Technical Licence Conditions for the 2.6 GHz band
Co-ordination Procedures for Radar

Stakeholder event

20 January 2012

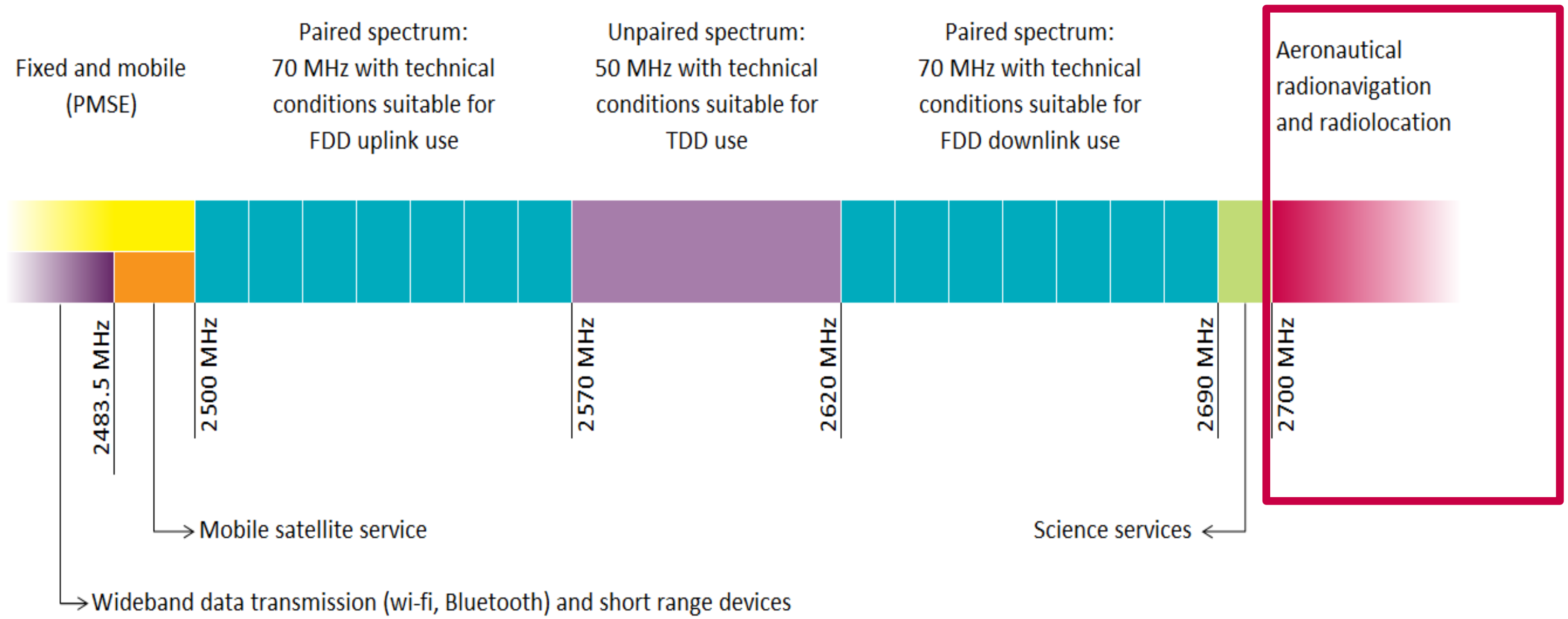
Agenda

• Background	Erika Forsberg	10:30
• Civil Aviation Authority (CAA)	Alistair Abington	10:40
• Current technical position	David Money	10:50
• Co-ordination procedures	Nick McFarlane	11:10
• Questions and Discussion	All	11:30
• Close / coffee / discussion opportunity		12:00

Introduction
Erika Forsberg (Ofcom)

Spectrum Clearance and Awards Programme

The 2.6 GHz band and adjacent spectrum



Radars currently expected to require protection

	Number of radar (approx)
Civil Air Traffic Control (ATC)	40
Port Authority surveillance	4
Military	47

This map shows approximate locations of civil and military radars that are expected to require protection from 2.6GHz transmissions.

Background

A Government programme comprising the Department for Culture Media and Sport (DCMS), the Department for Transport (DfT), and the Ministry of Defence (MoD), supported by Ofcom and the Civil Aviation Authority (CAA), is in place to help radar operators modify their radars to make them more resilient to transmissions in the 2.6 GHz band.

The aim is to complete modifications in areas covering the majority of the UK population by end of 2013, and across all UK as soon as possible thereafter.

The DfT is coordinating a prioritised roll-out plan for modifications to civil radar. The MoD is aligned with this roll-out plan and managing changes to military radars.

More information on the timetable for roll-out will be available in the Information Memorandum for the 2.6 GHz award.

Purpose

We will put in place technical licence conditions for the 2.6 GHz band, which will include co-ordination procedures to protect radars before and after modification.

Purpose of the meeting today is to brief you on the technical work we have done and share our current thinking on co-ordination procedures.

Civil Aviation Authority
Alistair Abington

The Role of the Civil Aviation Authority (CAA)

The Civil Aviation Authority carries out the regulatory function for aviation on behalf of the Secretary of State for transport in accordance with the Civil Aviation Act 1982. This includes protection of the spectrum used for Aviation systems.

