APREL Laboratories

Certification Report on

Specific Absorption Rate (SAR) Experimental Analysis

Kyocera Corporation

GMPCS Terminal
Single Mode IRIDIUM Handset

Date: 19 April, 1999

Telecommunications Approval Board - Spectrum Sciences Institute -
SAR Certified
APREL Laboratories
A941-SS66K

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CERTIFICATION REPORT

Subject:	**Specific Absorption Rate (SAR) Experimental Analysis**
Product:	GMPCS Terminal, Single Mode IRIDIUM Satellite Handset (Model SS-66K)
Client:	Kyocera Corporation
Address:	2-1-1-Kagahara, Tsuzuki-ku Yokohama-shi 224 Japan
Project #:	KYOB-SS66K-3182
Prepared by:	APREL Laboratories 51 Spectrum Way Nepean, Ontario K2R 1E6

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories A941-SS66K

Submitted by Paul G Cardinal Date: 04 May 99
Dr. Paul G. Cardinal
Director, Laboratories

Approved by [signature] Date: May 4/99
Dr. Jacek J. Wojcik, P. Eng.

Registered Professional Engineer J. J. Wojcik Province of Ontario

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CERTIFICATION REPORT

Subject: **Specific Absorption Rate (SAR) Experimental Analysis**

Product: GMPCS Terminal, Single Mode IRIDIUM Satellite Handset (Model SS-66K)

Client: Kyocera Corporation

Address: 2-1-1-Kagahara, Tsuzuki-ku
Yokohama-shi 224 Japan

Project #: KYOB-SS66K-3182

Prepared by: APREL Laboratories
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Submitted by ______________________________ Date: __________________
Dr. Paul G. Cardinal
Director, Laboratories

Approved by ______________________________ Date: __________________
Dr. Jacek J. Wojcik, P. Eng.

FCC ID: JOYKC-SSSD-66K
Applicant: Kyocera Corporation
Equipment: Single Mode IRIDIUM Handset
Model: SS-66K
Standard: FCC 96 –326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on a Kyocera single mode IRIDIUM handset, SS-66K. The measurements were carried out in accordance with FCC 96-326. The single mode IRIDIUM handset was evaluated for its maximum power level of 28 dBm (600 mW) average or 38.45 dBm (7 W) peak.

The SS-66K was tested at high, middle, and low frequencies, with the maximum SAR coinciding with the peak performance RF output power of channel 1 (low, 1621.6875 MHz). Test data and graphs are presented in this report.

Based on the test results, it is certified that the product meets the requirements as set forth in the above specifications, for uncontrolled RF exposure environment.

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of a sample of a Kyocera SS-66K single mode IRIDIUM handset. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

2. APPLICABLE DOCUMENTS

The following documents are applicable to the work performed:

1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

2) ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

3) ANSI/IEEE 95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 97-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

3. EQUIPMENT UNDER TEST

- Kyocera SS-66K GMPCS Terminal, single mode IRIDIUM handset, s/n 30002209500240

The antenna is a helical telescope antenna and is located on the left-hand side of the top of the handset, and positioned about 3 cm from the surface in contact with the head.

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4. TEST EQUIPMENT

- Narda 8021B miniature E-field probe, s/n 04007, Asset # 301339
- CRS Robotics A255 articulated robot arm, s/n RA2750, Asset # 301355
- CRS Robotics C500 robotic system controller, s/n RC584, Asset # 201354
- Tektronix 492 Spectrum Analyser, Asset # 100949
- APREL UH-1, Universal Head-Arm, s/n 001, Asset # 301376
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the single mode IRIDIUM handset complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.
2. The E-field is measured with a small isotropic probe (output voltage proportional to E^2).
3. The probe is moved precisely form one point to the next using the robot (1 cm increments for wide area scanning and 0.5 or 0.25 cm increments for the final measurements).
4. The probe travels in the homogeneous liquid simulating human tissue. Appendix D contains information about the recipe and properties of the simulated tissue used for these measurements.
5. The liquid is contained in a manikin simulating a portion of the human body.
6. The single mode IRIDIUM handset is positioned in a normal usage position.
7. All tests were performed with the highest power available from the sample single mode IRIDIUM handset, under transmit conditions.

More detailed descriptions of the test method is given in Section 6 when appropriate.

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6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The battery-powered transmitter will consume energy from its batteries, which may affect its transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run. In the case of the single mode IRIDIUM handset, which does not have an externally accessible feedpoint the radiated power was sampled. A spectrum analyser was connected to a probe, which was placed along the antenna in a reproducible position to sample the radiated power. The following table shows the difference between the sampled power before and after each of the five sets of data used for this report.

Scan		**D Relative Power Reading (dB)**	**Battery #**
Type	**Height (mm)**		
Area	2.5	0	1
Area	12.5	0	1
Zoom	2.5		
Zoom	7.5	-0.2	1
Zoom	12.5		

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6.2. SAR MEASUREMENTS

1) RF exposure is expressed as a Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points as shown in Appendix A Figure 2. SAR is expressed as RF power per kilogram of mass, averaged in 1 cubic centimetre of tissue.

2) The Kyocera SS-66K single mode IRIDIUM handset was put into test mode for the SAR measurements using a laptop computer and software to control the channel (initially - 1, low) and maximum operating power (28 dBm average, 38.45 dBm peak).

