

**Australia Telescope National Facility**

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SUBJECT: Narrabri L-S RF Band Spectrum Survey

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Revision History

Version	Date	Comment
1	6/06/07	Original release

## 1 Introduction

This technical report discusses the recently completed spectrum survey results measured at Narrabri, as part of the project to broaden the RF front ends of the existing L/S receivers. Measurements were undertaken from the 16<sup>th</sup> May, to the 23<sup>rd</sup> May, 2007. Similar survey measurements are to be performed for the C/X receivers, to be performed by Narrabri staff. This higher frequency survey will need to cover from 4GHz through to 11GHz.

## 2 Background, Investigation Procedure & Configurations

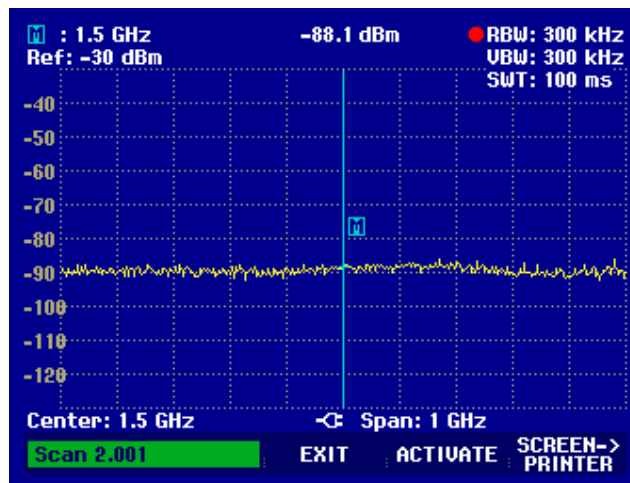
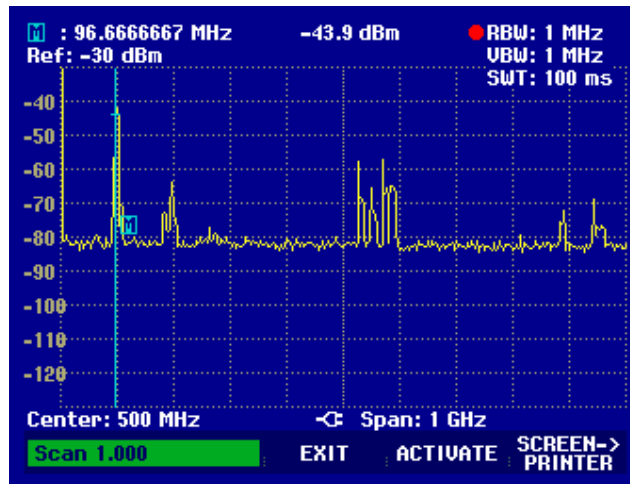
The motive for the spectrum survey was to identify any significant transmitters which may impact on the project to broaden the RF front-end response of the existing Narrabri L/S receivers. The existing L/S receivers cover the RF bands from 1200-1800MHz (L-Band) and 2200-2600MHz (S-Band). To maximize the 2GHz bandwidth of the proposed CABB back-end, the front ends of the receivers are to be broadened with the proposed frequency range of 1000-3000MHz, covering L/S in one complete pass-band. Experience from Parkes has found that significant out-of-band transmitters in close proximity to a receiver band edge can have detrimental impact to the system, particularly on the linearity of the system and in the operability of the back-end processing systems. In addition, of course, any in-band transmitters can also cause problems with back-end.

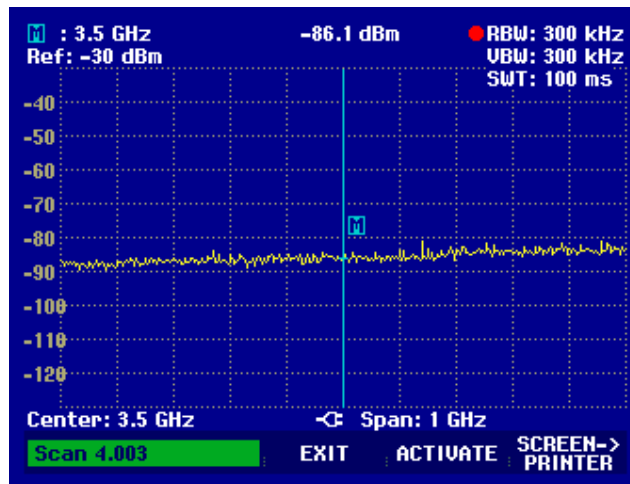
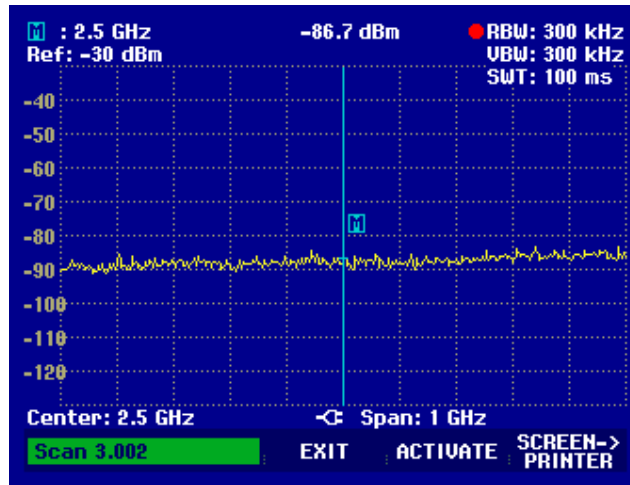
Equipment used in the spectrum survey included:

- Antenna Research Associates BSB-14 1-4GHz Slant Linear Biconical Omni antenna
- Interference Monitoring System (IMS) L-Band Amplifier LNA2 (1-2GHz), G=40dB
- IMS S-Band LNA (2-4GHz), G=60dB
- K&L Tunable Bandpass Filter (1-2GHz), 5% 3dB BW
- Trilithic Tunable Bandpass Filter (2-4GHz), 5% 3dB BW
- K&L Bandpass Filter (1200-2000MHz)
- K&L Bandpass Filter (2000-4000MHz)
- GCG Bandpass Filter (2600-3600MHz)
- Rohde&Schwarz FSH6 100kHz-6GHz Portable Spectrum Analyzer
- Andrews Antenna ¼" Helix Cable (11m) connecting output from LNA to R&S Spectrum Analyser.

The measurements were performed from atop the NML tower at the Narrabri site. This tower sits around 100m north of the main east-west track, and around 40m east of the north-south spur. The tower has a mechanically driven opening and closing roof, which assisted in enabling a good vantage point for the antenna to be positioned. Measurements were only performed during daylight hours, as the risk of bird attack early and after dusk were of a concern, hence, the roof was closed each evening, and the survey equipment powered down and secured.

Preliminary measurements of the RF spectrum were performed to identify any significant nearby transmitters, which may have the potential to cause any gain compression in the measurement amplifiers. Below are images of Scans 1-4, which show the RF spectrum from DC-4GHz, in 1GHz bands. The scan number is identifiable in the bottom left hand corner of each image. These measurements were performed with the Spectrum Analyser connected directly to the Omni directional antenna. Scan 1, which covers from DC to 1GHz, clearly shows the VHF TV and FM Bands, and the higher frequencies of the UHF Digital and Analogue TV, along with mobile base station transmitters. Given the levels recorded, it was then deemed necessary to use pre-selection filters on the finer measurements performed later, as many of the amplifiers have frequency responses which extend down in frequency that cover these VHF and UHF transmissions. The scans covering from 1-4GHz show no other significant transmissions.





The filtering between the omni antenna and the amplifier thus enforced a strategy to effectively cover the band with adequate dwell time and resolving capability (limits on how wide a span can be with a set resolution bandwidth). Spans of 50MHz, 100MHz, and 200MHz were used over the range from 1000-3600MHz, depending upon which pre-selection filter was in use. For the bottom end of the band, the K&L Tunable Bandpass filter (1000-2000MHz) which has a 3dB bandwidth of 5%, which effectively covers around 50MHz of spectrum at the lower frequencies, was used. For the slightly higher frequencies above 1200MHz, the fixed tuned K&L filter was used (1200-2000MHz) up to 2000MHz, with a Spectrum Analyser span of 200MHz setting the displayed spectrum. For frequencies between 2000-2400MHz, the Trilithic Tunable Bandpass filter, which has a 3dB bandwidth of again 5%, resulting in spectrum coverage of around 100MHz, was used. For surveying around the [key] microwave oven ISM band of 2400MHz, the fixed tuned K&L filter (2000-4000MHz) was used, whilst above 2600MHz, the GCG designed fixed tuned filter (2600-3600MHz) was used, with the spectrum analyzer setting the span to 200MHz. Around 2 hours was spent on each spectrum scan, using a peak detector, with a swept displayed set on max hold. Some experimentation with rms detection occurred at the end of the measurements, to test out other detection methods.

The full band from 1000-3600MHz was broken up as follows:

<b>Scan Number</b>	<b>Centre Frequency (MHz)</b>	<b>Bandpass (MHz)</b>
5	1050	1025-1075
7	1100	1075-1125
9	1150	1125-1175
11	1200	1175-1225
14	1300	1200-1400
16	1500	1400-1600
19	1700	1600-1800
21	1900	1800-2000
22	2050	2000-2100
23	2150	2100-2200
24	2250	2200-2300
25	2350	2300-2400
36-41	2500	2400-2600
26	2700	2600-2800
27	2900	2800-3000
28	3100	3000-3200
30	3300	3200-3400
31	3500	3400-3600
32-35	2500	2400-2600

The above table covers the scans required to cover the full band, with some extra scans for testing over the ISM Band. There are some scans not listed in the sequence, as they were sometimes used as test scans to compare a spectrum with a 2 hour max hold sweep, to ones with around 5 minutes of max hold sweep. Most scans had an average of 2 hours on max hold, with a few minor scans only having around 1 hour. Scans 36-41, of the important ISM Band, were of 2hour scans each, and were measured over a while day, to record if any other off-site microwave ovens or sources could be detected (of which there were).

