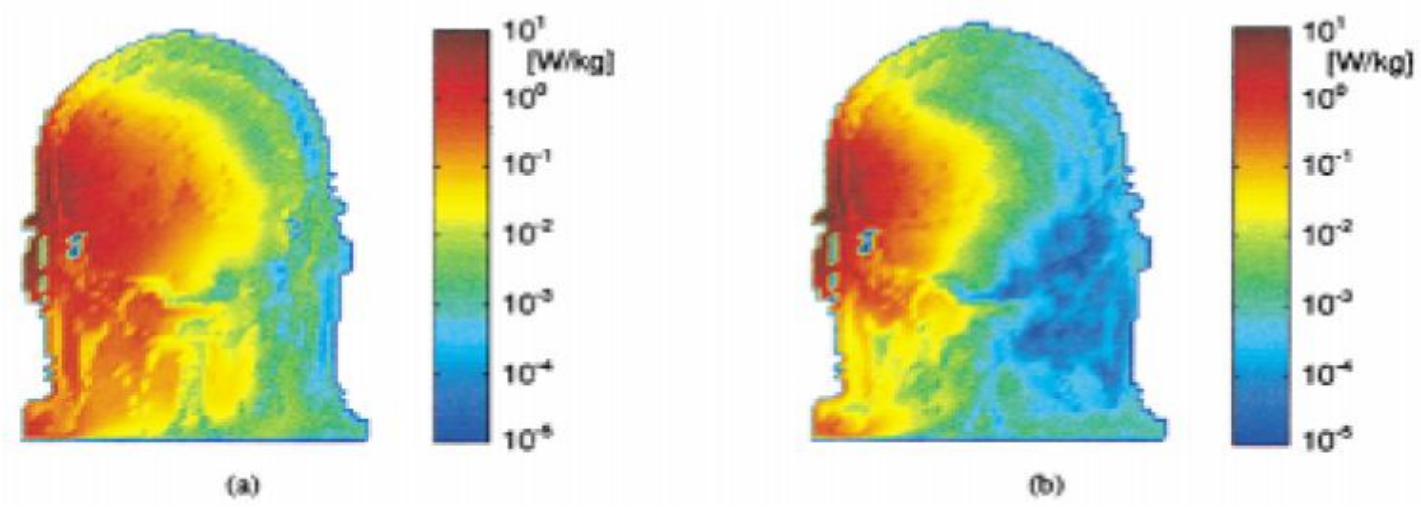
- The probe must be calibrated to ensure precise SAR measurement.
- first determine the calibration coefficient that relates the measured SAR to the output voltage or signal.
- The calibration system uses the theoretical value of the electric field inside a special waveguide tube to create the standard SAR.
- Because the dielectric properties of the phantom liquid differ according to frequency, calibration must be done for each frequency.

Liquid dielectric properties

Fréquence (MHz)	ε_r	σ (S/m)
300	45	0,85
450	44	0,88
900	42	0,99
1450	41	1,20
1800	40	1,38
2450	39	1,84
3000	39	2,40

SAR result

The rate at which radiation is absorbed by the human body is measured by the Specific Absorption Rate (SAR).



SAR distribution for a radiated power of 1 W. (a) $f = 900$ MHz. (b) $f = 1800$ MHz.

[SAR measurements 1]

[SAR measurements 2]

Limits *

Basic restrictions for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz)

Frequency range	Magnetic flux density (mT)	Current density (mA/m^2) (rms)	Whole body average SAR (W/kg)	Localised SAR (head and trunk) (W/kg)	Localised SAR (limbs) (W/kg)	Power density, S (W/m^2)
0 Hz	40	—	—	—	—	—
>0-1 Hz	—	8	—	—	—	—
1-4 Hz	—	8/f	—	—	—	—
4-1 000 Hz	—	2	—	—	—	—
1 000 Hz-100 kHz	—	f/500	—	—	—	—
100 kHz-10 MHz	—	f/500	0,08	2	4	—
10 MHz-10 GHz	—	—	0,08	2	4	—
10-300 GHz	—	—	—	—	—	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)**

Typical SAR values

List of top 10 lowest radiation mobile phones in the US - SAR

Manufacturer and Model *	SAR Level
1. Motorola StarTAC 7860	0,24
2. Qualcomm pdQ-1900	0,2634
3. Mitsubishi Trium Galaxy G-130	0,35
4. Motorola TalkAbout 2297	0,35
5a. Motorola ST7797	0,39
5b. Motorola T8097	0,39
5c. Motorola P8097	0,39
6. Motorola StarTAC 7790i	0,42
7. Motorola i1000plus	0,43
8a. Motorola G520	0,457
8b. Motorola M3682	0,457
9a. Ericsson KF-688	0,477
9b. Ericsson DF-688	0,477
10. Motorola M3097	0,53

List of top 10 highest radiation mobile phones in the US - SAR

Manufacturer and Model	SAR Level
1. Ericsson T28 World	1,49
2. Nokia Digital 5160	1,45
3. Nokia 5170	1,45
4. Denso TP 2200	1,44
5. Qualcomm QCP-1960	1,41
6. Sanyo SCP-4500	1,4
7. Sony CMB-1200, 2200, 3200	1,3906
8. Nokia 8860	1,39
9a. Motorola StarTAC 7867	1,38
9b. Motorola ST7767D	1,38
9c. Motorola Talkabout T8167	1,38
9d. Motorola Timeport P8167	1,38
10. Neopoint NP-1000	1,38

ART-MAN system (1)

- April 2012, ART-FI introduced the ART-MAN: the first working SAR assessment system capable of instant compliance accuracy measurements.

ART-MAN system (2)

- RF probe-array and amplitude/phase patented measurement technology
- Testing a variety of communication modes (GSM, WCDMA, WLAN, LTE, etc…) within the 0.7-6 GHz range
- Test 1g/10g peak spatial-average SAR from simultaneous multi-frequency transmitters in a single measurement
- Full 3D Specific Absorption Rate assessment with high absolute accuracy in a matter of seconds
- Standards compliant head and body mannequins
- IEC 62209 / IEEE 1528 compliant tissue material that does not need to be changed

ART-MAN system (3)

- ART-Fi is at the forefront of the new “Fast SAR” technologies.
- vector-based system
- reduces the time it takes to perform testing on handsets

ART-MAN system

Speed up your compliance

Thank you

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