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Skolgatan 11

930 70 Malå

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Title

**EMC Test, 1.6 GHz Shielded antenna**

Document

**Test Report**

Date

May 13, 2004

Prepared

FBM, Per Larsson

*EMC Test Engineer*

Ref. No

E014-TR 040062

Supersedes

Page

1 (23)

## Equipment under test (EUT):

Description: Ground Penetrating Radar System

Manufacturer: Malå Geoscience AB

Model name: 1.6 GHz Shielded antenna

## Summary:

The EUT complied with the requirement of radiated emissions given in FCC Part 15 Subpart F, measured in the frequency range 30 – 10 000 MHz.

## Approved:

Petter Gärdin

*Laboratory Technical Manager*

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## 1 Introduction

The object of the test is to show compliance with the emission requirements of FCC Part 15 Subpart F.

|                    |                                                             |
|--------------------|-------------------------------------------------------------|
| Date of test:      | Mars 29 – 31, 2004                                          |
| Location:          | AerotechTelub AB, Östersund                                 |
| Test performed by: | Per Larsson, AerotechTelub / FBM                            |
| Client:            | Malå Geoscience<br>Skolgatan 11<br>SE-930 70 Malå<br>Sweden |
| Client's observer: | Lars Mikaelsson, Malå Geoscience AB                         |

## 2 Test methods and results

### 2.1 Results

The test results in this report apply only for the tested specimen.

| EMISSION REQUIREMENTS ACCORDING TO FCC Part 15 Subpart F |             |                          |             |                                                                              |            |
|----------------------------------------------------------|-------------|--------------------------|-------------|------------------------------------------------------------------------------|------------|
| Environmental phenomena                                  | Test method | Requirement              | Result      | Comments                                                                     | Test order |
| Radiated emission                                        | ANSI C63.4  | FCC 15.209               | <b>PASS</b> |                                                                              | 1          |
| UWB definition                                           |             | FCC 15.503 (a) 15.509(a) | <b>PASS</b> | f <sub>L</sub> 250 MHz<br>f <sub>C</sub> 1125 MHz<br>f <sub>H</sub> 2000 MHz | 4          |
| Peak emission at f <sub>M</sub>                          | FCC 02-42   | FCC 15.509 (f)           | <b>PASS</b> |                                                                              | 5          |
| Radiated emission                                        | FCC 02-42   | FCC 15.509 (d)           | <b>PASS</b> |                                                                              | 2          |
| Radiated emission                                        | FCC 02-42   | FCC 15.509 (e)           | <b>PASS</b> |                                                                              | 3          |

## 3 Applicable documents

| Measurements |            |                                                                                                             |
|--------------|------------|-------------------------------------------------------------------------------------------------------------|
| ANSI C63.4   | 07/17/1992 | Radio noise emissions from low-voltage electrical and electronic equipment in the range of 9 kHz to 40 GHz. |
| FCC Part 15  | 12/8/2003  | Radio Frequency Devices                                                                                     |
| FCC 02-42    | 4/22/2002  | Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems                 |

## **4 Equipment under test (EUT)**

### **4.1 Identification of equipment under test**

Equipment under test (EUT):

|               |                                 |
|---------------|---------------------------------|
| Description:  | Ground Penetrating Radar System |
| Manufacturer: | Malå Geoscience AB              |
| Model name:   | 1.6 GHz Shielded antenna        |
| Build state:  | Production sample               |
| Serial no:    | 12014                           |

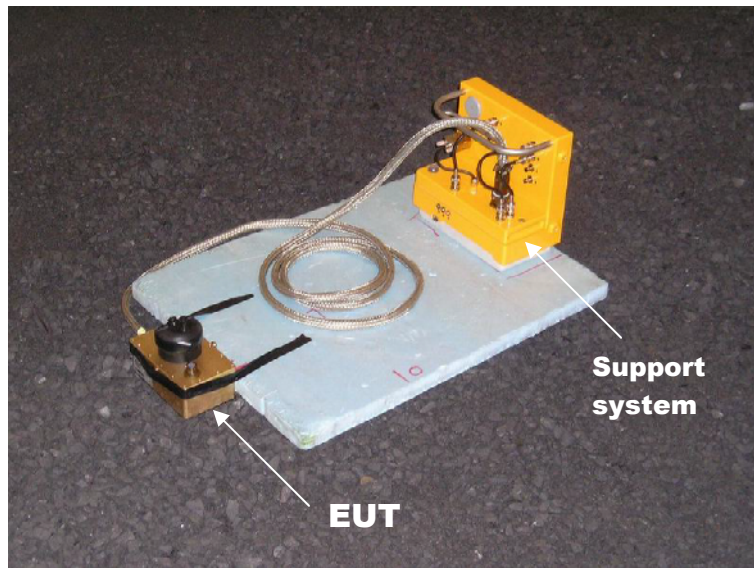
### **4.2 General configuration of EUT**

The EUT was connected to a support system for normal operation. The support system was battery powered.

### **4.3 Test set-up of EUT**

The EUT was placed directly on the dry sand with no ground plane under it.

The support system was placed on a non-conductive material to achieve the same arrangement of the EUT when rotated on the sand bed.