Scans 32-35 were used to test the lodge microwave oven, to see how the RF signature would appear on the measurement setup. The microwave in each case was set to full power, and ON for around 40seconds. Scan 32 displays the detection with peak detector and RBW/VBW set at 100kHz, whilst scan 35 displays the detection with peak detector and RBW/VBW set at 1MHz. Scans 33 and 34 show the detection with a RMS detector, and RBW 100kHz/VBW 1MHz and RBW 1MHz/VBW 3MHz respectively.

The Appendix A & B of the document contains the scans listed above.

### 3 Results Discussion

Looking through the entire spectrum plots, scans 5-11, covering the Aeronautical Radionavigation band from 960-1215MHz, show the most activity in terms of % of spectrum and level. Compared to Parkes, the Narrabri area has significantly more spectrum activity. This could well be due to the proximity of the site to the many large cotton farms that may have aeronautical infrastructure as part of their farming operations. In addition, with the area having a relatively flat terrain profile, particularly to the north towards Moree where a large airport exists, there is opportunity for transmissions from more distant sources to make their presence be felt.

Scan 16 shows a few of the point-to-point terrestrial communication links just appearing above the noise floor of the measurement system, with signatures just above 1500MHz and around 1525MHz. Above 1540MHz a few small spikes appear which could be associated with geo-stationary satellite transmissions, for which my measurement system is not overtly responsive to. The omni-directional antenna is best for picking up emissions coming to it from the local horizon, and has a beam pattern with a response slowly decreasing in gain in elevation. This pattern is therefore suitable for low-earth orbit satellite transmissions near the horizon, with a limited response for detecting geo-stationary satellites, which have an elevation of about 35degrees above the horizon.

Another strong source of transmissions are the satellite links appearing in Scan 19, around 1618-1626MHz. These transmissions are readily detected at Parkes as well, and are attributed to the Iridium low earth orbit satellite constellation. Again, a few other small spikes appear just above the noise floor above 1700MHz. Similarly, in Scan 21, between 1800-1900MHz, small low level spikes appear just above the noise floor.

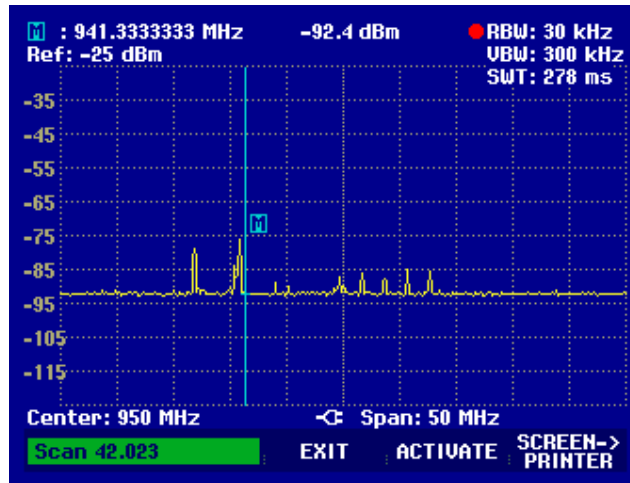
For the most part, the rest of the scans show little activity, as detected with the measurement setup. The only other area of significant activity is in the ISM Band, where low power unlicensed communication devices, as well as microwave ovens operate. Scan 36 shows the response, taken mid-morning, of a microwave oven, suspected to be from on site (not necessarily the lodge). A blanket ban on the use of site microwaves was enforced from 10am, through to midnight, thus ensuring that any signature captured, can be attributed to ovens off-site. There were no detections for the rest of the day, until around 6:15pm, when a large detection occurred, lasting for around 10 minutes.

### 4 Conclusions

It would seem that the largest identifiable threat to the broadening of the front-end receivers and RF electronics, apart from the already well-known microwave oven effects at 2460MHz, in terms of significant transmitters potentially causing gain compression, or at most, significant in-band RFI, would be the mobile base-station transmitters at around 850-950MHz and that of the transmissions associated with the aeronautical radio navigation band, from 960-1260MHz.