CAA Regulatory Environment

- Air Navigation Service Providers (ANSPs) are responsible for the movement of aircraft flying within controlled airspace
- Air traffic controllers use radar surveillance systems to see targets and safely control aircraft
- All aeronautical radar surveillance systems have to comply with national and international regulatory standards
- The CAA places regulatory requirements upon ANSPs to ensure safe air traffic management standards are maintained

The Airspace Environment

- Flight traffic is increasing and it is essential that airspace remains safe
- More radar services are being requested by ANSPs to support the increasing demand on air traffic control systems and controllers
- This has led to an increase of CAA approvals for radar services

Civil Aviation Authority

Radar Frequencies

- Radar systems interface with aircraft through dedicated aeronautical frequencies
- The national frequency band assigned to both civil and military aeronautical primary radar is between 2700MHz and 3100MHz as defined in the UK Frequency Allocation Table (FAT)
- Radar frequency assignments are provided with **safety-of-life protection status** from unwanted radio interference. Any compromise of this has a major safety impact
- Co-ordination procedures already exist between FM radio broadcast and CAA

Because radar operates in the radio spectrum adjacent to 2.6GHz band, it is important to have co-ordination procedures in place for network operators.

Civil Aviation Authority

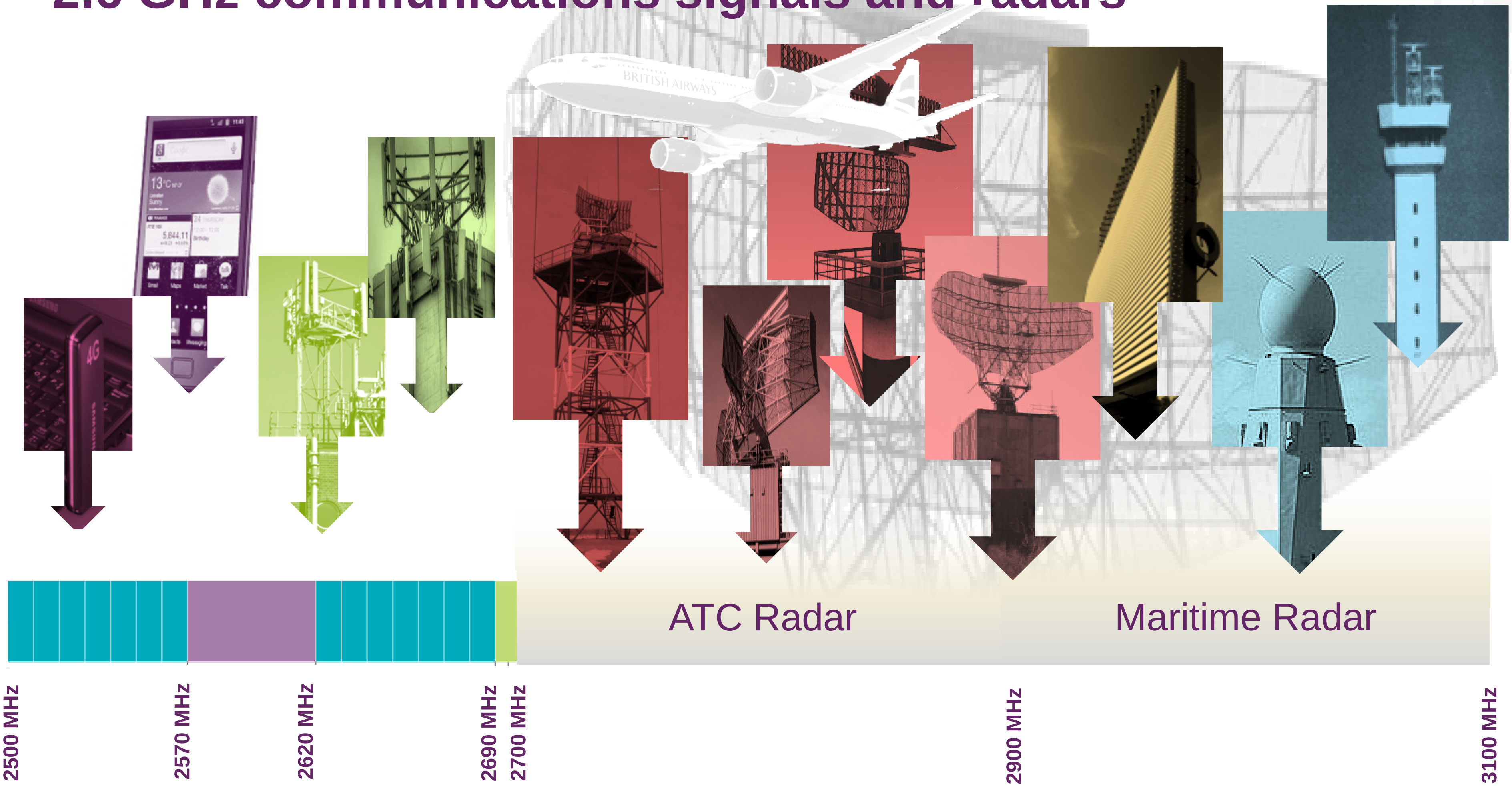
Current Technical Position
David Money (Ofcom)

