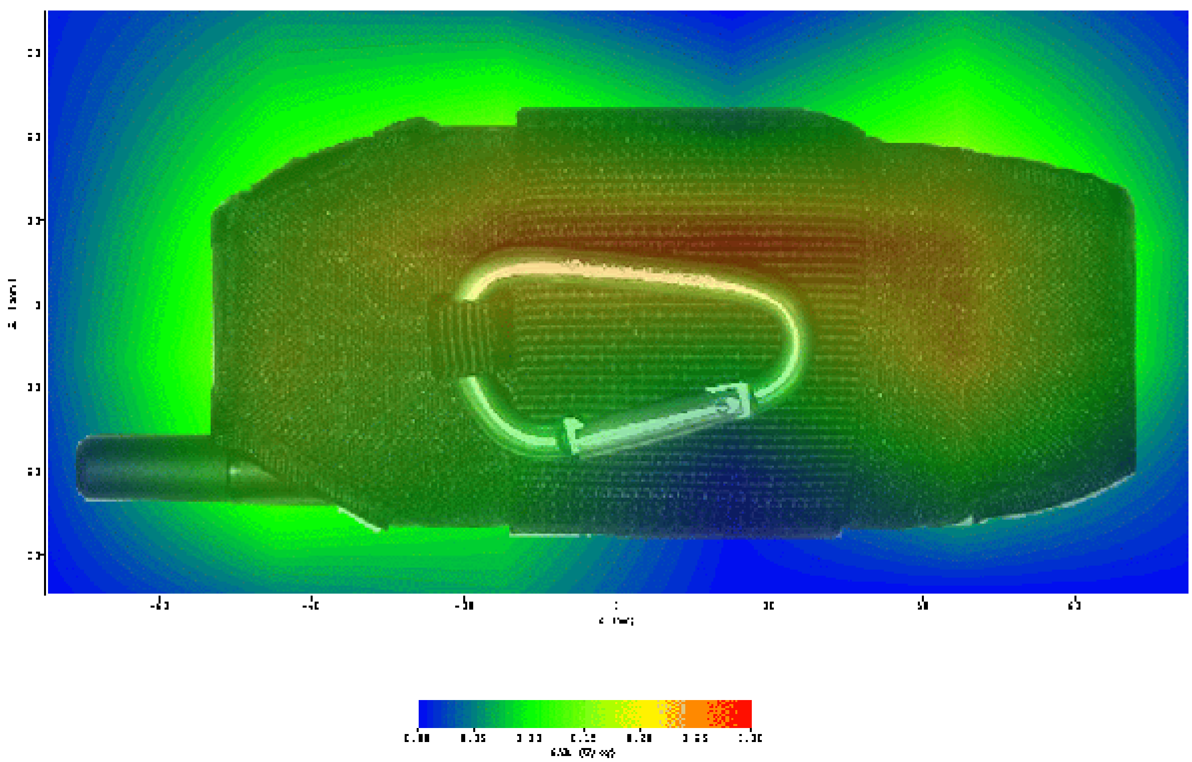
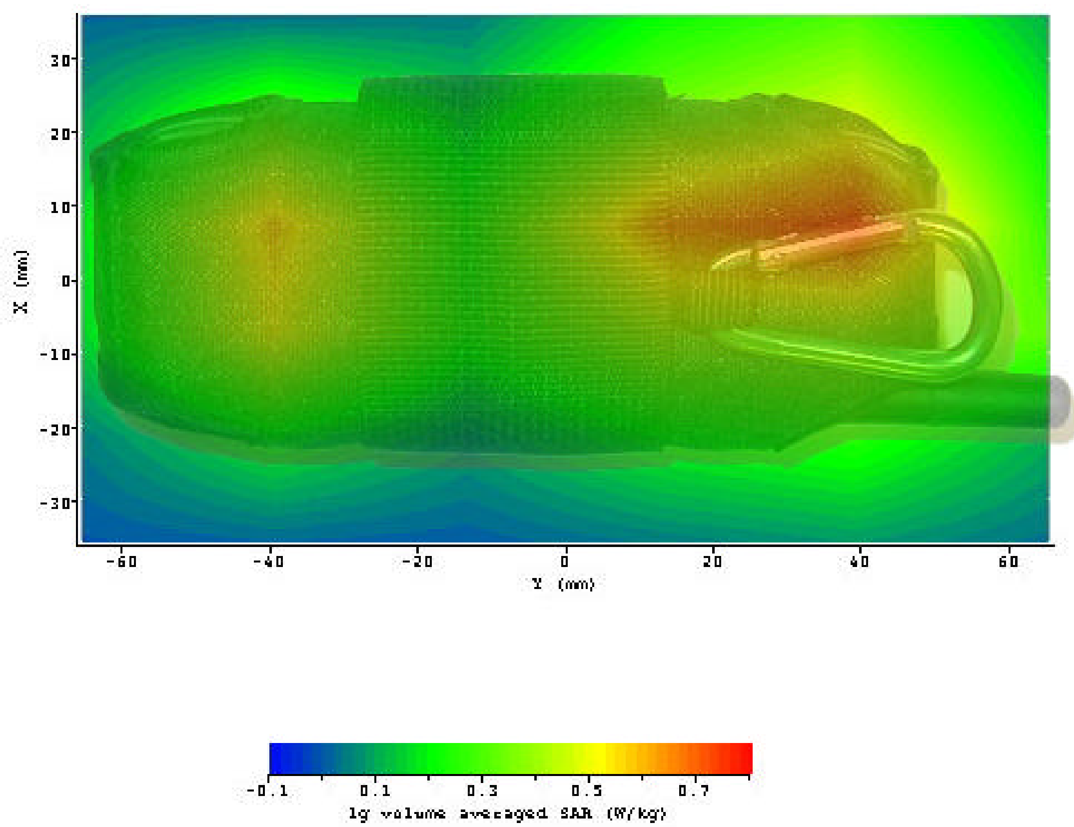
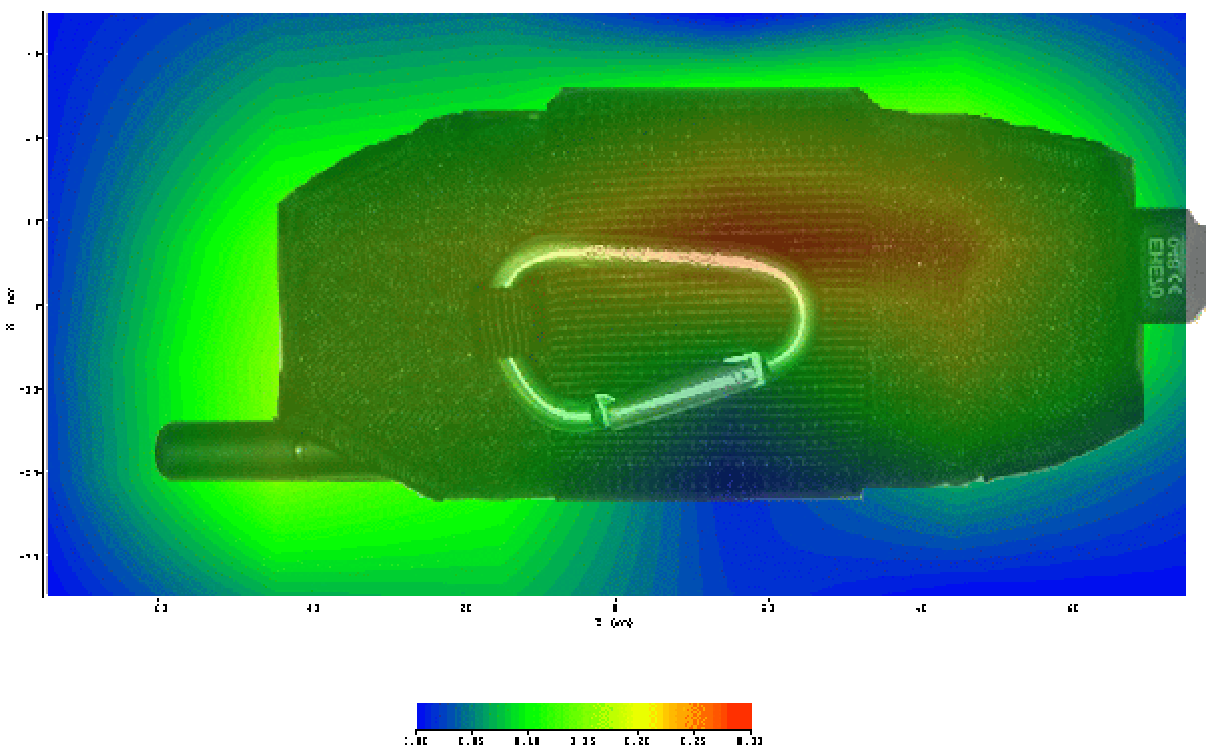
Test Position:	**Config1, per table 10**
Test Date:	**October 6,2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room Temperature:	**24.4 C**
Post Test Room Temperature:	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.238 W/Kg**



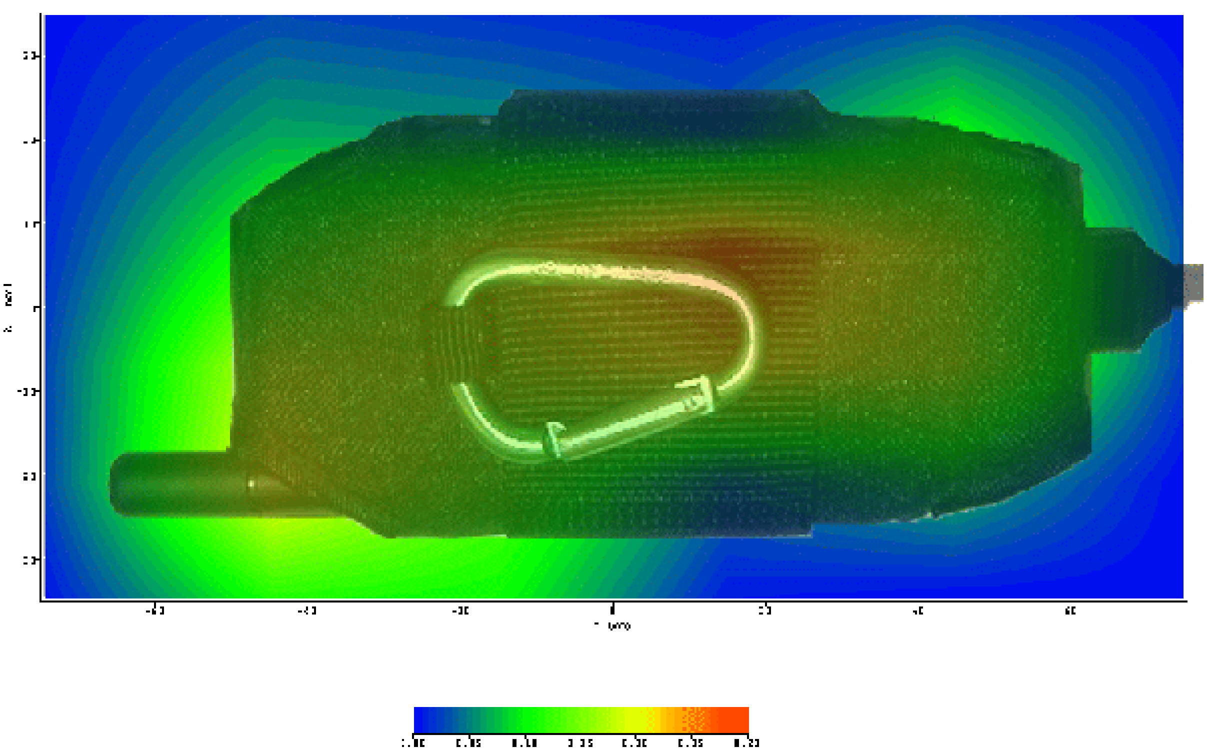
Test Position:	**Config1, per table 10**
Test Date:	**Dec. 27, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0122 – SARf(0.713, 0.713, 0.713) Probe Cal Date 10/2002**
Med. Parameters:	**1900 MHz Body: Ýr = 53.0; ó = 1.54**
Pre Test Room Temperature:	**24.4 C**
Post Test Room Temperature:	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.263 W/Kg**