3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the Kyocera SS-66K single mode IRIDIUM handset sample operating on the low channel. The presented values were taken 2.5 mm into the simulated tissue from the Universal Head-Arm's (UH-a) solid inner surface. Figure 1 and 2 in Appendix A shows the UH-a used in the measurements, with its arm (empty) in position to hold the single mode IRIDIUM handset against the composite ear. The top of the phone is aligned with the top of the composite pinna of the UH-a. A grid is shown inside of the UH-a indicating the orientation of the x-y grid used, with the origin (0,0) at top of the pinna. The x-axis is positive towards the left and the y-axis is positive towards the bottom.

   A different presentation of the same data is shown in Appendix A Figure 4. This is a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualisation aid.

   Similar data was obtained 12.5 mm into the simulated muscle tissue. These measurements are presented as a contour plot in Appendix A Figure 5 and surface plot in Figure 6.

   Figure 7 in Appendix A shows an overlay of the single mode IRIDIUM handset's outline, superimposed onto the contour plot previously shown as Figure 3.

   Figures 3 through 6 in Appendix A show that there is a dominant peak, in the contour plots, that diminishes in magnitude with depth into the tissue simulation.

4) Wide area scans were also performed for the middle (4) and high (8) channels. The peak single point SAR for the scans were:

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Channel	Frequency [MHz]	Channel #	Highest SAR [W/kg]			
			Antenna			
			in	out	tilt right	tilt left
Low	1621.6875	1	0.266	0.016	0.028	0.011
Middle	1623.8125	4	0.258	0.011	0.015	0.009
High	1625.9792	8	0.239	0.010	0.000	0.018

5) The low channel (1) SAR peak was then explored on a refined 0.5 mm grid in three dimensions. Figures 8, 9, and 10 show the measurements made at 2.5, 7.5, and 12.5 mm respectively. The SAR value averaged over 1 cm^3 was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured averaged over 1cm^3 was determined from these measurements to be 0.140 W/kg.

6) To extrapolate the maximum SAR value averaged over 1 cm^3 to the inner surface of the head phantom a series of measurements were made at a few (x,y) coordinates within the refined grid as a function of depth, with 2.5 mm spacing. Figure 11 in Appendix A shows the data gathered and the exponential curves fit to them (Microsoft Excel 97). The average exponential coefficient was determined to be (-0.0706 ± 0.0054 / mm.

The distance from the probe tip to the inner surface of the head phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the Narda 8021B miniature RF probe is 7 mm. The total extrapolation distance is 9.5 mm, the sum of these two.

Applying the exponential coefficient over the 9.5 mm to the maximum SAR value average over 1 cm^3 that was determined previously, we obtain **the maximum SAR value at the surface averaged over 1 cm^3** of 0.273 W/kg.

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7. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1 g, determined at 1621.875 MHz (channel 1, low), of the Kyocera SS-66K single mode IRIDIUM handset, is 0.273 W/kg. The overall margin of uncertainty for this measurement is ± 22.1%. The SAR limit given in the FCC 96-326 safety guideline is 1.6 W/kg. This unit as tested and as it will be marketed, is found to be compliant with this requirement

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APPENDIX A

Figure 1

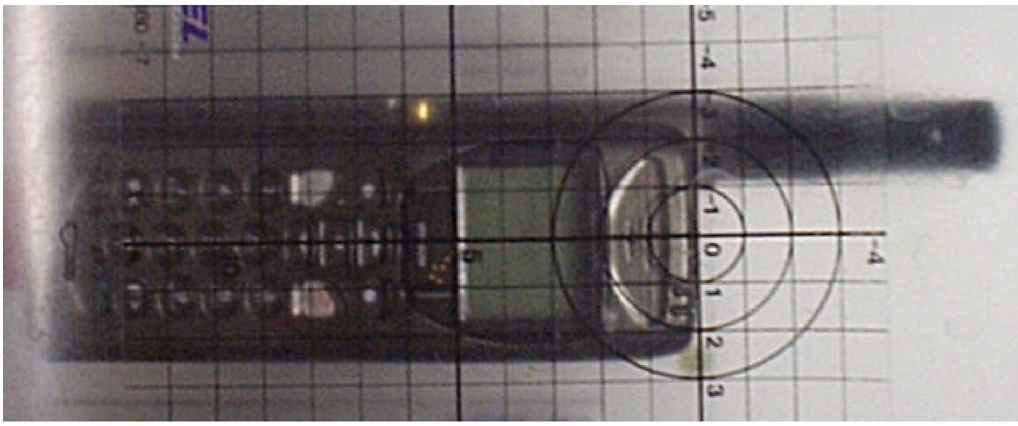

Figure 2

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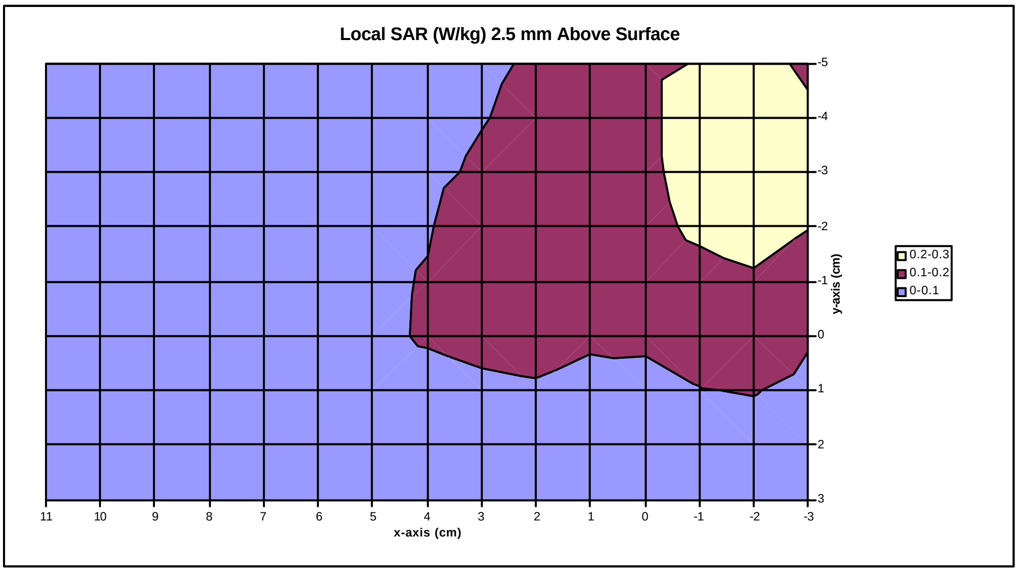

