Future Utilisation of the 470-694 MHz band

Scenarios for a post 2030 timeframe

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1st December 2022

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Content

Future Utilisation of the 470-694 MHz Band

WRC-23 Agenda item 1.5 will consider the use of 470-694 MHz band

- UK should consider the future needs for the band from existing users especially mobile, DTT and PMSE in the interleaved spectrum
- One of the main uses of the band, broadcasting, is facing significant market and technological change
- Another potential use is for mobile for which it is potentially attractive
- We will need to understand if this is possible and how PMSE can be accommodated

We conducted an extensive literature search and held interviews with 17 stakeholders*

Stakeholders interviewed:

Ofcom
FCC (USA)
BT/EE
Three
Virgin Media O2
Nokia
Copsey Communications Consultants
Sennheiser
Shure
BEIRG
BBC
Digital 3&4
DTG
DMSL
Rohde & Schwarz
Qualcomm

* Including one anonymous stakeholder organisation

Many risks of social harm have been highlighted by stake-holders but not all are equally severe – balance is needed

	Economic and social harm	Economic, cultural and social harm	Mainly social harm
Higher social harm	Perpetuating the Digital Divide	Hampering creative industries, performing arts and special events	Depriving vulnerable social groups of TV
	More limited access to mobile broadband where alternatives exist	*Affordability issues when mobile used as a substitute for fixed Broadband access*	Fewer TV channels accessible by vulnerable social groups
	SD rather than HD mobile video and gaming (at certain times)		Some channels SD only, others HD only
Lower social harm	MNOs having to explain temporary bandwidth limitations to customers	Replacement of PMSE equipment (with government support) *e.g. in PMSE UHF sharing scenarios*	Lower competitiveness of DTT versus alternative platforms

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DTT usage and penetration still high but declining

Usage

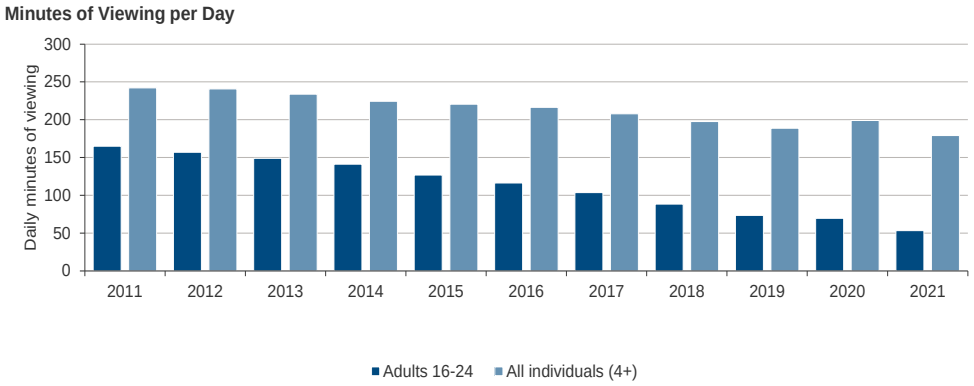
- DTT usage is 179 minutes per day for all individuals but it has declined 26% from 2011 to 2021
- Decline was however 68% for 16 to 24 year olds
- Usage has shifted to other platforms such as IPTV

Penetration

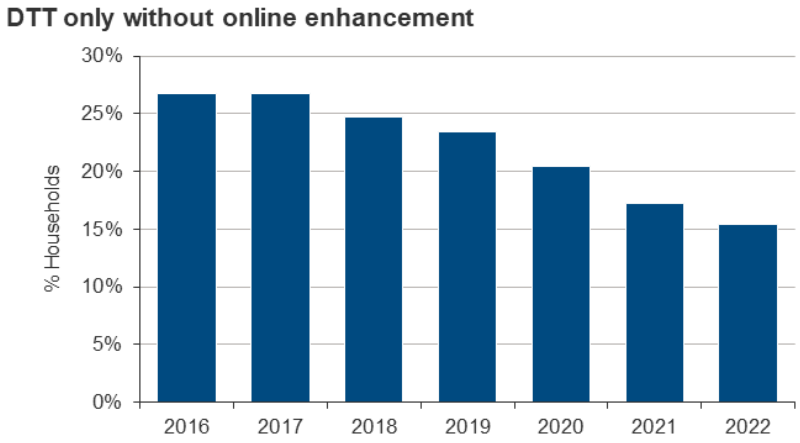
- 62% of households receive DTT (2020)
  - Includes DTT for additional TV sets
- 15% of households receive TV from DTT alone (2022)
  - This declined from 27% of households in 2016