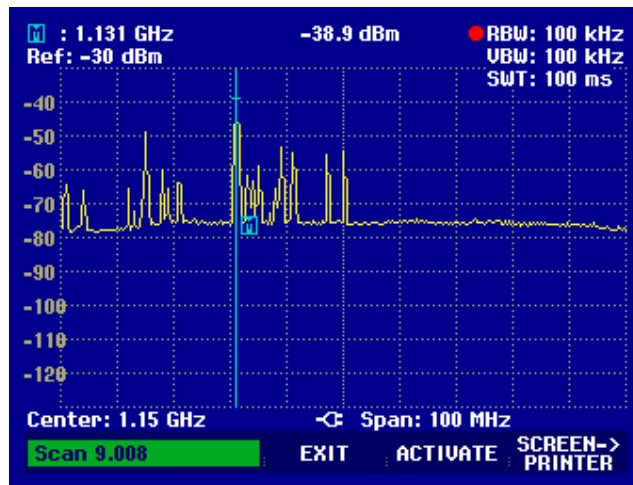
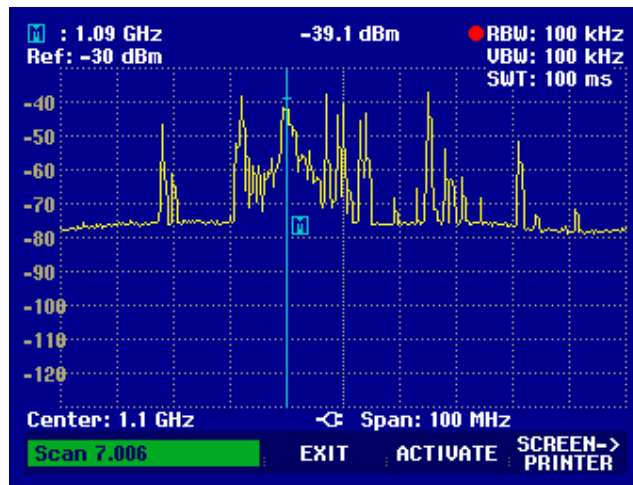
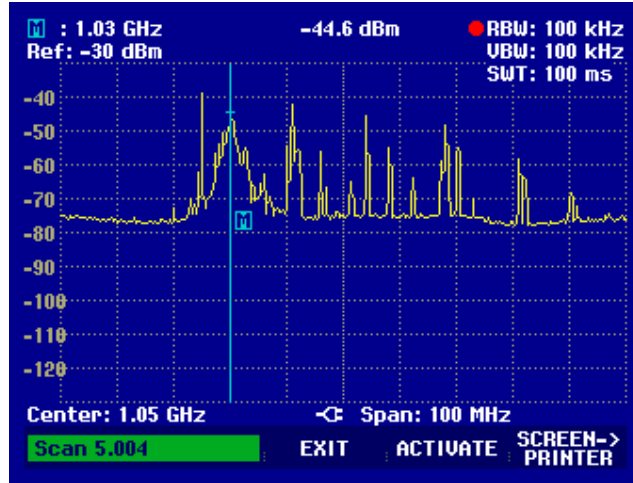
Experience at Parkes from the effects of aeronautical navigational devices on the operation of the multibeam pulsar survey measurements required the relocation of the Distance Measuring Equipment (DME), beacon frequency, originally operating at 1168MHz, to a frequency of 1018MHz, further away from the pass-band of the Multibeam receiver, which was designed to operate from 1200-1500MHz. The original receiver design had notch filters as part of the suppression of the beacon at 1168MHz, with filters located in the RF modules. Over time, these filters slowly detuned, and the notch no longer provided enough suppression of the beacon, causing it to break through, and affect the total power of the system. This situation occurred during the point at which the under side of the focus cabin, had clear line-of-sight towards the Parkes airport. The overall affect on the system for the pulsar survey, was to significantly compromise the detection capabilities of the filter-bank back-end system.