*Picture 1: EUT set-up on sand bed*

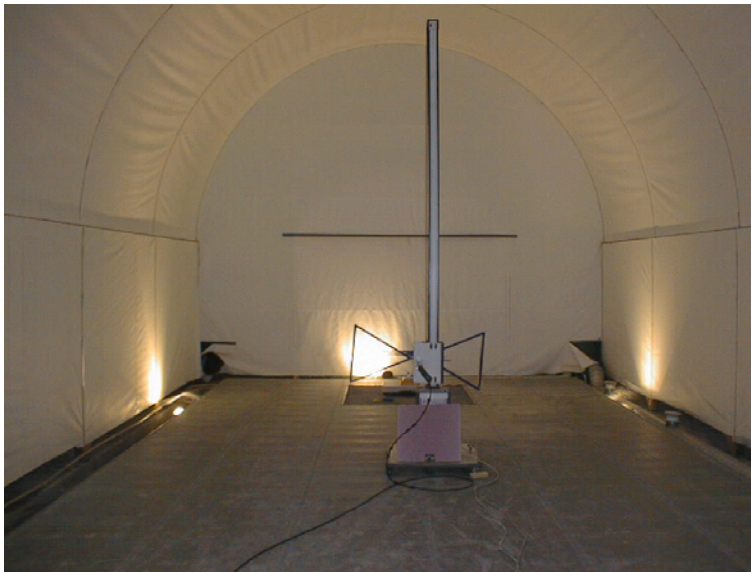
#### **4.4 Operation of EUT during tests**

The EUT was gathering data like in normal operation.

## 5 Test site

### 5.1 Description

The measurements were all performed on a weather protected open area test site that was modified with a flat sand bed located in the ground plane. The sand bed is about 50 cm deep.



*Picture 2: Test Site*

The measurement distance antenna – EUT was 1 and 3 m. The measurement system and related equipment were placed next to the test site.

### 5.2 Ambient signals

A number of ambient signals were detected in the different frequency ranges measurement was made; some of those are listed below.

|                    |                                       |
|--------------------|---------------------------------------|
| Mobile telephones: | 460 – 470 MHz, 935 – 960 MHz, 1.8 GHz |
| FM broadcasts:     | 87 – 108 MHz                          |
| Television:        | 60 – 70 MHz, 650 – 800 MHz            |
| Radar system:      | 1.3 GHz                               |

In addition many signals of short-term duration were found. Each measurement signal close to or above the limit was examined if ambient or related to the EUT.

## 6 Emission

### 6.1 Measurement of radiated emission, ANSI C63.4

#### 6.1.1 Requirements according to FCC 15.509 (d) and 15.209

Radiated emission from the EUT in the frequency range 30 to 960 MHz shall not exceed the limit as specified below.

| Frequency range | Limit             |
|-----------------|-------------------|
| 30 - 88 MHz     | 40 dB $\mu$ V/m   |
| 88 – 216 MHz    | 43.5 dB $\mu$ V/m |
| 216 – 960 MHz   | 46 dB $\mu$ V/m   |

#### 6.1.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) with 3 meters measuring distance described in section 5.

The EUT was configured and the test was performed in accordance with ANSI C63.4.

The test was initiated with a pre-scan in the frequency range 30 - 960 MHz, where the emission level was measured in 16 different combinations of 8 EUT angle positions and vertical/horizontal polarisation. For each position the EUT was turned manually.

Measurement software added antenna factors and cable attenuation and a composite trace of the peak field strength measurement were drawn.

Subsequently, frequencies with the highest emission were selected. EUT position, antenna height and polarisation were adjusted in order to find the position with the highest emission level. Quasi peak values were measured in the maximised positions.

The diagrams are shown with the quasi peak limit according to FCC 15.209.

### 6.1.3 Deviations from the standard

The ground plane was arranged according to FCC 02-42.

### 6.1.4 Climatic conditions

|                   | Requirement according to standard | Climatic conditions during the test |
|-------------------|-----------------------------------|-------------------------------------|
| Temperature       | -                                 | 2 – 10 °C                           |
| Relative humidity | -                                 | Not measured                        |

### 6.1.5 Results

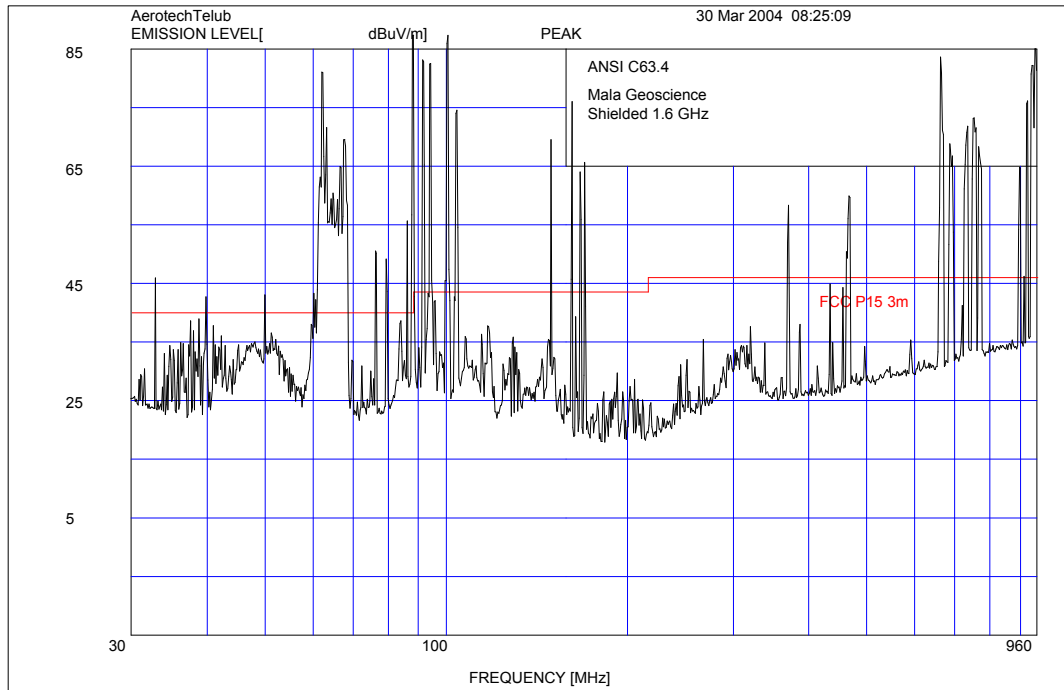
Given measured values are valid for the described arrangement and operation of the EUT.

