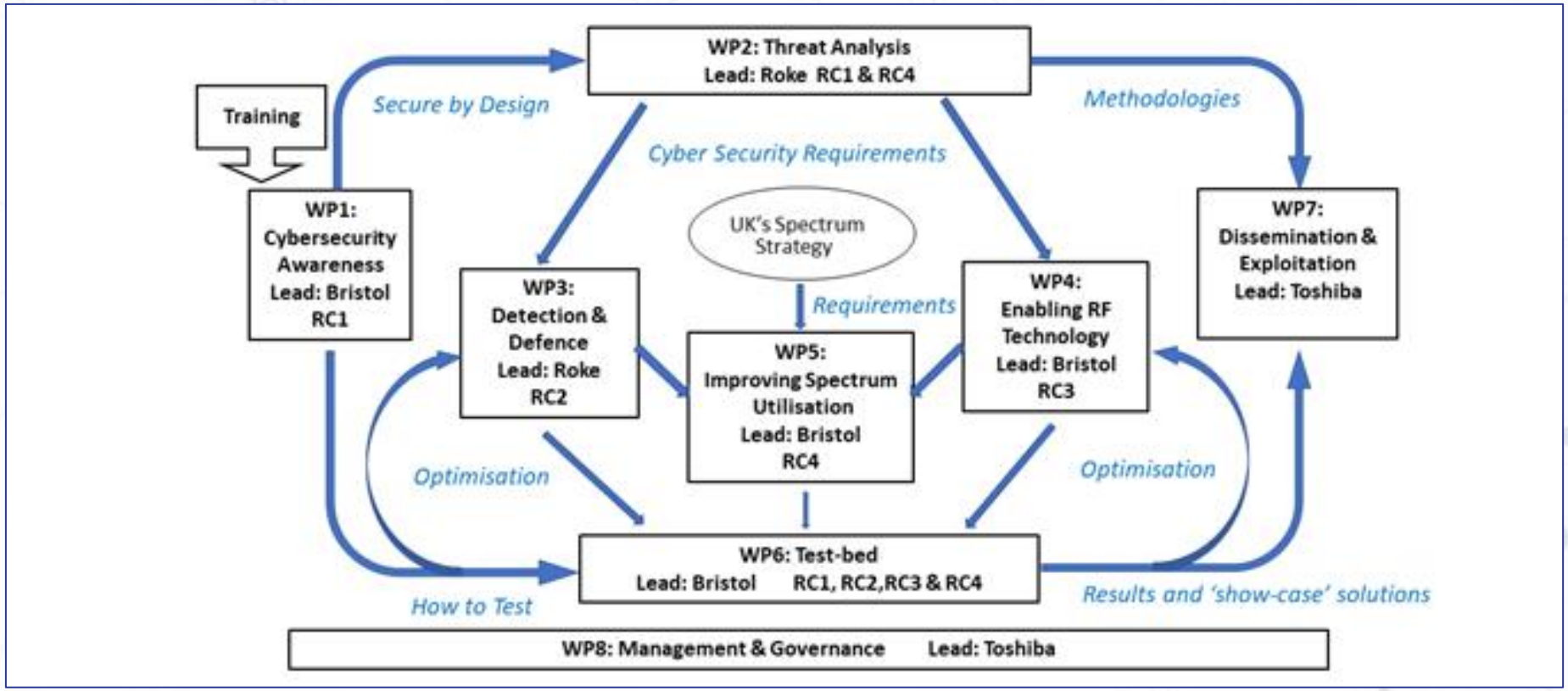
SECURE WIRELESS AGILE NETWORKS

Enhancing Spectrum Sharing with Fixed Links DCMS-SPF Workshop 26th May 2021

Simon Wilson
Prof Mark A Beach
Dr Simon Armour
University of Bristol

Engineering and Physical Sciences Research Council
TOSHIBA
University of BRISTOL
ROKE
GCHQ