Figure 3

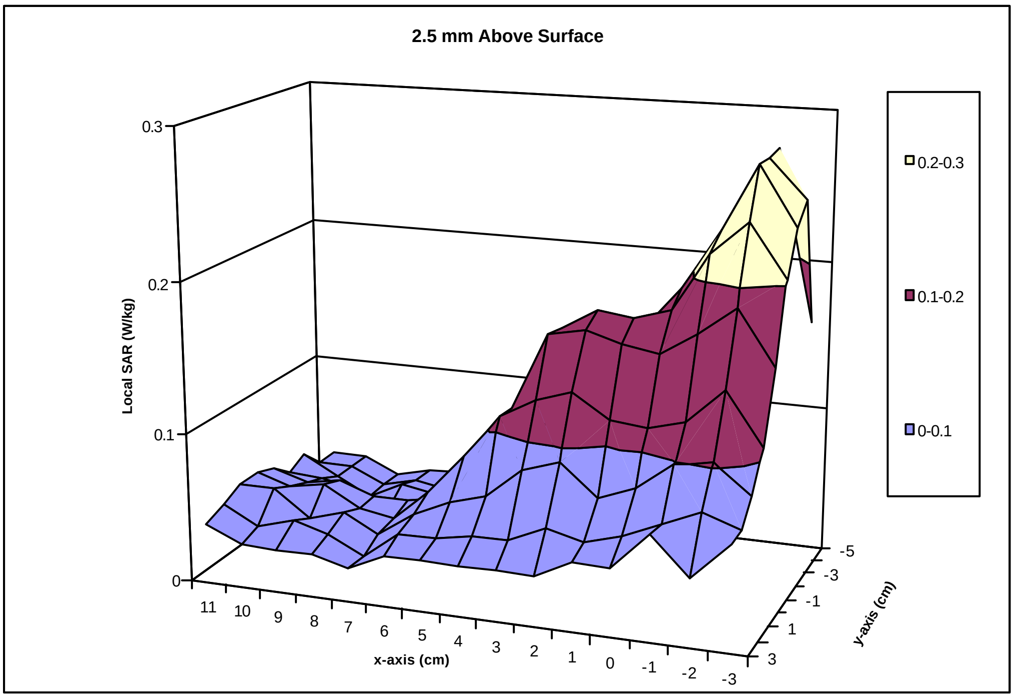

Figure 4

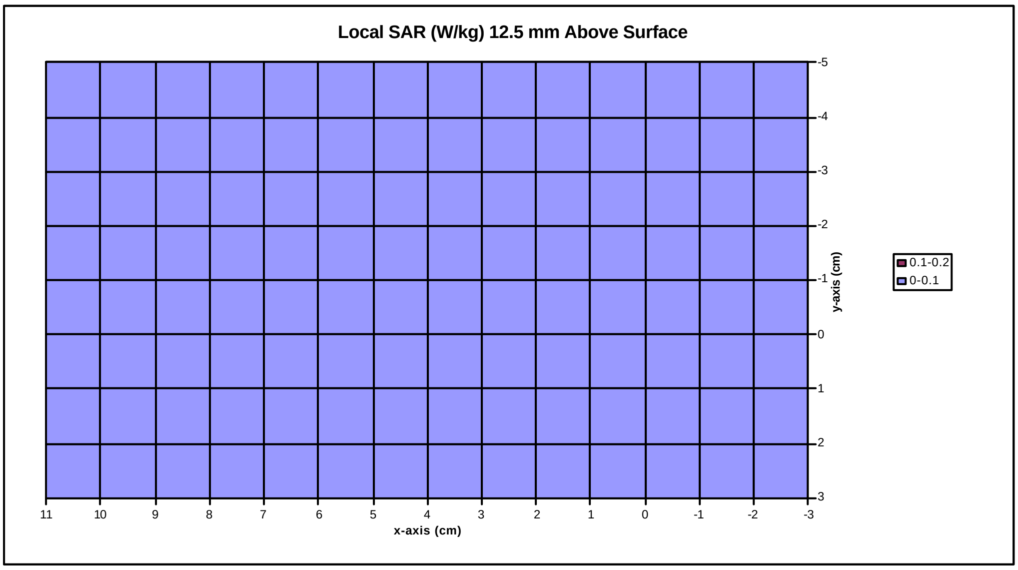

Figure 5

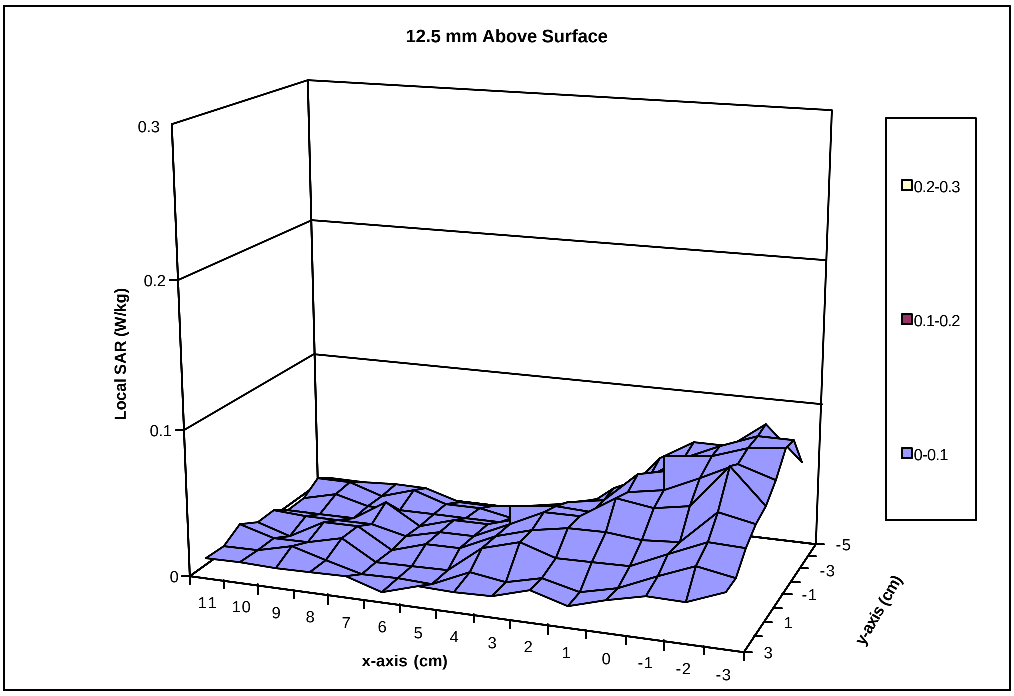

Figure 6