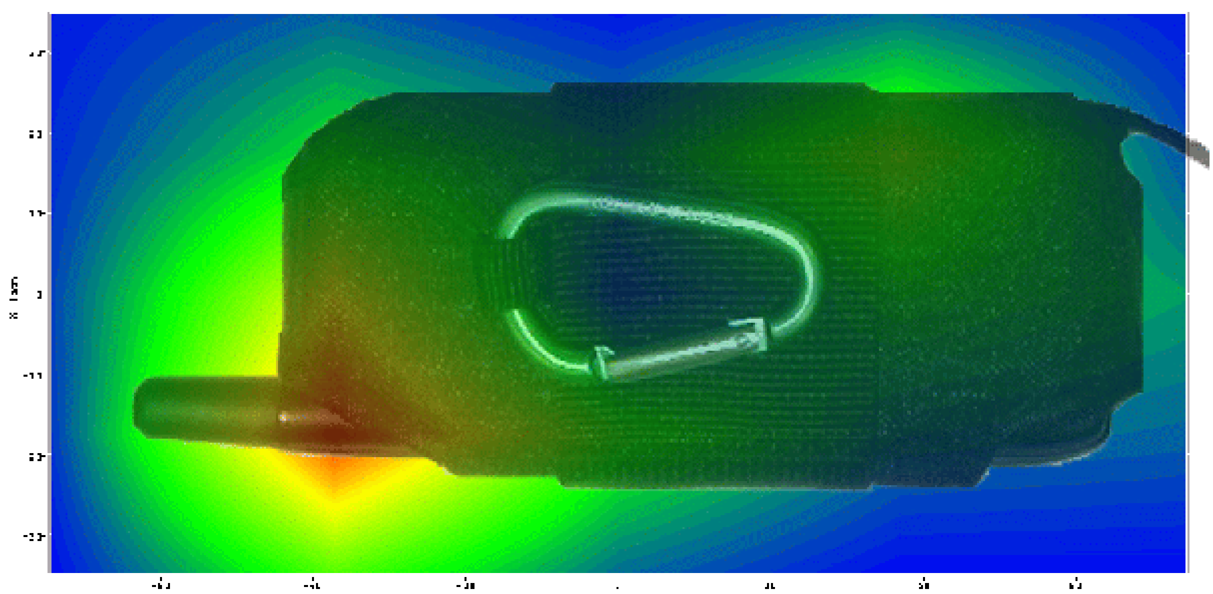
Test Position:	**Config2, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.209 W/Kg**

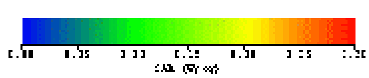


Test Position:	**Config3, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.208 W/Kg**

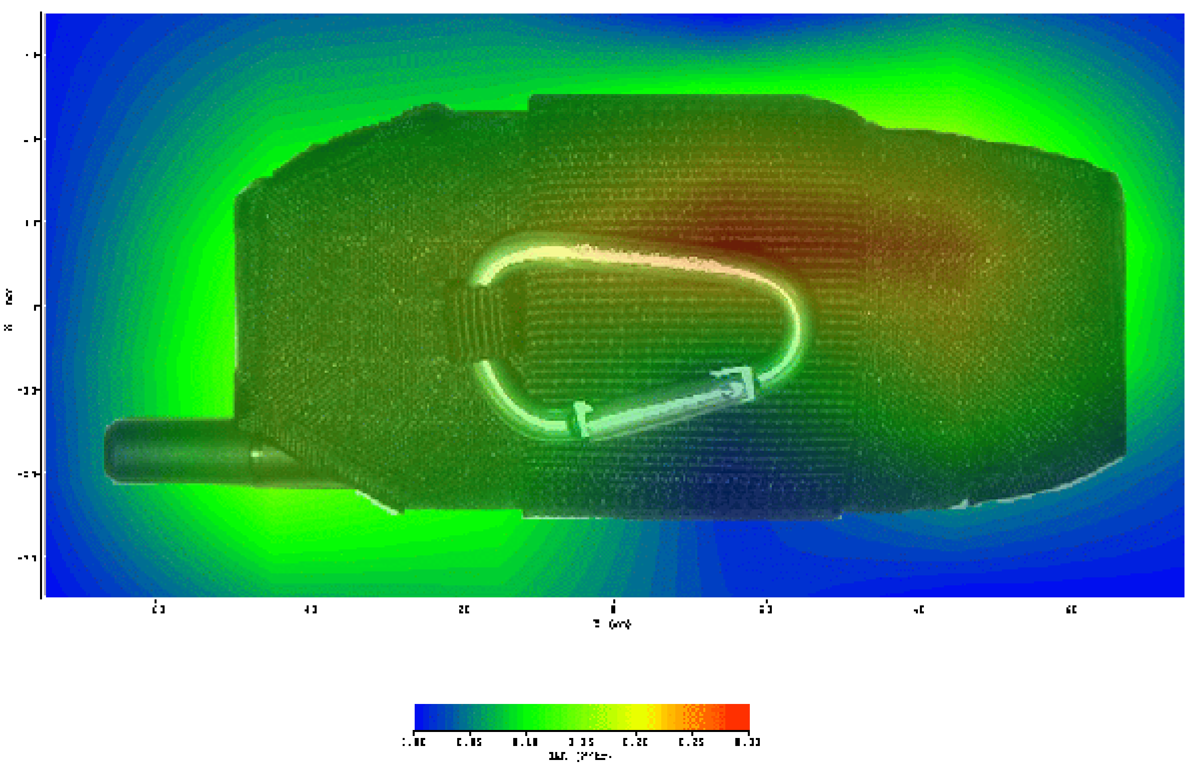


Test Position:	Config4, per table 10
Test Date:	October 6, 2002
Antenna Position:	Fixed PCS Antenna
Probe:	IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002
Med. Parameters:	1900 MHz Body: 55.3 ; ó = 1.47
Pre Test Room	24.4 C
Post Test Room	24.5 C
Pre Test Simulant Liquid	24.6 C
Post Test Simulant Liquid	24.8 C
CH 660;	Crest Factor = 8(GSM)
SAR Drift	< 2%
SAR (1g):	0.144 W/Kg

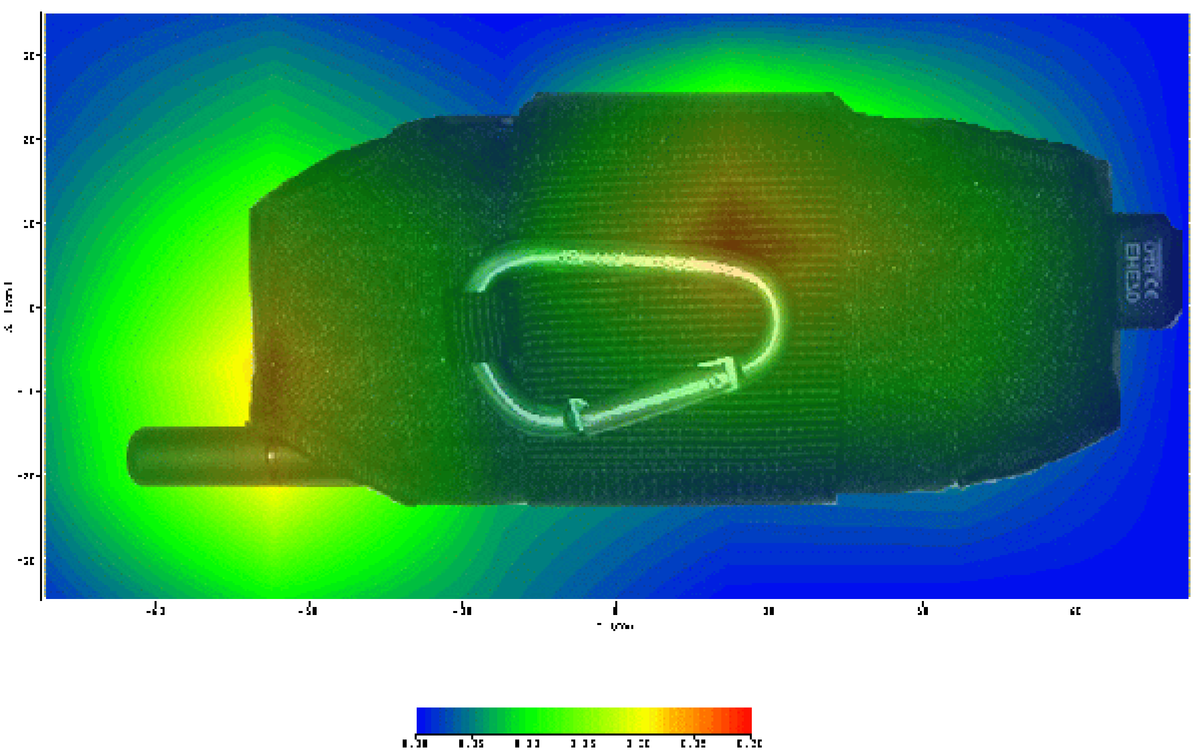




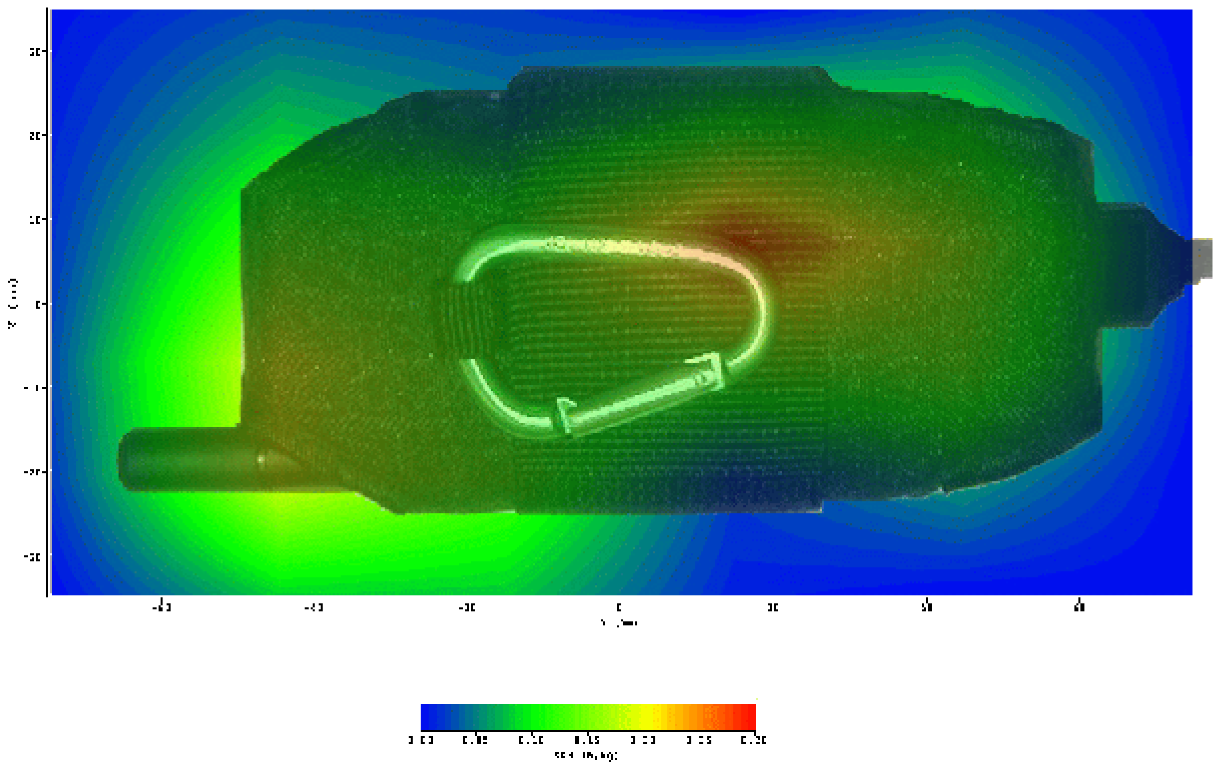
Test Position:	**Config5, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.216 W/Kg**