Spectrum Clearance and Awards Programme

Technical presentation - contents

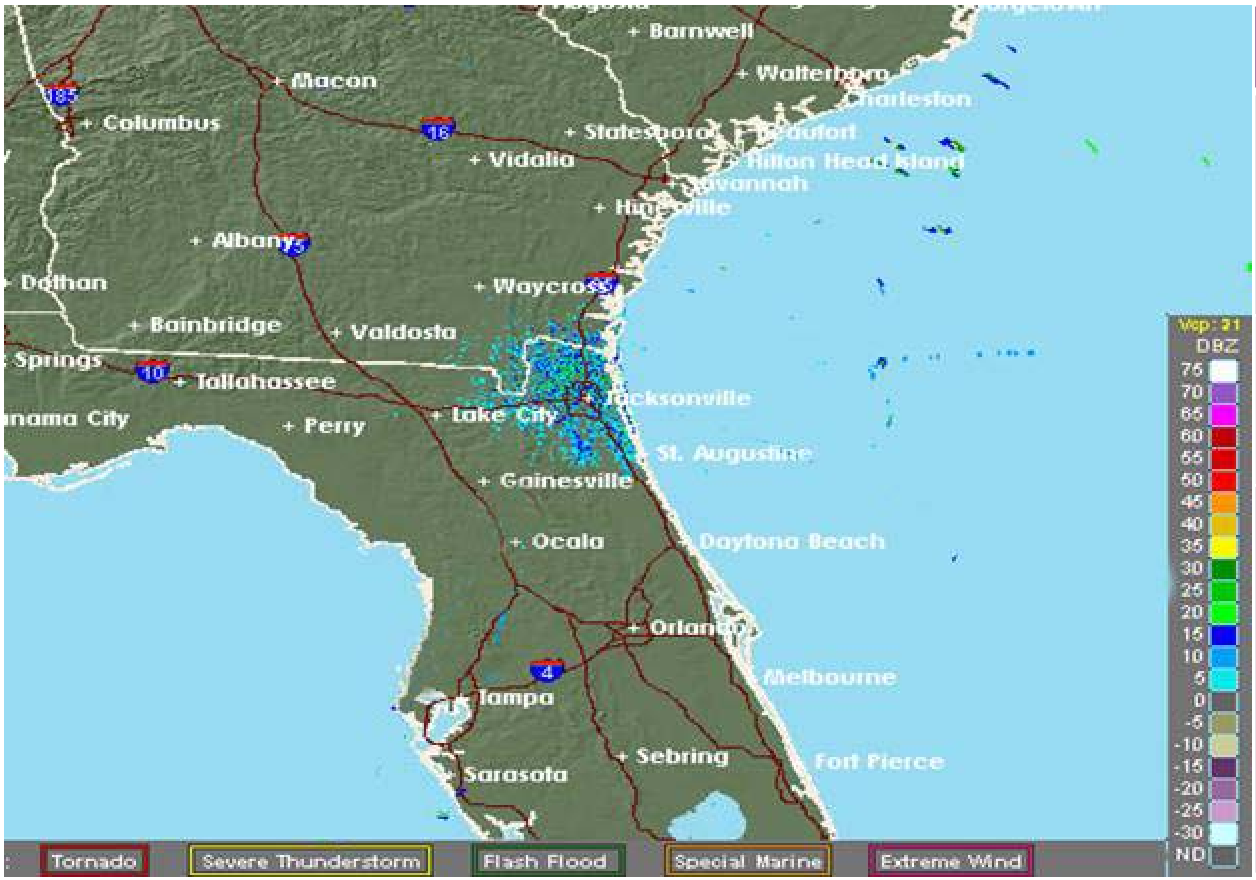
- 2.6 GHz communications signals and radars
- Radar performance degradation associated with communications transmissions
- Interference effect on unmodified radar
- Anticipated changes
- Indicative Out of Communications Band (OOB) measurements
- Summary

2.6 GHz communications signals and radars



Interference effects on unmodified radar

Interference on S-band weather radar



No.	1
Cause	Radar compression due to in communications band signals
Effect	Target amplitude loss: radar loses sensitivity
Factors	Radar to communications frequency separation, radar filtering (selectivity) and physical separation

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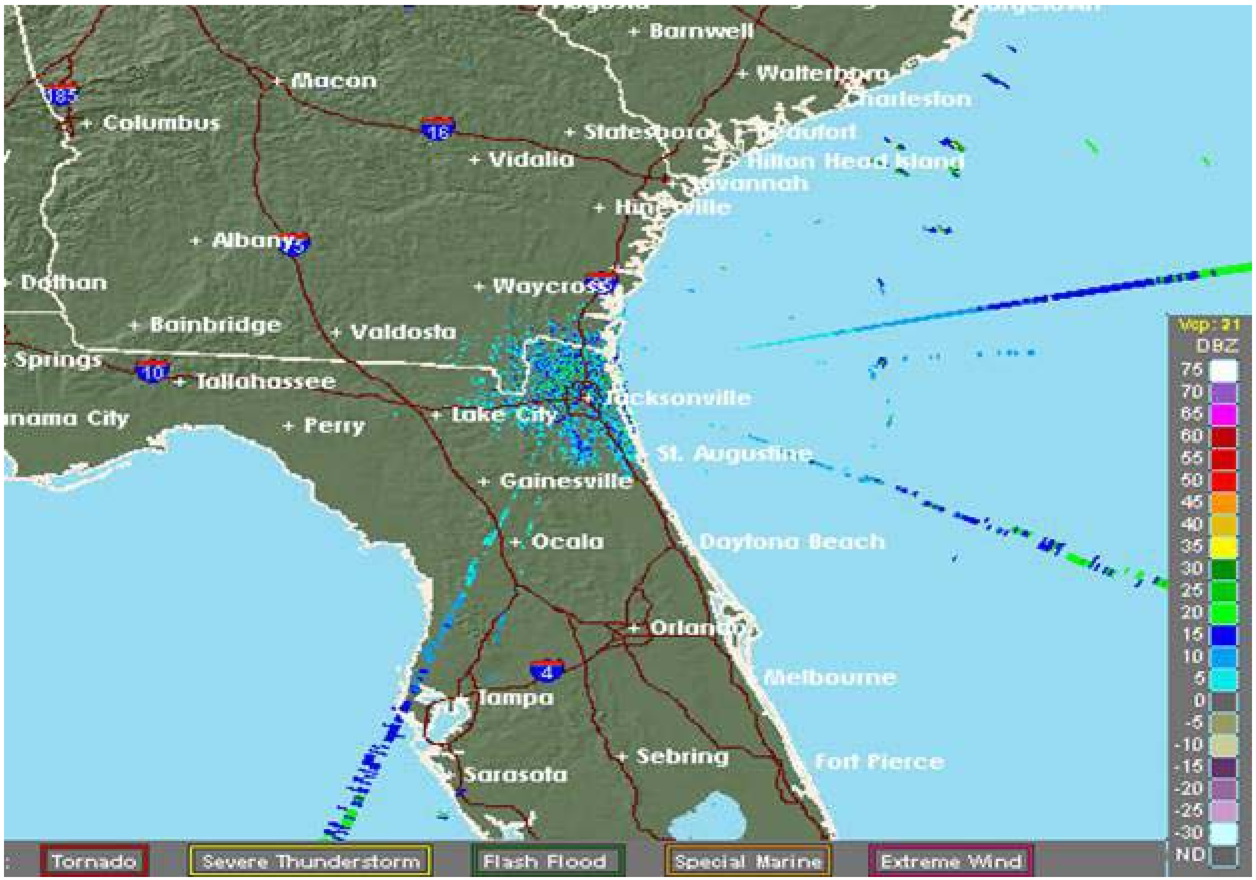
Interference effects onunmodified radar