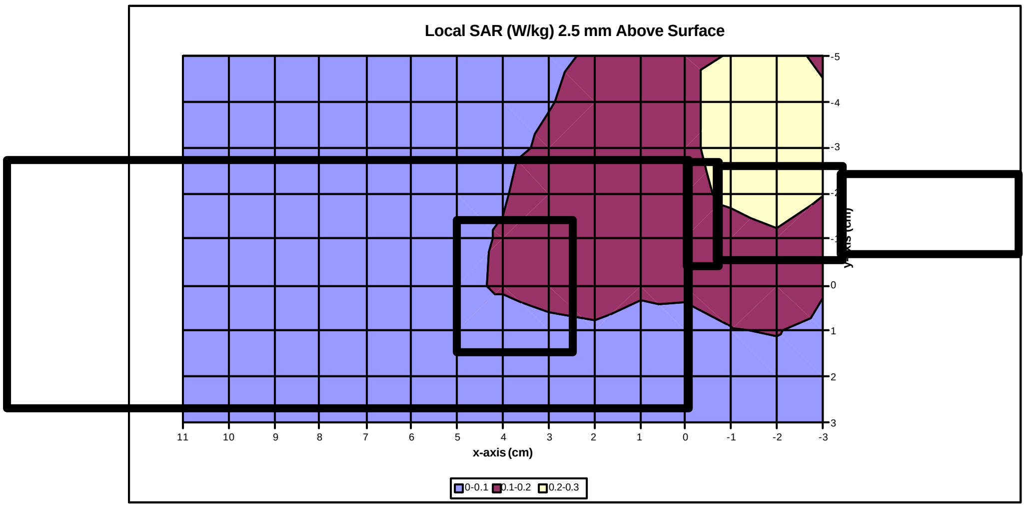

Figure 7

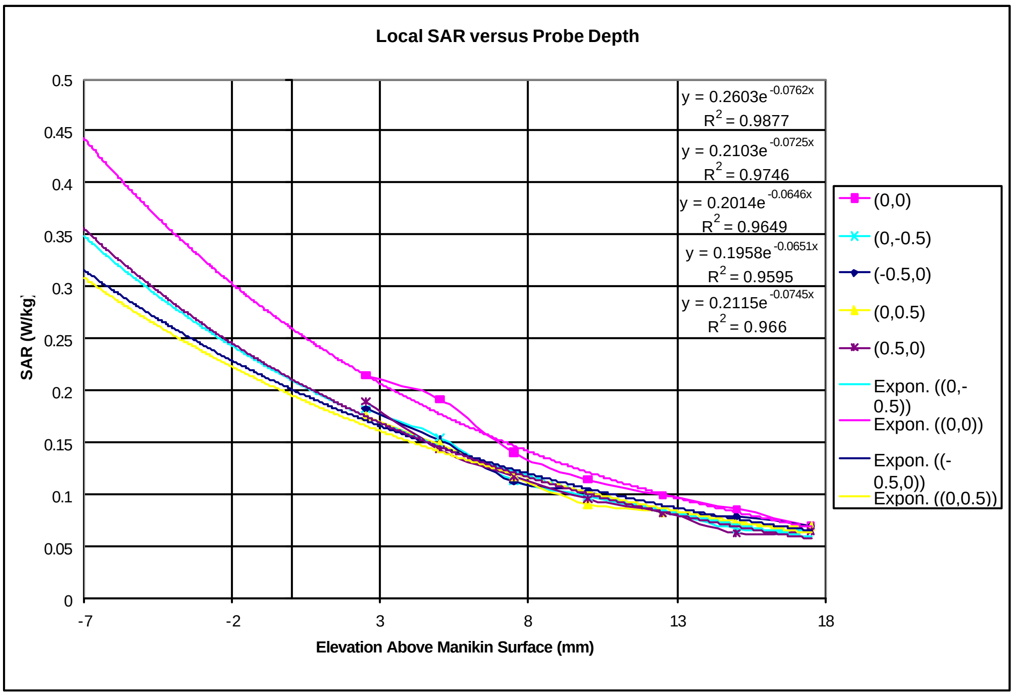

Figure 8

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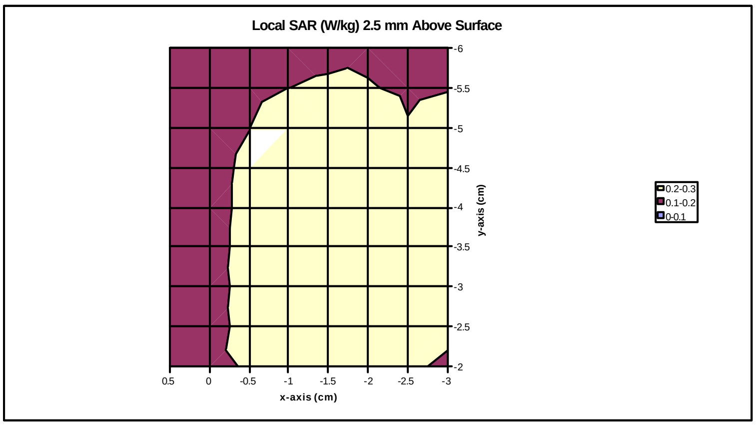