The EUT complied with the requirement of radiated emission specified in FCC 15.209 in the frequency range 30 – 960 MHz. No narrowband signals above the limit line were related to the EUT.

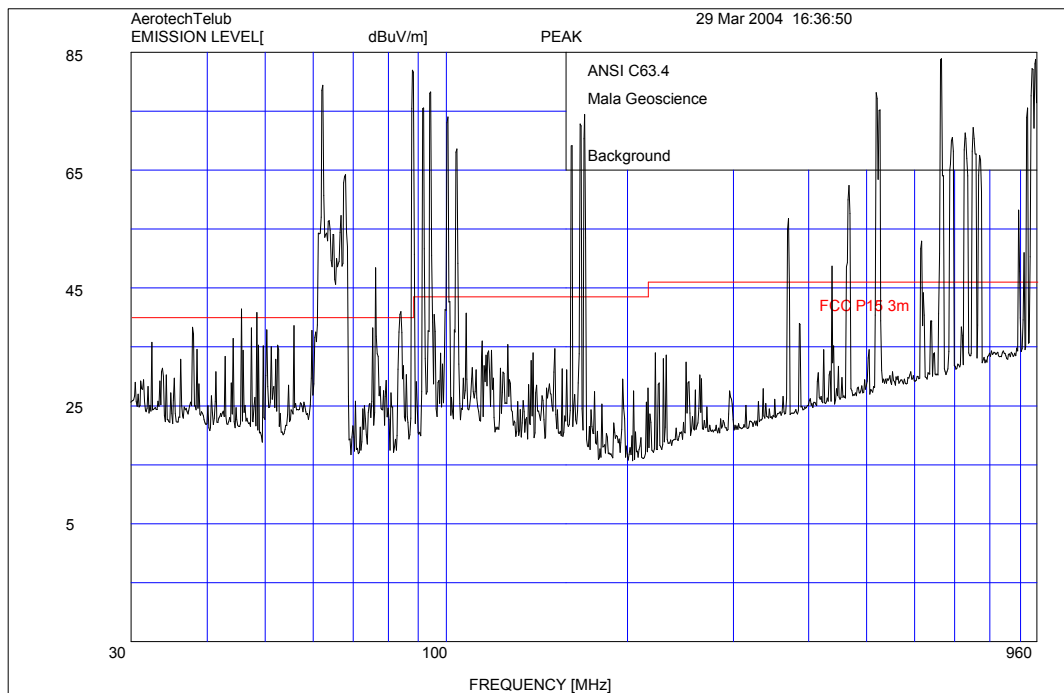
### Emission measured with quasi-peak detector

| Frequency (MHz) | Raw value (dB $\mu$ V) | Cable loss (dB) | Antenna factor | Limit (dB $\mu$ V/m) | Result (dB $\mu$ V/m) | Margin (dB) | Notes |
|-----------------|------------------------|-----------------|----------------|----------------------|-----------------------|-------------|-------|
| 42.41           | 14.0                   | 0.67            | 12.9           | 40                   | 27.6                  | 12.4        | PASS  |
| 46.73           | 16.9                   | 0.69            | 10.4           | 40                   | 28.0                  | 12.0        | PASS  |
| 51.84           | 21.1                   | 0.72            | 7.8            | 40                   | 29.6                  | 10.4        | PASS  |
| 59.54           | 28.3                   | 0.80            | 6.4            | 40                   | 35.5                  | 4.5         | PASS  |
| 105.6           | 15.4                   | 1.25            | 10.4           | 43.5                 | 27.0                  | 16.5        | PASS  |
| 108.01          | 23.5                   | 1.27            | 10.4           | 43.5                 | 35.2                  | 8.3         | PASS  |
| 110.66          | 15.2                   | 1.29            | 10.9           | 43.5                 | 27.4                  | 16.1        | PASS  |
| 114.96          | 20.4                   | 1.32            | 10.9           | 43.5                 | 32.6                  | 10.9        | PASS  |
| 117.78          | 23.2                   | 1.34            | 11.1           | 43.5                 | 35.6                  | 7.9         | PASS  |
| 320.34          | 18.8                   | 2.29            | 13.6           | 46                   | 34.7                  | 11.3        | PASS  |