Outlook

- If these trends continue we could see a dramatic shift in customer usage moving to other platforms
- Downward trend may slow however due to constraints:
  - Superfast >30 Mbps broadband: 96% of households covered but take-up only 69%
  - Social factors: harder to migrate groups with lower incomes and/or limited digital skills
- Policy makers will need to safeguard the interests of citizens and consumers in this changing landscape



Source: Ofcom Media Nations 2022. BARB Data

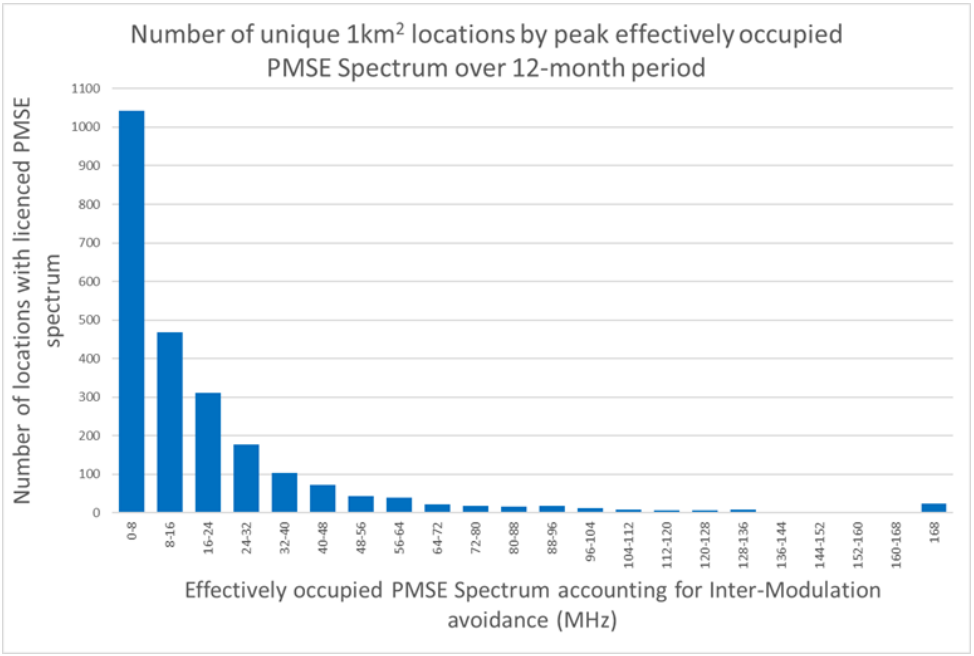


Source: Ofcom Media Nations 2022. Q1 data 2022

PMSE has a high and growing bandwidth demand but is highly localised in time and space and is largely predictable

Strong pareto effects

- Analysis of over 120k PMSE licences over a 12 month period reveals the following:
  - 2400 unique locations in the UK where licenced PMSE was used. c1% of landmass
  - Less than 2.5% of locations occupied greater than 104MHz
  - 63% of PMSE locations used less than 16MHz
- Special events (Eurovision, etc): very high bandwidth needs but short durations in very specific areas
- Very limited overlap between IMT and PMSE needs in rural areas
- Significant overlap between IMT and PMSE needs in some urban areas (e.g. West End), but limited overlap in time elsewhere
- High-demand PMSE usage is usually very predictable geographically and temporally