Figure 9

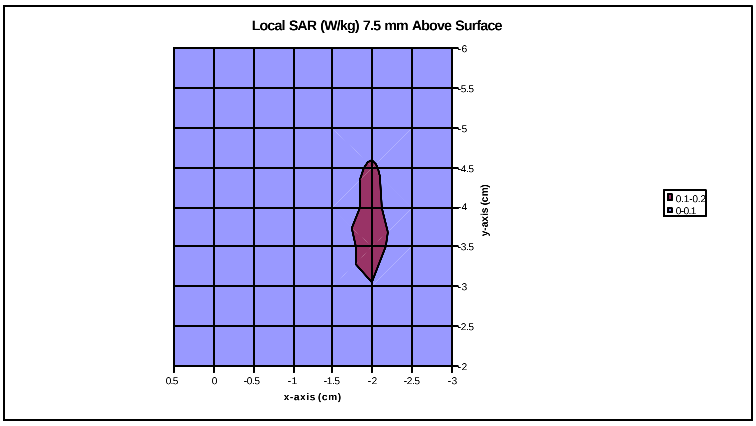


Figure 10

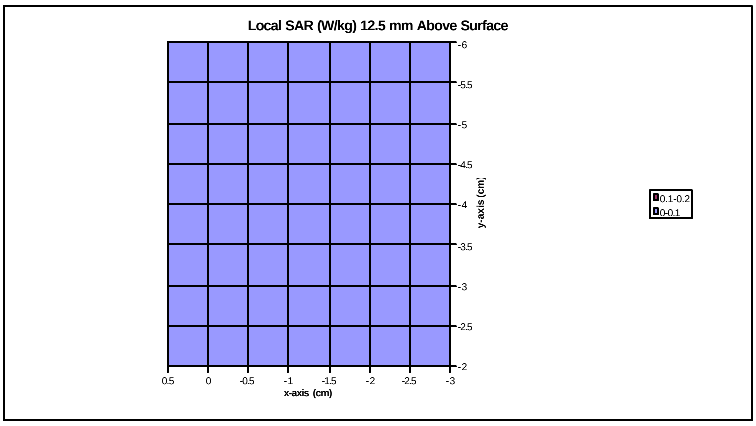
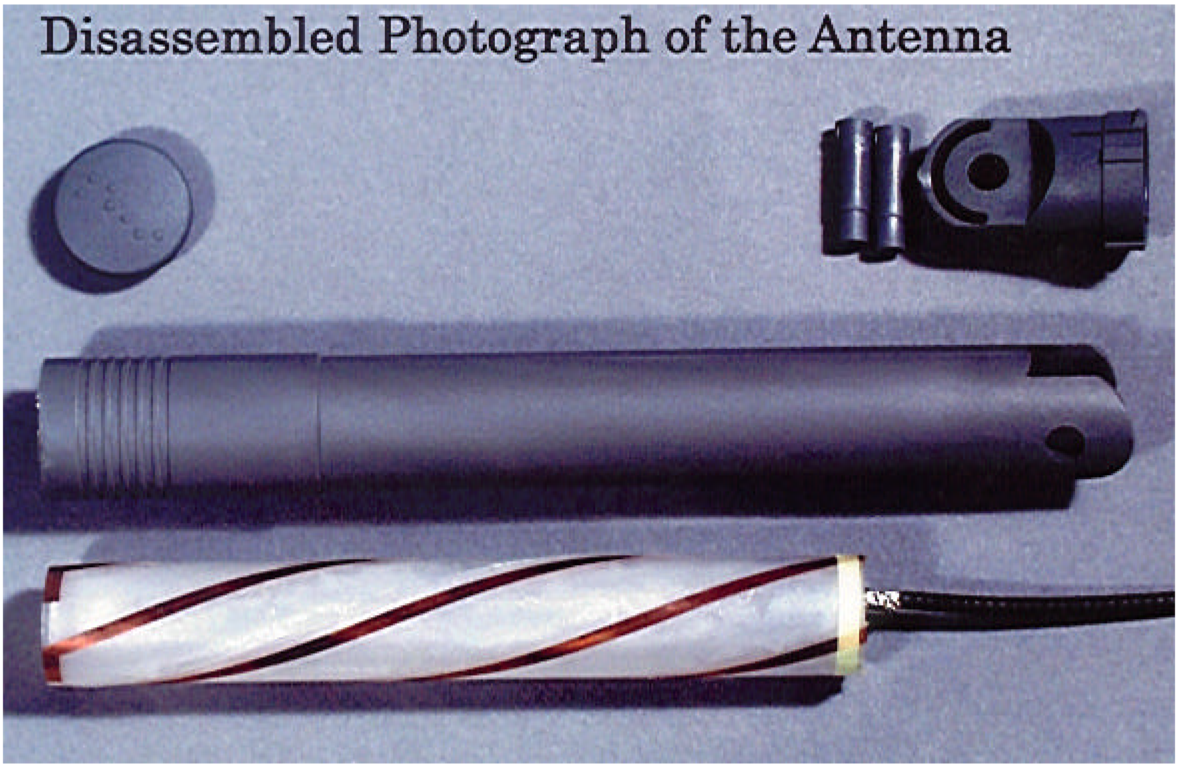
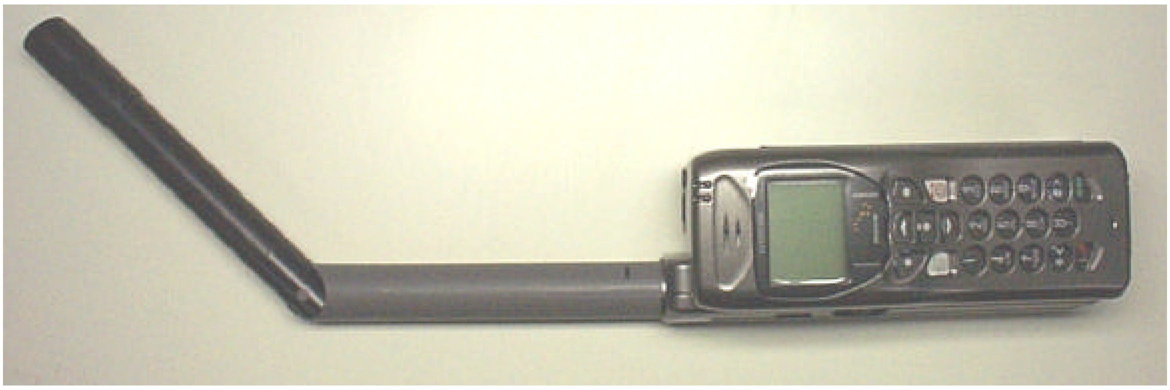