## Emission measured with peak detector



## Background emission measured with peak detector



### 6.1.6 Instrumentation

|                                       |          |                 |                         |
|---------------------------------------|----------|-----------------|-------------------------|
| Hewlett Packard<br>RF Preselector     | 85685A   | 20 Hz - 2 GHz   | 2724A00609              |
| Hewlett Packard<br>Spectrum analyser  | 8566B    | 100 Hz - 22 GHz | 2404A08864 / 2504A01320 |
| Hewlett Packard<br>Quasi-Peak Adapter | 85650A   |                 | 3303A01810              |
| Chase<br>Bilog antenna                | CBL6111A | 30 - 1000 MHz   | 1831                    |

## 6.2 Measurement of radiated emission

### 6.2.1 Requirements according to FCC 15.509 (d) and (e)

Radiated emission from the EUT shall not exceed the limit as specified below.

| Frequency range  | Limit          | Limit*            |
|------------------|----------------|-------------------|
| 960 – 1610 MHz   | -65.3 dBm EIRP | 29.9 dB $\mu$ V/m |
| 1610 – 1990 MHz  | -53.3 dBm EIRP | 41.9 dB $\mu$ V/m |
| 1990 – 3100 MHz  | -51.3 dBm EIRP | 43.9 dB $\mu$ V/m |
| 3100 – 10600 MHz | -41.3 dBm EIRP | 53.9 dB $\mu$ V/m |
| > 10600 MHz      | -51.3 dBm EIRP | 43.9 dB $\mu$ V/m |

| Frequency range | Limit          | Limit*            |
|-----------------|----------------|-------------------|
| 1164 – 1240 MHz | -75.3 dBm EIRP | 19.9 dB $\mu$ V/m |
| 1559 – 1610 MHz | -75.3 dBm EIRP | 19.9 dB $\mu$ V/m |

\* Converted to field strength level at 3 meters according to FCC 15.521 (g)

### 6.2.2 Procedures

The radiated emission was measured on an Open Area Test Site (OATS) as described in section 5 with 1 meters measuring distance. The measurement level was re-calculated to a 3 m measurement distance (with 9.5 dB).

According to the provisions of FCC 15.509 (d) and (e) the emissions shall be measured with a RMS detector.

The following resolution bandwidths and video bandwidths were used during the measurements.

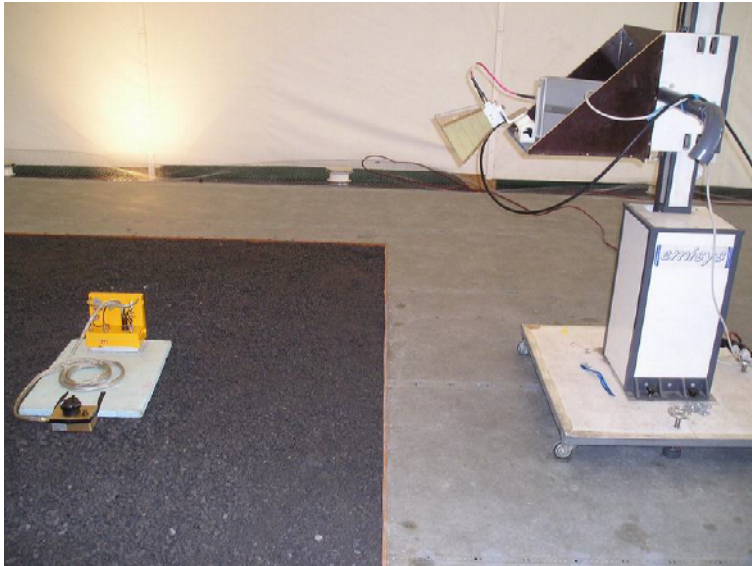
| Frequency range  | RBw   | VBw   |
|------------------|-------|-------|
| 960 – 10 000 MHz | 1 MHz | 3 MHz |
| 1164 – 1240 MHz  | 1 kHz | 1 kHz |
| 1559 – 1610 MHz  | 1 kHz | 1 kHz |

The measurements were made with the EUT in 8 different positions on the sand bed and the antenna position was changed as well as its polarization.

A sweep of the frequency range was made at each position. Measurement software added antenna factors and cable attenuation and the resulting maximum field strength level were plotted.

After the sweeps the maximum radiated field strength were controlled manually due to the high number of ambient signals.

The maximum emission was then manually measured with a RMS detector and then calculated to the correct field strength shown in the spreadsheets under section 6.2.3.  
*Results.*



*Picture 3: Test set-up*

### 6.2.3 Results

Given measured values are valid for the described arrangement and operation of the EUT.

The EUT complied with the requirement of radiated emission specified in FCC 15.509 (d) and (e) in the frequency range 960 – 10 000 MHz.