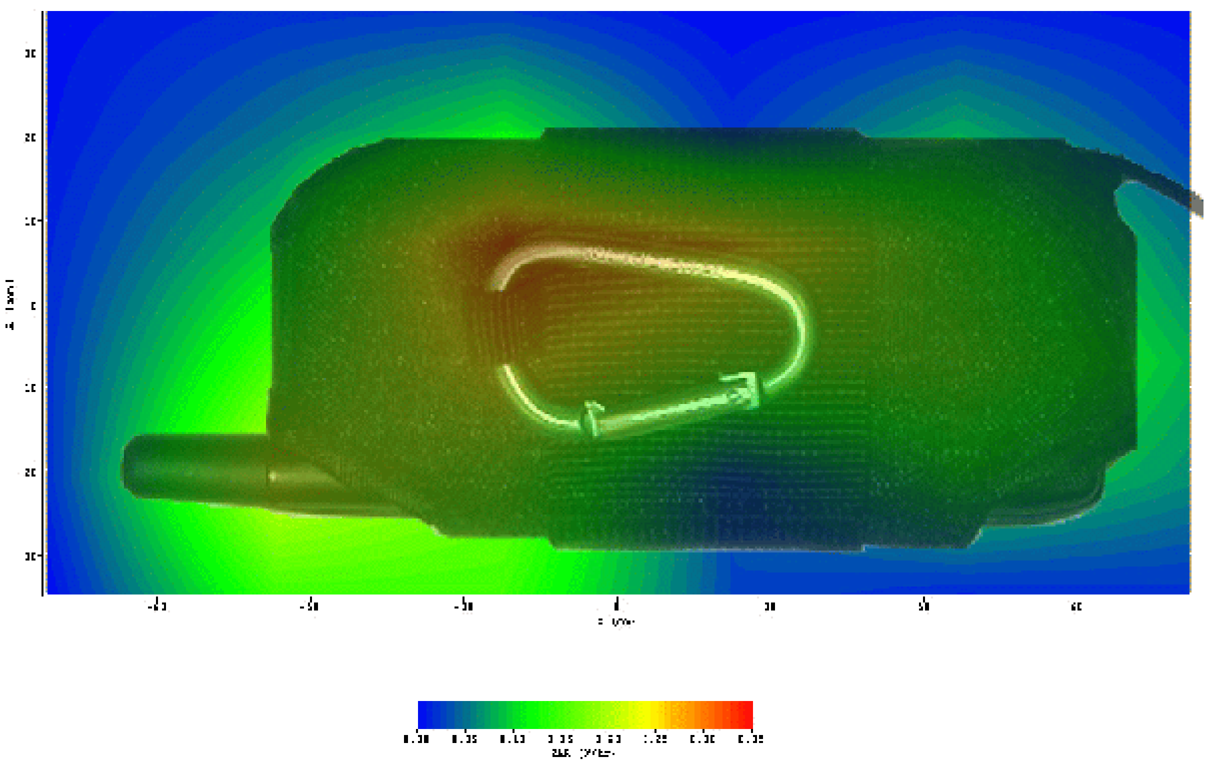
Test Position:	**Config6, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.178 W/Kg**



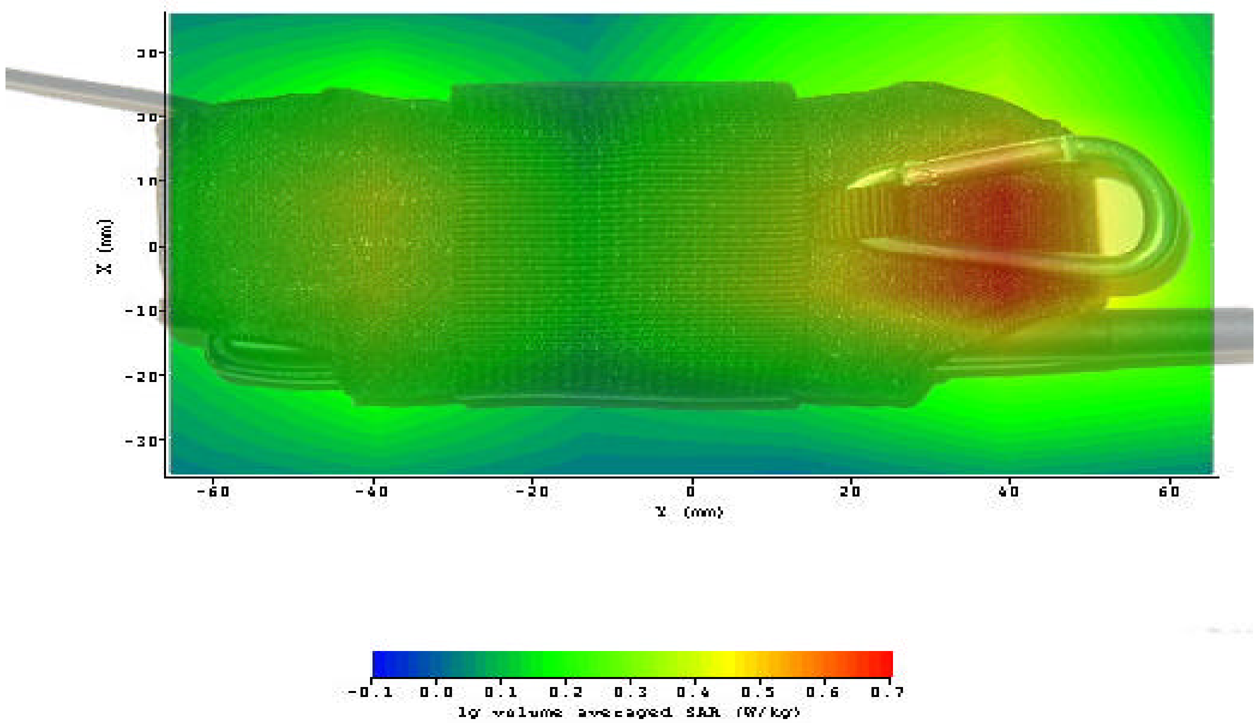
Test Position:	**Config7, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.189 W/Kg**



Test Position:	**Config8, per table 10**
Test Date:	**October 6, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0082 – SARf(0.51, 0.53, 0.53) Probe Cal Date 03/2002**
Med. Parameters:	**1900 MHz Body: 55.3 ; ó = 1.47**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.258 W/Kg**



Test Position:	**Config8, per table 10**
Test Date:	**Dec. 27, 2002**
Antenna Position:	**Fixed PCS Antenna**
Probe:	**IXP-050/SN 0122 – SARf(0.713, 0.713, 0.713) Probe Cal Date 10/2002**
Med. Parameters:	**1900 MHz Body: Ýr = 53.0; ó = 1.54**
Pre Test Room	**24.4 C**
Post Test Room	**24.5 C**
Pre Test Simulant Liquid	**24.6 C**
Post Test Simulant Liquid	**24.8 C**
CH 660;	**Crest Factor = 8(GSM)**
SAR Drift	**< 2%**
SAR (1g):	**0.212 W/Kg**



Setup Pictures

Test Positions for the Device Under Test

Figure S1. Configuration #1 - Tilt (15 ^{0}) position, right side, GPS In, 1200 mAH Battery

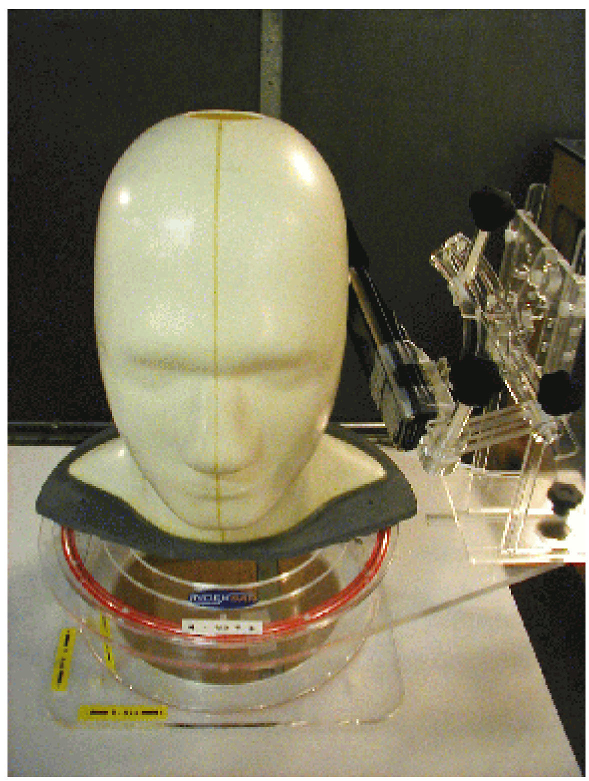


Figure S2. Configuration #2 - Tilt (15 ^{0}) position, right side, GPS Out, 1200 mAH Battery

Figure S3. Configuration #3 - Cheek (0^0) position, right side, GPS In, 1200 mAH Battery

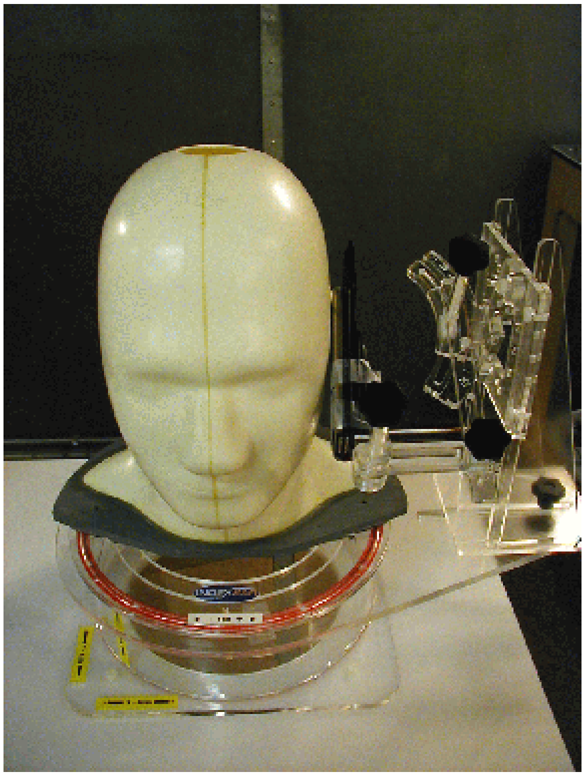


Figure S4. Configuration #4 - Cheek (0^0) position, right side, GPS Out, 1200 mAH Battery

Figure S5. Configuration #5 - Tilt (15 ^{0}) position, right side, GPS In, 900 mAH Battery

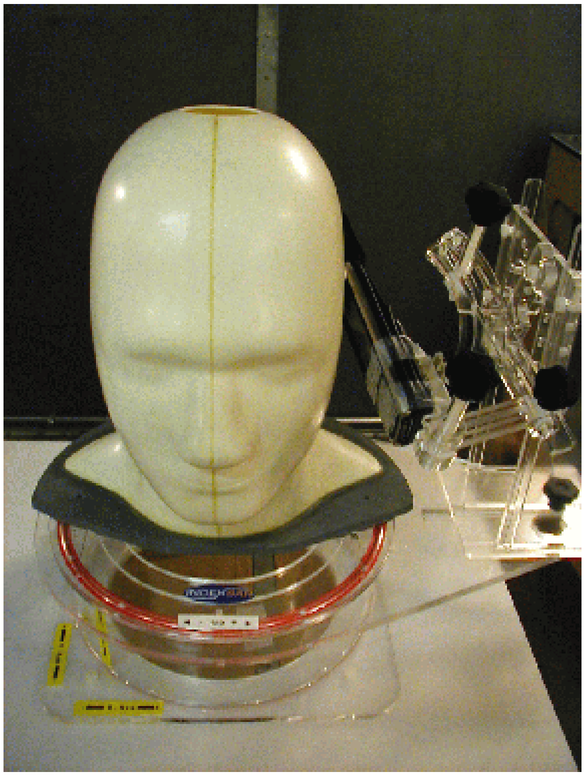


Figure S6. Configuration #6 - Tilt (15 ^{0}) position, right side, GPS Out, 900 mAH Battery