Figure 11

APPENDIX B

Manufacturer's Antenna Specifications





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APPENDIX C

Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	Specific to	Uncertainty	
Power variation due to battery condition	phone	9.4%	
Extrapolation due to curve fit of SAR vs depth	phone	15.3%	
Extrapolation due to depth measurement	setup	3.5%	
Conductivity	setup	6.0%	
Density	setup	2.6%	
Tissue enhancement factor	setup	7.0%	
Voltage measurement	setup	7.1%	
Probe sensitivity factor	setup	3.5%	
		22.1%	**RSS**

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APPENDIX D

Simulated Tissue Material and Calibration Technique

The brain mixture used was based on that presented SSI/DRB-TP-D01-033, "Tissue Recipe and Calibration Requirements".

De-ionised water	40.6 %
Sugar	58.0 %
Salt	1.0 %
HEC	0.3 %
Bactericide	0.1 %

Mass density, ρ	1.30 g/ml (The density used to determine SAR from the measurements was the recommended 1030 kg/m^3 found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01)

Dielectric parameters of the simulated tissue material were determined using a Hewlett Packard 8510 Network Analyser, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

The dielectric properties are:

Dielectric constant, ε_r	40.02
Conductivity, σ	1.51 S/m
Tissue Conversion Factor, γ	4.6

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SIMULATION FLUID #	**981125-MB**
CALIBRATION DATE	**26-Mar-99**
CALIBRATED BY	**Heike**
Frequency Range	**1GHz-2.5GHz**
Frequency Calibrated	**1624 MHz**
Tissue Type	**MIXED BRAIN**

Position [cm]	**Amplitude [dBm]**	**Phase [deg]**
0	-34.74	-101.8
0.5	-36.66	-164.88
1	-38.54	131.59
1.5	-40.42	69.89
2	-42.33	7.02
2.5	-44.31	-57.5
3	-46.15	-119.2
3.5	-48.11	177.19
ΔdB_1	-7.59	Δdeg_1
ΔdB_2	-7.65	Δdeg_2
ΔdB_3	-7.61	Δdeg_3
ΔdB_4	-7.69	Δdeg_4
ΔdB_{AVG} [dB]	-7.64	Δdeg_{AVG} [deg]
dB_{AVG} (α_{AVG}) [dB/cm]	-3.82	deg_{AVG}(β_{AVG}) [deg/cm]
(α_{AVG}) [NP/cm]	-0.43950593	(β_{AVG}) [rad/cm]
f [Hz]	1.62E+09	
μ [H/cm]	1.25664E-08	
ε_0 [F/cm]	8.854E-14	
ε_r	**40.02**	
$\sigma_{effective}$ [S/m]	**1.51**	