Interference on S-band weather radar



No.	2
Cause	Radar compression due to in communications band signals
Effect	3rd order products, mixer products, due to non-linear effects in the receiver: radar loses sensitivity
Factors	Radar to comms frequency separation, radar filtering (selectivity) and physical separation

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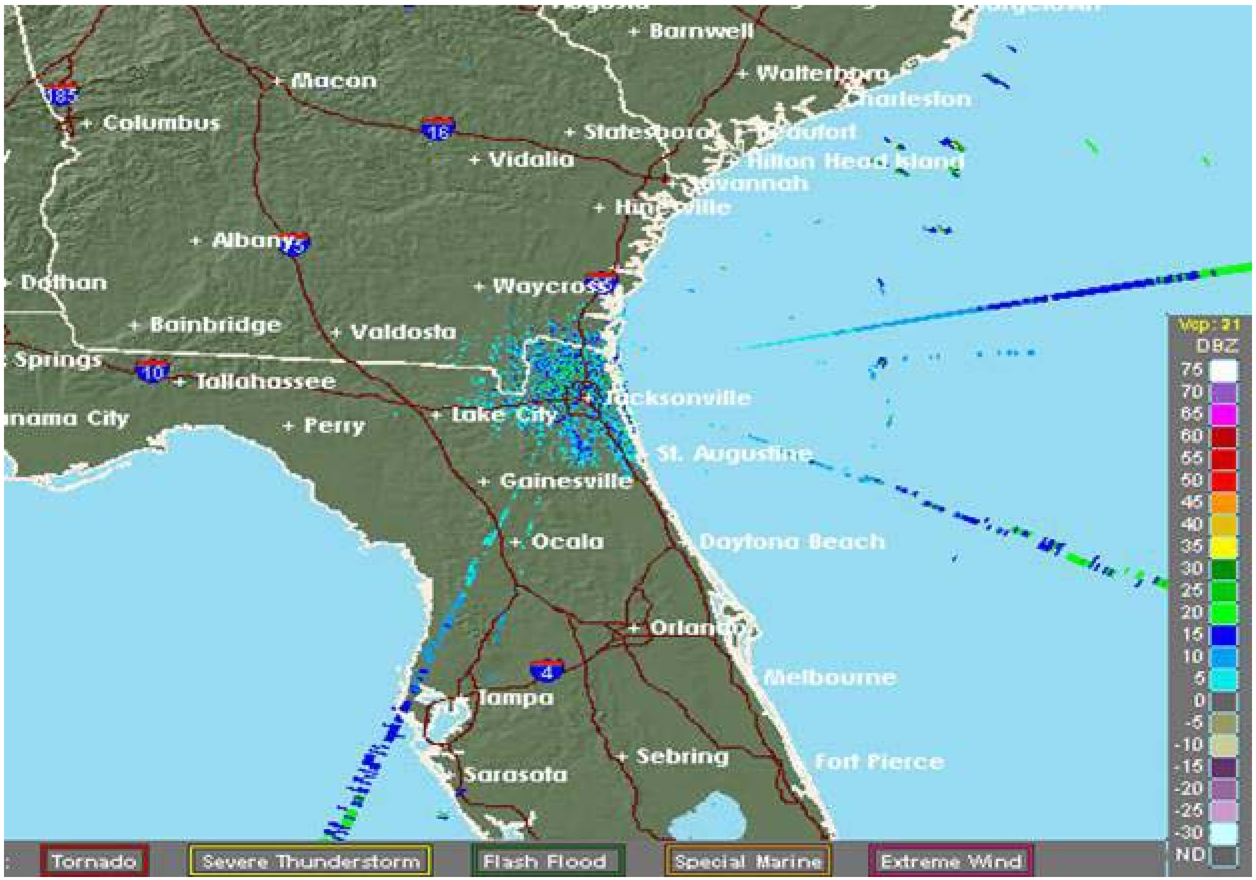
Interference effects on unmodified radar