FigureS7. Configuration #7 - Cheek (0 ^{0}) position, right side, GPS In, 900 mAH Battery

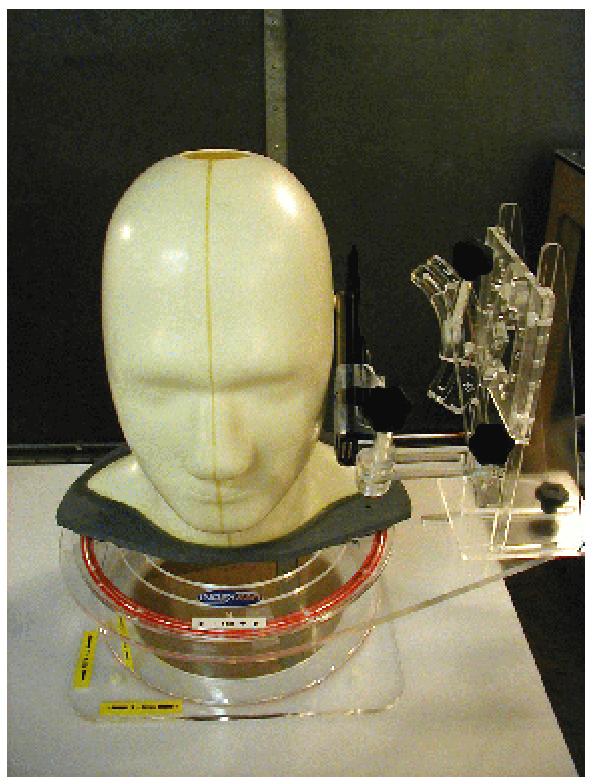


Figure S8. Configuration #8 - Cheek (0 ^{0}) position, right side, GPS Out, 900 mAH Battery

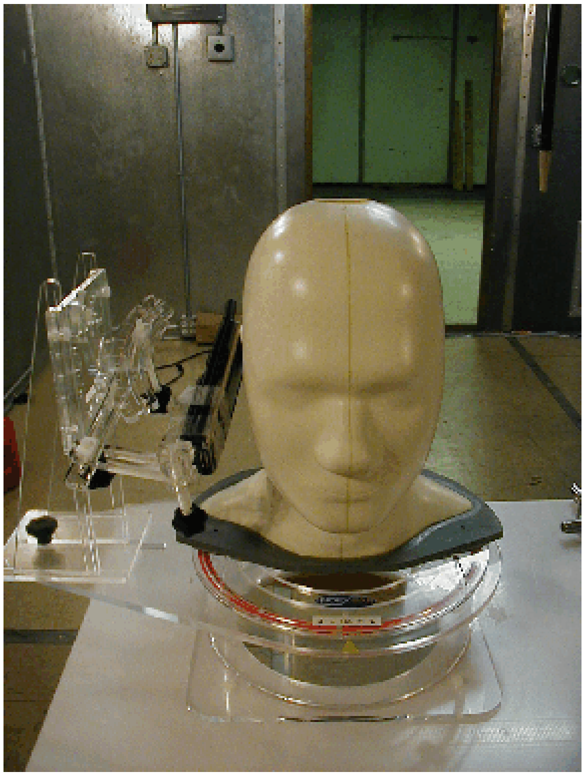


Figure S9. Configuration #9 - Tilt (15 ^{0}) position, left side, GPS In, 1200 mAH Battery

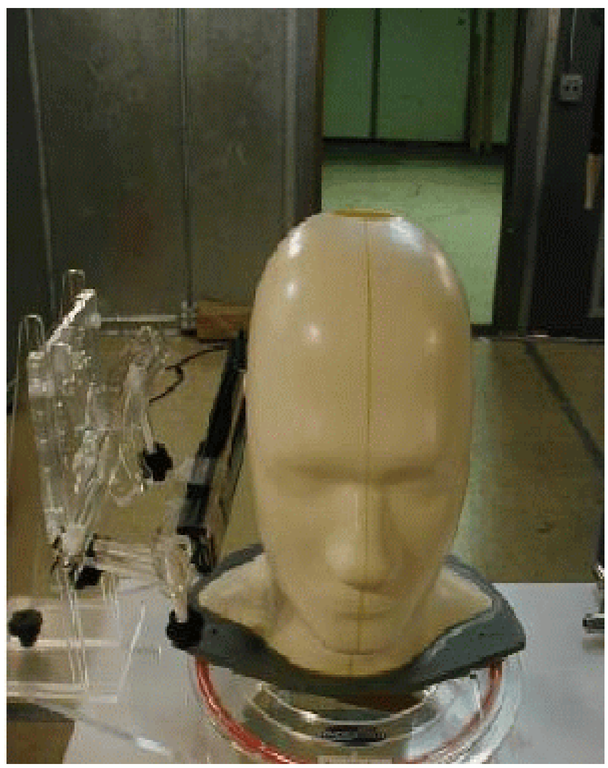


Figure S10. Configuration #10 - Tilt (15 ^{0}) position, left side, GPS Out, 1200 mAH Battery

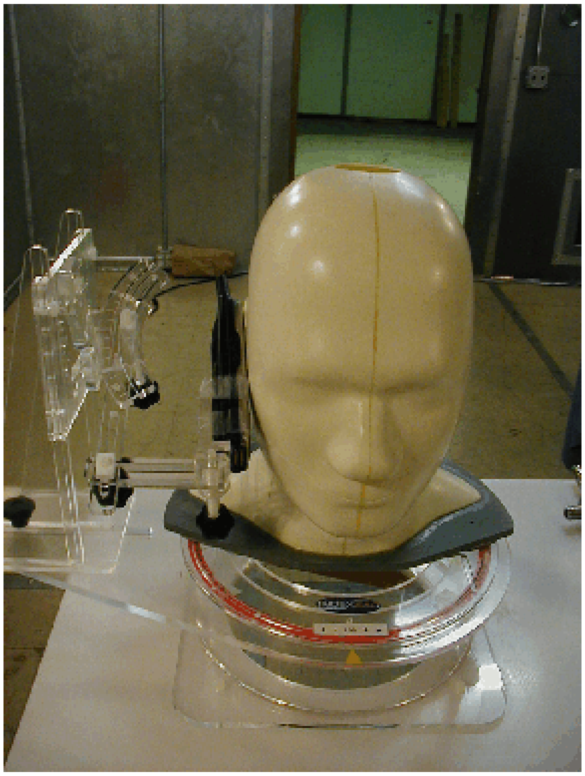
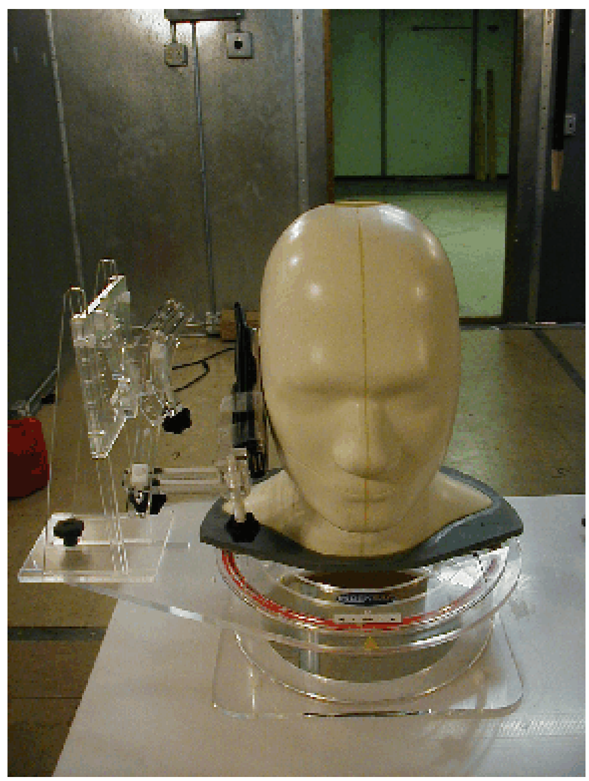


Figure S11. Configuration #11 - Cheek (0 ^{0}) position, left side, GPS In, 1200 mAH Battery



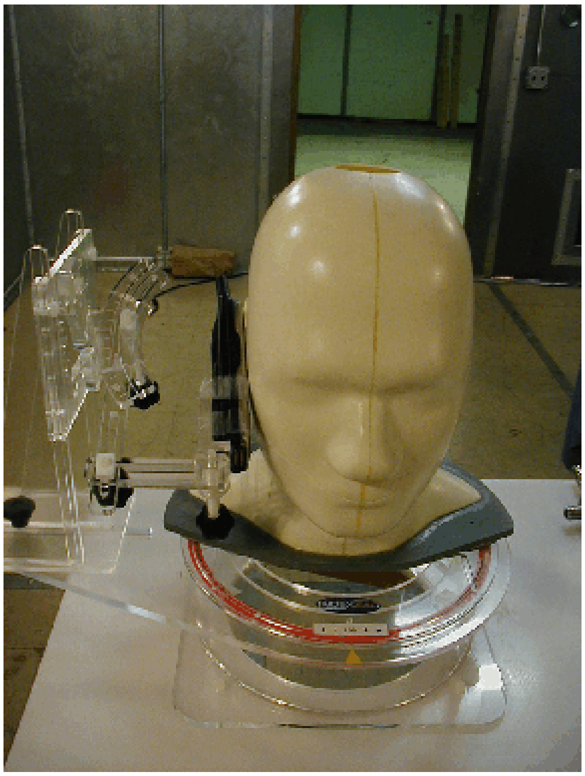


Figure S12. Configuration #12 - Cheek (0 ^{0}) position,

left side, GPS Out, 1200 mAH Battery

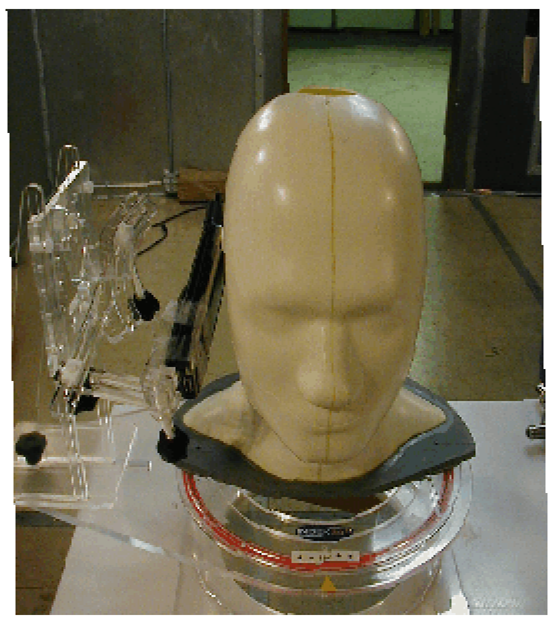


Figure S13. Configuration #13 - Tilt (15 ^{0}) position,
left side, GPS In, 900 mAH Battery