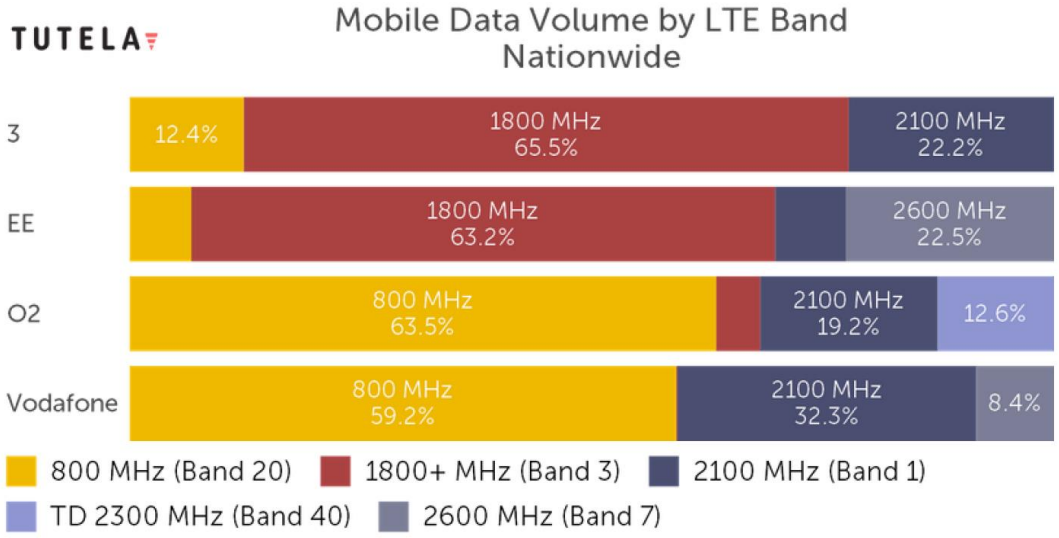
Source: Coleago and Ofcom

A priori, there would appear to be scope to satisfy the needs of PMSE while also allowing IMT needs in the majority of locations and times to be addressed with extra UHF spectrum

Expected growth in mobile usage will increase demand for sub 1 GHz spectrum to address rural & indoor capacity needs

Sub 1GHz bands carry a disproportionate amount of traffic

- Especially VOD and VMO2 (original 900MHz grid, vs original mid-band grid for EE and 3UK)
- Average: 800MHz carried 2.2x the average LTE traffic per MHz deployed for LTE in 2020
  - Due mainly to urban indoor use (since urban use accounts for overriding majority of traffic)
  - MNO feedback ranges from “over 10% of urban traffic unreachable with mid-bands” to “~30% of traffic on low bands”
  - “Significant low-band congestion today”
  - “Will need 3x as much sub-1GHz spectrum in future just to stay still”
- By 2027, MBB traffic might exceed 3.6x 2021 levels[1]; by 2030 based on industry forecasts
- By 2030, MBB traffic might to be over 5.1x 2021 levels[2]. If the traffic distribution remains as is, this would put huge pressure on low-bands



Source: Tutela based on data from March-August 2020

- Without extra low-band, MBB quality will suffer and the (rural) Digital Divide will likely persist
- Hence the industry will eventually “run out of road” – even with extra UHF

Industry expectations: MBB traffic > 100GB per capita in 15-20 years i.e. 15x current level

[1] Based on Ericsson forecast for Western Europe (24% CAGR 2021-2027); 2020-2021. Growth implied by Ofcom for the UK was 36% in 2021; one UK MNO reported a 40% pa current rate.
[2] Assuming growth slows to a CAGR of 12% between 2027-2030

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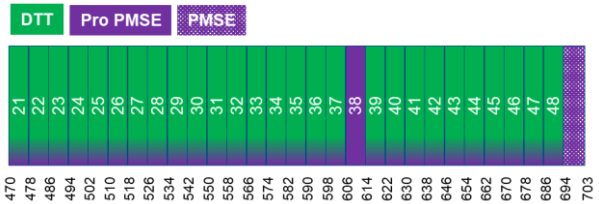
Four main scenarios post 2030 were analysed

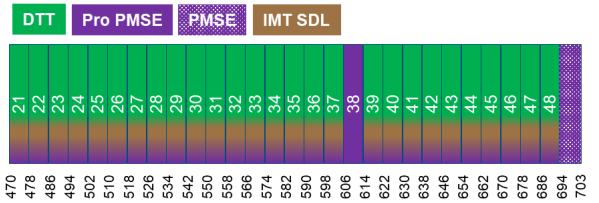
Co-ordination Framework
Adhere to existing Bilateral agreements