#### Maximum emissions measured with a RMS detector

| Frequency (MHz) | Raw value (dBμV) | Cable loss (dB) | Antenna factor | Distance factor | Limit (dBμV/m) | Result (dBμV/m) | Margin (dB) | Notes |
|-----------------|------------------|-----------------|----------------|-----------------|----------------|-----------------|-------------|-------|
| 962             | 45.10            | -34.79          | 24.27          | 9.5             | 29.9           | 25.1            | 4.8         | PASS  |
| 998             | 43.62            | -34.61          | 24.28          | 9.5             | 29.9           | 23.8            | 6.1         | PASS  |
| 1069            | 46.80            | -34.23          | 24.00          | 9.5             | 29.9           | 27.1            | 2.8         | PASS  |
| 1184            | 44.70            | -33.67          | 24.00          | 9.5             | 29.9           | 25.5            | 4.4         | PASS  |
| 1277            | 44.96            | -33.26          | 24.70          | 9.5             | 29.9           | 26.9            | 3.0         | PASS  |
| 1399            | 40.50            | -32.76          | 24.70          | 9.5             | 29.9           | 22.9            | 7.0         | PASS  |
| 1503            | 38.42            | -32.37          | 25.40          | 9.5             | 29.9           | 22.0            | 7.9         | PASS  |
| 1770            | 34.35            | -31.47          | 26.60          | 9.5             | 41.9           | 20.0            | 21.9        | PASS  |
| 1790            | 36.50            | -31.41          | 26.60          | 9.5             | 41.9           | 22.2            | 19.7        | PASS  |
| 1807            | 39.80            | -31.36          | 26.60          | 9.5             | 41.9           | 25.5            | 16.4        | PASS  |
| 1856            | 39.40            | -31.21          | 26.60          | 9.5             | 41.9           | 25.3            | 16.6        | PASS  |

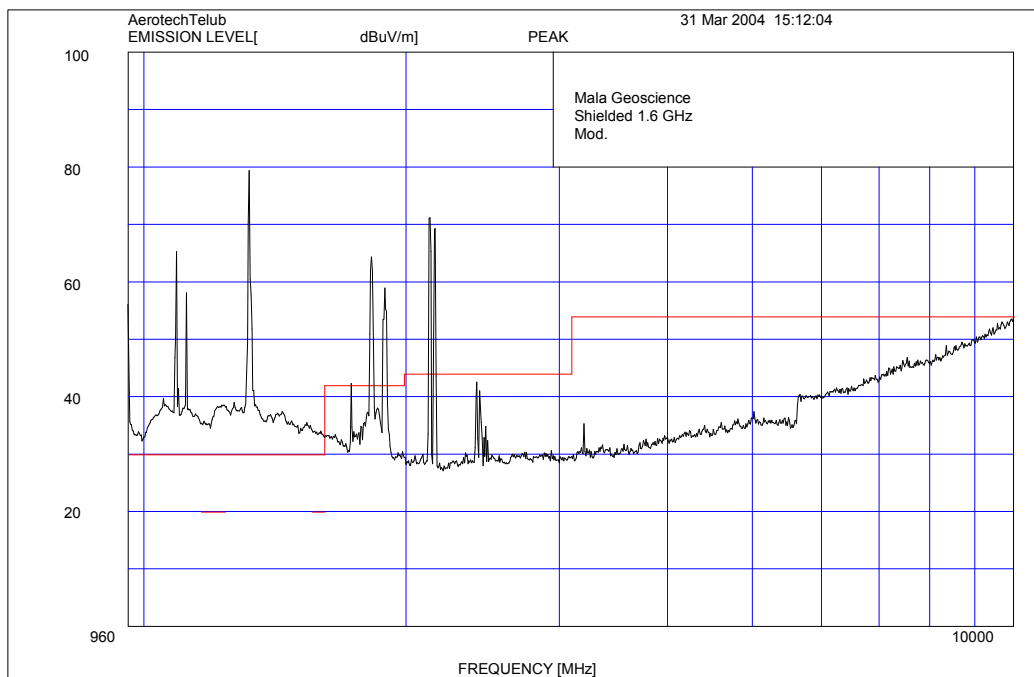
In the spreadsheets “cable/amp” denotes the total correction for cable loss and preamplifier gain. Negative value means amplification.