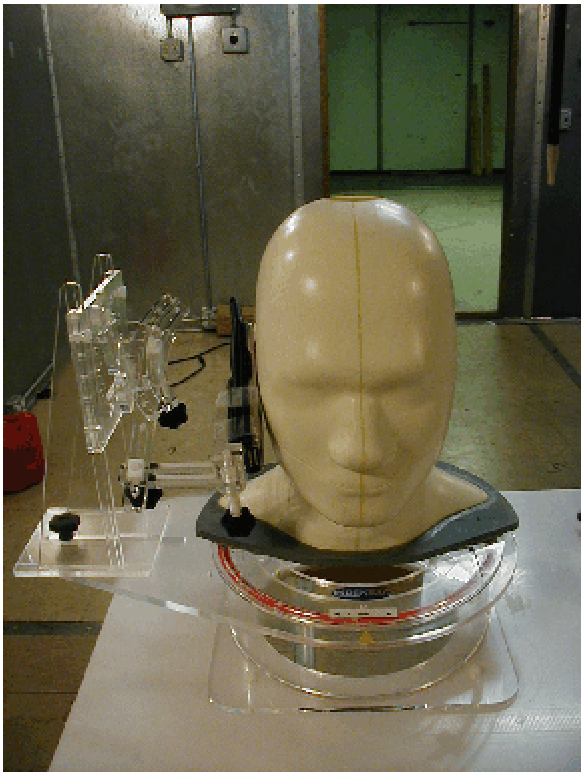


Figure S14. Configuration #14 - Tilt (15 ^{0}) position, left side, GPS Out, 900 mAH Battery

Figure S15. Configuration #15 - Cheek (0 ^{0}) position, left side, GPS In, 900 mAH Battery

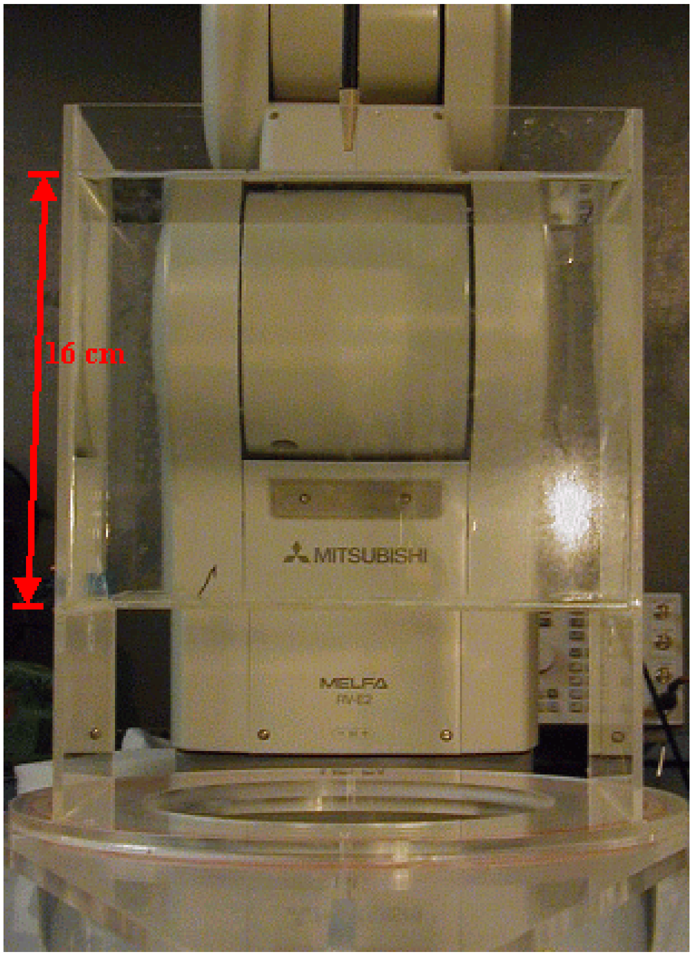


Figure S16. Configuration #16 - Cheek (0[0]) position, left side, GPS Out, 900 mAH Battery

Figure S17. Liquid depth maintained during Body SAR testing is illustrated

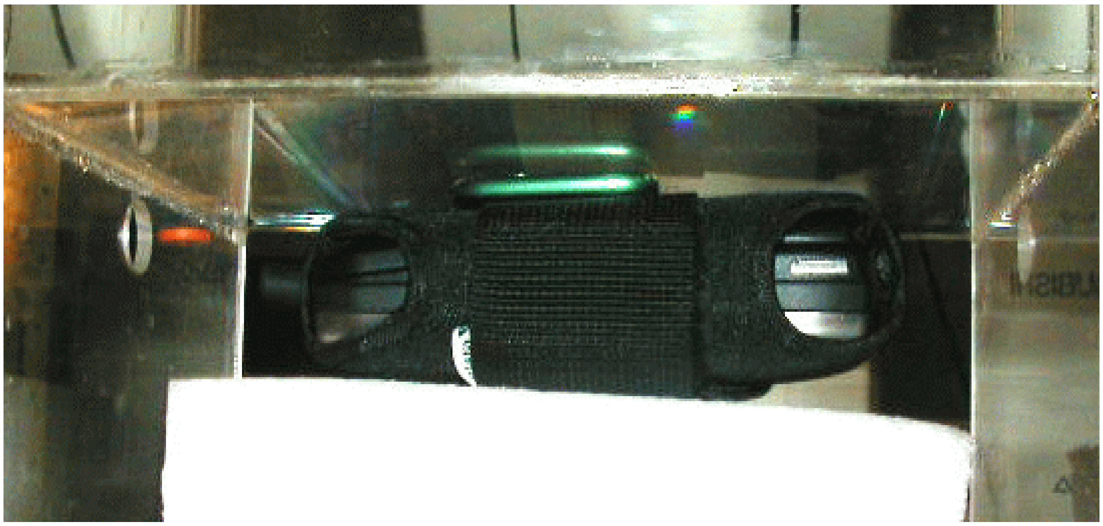


Figure S18. Phone with carrying case (black) - 900 mAH Battery

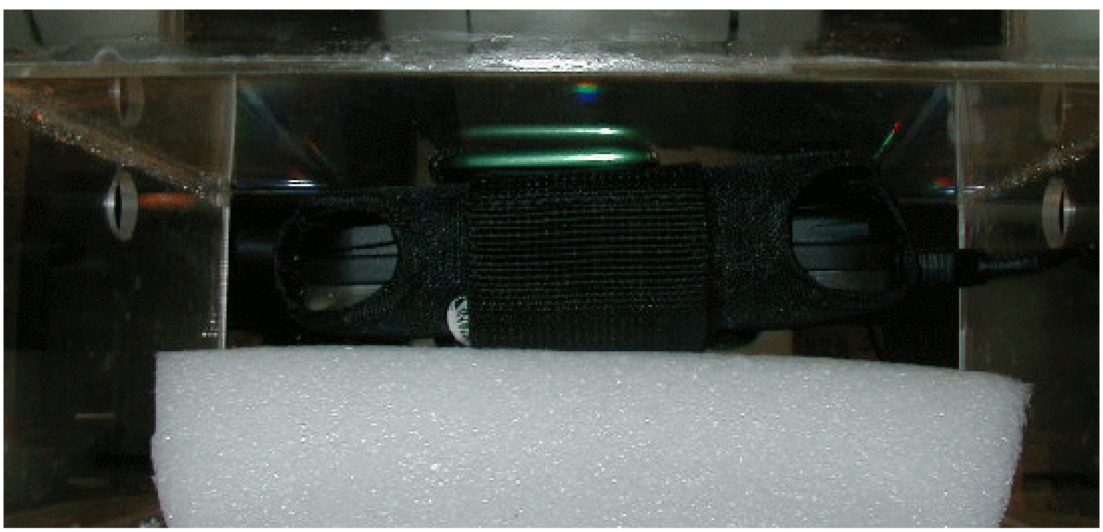


Figure S19. Phone with carrying case (black) and Headset - 900 mAH Battery

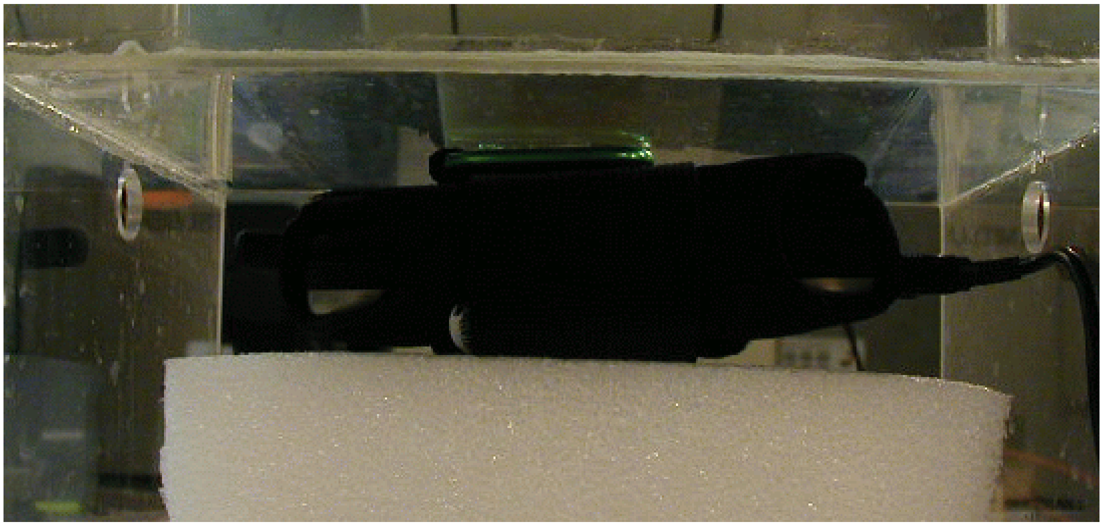


Figure S20. Phone with carrying case (black) and Data Cable - 900 mAH Battery

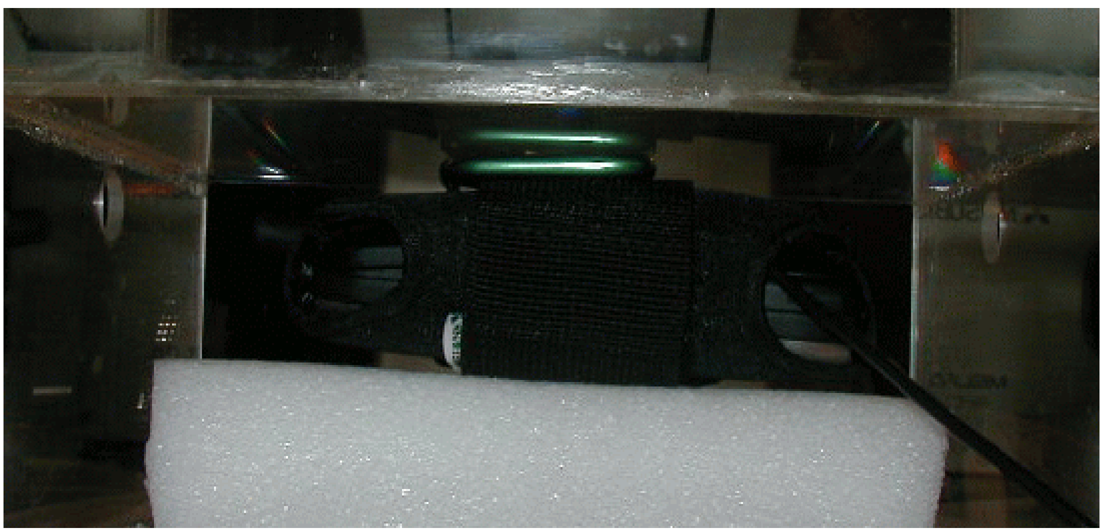


Figure S21. Phone with carrying case (black) and External GPS Antenna - 900 mAH Battery