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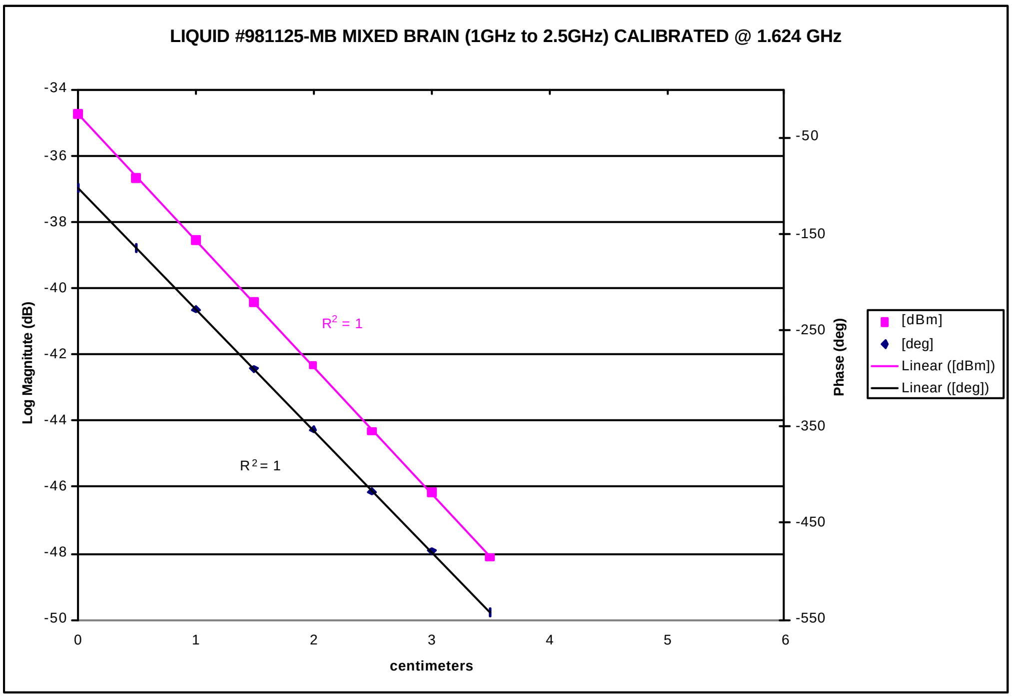

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1624 MHz Data (Heike & Tony) BRAIN

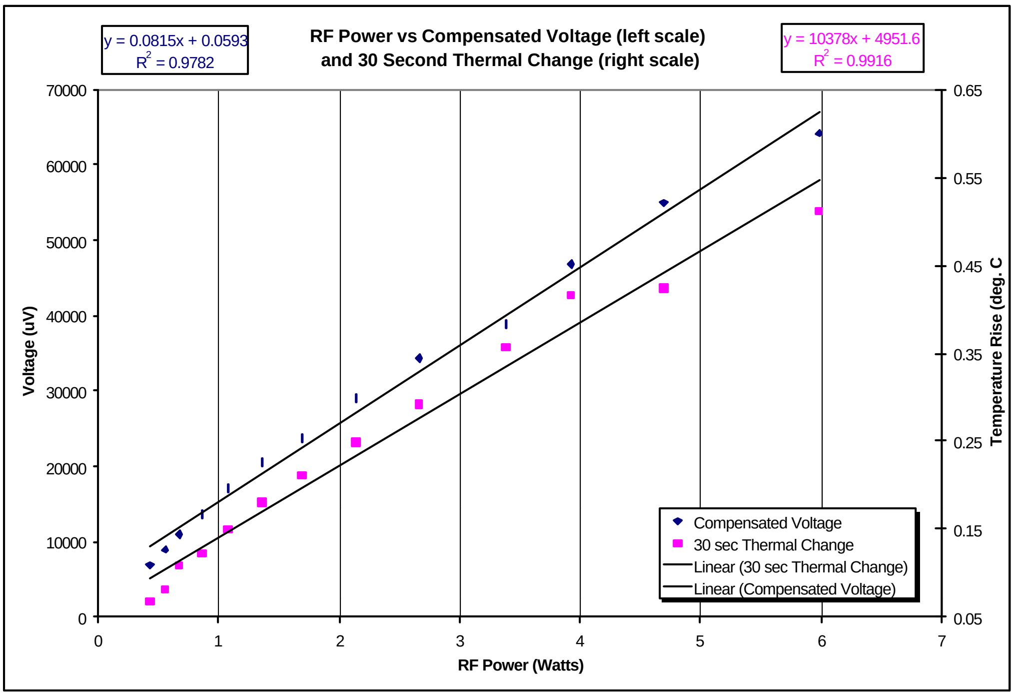
RF Power			Ch0	Ch1	Ch2	delta T (30 sec)	Sum Vi/Ei		Thermal SAR
W	dBm	R&S	uV	uV	uV	deg. C			W/kg
0.698232	28.44	-12.82	3411	1541	474	0.0674	6895.15		6.23
0.891251	29.5	-11.76	4478	1895	684	0.0818	8974.65		7.57
1.081434	30.34	-10.92	5474	2080	1011	0.1088	10907.4		10.06
1.380384	31.4	-9.86	6875	2529	1323	0.1226	13665.7		11.34
1.733804	32.39	-8.87	8472	3076	1831	0.1504	17052.5		13.91
2.187762	33.4	-7.86	10156	3662	2295	0.1805	20541.5		16.70
2.722701	34.35	-6.91	11621	4224	2783	0.2114	23751.4		19.55
3.443499	35.37	-5.89	14233	5176	3418	0.2491	29105.5		23.04
4.285485	36.32	-4.94	16722	6128	4070	0.2918	34324.2		26.99
5.432503	37.35	-3.91	18799	6958	4687	0.357	38818.2		33.02
6.309573	38	-3.26	22559	8447	5711	0.4161	46815.5		38.49
7.550922	38.78	-2.48	26074	10254	6787	0.4243	54959.4		39.25
9.616123	39.83	-1.43	30249	12012	8130	0.5118	64237.8		47.34