SWAN Work Packages

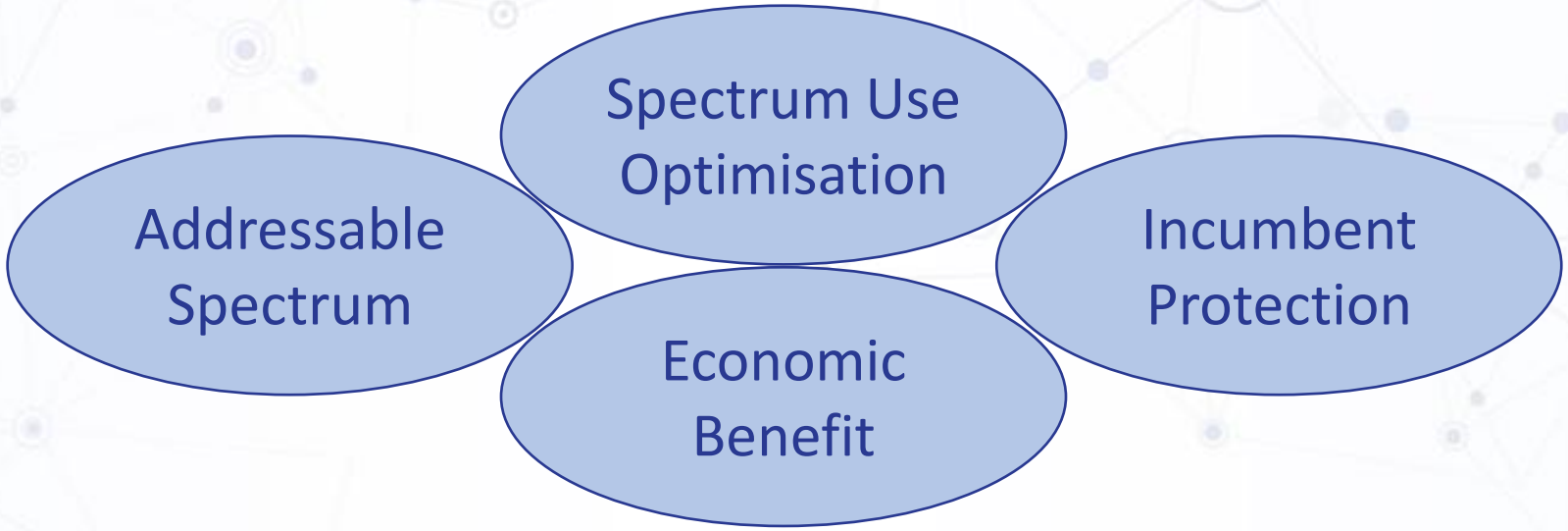


PhD studies are linked to WP5 – improving spectrum utilisation

Motivation

Encourage MNO use of opportunistic, dynamically accessed spectrum to improve the overall utilisation of spectrum

Hypothesis: DSA systems improve the technical efficiency of spectrum usage, leading to economic benefit



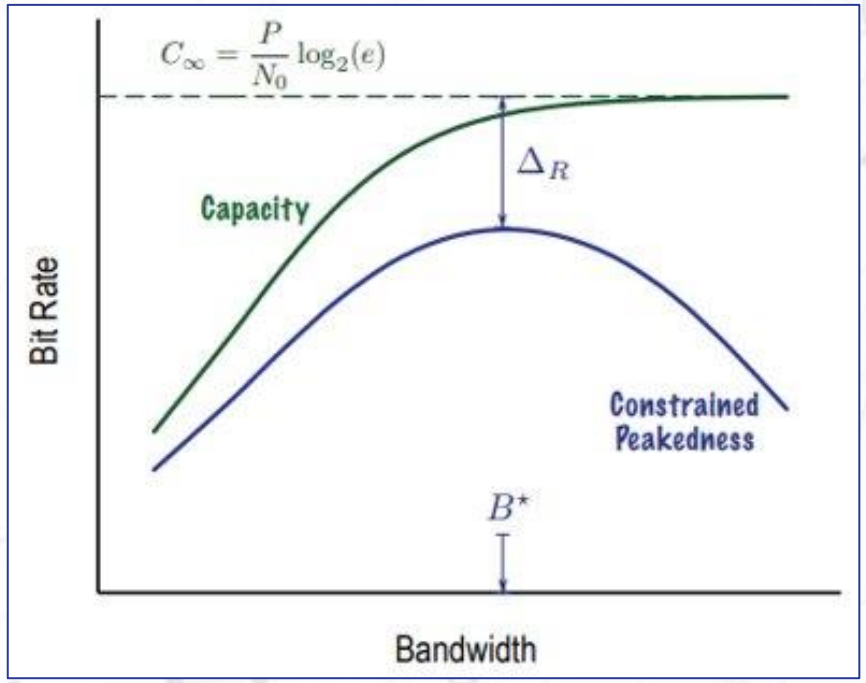
Bandwidth

Lozano and Porrat showed that the asymptotic decay of bit rate usually takes hold where