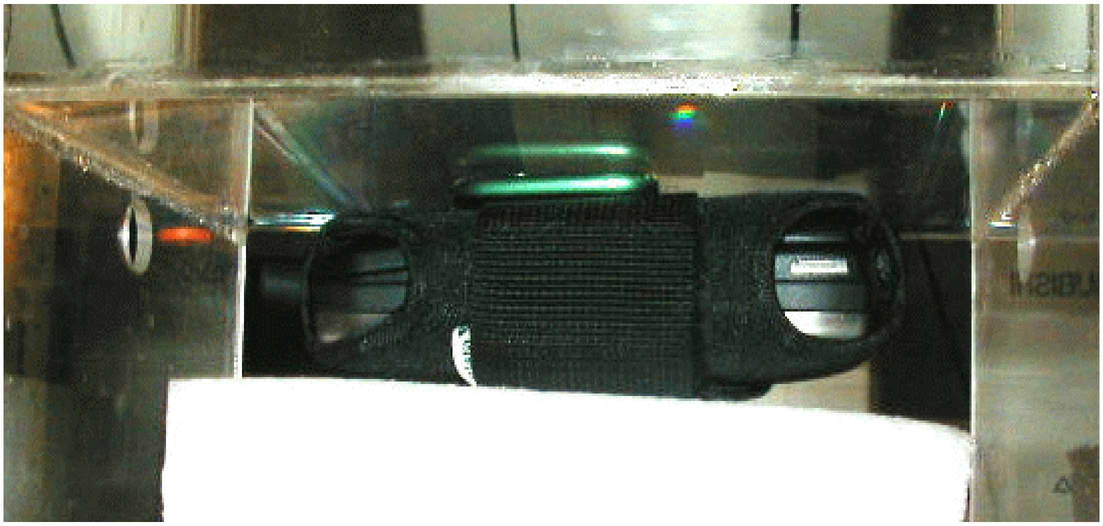


Figure S22. Phone with carrying case (black) - 1200 mAH Battery

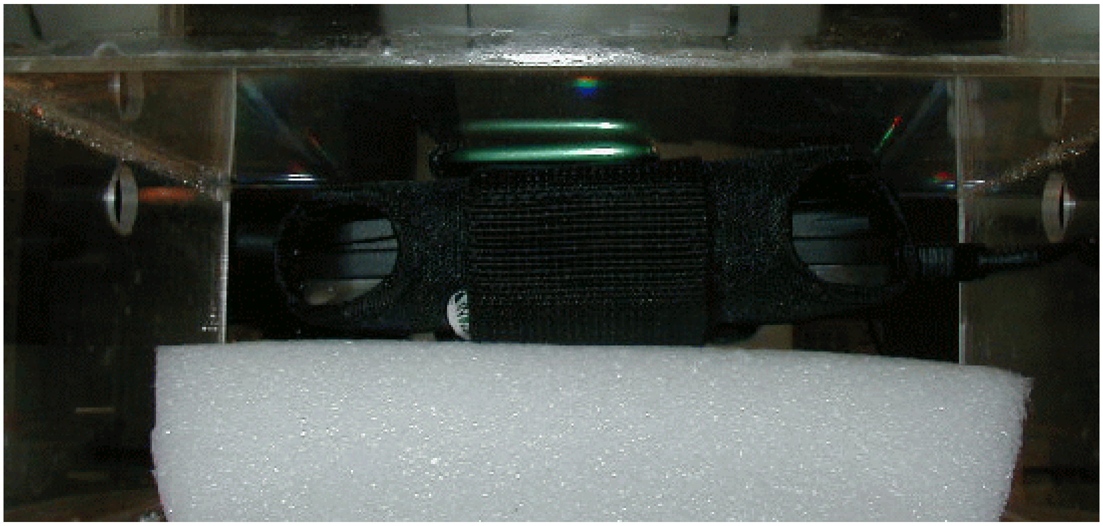


Figure S23. Phone with carrying case (black) and Headset -1200 mAH Battery

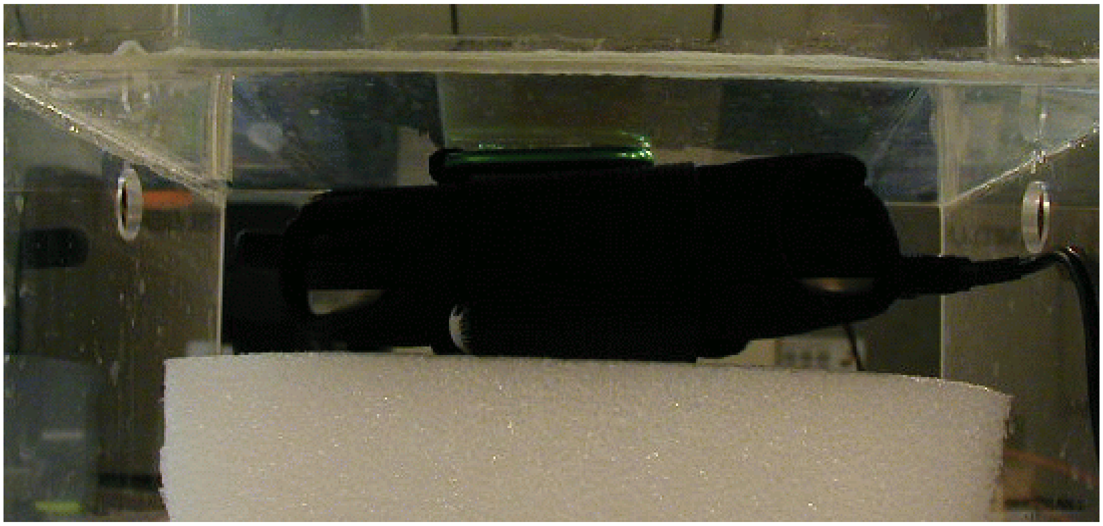


Figure S24. Phone with carrying case (black) and Data Cable - 1200 mAH Battery

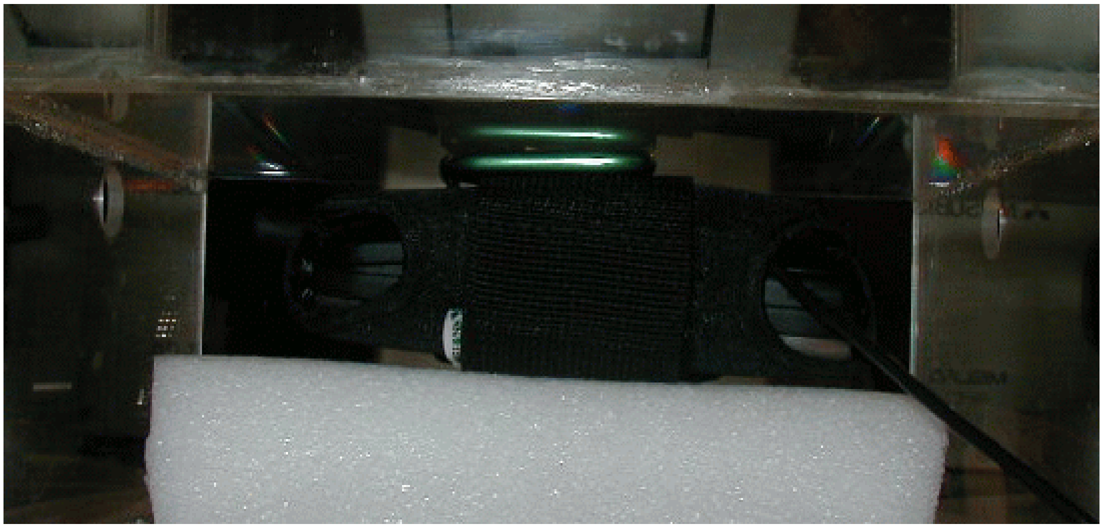


Figure S25. Phone with carrying case (black) and External GPS Antenna - 1200 mAH Battery

Measurement System Used

Measurement System - SARA2 System Specification

The SAR measurement system being used is the IndexSAR SARA2 system, which consists of a Mitsubishi RV-E2 6-axis robot arm and controller, IndexSAR probe and amplifier and SAM phantom Head Shape. The robot is used to articulate the probe to programmed positions inside the phantom head to obtain the SAR readings from the EUT.

The system is controlled remotely from a PC, which contains the software to control the robot and data acquisition equipment. The software also displays the data obtained from test scans.

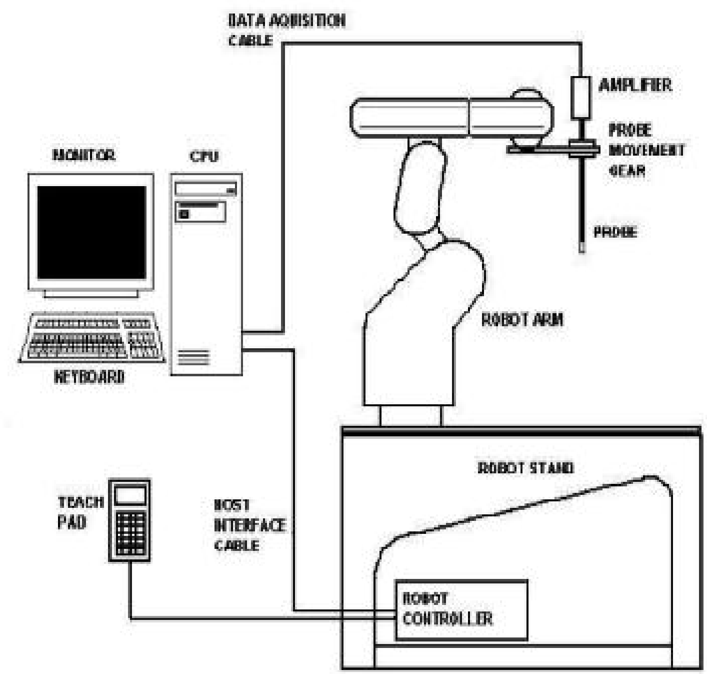


Figure 17. Block Diagram of SARA 2 System

The position and digitised shape of the phantom heads are made available to the software for accurate positioning of the probe and reduction of set-up time.

The SAM phantom heads are individually digitised using a Mitutoyo CMM machine to a precision of 0.001mm. The data is then converted into a shape format for the software, providing an accurate description of the phantom shell.

In operation, the system first performs an area (2D) scan at a fixed depth within the liquid from the inside wall of the phantom. When the maximum SAR point has been found, the system will then carry out a 3D scan centred at that point to determine volume averaged SAR level.

SPECIFICATIONS

ROBOTIC SYSTEM

Type:	Mitsibishi Movemaster RV-2E/ 6 Axis vertical articulated robot
Dimensions (Robot):	Height: 790mm (in home position)
Dimensions (Robot Stand):	1010L x 450W x 820H mm
Weight:	Approx. 36 kgf
Position Repeatability:	+/- 0.04mm
Drive Method:	AC servomotor

CONTROLLER UNIT

Type:	CR-E116
Dimensions:	422W x 512D x 202H mm
Weight:	Approx. 27 kgf
Power source:	single-phase AC200V +/- 10%, 50/60 Hz, 3KVA

E-FIELD PROBE

Type: Three orthogonal dipole sensors arranged on triangular, interlocking substrates

Dimensions: Overall length: 350mm
Tip length: 10mm
Body diameter: 12mm
Tip diameter: 5mm
Distance from probe tip to dipole centers: 2.5mm

Isotropy: +/- 0.5 dB in brain liquids (rotation about probe axis)
+/- 1.0 dB in brain liquids (rotation normal to probe axis)

Calibration: Indexsar calibration in brain tissue simulating liquids at
frequencies of 900 MHz and 1800 MHz

Dynamic Range: 0.01 W/kg to 100 W/kg in liquid. Linearity +/- 0.2 W/kg

Data Acquisition

Processor	Pentium III
Clock Speed	700MHz
Operating System	Windows 98 or 2000
I/O	Two RS232, or One RS232 and One USB
Software	SARA2 Ver.xx, IXU-010X Utility Software Ver.xx, Microsoft Excel
Memory	10GB Hard drive, CDROM

IXP-050 IndexSAR isotropic immersible SAR probe

The probes are constructed using three orthogonal dipole sensors arranged on an interlocking, triangular prism core. The probes have built-in shielding against static charges and are contained within a PEEK cylindrical enclosure material at the tip. Probe calibration is described in the Calibration report appendix.