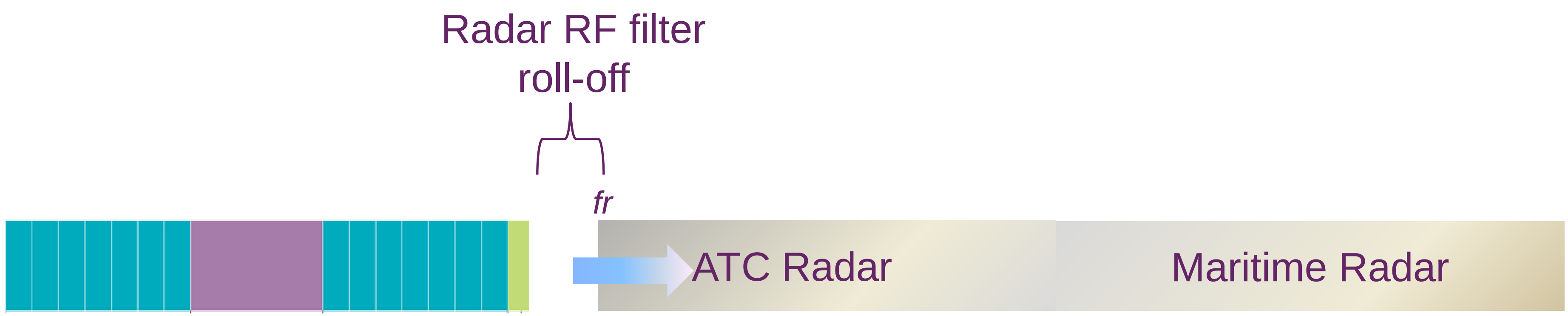
Interference on S-band weather radar



No.	3
Cause	Communications OOB noise in the radar band
Effect	Direct noise in final radar bandwidth: radar loses sensitivity
Factors	Radar to communications frequency separation, communications OOB noise level, physical separation

http://radar.weather.gov/radar.php?rid=jax&product=N0R&overlay=11101111&loop=no

Anticipated changes



Items 1 and 2, can be mitigated by modifying the current radar fleet. Modifications are currently being developed by radar manufactures and these will include RF filters to improve radar selectivity.

- We expect the lowest frequency radars to move up in frequency to accommodate new radar filter roll-off and maintain radar performance
- Exact frequency values (fr) to be determined, fr is expected to be in range 2720 – 2730 MHz

Indicative OOB measurements

Base stations and user equipment have been measured for emissions in the radar band.

The following slides show:

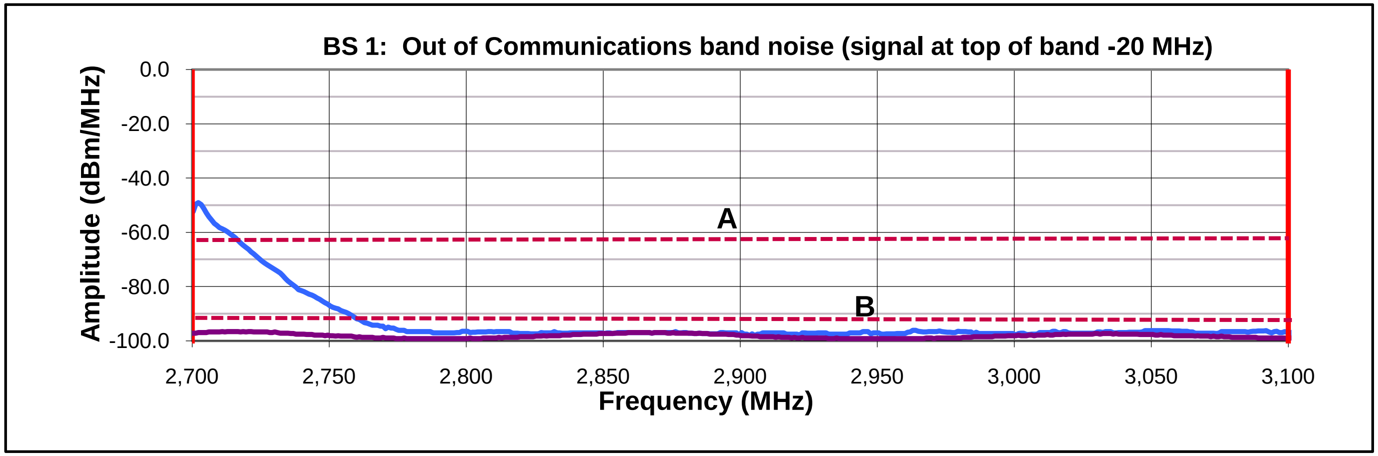
1. Comparison of two base stations
2. One base station with communications carrier at the top and bottom of the band
3. Measurements of two production user equipments

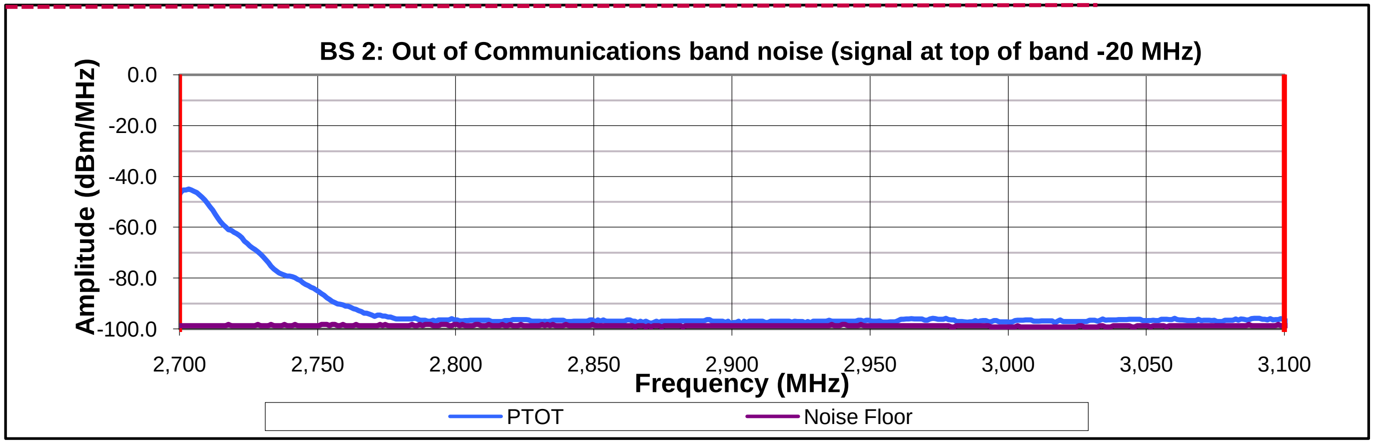
Base Station (BS) / User Equipment (UE) measurements are conducted emissions not Equivalent Isotropically Radiated Power (EIRP)