Status Quo
No Change
Broadcast as Primary
Mobile as Secondary



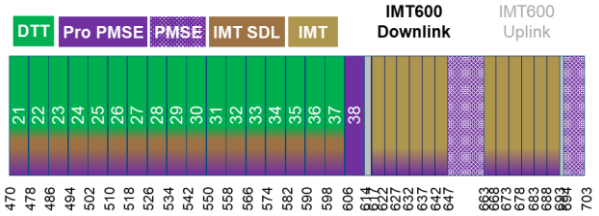
Adhere to existing Bilateral agreements

Flexible Use
Co-operative use
Broadcast & Mobile
Co-Primary



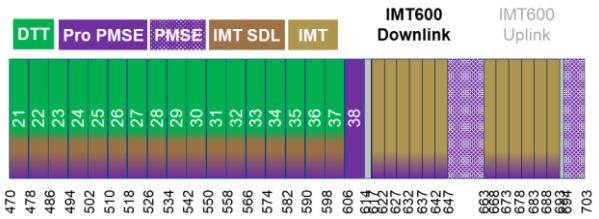
Re-negotiate bi-lateral agreements

IMT600 Band Plan
Divided Spectrum
Broadcast Primary in 470-606
Mobile Secondary 470-606
Mobile Primary in 606-694



Re-negotiate bi-lateral agreements

Transition to IPTV
Divided & Co-Primary
Co-Primary in 470-606
Mobile Primary in 606-694



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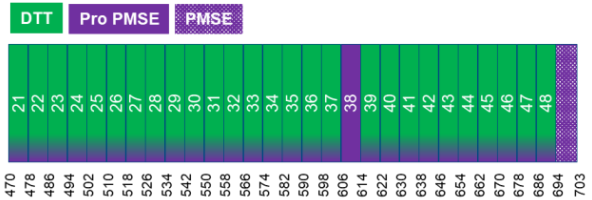
Scenario 1 post 2030: Status Quo
No change in allocation

Co-ordination Framework
Adhere to existing Bilateral agreements



No Change
Broadcast as Primary
Mobile as Secondary

IMT demand grows
IMT needs more supply esp. in Rural areas

IMT 700/800/900 re-pack exploration

IMT below 700MHz has no IMT SDL take-up and IMT600 FDD deemed too risky due to international co-channel interference concerns

DTV demand
DTT evolution cases

Case 1: Demand grows → 6xDTT Muxes

Case 2: *Demand drops* → *4xDTT Muxes*

Investments made into MPEG4 & HDTV

PMSE demand grows
PMSE continues using interleaved DTT

Case 1: PMSE has same spectrum

Case 2: PMSE has more spectrum

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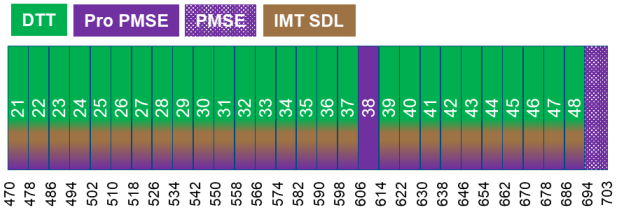
Scenario 2 post 2030: Flexible Use Co-Primary Broadcast/Mobile (IMT SDL)



Co-ordination Framework
Adhere to existing Bilateral agreements

Co-operative use
Broadcast & Mobile Co-Primary

IMT demand grows
IMT needs more supply esp. in Rural areas

DTV demand
DTT evolution cases

PMSE demand grows
PMSE continues using interleaved spectrum

Chipset eco-system for IMT SDL evolves (e.g. due to some 5G Broadcast traction globally)

Case 1: IMT has 8-16MHz for SDL
Case 2a: IMT has 16-32MHz for SDL
Case 2b: IMT has 24-48MHz for SDL

Case 1: Supply declines. → 5xDTT Muxes
Case 2a: *Supply drops + MPEG4* → *4xDTT Muxes*
Case 2b: *Supply drops + MPEG4 DVB-T2* → *3xDTT Muxes*

Case 1: Approx same spectrum nationally
Case 2a: Approx same spectrum nationally
Case 2b: Approx same spectrum nationally

MNO's agree to not use IMT SDL in some Urban centres & during events

Investment *More investment*

Ofcom framework for geo/time sharing between IMT/PMSE

PMSE also has access to IMT spectrum in some Urban centres & events

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Scenario 3 post 2030: IMT600 Band Plan
IMT600 Band Plan (Broadcast & Mobile Split)