IXP-010 Amplifier

The amplifier unit has multi-pole connector to connect to the probe and a multiplexer selects between the 3-channel single-ended inputs. A 16-bit AtoD converter with programmable gain is used along with an on-board micro-controller with non-volatile firmware. Battery life is around 150 hours and data are transferred to the PC via 3m of duplex optical fibre and a self-powered RS232 to optical converter.

Amplifier Specification

1	Input	Multipole connector to suit probe in use
2	Channels	Muliplewd 3 channel single ended inputs
3	Amplifier	16 bit A/D Converter with programable gain
4	Dimensions	120x60x30 mm
5	Weight	170g(with batteries)
6	Optical Link	3 m duplex optical fiber

PHANTOMS

SAM Twin Horizontal Phantom per IEEE Draft 1528
The SAM Twin Horizontal is fabricated to the CAD files as specified by FCC OET 65 Supplement C 01-01 and IEEE Draft 1528. It is mounted on a dielectric table which includes mounting brackets for EUT positioners and a shelf for dipole holders. The phantom has three integrated positioning reference points.

SAM Upright Phantom per CENELEC EN50361
The SAM Upright Phantom is fabricated to the CAD files as specified by CENELEC EN50361. It is mounted on the base table which holds the robotic positioner. The phantom and robot alignment is assured by both mechanical and laser registration systems.
Flat Bath Phantom for testing above 800 MHz
The Flat Bath Box Phantom is fabricated to the specifications of the OET 65 Supplement C and CENELEC EN50361 standard. It is mounted on a similar rotational base to that of which the SAM upright phantom is attached to. It is positioned in place of the SAM upright head when doing validations or flat bath testing.

Phantom Properties:

Phantom Type	Material	Permittivity (g)	Conductivity (ó - S/m)
SAM Upright Phantom	Head:polyurethane Resin Base:PVC	<3.15 above 200 MHz	<0.02 below 2 GHz
Box Phantom	Clear: Perspex	<2.85 above 500 MHz	<0.015 below 2 GHz

Table 11. Phamtom Properties

PHONE POSITIONER

Experience has shown that SAR results can vary considerably when plastic or material fixtures used to position the test devices are too close to the antennas (especially for phones with internal antennas). The MapSAR positioner has been designed to have no support material close the top of the phone and is arranged so that the phone pivots around the earpiece position. The positioner gives a range of phone angles from the starting touch position to +15º as required by CENELEC Pr EN 50361 or any position within a range of 30º. A graduated scale allows for easy setting. Adjustment is made by means of simple hand screws. For tests requiring phantom hands or hand material, space is made available behind the phone.

Measurement Procedure

The major components of the test bench are shown in the picture above. A test set and dipole antenna control the handset via an air link and a low-mass phone holder can position the phone at either ear. Graduated scales are provided to set the phone in the 15 degree position. The upright phantom head holds approx. 7 liters of simulant liquid. The phantom is filled and emptied through a 45mm diameter penetration hole in the top of the head.

After an area scan has been performed at a fixed distance of 8mm from the surface of the phantom on the source side, a 3D scan is set up around the location of the maximum spot SAR. First, a point within the scan area is visited by the probe and a SAR reading taken at the start of testing. At the end of testing, the probe is returned to the same point and a second reading is taken. Comparison between these start and end readings enables the power drift during measurement to be assessed.

SARA2 Interpolation and Extrapolation schemes

SARA2 software contains support for both 2D cubic B-spline interpolation as well as 3D cubic B-spline interpolation. In addition, for extrapolation purposes, a general n^{-th} order polynomial fitting routine is implemented following a singular value decomposition algorithm presented in [4]. A 4th order polynomial fit is used by default for data extrapolation, but a linear-logarithmic fitting function can be selected as an option. The polynomial fitting procedures have been tested by comparing the fitting coefficients generated by the SARA2 procedures with those obtained using the polynomial fit functions of Microsoft Excel when applied to the same test input data.

Interpolation of 2D area scan

The 2D cubic B-spline interpolation is used after the initial area scan at fixed distance from the phantom shell wall. The initial scan data are collected with approx. 10mm spatial resolution and spline interpolation is used to find the location of the local maximum to within a 1mm resolution for positioning the subsequent 3D scanning.

Extrapolation of 3D scan

For the 3D scan, data are collected on a spatially regular 3D grid having (by default) 6.4 mm steps in the lateral dimensions and 3.5 mm steps in the depth direction (away from the source). SARA2 enables full control over the selection of alternative step sizes in all directions.

The digitised shape of the head is available to the SARA2 software, which decides which points in the 3D array are sufficiently well within the shell wall to be 'visited' by the SAR probe. After the data collection, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

Interpolation of 3D scan and volume averaging

The procedure used for defining the shape of the volumes used for SAR averaging in the SARA2 software follow the method of adapting the surface of the 'cube' to conform with the curved inner surface of the phantom. This is called, here, the conformal scheme.

For each row of data in the depth direction, the data are extrapolated and interpolated to less than 1mm spacing and average values are calculated from the phantom surface for the row of data over distances corresponding to the requisite depth for 10g and 1g cubes. This results in two 2D arrays of data, which are then cubic B-spline interpolated to sub mm lateral resolution. A search routine then moves an averaging square around through the 2D array and records the maximum value of the corresponding 1g and 10g volume averages. For the definition of the surface in this procedure, the digitised position of the headshell surface is used for measurement in head-shaped phantoms. For measurements in rectangular, box phantoms, the distance between the phantom wall and the closest set of gridded data points is entered into the software.

For measurements in box-shaped phantoms, this distance is under the control of the user. The effective distance must be greater than 2.5mm as this is the tip-sensor distance and to avoid interface proximity effects, it should be at least 5mm. A value of 6 or 8mm is recommended. This distance is called dbe in EN 50361.

For automated measurements inside the head, the distance cannot be less than 2.5mm, which is the radius of the probe tip and to avoid interface proximity effects, a minimum clearance distance of x mm is retained. The actual value of dbe will vary from point to point depending upon how the spatially-regular 3D grid points fit within the shell. The greatest separation is when a grid point is just not visited due to the probe tip dimensions. In this case the distance could be as large as the step-size plus the minimum clearance distance (i.e with x=5 and a step size of 3.5, dbe will be between 3.5 and 8.5mm).

The default step size (dstep in EN 50361) used is 3.5mm, but this is under user-control. The compromise is with time of scan, so it is not practical to make it much smaller or scan times become long and power-drop influences become larger. The robot positioning system specification for the repeatability of the positioning (dss in EN50361) is +/- 0.04mm.

The phantom shell is made by an industrial moulding process from the CAD files of the SAM shape, with both internal and external moulds. For the upright phantoms, the external shape is subsequently digitised on a Mitutoyo CMM machine (Euro C574) to a precision of 0.001mm. Wall thickness measurements made non-destructively with an ultrasonic sensor indicate that the shell thickness (dph) away from the ear is 2.0 +/- 0.1mm. The ultrasonic measurements were calibrated using additional mechanical measurements on available cut surfaces of the phantom shells. See support document IXS-020x.

For the upright phantom, the alignment is based upon registration of the rotation axis of the phantom on its 253mm diameter baseplate bearing and the position of the probe axis when commanded to go to the axial position. A laser alignment tool is provided (procedure detailed elsewhere). This enables the registration of the phantom tip (dmis) to be assured to within approx. 0.2mm. This alignment is done with reference to the actual probe tip after installation and probe alignment. The rotational positioning of the phantom is variable – offering advantages for special studies, but locating pins ensure accurate repositioning at the principal positions (LH and RH ears).

Figure 18. Photograph of SARA2 System

UNCERTAINTY ASSESSMENT

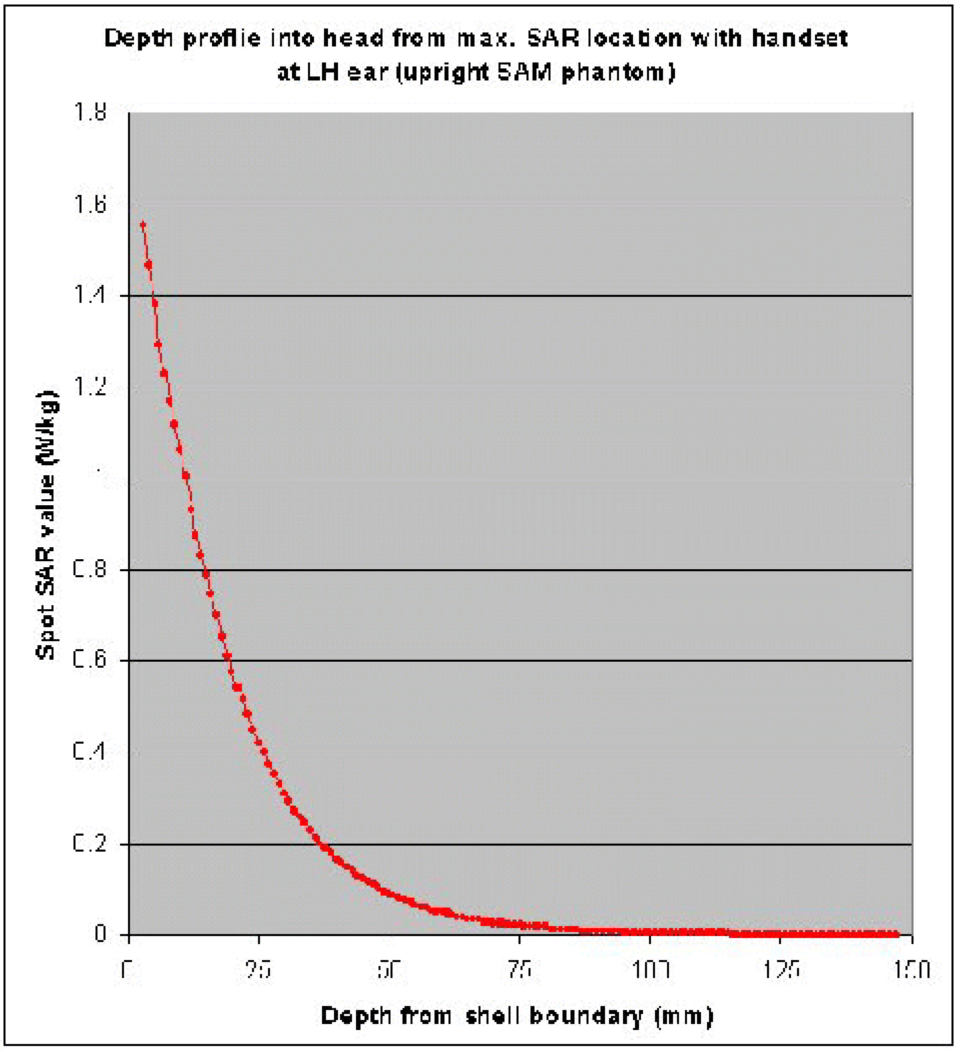
Uncertainty Component	Sec.	Tol. (+/-)			Prob. Dist.	Divisor (descrip)	Divisor (value)	c1	Standard Uncertainty (%)	
		(dB)		(%)						sqr
Measurement System										
Probe Calibration	E1.1			10	N	1 or k	2	1	5.00	25.00
Axial Isotropy	E1.2	0.25	5.93	5.93	R	%v3	1.73	0	0.00	0.00
Hemispherical Isotropy	E1.2	0.5	12.2	12.20	R	%v3	1.73	1	7.04	49.63
Boundary effects	E1.3		4	4.00	R	%v3	1.73	1	2.31	5.33
Linearity	E1.4	0.04	0.93	0.93	R	%v3	1.73	1	0.53	0.29
System Detection Limits	E1.5		1	1.00	R	%v3	1.73	1	0.58	0.33
Readout Electronics	E1.6		1	1.00	N	1 or k	1.00	1	1	1.00
Response time	E1.7		0	0.00	R	%v3	1.73	1	0	0.00
Integration time	E1.8		1.8	1.80	R	%v3	1.73	1	1.04	1.08
RF Ambient Conditions	E5.1		3	3.00	R	%v3	1.73	1	1.73	3.00
Probe Positioner Mechanical Tolerance	E5.2		0.6	0.60	R	%v3	1.73	1	0.35	0.12
Probe Position wrt. Phantom Shell	E5.3		5	3.80	R	%v3	1.73	1	2.19	4.81
SAR Evaluation Algorithms	E4.2		8	4.00	R	%v3	1.73	1	2.31	5.33
Test Sample Related										
Test Sample Positioning	E3.2.1		10	10.00	R	%v3	1.73	1	5.77	33.33
Device Holder Uncertainty	E3.1.1		10	8.00	R	%v3	1.73	1	4.62	21.33
Output Power Variation	E5.6.2		5	5.00	R	%v3	1.73	1	2.89	8.33
Phantom and Tissue Parameters										
Phantom Uncertainty (shape and	E2.1		4	4.00	R	%v3	1.73	0.5	1.15	1.33
Liquid conductivity (Deviation from	E2.2		5	5.00	R	%v3	1.73	0.5	1.44	2.08
Liquid conductivity (measurement	E2.2		10	10.00	R	%v3	1.73	0.5	2.89	8.33
Liquid permittivity (Deviation from	E2.2		5	5	R	%v3	1.73	0.5	1.44	2.08
Liquid permittivity (measurement	E2.2		5	5.00	R	%v3	1.73	0.5	1.44	2.08
Combined standard uncertainty					RSS			13.2		
Expanded uncertainty k=2 (95% Confidence Level)				25.9%						