$$B > 0.2 f_C$$

They characterised the highest bit rate achievable by non-peaky signals and the approximate bandwidth B^* where that apex occurs:

$$B^* \cong 0.2 f_C$$

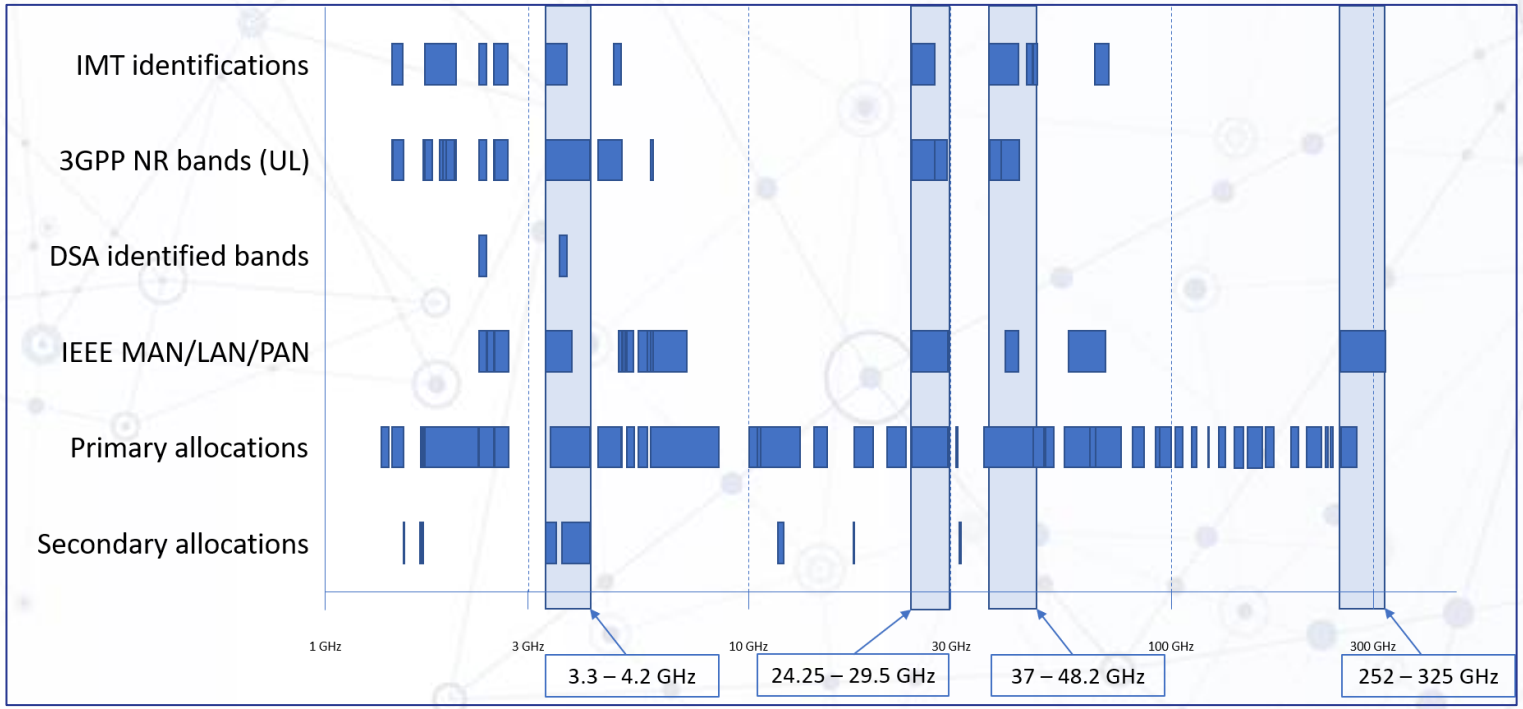


Bit rate as a function of bandwidth
(Lozano and Porrat 2012)