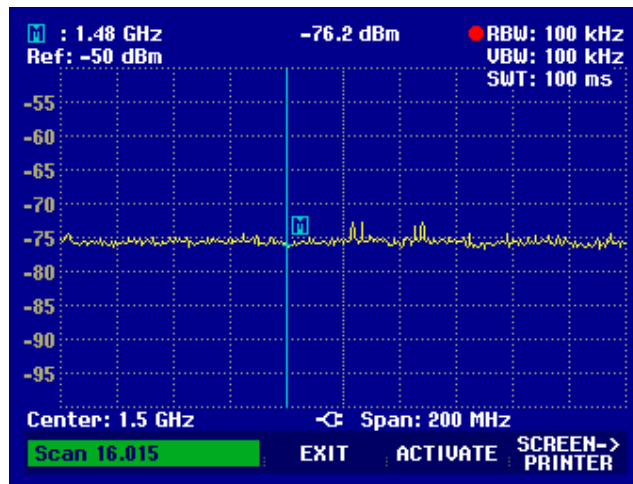
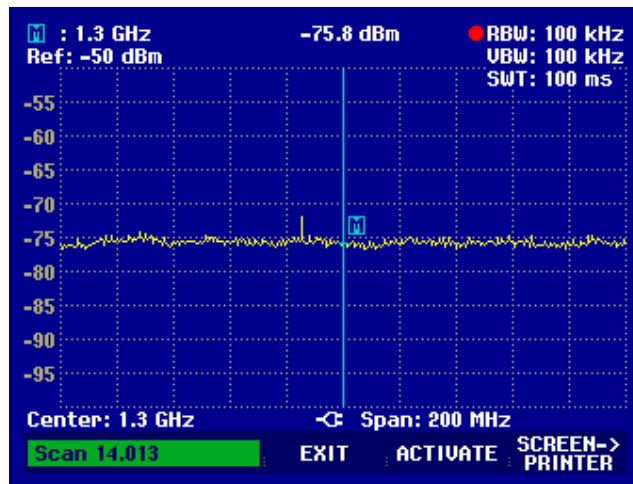
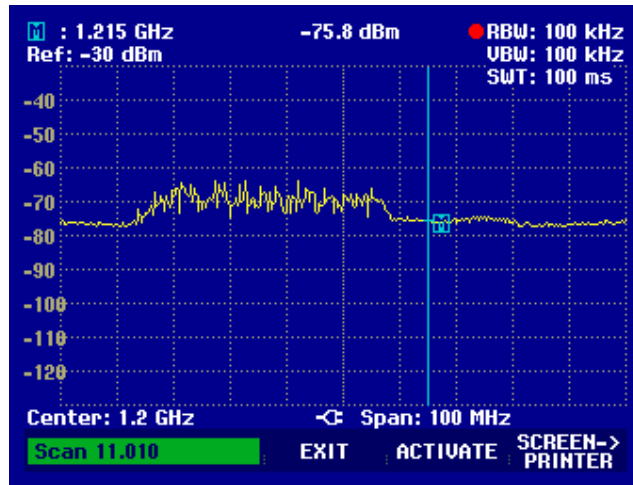
Obviously, for the mobile base station transmitters below 1GHz, at around 950MHz, their effects will be determined in some way by the frequency response of the L/S feedhorn, and how well it cuts off below 1GHz. A zoomed-in image of the base station is shown below.

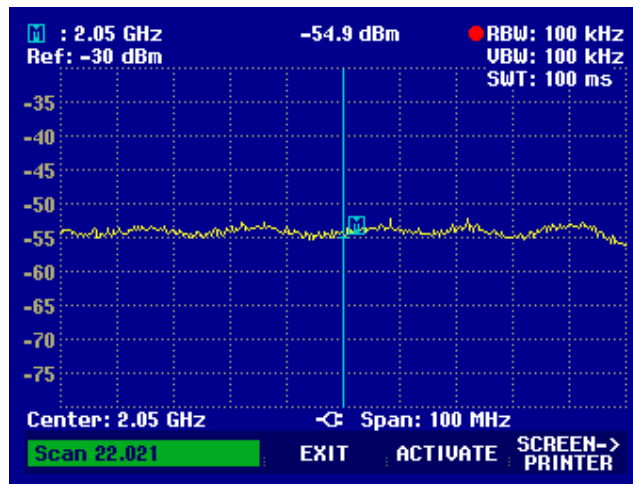
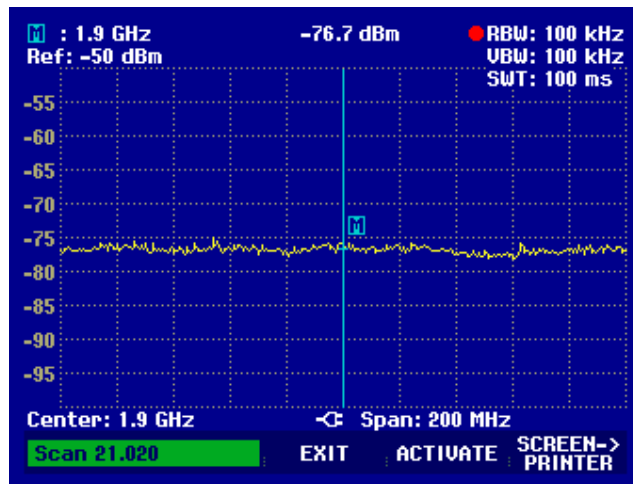
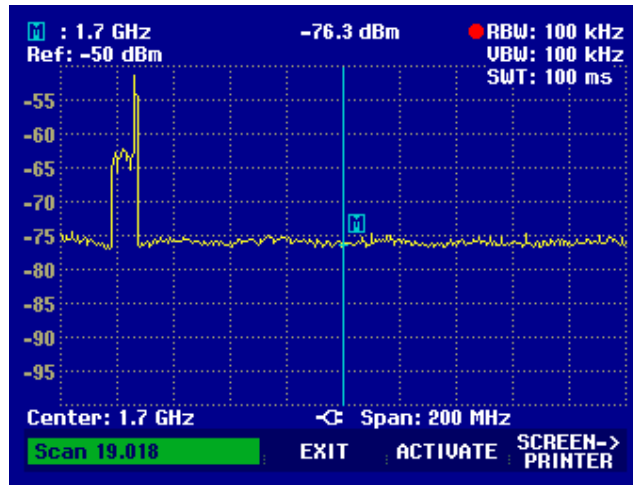