Power Total of Transmission (PTOT)

Indicative OOB measurements

Two base stations compared





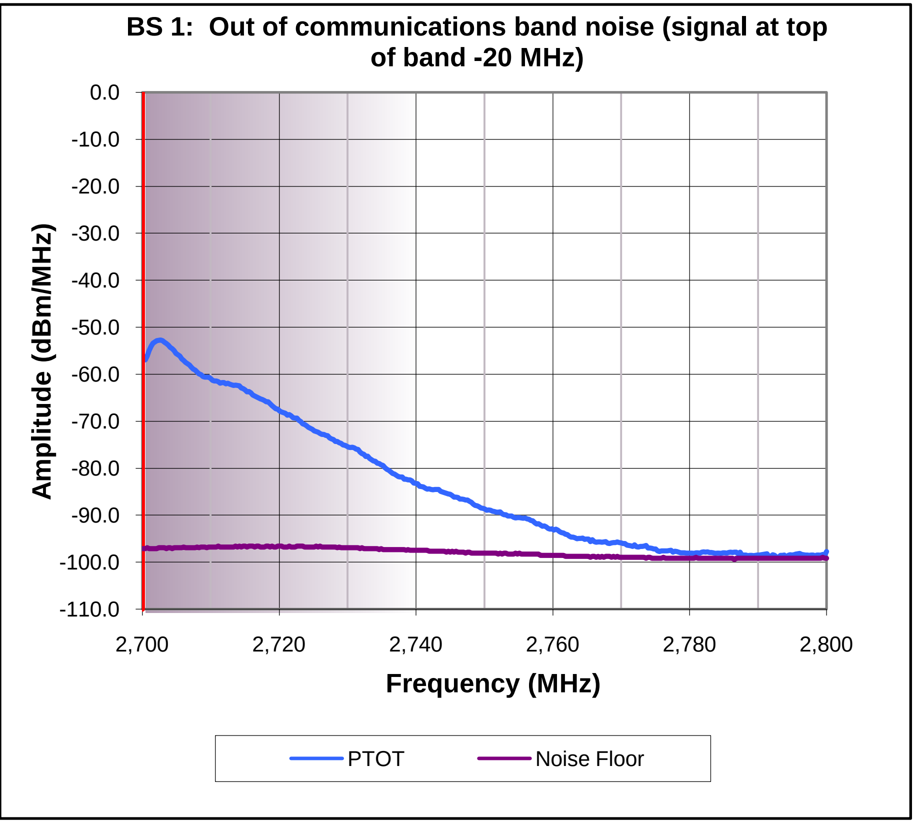
Equivalent conducted powers (approximate)

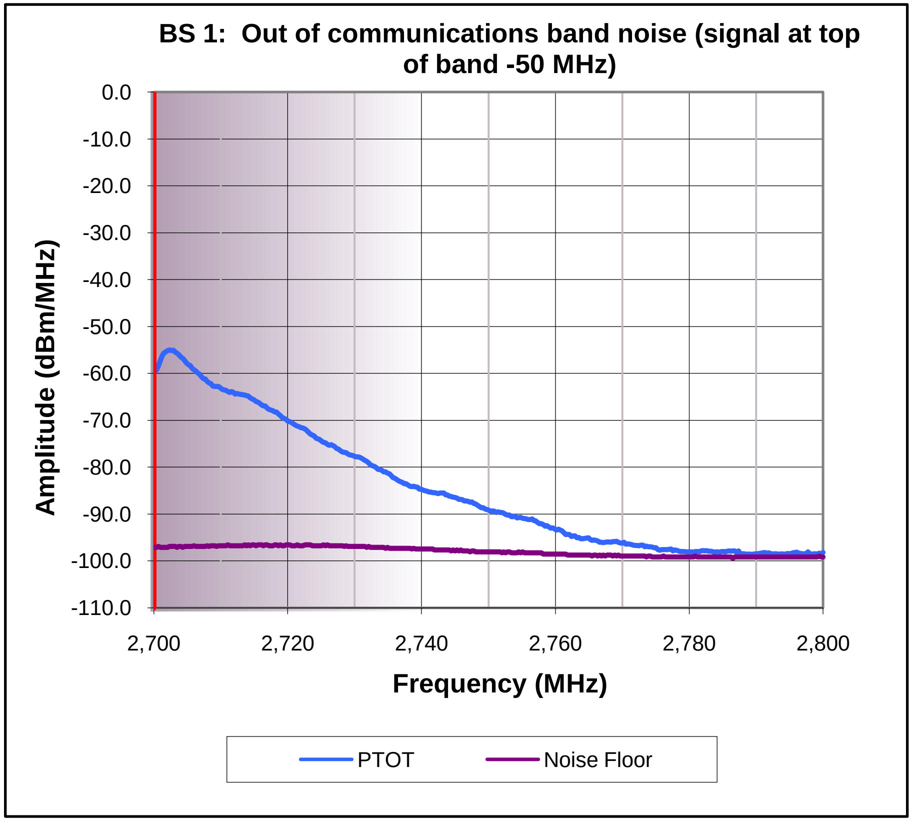
'**A**' equivalent to -45 dBm/MHz EIRP

'**B**' noise per operator using 4 x 5 MHz channels that would cause the expected OOB threshold to be exceeded. Assumes the BS is at 1 km distance from the radar
(34 dBi radar gain, and 17.5 dBi comms antenna gain)