➢ **Look for candidate operating bands with $B \cong 0.2 f_C$**

Operating Bands

- 3.3 – 4.2 GHz
  $\frac{B}{f_C} = 24\%$
- 24.25 – 29.5 GHz
  $\frac{B}{f_C} = 20\%$
- 37 – 48.2 GHz
  $\frac{B}{f_C} = 26\%$
- 252 – 325 GHz
  $\frac{B}{f_C} = 25\%$



Frequency Bands > 1 GHz by IMT identification, standardisation and allocation (Wilson 2020)

➢ **Start by looking at lowest frequency band: 3.3 – 4.2 GHz**

Maximum Bandwidth

- 3.3 – 4.2 GHz
  $\frac{B}{f_C} = 24\%$
  300 MHz (3GPP)
  8%
- 24.25 – 29.5 GHz
  $\frac{B}{f_C} = 20\%$
  2 GHz (3GPP)
  7%
- 37 – 48.2 GHz
  $\frac{B}{f_C} = 26\%$
  2.95 GHz (3GPP)
  7%
- 252 – 325 GHz
  $\frac{B}{f_C} = 25\%$
  69.12 GHz (IEEE)
  24%

➢ **Need to continue increasing maximum bandwidth in 3GPP**

Protecting Primary Users – Case 1: UK

3.3 – 3.8 GHz

Ministry of Defence

3.3 – 3.41 GHz
Radiolocation

Protection ratios defined in ITU-R M.2111 (I/N = -6 dB)

3.41 – 3.8 GHz
Mobile

Protection ratios defined in ITU-R M.2101 (I/N = -6 dB)

3.41 – 4.2 GHz

MNOs & BWO

3.41 – 4.2 GHz
Mobile

Protection ratios defined in ITU-R M.2101 (I/N = -6 dB)

(This study is also applicable to broadband wireless systems)

3.8 – 4.2 GHz

Various

3.8 – 4.2 GHz
Earth Stations

Protection ratios defined in ITU-R M.2109 and S.2368 (I/N = -10 dB to I/N = -20 dB long term, I/N = -1.3 dB short term)

3.8 – 4.2 GHz
Fixed Links

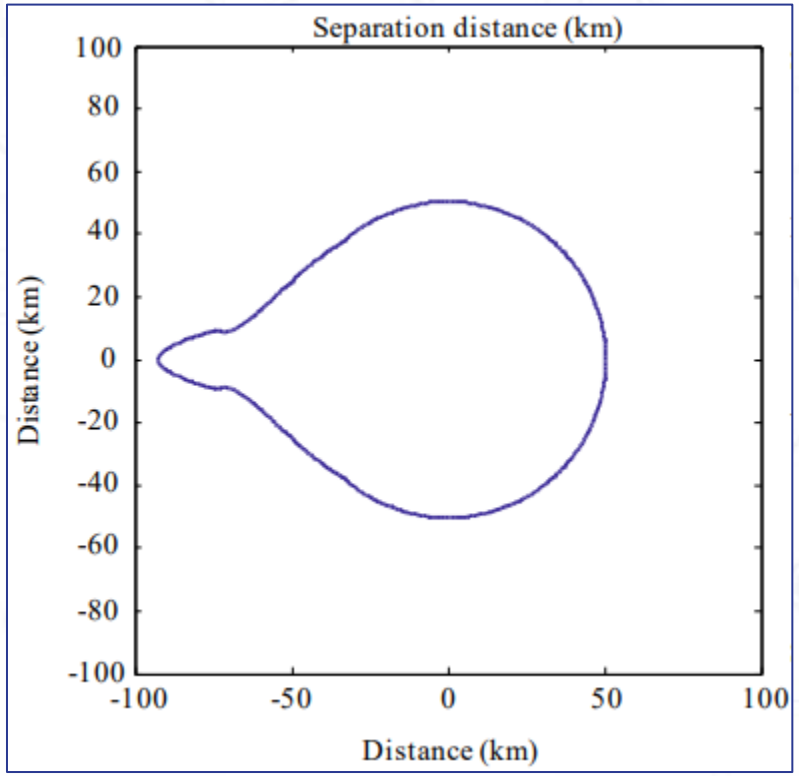
Protection ratios defined in ITU-R F.2328 (I/N = -10 dB)