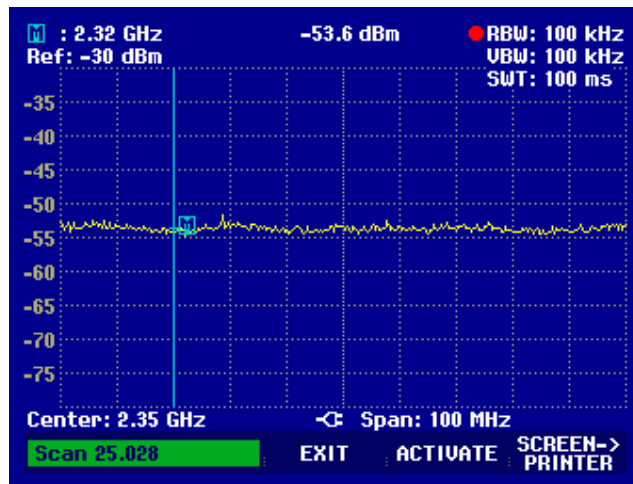
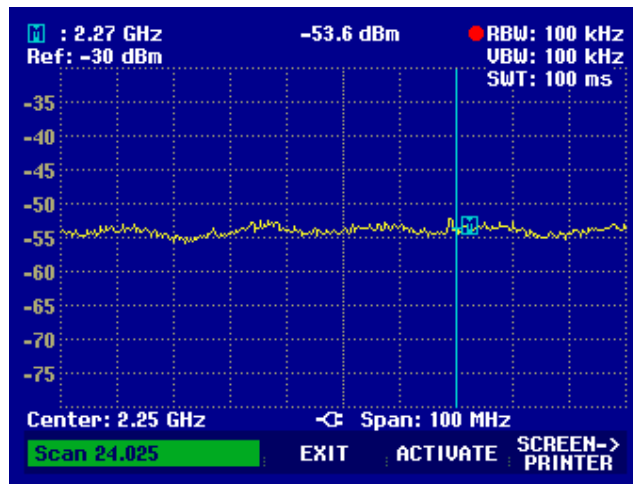
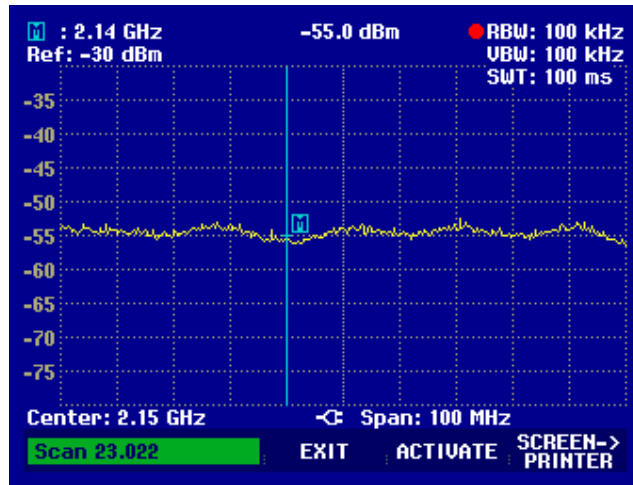
It seems that there may be some need to seriously look as to what benefits will be won, by going below 1200MHz, from the existing system, when mobile base station transmitters and impulsive beacons residing around 960-1215MHz exist.