Indicative OOB measurements

Base station with communications carrier at the top and bottom of the band





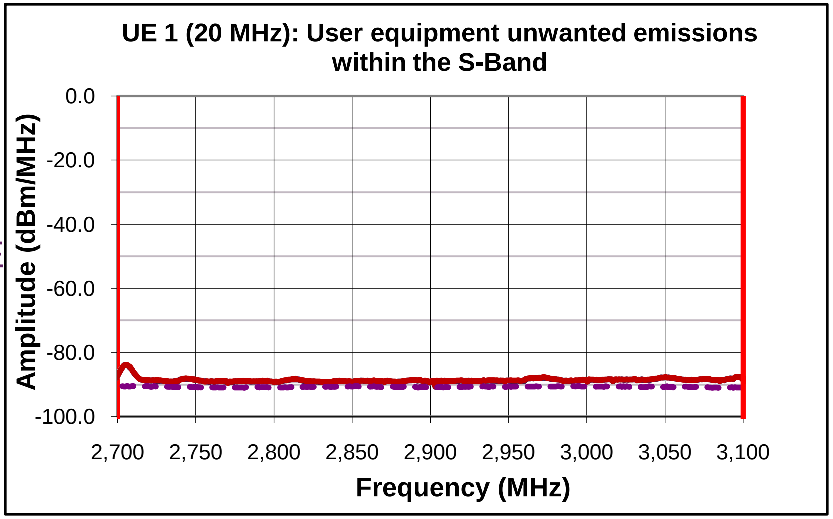
Radar frequencies that may be moved

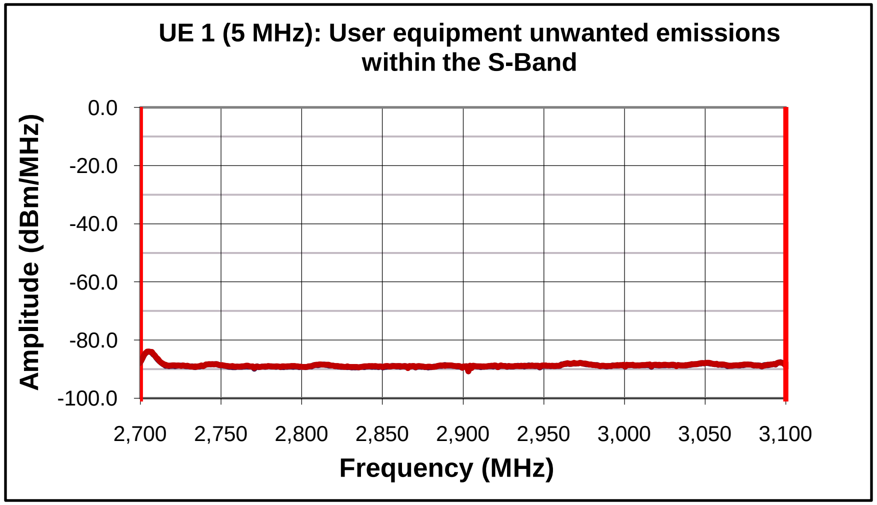
5. Indicative OOB Measurements

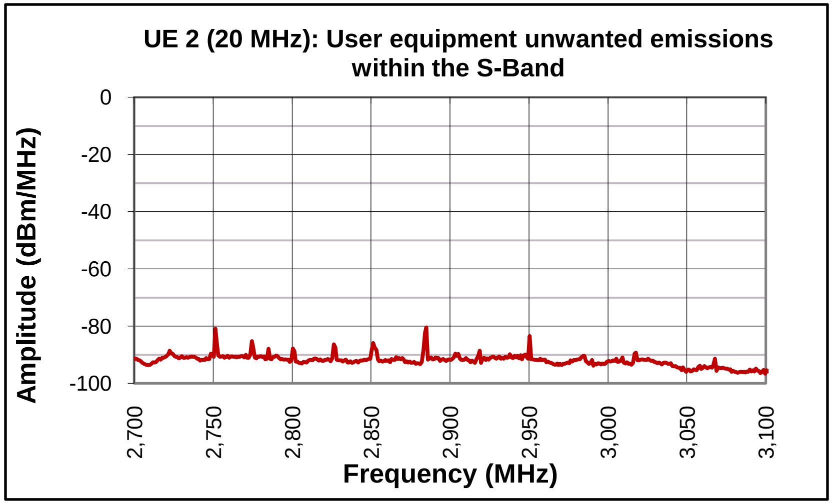
Measurements of two production user equipments

is the measured OOB emissions of the UE

represents the measurement noise (approximately same level for all graphs)







Summary

- In communications band signals radar compression effects
  - Pre-modification, the susceptibility of the radar to communication signals is high
  - Post-modification the expectation is that the radar modifications should allow the operation of a full suite of full power FDD and TDD base station transmissions at approximately 1+ km from the radar (dependent on number, location and precise deployment)
- Noise OOB indicative measurements
  - For base stations that are physically close to low frequency radars, action is required to ensure the radars are not interfered with
  - At higher radar frequency substantial action may not be necessary to ensure the radars are not interfered with
  - Measurements of user equipment indicate relatively low OOB emissions

Summary

Pre-modification

There would need to be careful adjustment and positioning of any base station to allow deployment within any significant distance of un-modified radars. This will limit the widespread deployment of 2.6 GHz base stations.