Directional Coupler factor	21.26	dB (Asset 100251 cal file data (Janusz, 21 Jul 96))	
Additional inline attenuation	20	dB	

Sensitivity (e)	0.52	0.54	0.51	- Sensor Sensitivity in mV/ (mW/cm^2)
η = 1.50 e	0.78	0.81	0.765	

Density	1.3	g/cm^3	1300	kg/m^3	- Marcin, summer 97
Conductivity	15.1	mS/cm	1.51	S/m	- Heike 1-Mar-99
Heat Capacity (c)	2.775	J/C/g	2775	J/C/kg	- average of Balzano (2.7) and Kuster (2.85) values
Exposure Time	30	seconds	30	seconds	
Slope of Measure Voltage (m_V)	6457.95	uV/W	0.00646	V/W	
- standard error or m_V	256.477	uV/W	0.00026	V/W	4.0%
Slope of Measure Temp Change (m_T)	0.06213	C/W	0.06213	C/W	
- standard error or m_T	0.00251	C/W	0.00251	C/W	4.0%

Tissue Conversion Factor ($\frac{e}{\eta}$)	4.6



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APPENDIX E

Validation Scans

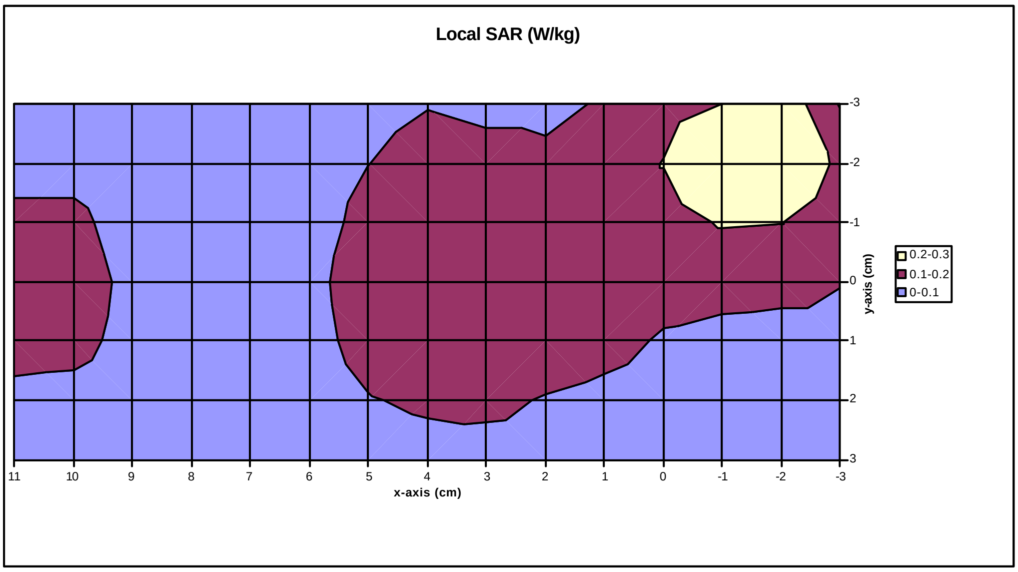

Figure 12

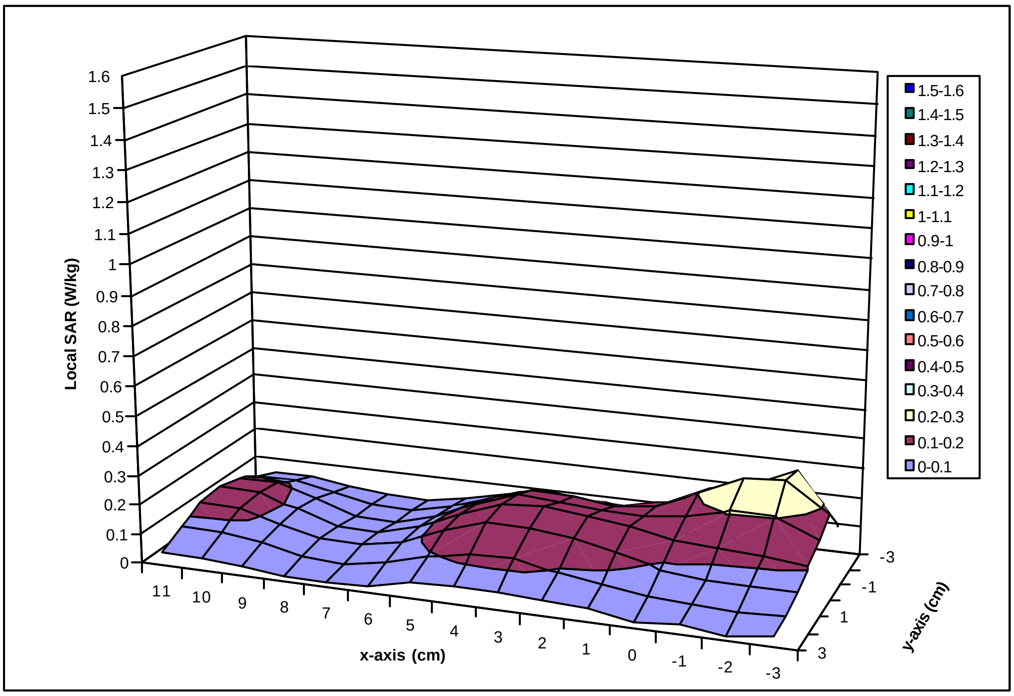

Figure 13

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