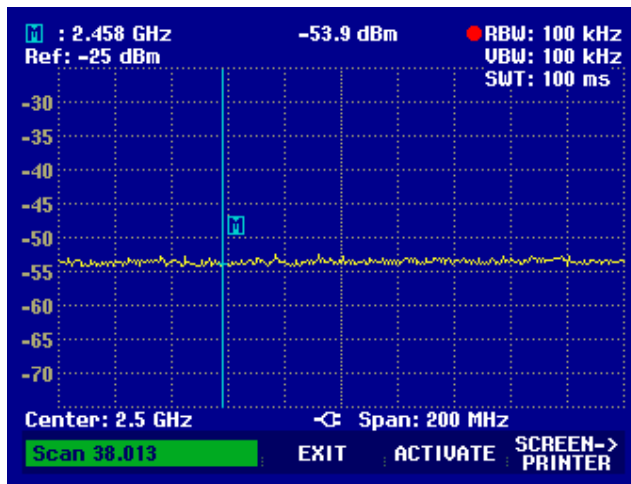
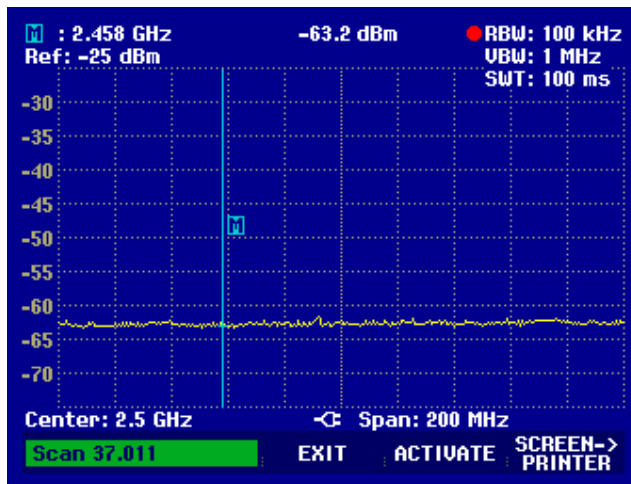
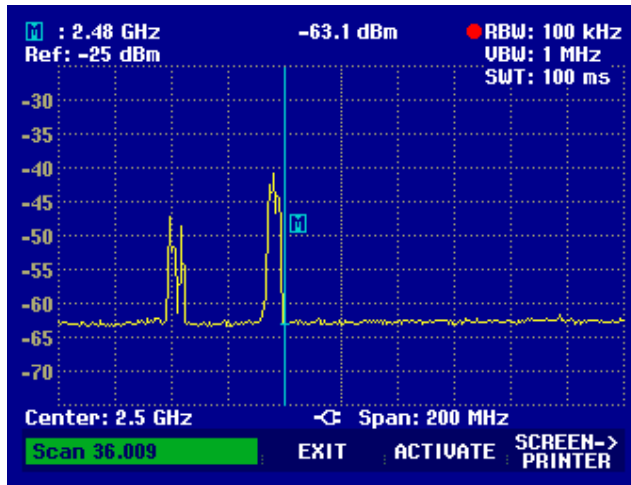
Appendix A Reference Plots

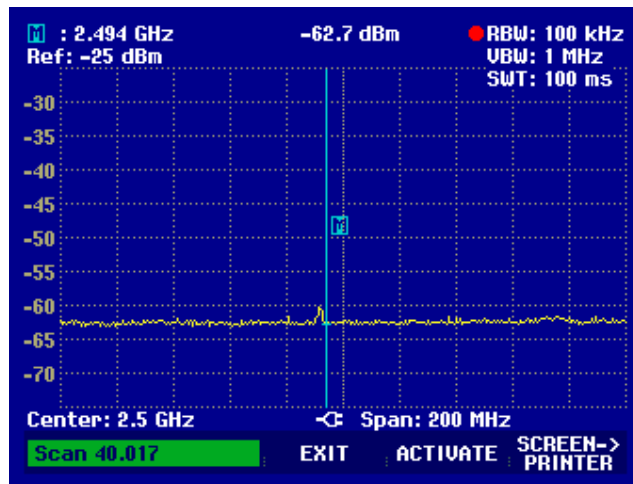
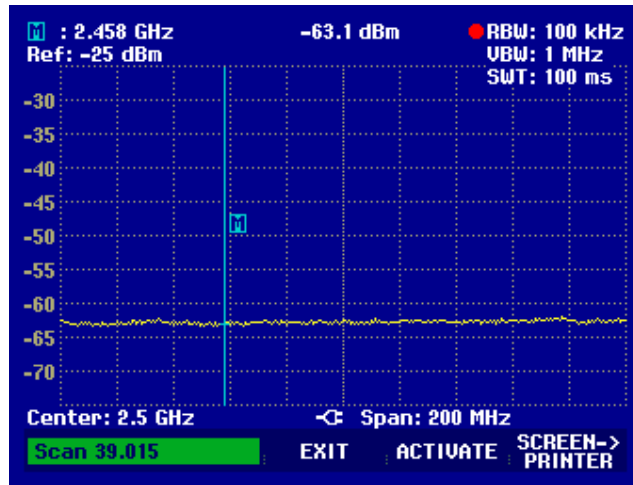