Post-modification

There should not be significant limitations to widespread deployment of 2.6 GHz base stations and in many areas this may be achieved without any base station adjustments at all.

Co-ordination procedures
Nick McFarlane (Ofcom)

Spectrum Clearance and Awards Programme

Co-ordination Procedures - Contents

- Overview
- What are the radar protection thresholds?
- Compliance with the protection thresholds
- Changes to radar

Overview

- Radar protection thresholds are expected to be defined for radar pre- and post-modification
- If cumulative 2.6 GHz base station signals are below these thresholds there should be no impact on radar performance
- Each Network Operator is expected to be allocated a proportion of the protection thresholds
- Network Operators must assess their whole network deployments against their proportion of the protection thresholds
- Very close to a radar, special procedures may be required
  - Because local propagation effects may be significant and other factors such as near-field effects must be considered
  - We are considering how to deal with this, for example, by adding additional margins or requiring consent of the radar operator within a certain range of the radar

What are the Radar Protection Thresholds?

The expected protection thresholds for ATC radar

In communications band signal		Out of communications band noise
Pre-modification	Post-modification	Pre & Post-modification
Power flux density threshold for signals in the 2.57-2.69 GHz band	Power flux density threshold for signals in the 2.57-2.69 GHz band	Noise spectral power flux density threshold at and above a defined radar frequency
-54 dBm/m^2	8 dBm/m^2	-136 dBm/MHz/m^2

These thresholds are defined during the ‘on’ period of the transmit signal

Thresholds for some MoD radars may differ. The MoD may require information about base station deployment to be made available to manage interference

What are the Radar Protection Thresholds?

Apportioning thresholds between Network Operators

- The total 120 MHz down link transmission channel bandwidth is expected to be apportioned into 5 MHz channels

- Each 5 MHz channel will be allocated a proportion of the total protection threshold, which is expected to be -13.8 dB per channel of the total protection threshold

$$10\log_{10}\left(\frac{5}{120}\right) = -13.8dB$$

- If an operator operates multiple 5 MHz channels then the aggregate power must not exceed the total threshold for all of its channels

Example

A Network Operator that operates 4 of the 5 MHz channels would not exceed an aggregate power of -7.8 dB of the protection thresholds

$$10\log_{10}\left(\frac{20}{120}\right) = -7.8dB$$

Compliance with the Protection Thresholds

Power density calculations

Network Operators would be expected to satisfy themselves that their proportion of the protection thresholds will not be exceeded

A computer model can be used for calculating compliance. It should include the effects of:

- Line of sight/diffraction
  - Diffraction
  - Multipath and focussing effects
  - Gaseous absorption
- Tropospheric scatter
  - Gaseous absorption
- Ducting/layer reflection
  - Gaseous absorption
- Terrain and clutter

A full implementation of ITU-R P.452 will include these effects. Example parameters are shown in the Annex.

A Network Operator would be required to continue to meet these thresholds at all times even after a change in base stations

It should be noted that out of communications band emissions can be influenced by nearby base stations (including those operated by a different Network Operator)

Compliance with the Protection Thresholds

Terrain and clutter

- A suitable terrain and clutter map will need to be used for modelling, and it may change over time
- Ofcom analysis shows that the results can be sensitive to the clutter map
- Local propagation effects could be significant and must be taken account in the power density calculations; for example, a higher resolution clutter map may be required

Radar antenna gain

- Network Operators must ensure that the protection thresholds are not exceeded in any radar direction
- A radar horizontal antenna gain pattern should be used when making this calculation

Changes to Radar

- Network Operators will need to be notified of changes, including the completion of modification work
- If there are changes to a radar, it will still need to be protected e.g.
  - If its frequency is changed, e.g. due to frequency re-planning by the CAA
  - If it is relocated

Conclusions

- We know that radars are vulnerable to interference from transmissions in the 2.6 GHz band and co-ordination procedures are needed to ensure they can continue to operate effectively
- Radar resilience to interference can be improved if radars are modified, and a Government programme is underway to support modification of these radars
- Before radars are modified, it will be difficult to deploy base stations in the 2.6 GHz band near radars
- After radars have been modified, widespread deployment should be feasible
- The timetable for roll out of modifications will be included in the Information Memorandum

Next Steps

The Presentation will be available on the Ofcom website
http://stakeholders.ofcom.org.uk/binaries/consultations/award-800mhz/annexes/RADAR_Event_Presentation.pdf

Any further questions relating to this presentation welcome via email
tricia.ward@ofcom.org.uk

Confirmation of TLCs & Co-ordination Procedures will be provided in the Information Memorandum

Annex

Annex. Example parameters for ITU-R P.452

Clear-air propagation attenuation components included:	Line of sight/Diffraction - Diffraction - Multipath and focussing effects - Gaseous absorption Tropospheric scatter - Gaseous absorption Ducting/Layer reflection - Gaseous absorption
Time percentage	0.100 %
Sea level surface refractivity N0	325
deltaN = [N(0m) - N(1000m)]	45
Dry air pressure (hPa)	1013
Temperature (°C)	15.0
Path center latitude (°)	51.0
The path centre latitude must be selected on a case by case basis	
Path loss should be calculated using 50m or better terrain and clutter databases	