Co-ordination Framework

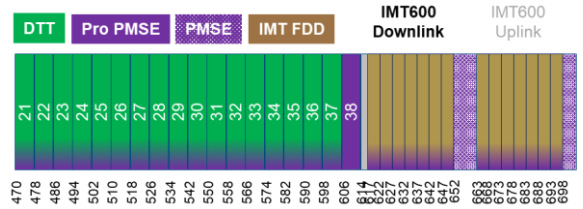
Re-negotiate bi-lateral agreements

Divided Spectrum

Broadcast Primary in 470-606

Mobile Secondary 470-606

Mobile Primary in 606-694



IMT demand grows

IMT needs more supply esp. in Rural areas

DTV demand

Spectrum dividend through DTT upgrade

PMSE demand grows

PMSE using interleaved DTT (Max ~168MHz)

IMT adopts US (or APT) 600MHz FDD plan

4-5xDTT Muxes

HDTV MPEG4/HEVC DVB-T2 Some SFNs

~104MHz nationally + extra 80MHz for Peak PMSE demand

Investments in DTT

IMT/PMSE Geo & Time Sharing

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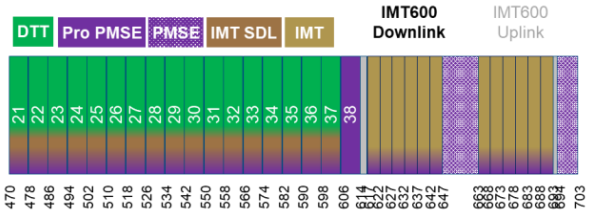
Scenario 4 post 2030: Transition to IPTV
Transition to IPTV (Broadcast/Mobile & Mobile Split)

Co-ordination Framework
Re-negotiate bi-lateral agreements

Divided & Co-Primary
Co-Primary in 470-606
Mobile Primary in 606-694



IMT demand grows
IMT needs more supply esp. in Rural areas

DTV demand
Spectrum gradually re-farmed from DTT to IMT

PMSE demand grows
PMSE using interleaved DTT (~168MHz)

IMT adopts US (or APT) 600MHz FDD plan

4-5xDTT Muxes

HDTV MPEG4/HEVC DVB-T2 Some SFNs

~104MHz nationally + extra 80MHz for Peak PMSE demand

IMT/PMSE Geo & Time Sharing

Chipset eco-system for IMT SDL evolves (due to B5G traction elsewhere or other reason)

Investments in DTT

Spectrum released for IMT SDL by region

DTT moves to 1-2x DTT Muxes from 2040, region by region

40MHz Min nationally Up to 136MHz elsewhere

IMT/PMSE Geo & Time Sharing

Investment in IPTV

Prospective areas for further research

Topic	Aspect
Assessment of potential DTT spectral efficiency improvements	Technical and economic
Assessment of impact of potential PMSE exclusion zones for IMT 600	Technical and economic
Assessment of the potential use of other bands for PMSE	Technical and economic
Cost/benefit analysis for potential end-user PMSE equipment upgrade/swap	Technical and economic
Assessment of potential use of 5G Broadcast (5GB) technology	Technical and economic
Analysis of the potential business models for 5G PMSE and 5G Broadcast	Economic
Assessment of MNO Low-Band spectrum defragmentation options capturing Trading, Carrier Aggregation Combos, PIM Interference risks and 4T4R Low-Band Radio architectures (for 4x4 MIMO)	Technical
Analysis of co-channel interference risk to IMT600 Uplink from DTT stations located in France, Ireland, Netherlands, and Belgium. Conduct measurements and monitoring of non-UK DTT transmissions and analyse results for interference risks into IMT600 FDD Uplink	Technical
Analysis of IMT600 FDD uplink interference mitigation methods.	Technical
Study of 2x40 MHz APT vs 2x35 MHz Band 71 IMT600 band plan for UK. Device support projections, IMT600 Downlink to DTT Receiver interference risk assessment.	Technical

Prospective areas for further research (continued)

Topic	Aspect
Study of 2x40 MHz APT vs 2x35 MHz Band 71 IMT600 band plan for UK. Device support projections, IMT600 Downlink to DTT Receiver interference risk assessment.	Technical
Cost and impact analysis to PMSE community with a UK IMT600 band plan adopted, assuming different levels of IMT/PMSE geographic coordination.	Technical and economic
Transition to IPTV study - examination of digital skills gaps and solutions, broadband infrastructure projections by region.	Economic
Analysis of the resilience of scenarios to a wide range of international regulatory decisions and assessment of the opportunity costs related to such decisions	Technical and economic