**Maximum emission in GPS band 1164 – 1240 MHz and  
1559-1610 MHz, measured with RMS detector**

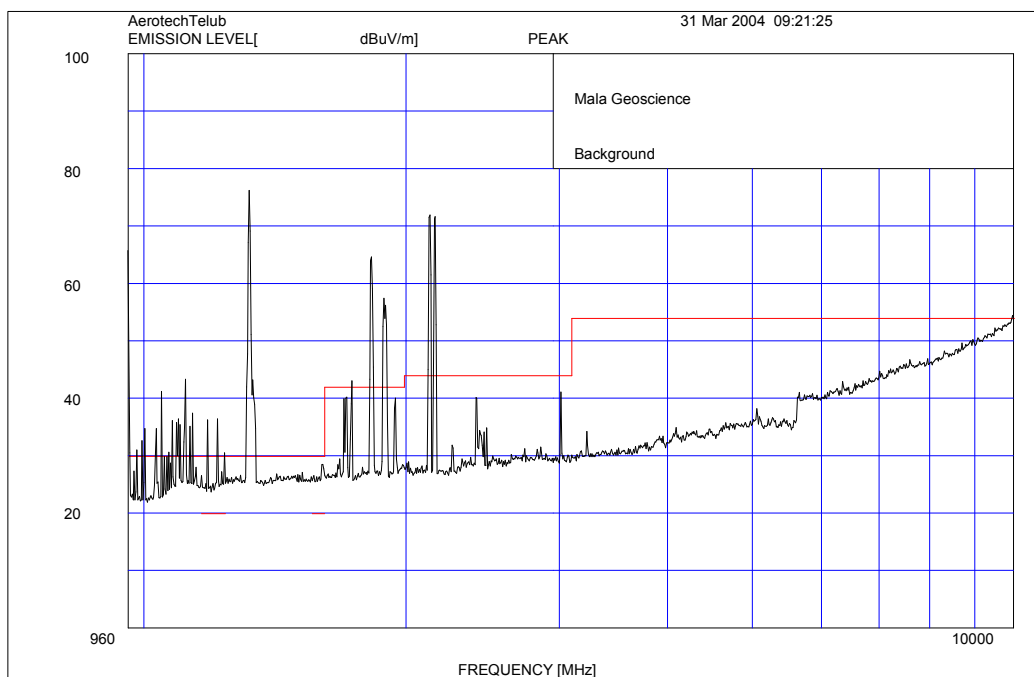
| Frequency<br>(MHz) | Raw<br>value<br>(dBμV) | Cable<br>loss<br>(dB) | Antenna<br>factor | Distance<br>factor | Limit<br>(dBμV/m) | Result<br>(dBμV/m) | Margin<br>(dB) | Notes |
|--------------------|------------------------|-----------------------|-------------------|--------------------|-------------------|--------------------|----------------|-------|
| 1164               | 12.9                   | -33.77                | 24                | 9.5                | 19.9              | -6.4               | 26.3           | PASS  |
| 1180               | 15.68                  | -33.69                | 24                | 9.5                | 19.9              | -3.5               | 23.4           | PASS  |
| 1200               | 12.5                   | -33.60                | 24                | 9.5                | 19.9              | -6.6               | 26.5           | PASS  |
| 1240               | 13.78                  | -33.42                | 24                | 9.5                | 19.9              | -5.1               | 25.0           | PASS  |
| 1559               | 5.7                    | -32.17                | 25.4              | 9.5                | 19.9              | -10.6              | 30.5           | PASS  |
| 1580               | 6.14                   | -32.09                | 25.4              | 9.5                | 19.9              | -10.1              | 30.0           | PASS  |
| 1590               | 4.59                   | -32.06                | 25.4              | 9.5                | 19.9              | -11.6              | 31.5           | PASS  |
| 1610               | 7.34                   | -31.99                | 25.4              | 9.5                | 19.9              | -8.7               | 28.6           | PASS  |

In the spreadsheets “cable/amp” denotes the total correction for cable loss and preamplifier gain. Negative value means amplification.

## Composite trace of peak emissions



## Composite trace of background peak emissions



#### 6.2.4 Instrumentation

|                                       |       |                   |                         |
|---------------------------------------|-------|-------------------|-------------------------|
| Hewlett Packard<br>Spectrum analyser  | 8566B | 100 Hz - 22 GHz   | 2404A08864 / 2504A01320 |
| Hewlett Packard<br>Pre-amplifier      | 8449B | 1 GHz - 26.5 GHz  | 3008A00103              |
| Rohde & Schwartz<br>Spectrum analyser | FSP40 | 9 kHz - 40 GHz    | 100011                  |
| Emco<br>Double Ridge Waveguide        | 3115  | 0.96 GHz - 18 GHz | 2800                    |

## 6.3 Measurement of UWB bandwidth and peak emissions

### 6.3.1 Requirements according to FCC 15

#### 6.3.1.1 Definition according to FCC 15.503 (a)

The UWB bandwidth is the frequency band bounded by the points that are 10 dB below the highest radiated emission, as based on the complete transmission system including antenna.

#### 6.3.1.2 Requirements according to FCC 15.509 (a)

The UWB bandwidth of an imaging system operating under the provisions of this section must be below 10.6 GHz.

#### 6.3.1.3 Requirements according to FCC 15.509 (f)

For UWB devices where the frequency at which the highest radiated emission occurs,  $f_M$ , is above 960 MHz, there is a limit on the peak level of the emissions contained within a 50 MHz bandwidth centered on  $f_M$ . That limit is 0 dBm EIRP. It is acceptable to employ a different resolution bandwidth and a correspondingly different peak emission limit, following the procedures described in Section 15.521.

### 6.3.2 Procedures

The equipment was placed on the test site described under section 5 and the radiated emission was measured at 3 meters or 1 meter.

The measurements were made with the EUT in 8 different positions on the sand bed and the antenna position was changed as well as its polarization resulting in 16 different sweeps of the frequency range.

A 1 MHz resolution bandwidth was used during the measurement.

Measurement software added antenna factors and cable attenuation and a composite trace of the peak field strength were drawn.

At the peak of emission ( $f_M$ ), the emission was measured with a resolution bandwidth of 1 MHz.

### 6.3.3 Results

Given measured values are valid for the described arrangement and operation of the EUT.

The EUT complies with the requirement in FCC 15.509 (a) and (f).

#### According to 15.509 (a)

Data regarding UWB transmissions was gathered and calculated from the diagrams below:

Frequency of highest emission  $f_M$ : ~ 1100 MHz

Upper boundary  $f_H$ : ~ 2000 MHz

Lower boundary  $f_L$ : ~ 250 MHz

Centre frequency  $f_C$ : 1125 MHz

Fractional bandwidth: 1.56

#### According to 15.509 (f)

Emission at  $f_M$ : Radiated emission 39 dB $\mu$ V/m at a 1 MHz RBw.