➢ **Example chosen: 3.8 – 4.2 GHz, Fixed Links**

Separation

Fixed Links

Protection ratios defined in ITU-R F.2328 (*I*/*N* = -10 dB)

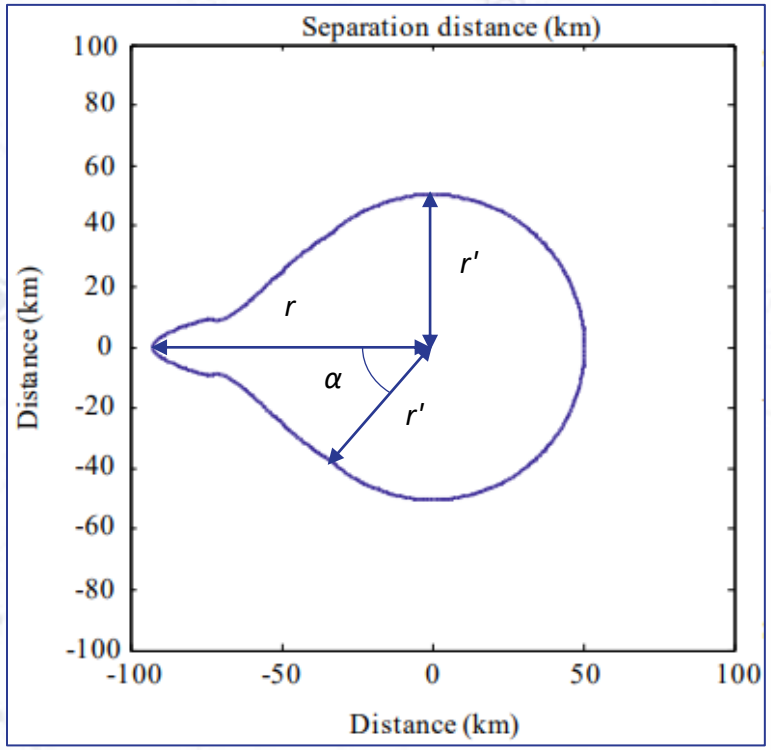


Separation distance – IMT Macro BS Tx to FS Rx (ITU 2014)

- For IMT macro sites in a suburban environment, the separation distance needed to avoid co-channel interference is 50.4 – 92.0 km
- This distance reduces by ~50% when small cells are deployed

➢ **Mitigate by reducing IMT base station power**
(for example, per Ofcom local access and medium power licences)

Power Reduction



Using Ofcom microcell characteristics (low power, local access licences) SEAMCAT simulations give values for r, r' and α_{min}

- r = 60 km (for I/N = -10 dB)
- r' = 12 km
- α_{min} = 49° (for r' = 12 km)

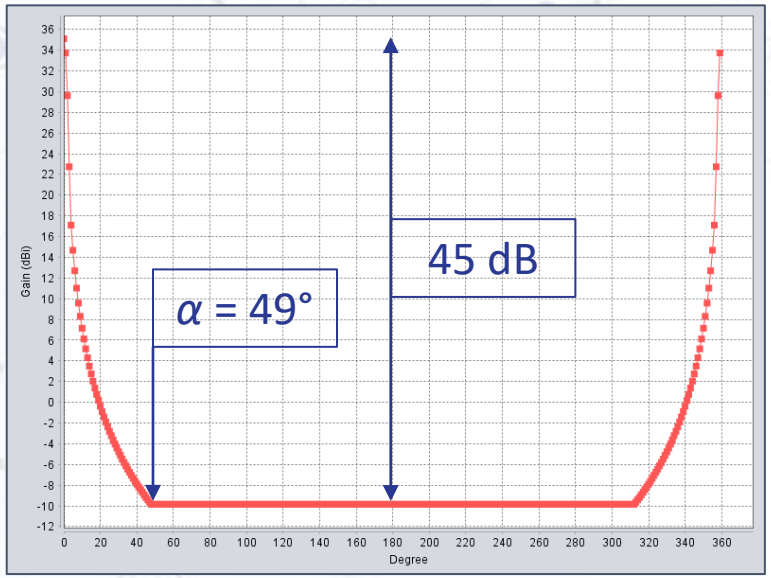
Separation distance – IMT Macro BS Tx to FS Rx (ITU 2014)