International regulatory implications

Scenario	Regulatory Outcome		Impact on competing services		
	No Change	Co-Primary	DTT	Mobile	PMSE
1: Status Quo	✓	If no IMT SDL ecosystem ✓ Otherwise ✗	(U)HD content opportunity	Rural capacity constraints Defragment	Opportunity for more spectrum
2: Flexible Use	✗	Embodiment of co-primary ✓	3-5 MUXes; existing payload	IMT SDL dividend – if DTT upgraded	More spectrum (Coordination with IMT)
3: IMT600 Band Plan	✗	Only if IMT600 decision made at WRC30/31 ✓	4-5 MUXes but more HD channels?	More spectrum (Coordination with PMSE)	More spectrum (Coordination with IMT)
4: Transition to IPTV	✗	Only if IMT600 decision made at WRC30/31 ✓	4-5 MUXes in 2030s & possibly 1-2 in 2040s	More spectrum in 2030s (FDD) & 2040s (SDL) (Coordination with PMSE)	Significantly more spectrum (Coordination with IMT)

Thank you

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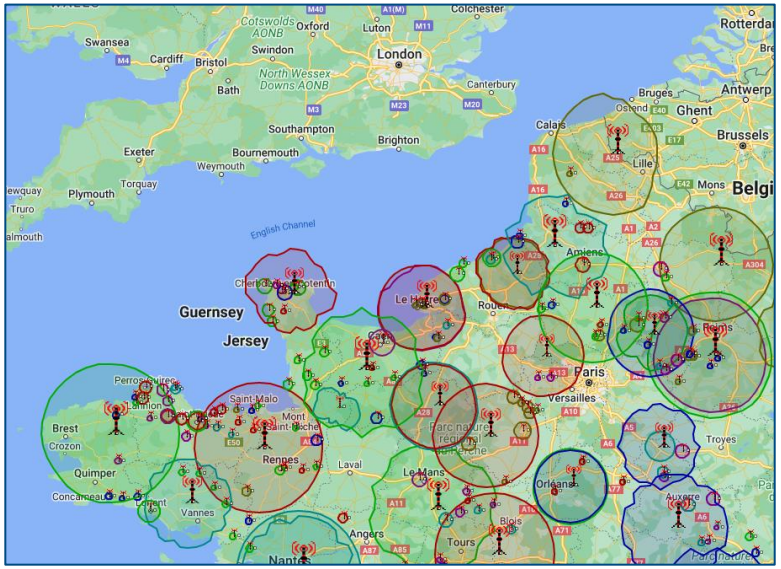
Appendix

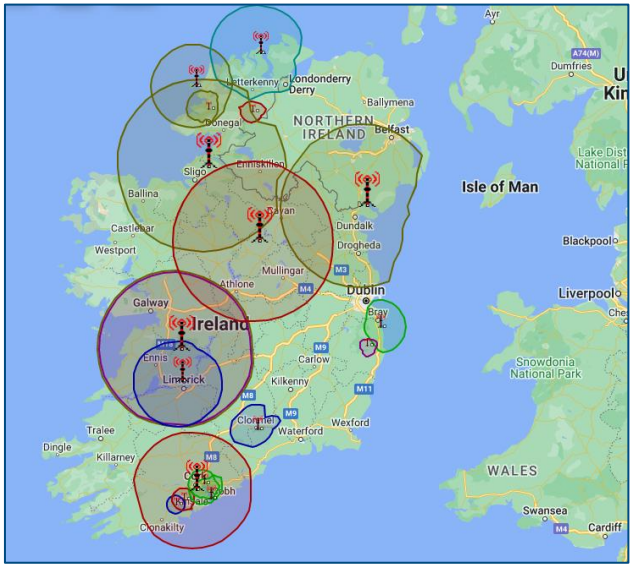
Additional Slides

ITU Region 1 is Broadcast only
UK Frequency Allocation Table has Mobile as Secondary