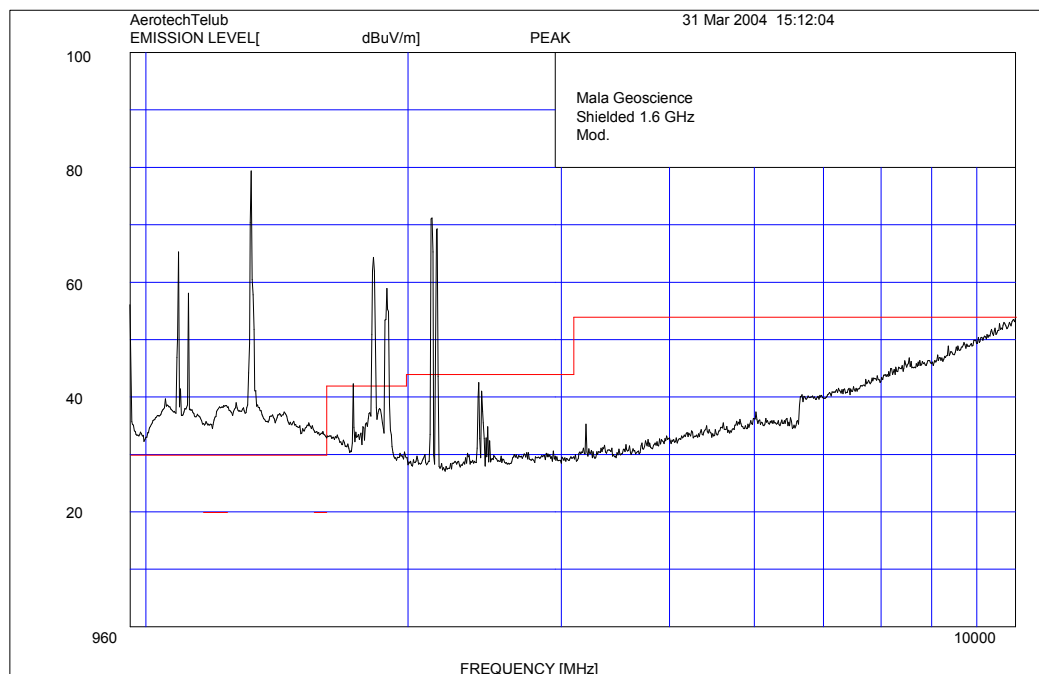
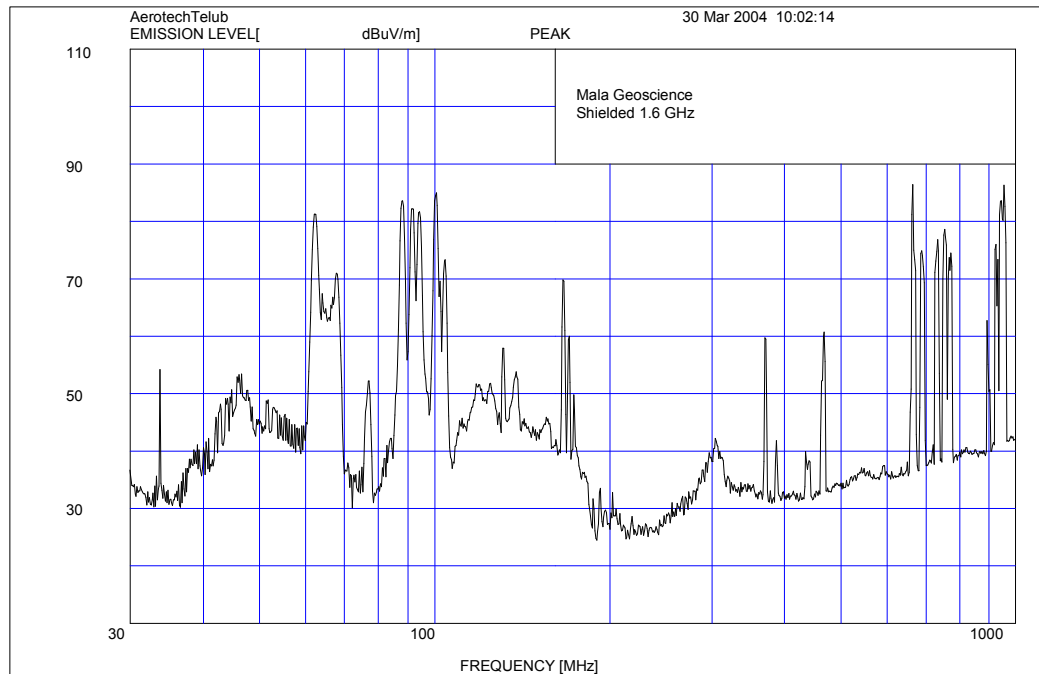
Limit 0 dBm EIRP at 50 MHz RBw