Table 12. Uncertainty budget of SARA2

Table 12 includes the preliminary uncertainty budget. The extended uncertainty is assessed to be 25.9%. This uncertainty includes probe calibration, positioning and evaluation errors, as well as errors of the correct dielectric parameters for the tissue simulating liquid, etc.

Appendix

Z-SCAN PLOTS


Depth profile into head from max. SAR location with handset at LH ear (upright SAM phantom)
Spot SAR value (W/kg)
1.8
1.6
1.4
1.2
0.8
0.6
0.4
0.2
0
0
25
50
75
100
125
150
Depth from shell boundary (mm)

FCC Exposure Criteria

In the USA the recent FCC exposure criteria [FCC 2001] are based upon the IEEE Standard C95.1 [IEEE 1999]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.
2.1 Distinction Between Exposed Population, Duration of Exposure and Frequencies. The American Standard [IEEE 1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered.
Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Distinction between Maximum Permissible
The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity s and the mass density r of the biological tissue:

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

The specific absorption rate describes the initial rate of temperature rise as a function of the specific heat capacity c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.
As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric E and magnetic field strength H and power density S, derived from the SAR limits. The limits for E, H and S have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded. For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

2.3 SAR Limit
In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded. Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR1g) with the shape of a cube.

Standard	Status	SAR limit [W/kg]
OET 65 Supplement C Edition 01-01	In Force	1.6

Table 13. SAR Limit

The FCC Measurement Procedure
The Federal Communications Commission (FCC) has published a report and order on the 1 st of August 1996 [FCC 1996], which requires routine dosimetric assessment of mobile telecom-munications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65.
This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [FCC 2001].

General Requirements
The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity.

Device Operating Next to a Person's Ear
3.2.1 Phantom Requirements
The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues. The physical characteristics of thephantom model shall resemble the head and the neck of a user since the shape is a dominant parameter for exposure.

Test Positions
As it cannot be expected that the user will hold the mobile phone exactly in one well defined position, different operational conditions shall be tested. The Supplement C to OET Bulletin 65 requires two test positions. For an exact description helpful geometrical definitions are introduced and shown in Fig. 2 - 3.
There are two imaginary lines on the mobile, the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width wt of the handset at the level of the acoustic output (point A on Fig. 2), and the midpoint of the width wb of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Fig. 2). The two lines intersect at point A.

According to Fig. 3 the human head position is given by means of the following three reference points: auditory canal opening of both ears (RE and LE) and the center of the closed mouth (M). The ear reference points are 15-17 mm above the entrance to the ear canal along the BM line (back-mouth), as shown in Fig. 3. The plane passing through the two ear canals and M is defined as the reference plane. The line NF (Neck-Front) perpendicular to the reference plane and passing through the RE (or LE) is called the reference pivoting line. Line BM is perpendicular to the NF line. With this definitions the test positions are given by;

Cheek position (see Fig. 4):
Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Fig. 3), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom. Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the ear. While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane). Rotate the phone around the vertical centerline until the phone (horizontal line) is symmetrical with respect to the line NF. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, rotate the handset about the line NF until any point on the handset is in contact with a phantom point below the ear. While maintaining the orientation of the phone retract the phone parallel to the reference plane far enough to enable a rotation of the phone by 15°. Rotate the phone around the horizontal line by 15°. While maintaining the orientation of the phone, move the phone parallel to the reference plane until any part of the phone touches the head. In this position, point A will be located on the line RE-LE.

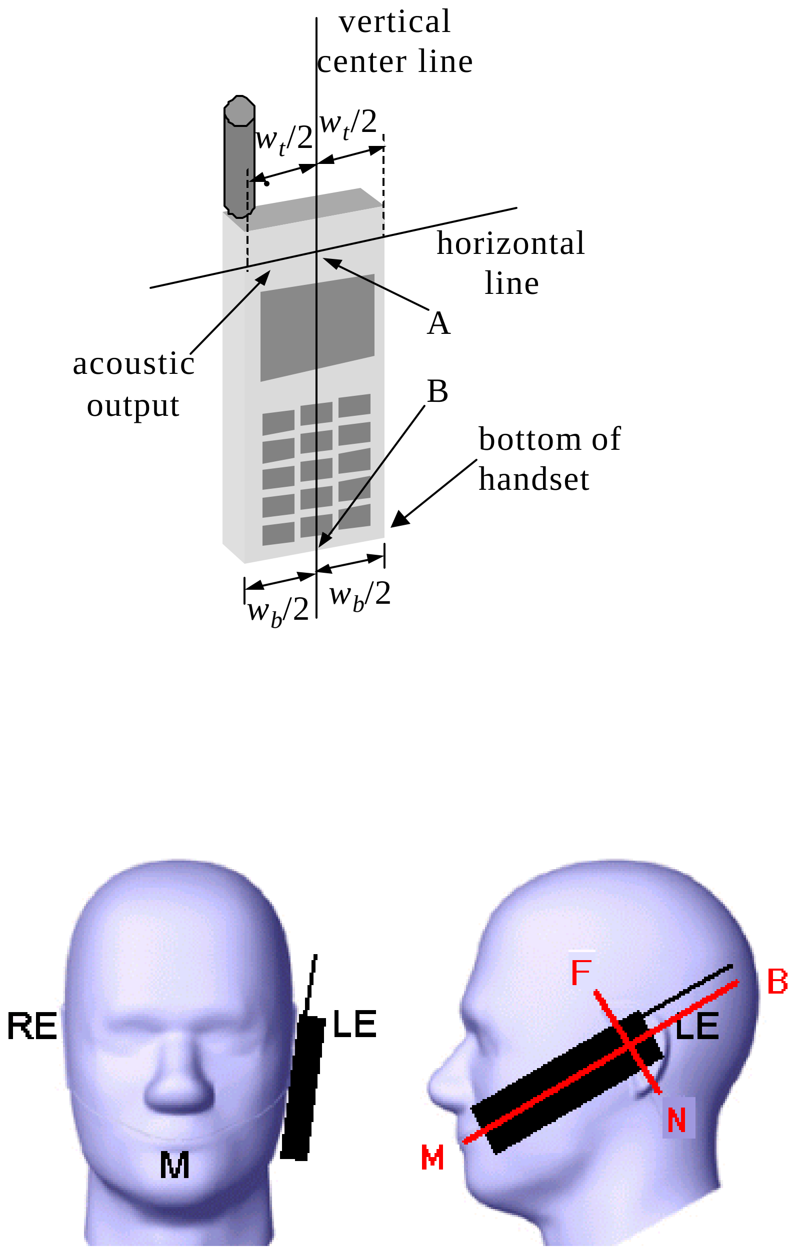


Fig.19: Phantom reference points.

Test to be Performed

The SAR test shall be performed with both phone positions described above, on the left and right side of the phantom. The device shall be measured for all modes operating when the device is next to the ear, even if the different modes operate in the same frequency band.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value. The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

Body-worn and Other Configurations

Phantom Requirements

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

Test Position

The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset.

Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

If the manufacturer provides none body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value. The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

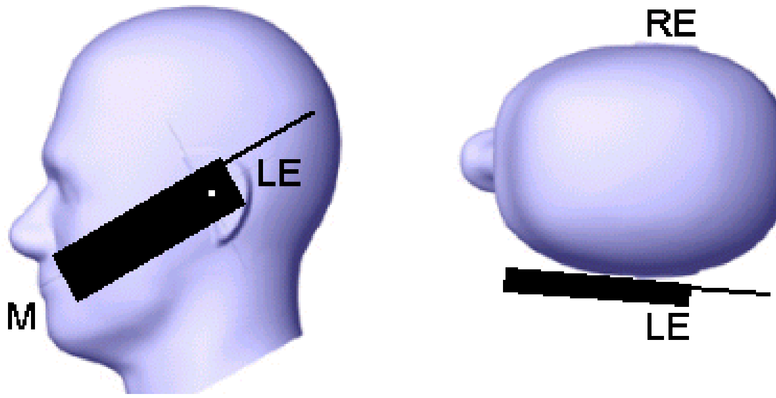


Fig.20: The cheek position.

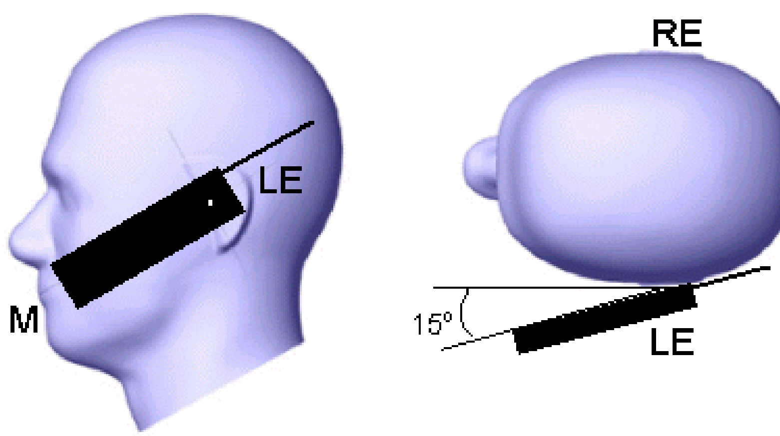


Fig. 21: The tilted position

List of Terms and Abbreviations

AC	Alternating Current
ANSI	American National Standards Institute
Cal	Calibration
d	Measurement Distance
dB	Decibels
dBFA	Decibels above one microamp
dBFV	Decibels above one microvolt
dBFA/m	Decibels above one microamp per meter
dBFV/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
EUT	Equipment Under Test
f	Frequency
FCC	Federal Communications Commission
CISPR	Comite International Special des Perturbations Radioelectriques (International Special Committee on Radio Interference)
GRP	Ground Reference Plane
H	Magnetic Field
Hz	Hertz
IEC	International Electrotechnical Commission
IEEE	Institute for Electrical and Electronic Engineers
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
MPE	Maximum Permissible Exposure
FH	microhenry
FF	microfarad
Fs	microseconds
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
SAR	Specific Absorption Rate
TWT	Traveling Wave Tube
V/m	Volts per meter

END of Report