➢ **The ITU Report result for small cells** (r = 45 km, r' = 13.4 km) **appears to be a little conservative off-boresight**

Antenna Radiation Pattern

Ofcom's Wireless Telegraphy Register includes details of antennas used.

In the Fixed Links band, they are mainly Andrews HSX6-36.



Gain plot of ITU-R F.1245-2
(ECO, 2021)

Front-to-back ratio comparison:

- ITU-R F.1245-2 45 dB
- Andrews HSX6-36 65 dB

Real antennas reduce off boresight separation distances further.

➢ **Use extant antenna characteristics in DSA simulation algorithms**

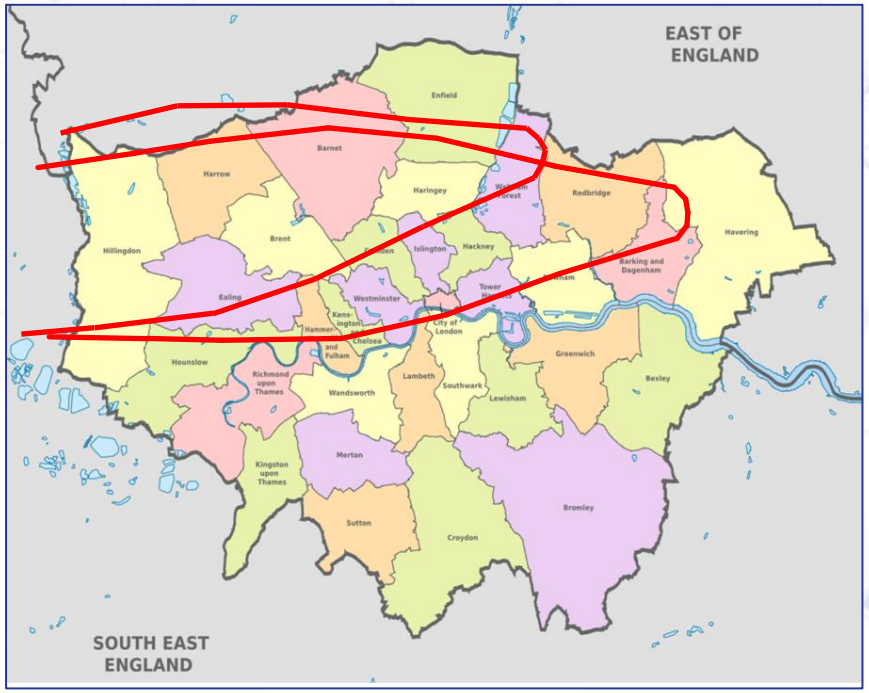
Addressable Spectrum example– Greater London

Fixed Link co-channel exclusion zones (EZs) simulated and mapped, population affected estimated:

Population of Greater London impacted by EZs at 3.83 GHz

(Licence numbers 0979891/1 and 0980509/1)

Co-channel only



-10dB I/N contours

Fixed link EZs at 3.83 GHz in Greater London (Wilson 2021)

100% population of:

- 8 Boroughs
- City of London

➢ ~2.2m people

Partial population of:

- 15 Boroughs

➢ ~2.3m people

No population in:

- 9 Boroughs

Total: ~4.5m people

Addressable Spectrum example– Greater London

Fixed Link non-co-channel exclusion zones (EZs) simulated and mapped, population affected estimated:

Population of Greater London impacted by EZs at 4.18 GHz

(Licence numbers 0979703/1 and 0979708/2)

Co-channel and non-co-channel

-10dB I/N non-co-channel contours

Fixed link EZs at 4.18 GHz in Greater London (Wilson 2021)

100% population of:

- 0 Boroughs

Partial population of:

- 6 Boroughs

➢ Up to ~0.4m people

No population in:

- 26 Boroughs
- City of London

Total: ~0.4m people

adjacent channel

~0.1m people

least adjacent channel

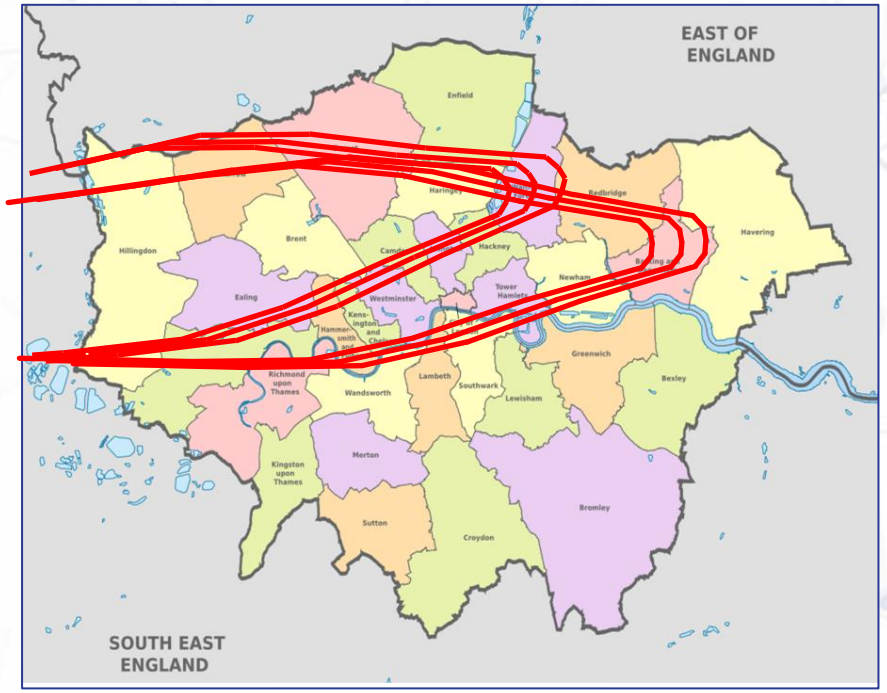
Addressable Spectrum example– Greater London

Fixed Link exclusion zones (EZs) mitigation simulated and mapped, population affected estimated:

Population of Greater London impacted by EZs at 3.83 GHz

(Licence numbers 0979891/1 and 0980509/1)

Co-channel only, IMT Tx power reduced by 3/6 dB



-10dB I/N contours

Fixed link EZs at 3.83 GHz in Greater London (Wilson 2021)

No mitigation

Total: ~4.5m people

3 dB mitigation

Total: ~4.1m people

6 dB mitigation

Total: ~3.7m people

Addressable Spectrum example– Greater London

Availability of spectrum outside Fixed Link exclusion zones (EZs) estimates:

- Maximum potential

  400 MHz x 8.96 million pop — 3.58×10^9 [MHz.pop]

- Unavailable at *I/N* = -10 dB

  1. [MHz.pop] affected by co-channel interferers — 3.18×10^8 [MHz.pop]
  2. [MHz.pop] affected by non co-channel interferers — 7.78×10^7 [MHz.pop]

- **% availability without (further) mitigation — 89%**
- **% availability with additional 3 dB IMT BS power mitigation — 91%**
- **% availability with additional 6 dB IMT BS power mitigation — 92%**

Summary and Recommendations to date

To be most attractive to MNOs, DSA bands should be adjacent to licensed IMT bands and standardised. In the UK we should aim to make available the whole 3.8 – 4.2 GHz and other bands for DSA.

This also requires:

- Increasing the maximum allowable bandwidth from 100 MHz
- Standardisation of CA up to 800 MHz in Band n77
- Wideband, flexible RF capability in hardware

Current power limits (24 dBm / 20 MHz) should be appealing enough to MNOs and further restrictions may not be beneficial

- Further work will follow on the benefits of relaxing power limits

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I'd be very happy to answer any questions you may have, either now or we can chat another day!

Simon

simon.wilson@bristol.ac.uk