Limit -34 dBm EIRP at 1 MHz RBw

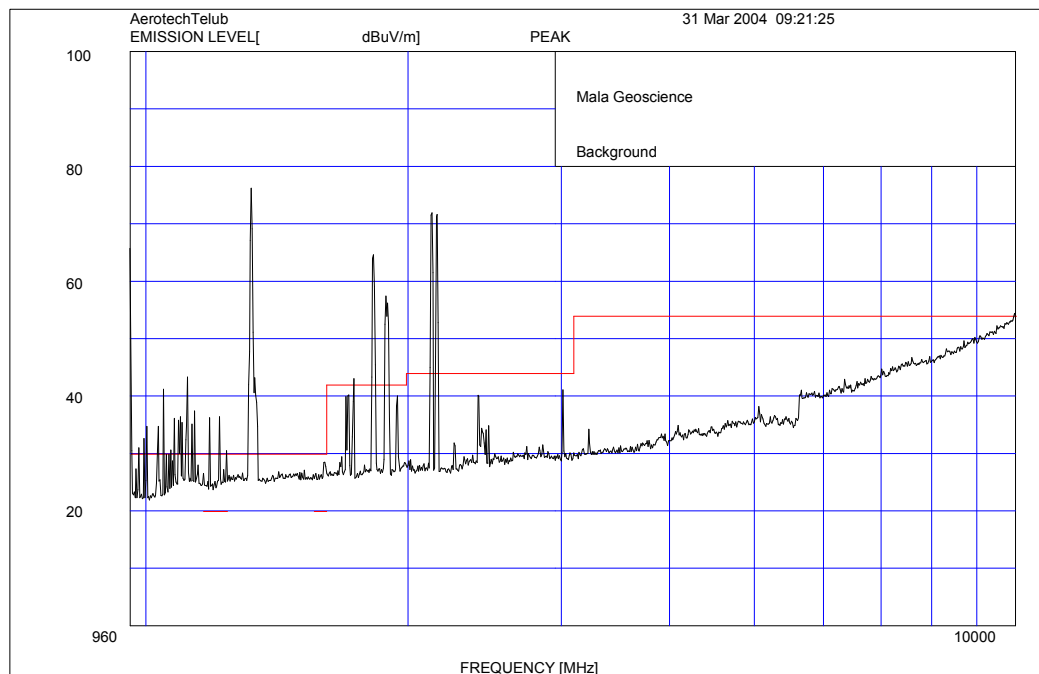
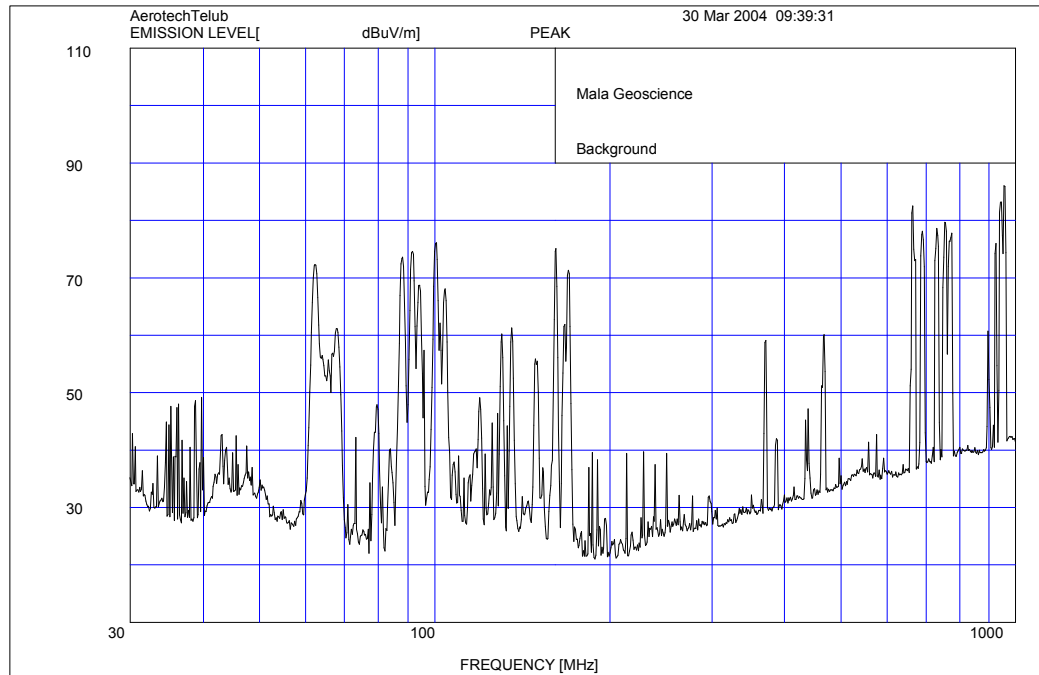
Limit -34 dBm EIRP = 61.2 dB $\mu$ V/m

Margin to limit 61.2 – 39 = 22.2 dB

## Composite trace of peak emission



## Composite trace of background emission



### 6.3.4 Instrumentation

|                                       |          |                   |                         |
|---------------------------------------|----------|-------------------|-------------------------|
| Hewlett Packard<br>Spectrum analyser  | 8566B    | 100 Hz - 22 GHz   | 2404A08864 / 2504A01320 |
| Hewlett Packard<br>Pre-amplifier      | 8449B    | 1 GHz - 26.5 GHz  | 3008A00103              |
| Rohde & Schwartz<br>Spectrum analyser | FSIQ26   | 9 kHz - 26 GHz    | 100012                  |
| Emco<br>Double Ridge Waveguide        | 3115     | 0.96 GHz - 18 GHz | 2800                    |
| Chase<br>Bilog antenna                | CBL6111A | 30 - 1000 MHz     | 1831                    |