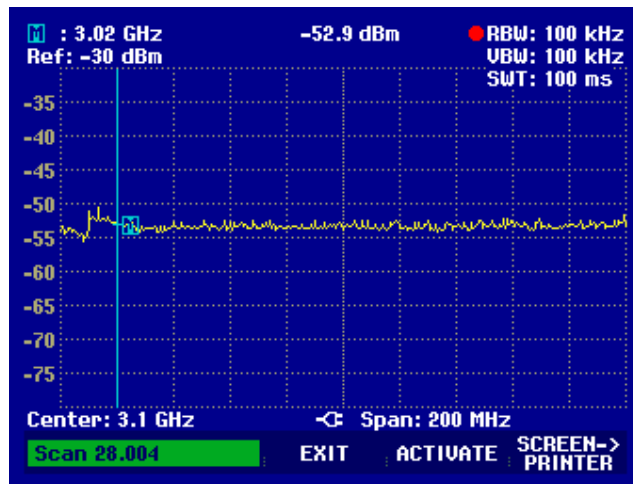
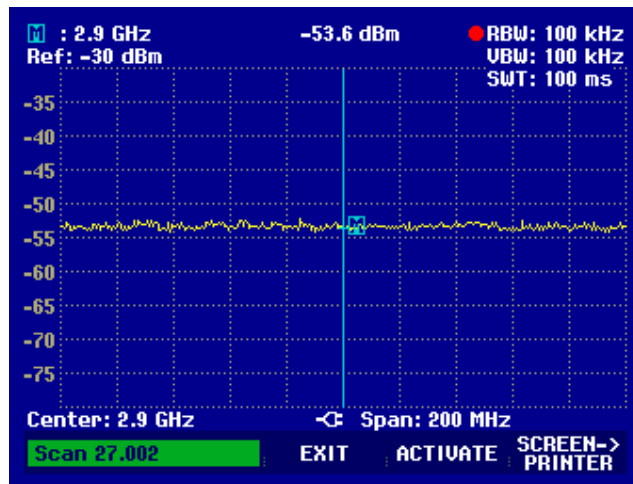
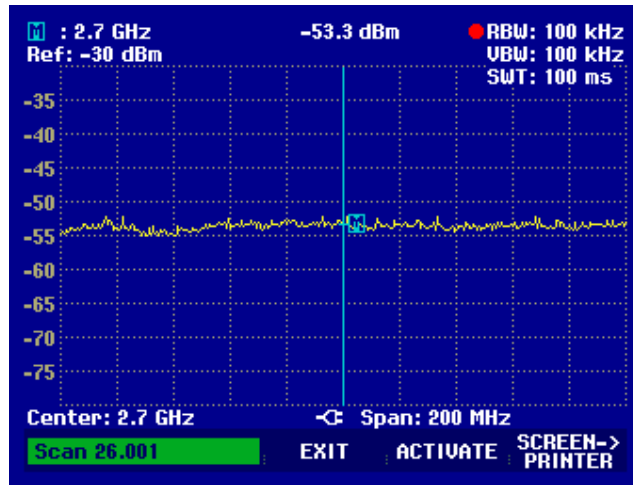


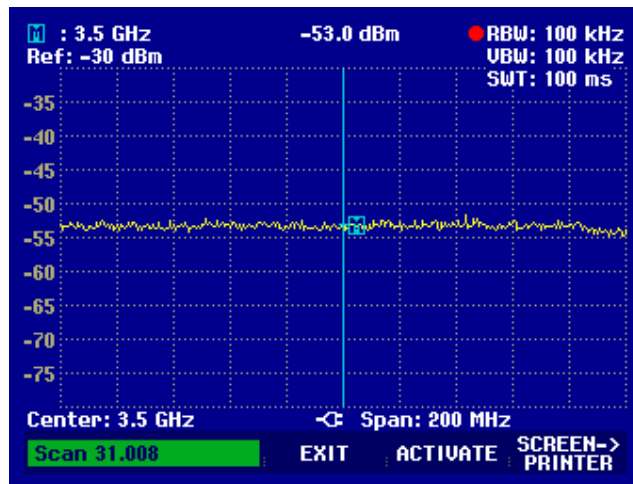
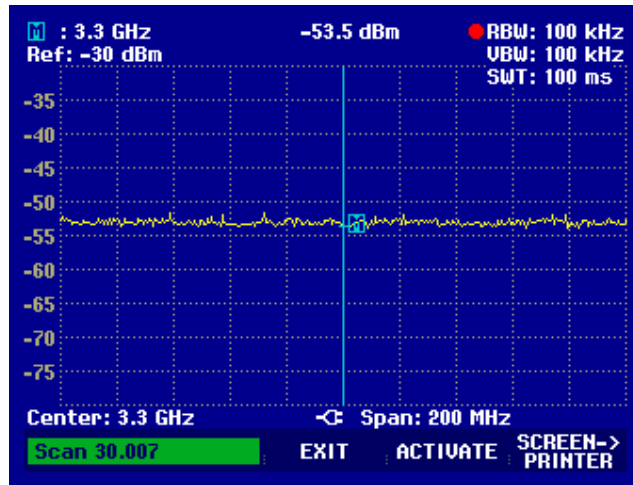












### Appendix B – Microwave Oven Test Scans