United Kingdom	UK footnote	Region 1	Region 2	Region 3
459 – 460 MHz FIXED MOBILE 5.286AA 5.209 5.286A 5.287	UK 1.1, UK 3.1 UK 1.1, UK 3.1	459 – 460 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	459 – 460 MHz FIXED MOBILE 5.286AA MOBILE-SATELLITE (Earth-to-space) 5.209 5.286A 5.286B 5.286C	459 – 460 MHz FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E
460 – 470 MHz FIXED MOBILE 5.286AA 5.287 5.289	UK 1.1, UK 3.1 UK 1.1, UK 3.1	460 – 470 MHz FIXED MOBILE 5.286AA Meteorological-satellite (space-to-Earth) 5.287 5.288 5.289 5.290		
470 – 694 MHz BROADCASTING Land Mobile 5.149 5.296 5.306 5.311A	UK 1.1 UK 1.1	470 – 694 MHz BROADCASTING 5.149 5.291A 5.294 5.296 5.300 5.304 5.306 5.311A 5.312	470 – 512 MHz BROADCASTING Fixed Mobile 5.292 5.293 5.295 512 – 608 MHz BROADCASTING 5.295 5.297	470 – 585 MHz FIXED MOBILE 5.296A BROADCASTING 5.291 5.298

Scenario 3 post 2030
DTT Interference into IMT600 – coordination

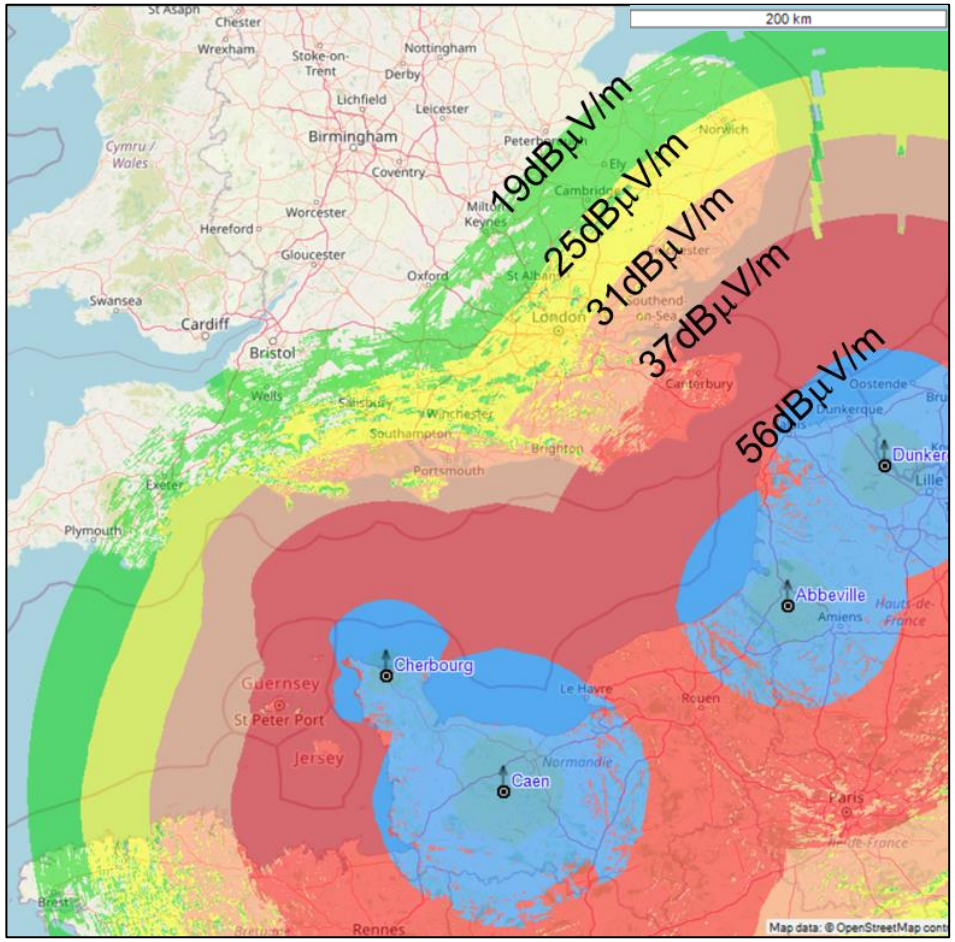




- Inspection of public domain DTT databases reveals:
  - Belgium uses only 6 UHF channels. May become 4 UHF channels by 2030.
  - Netherlands uses Medium Power Medium Tower infrastructure
  - Ireland uses only two Multiplexes nationally

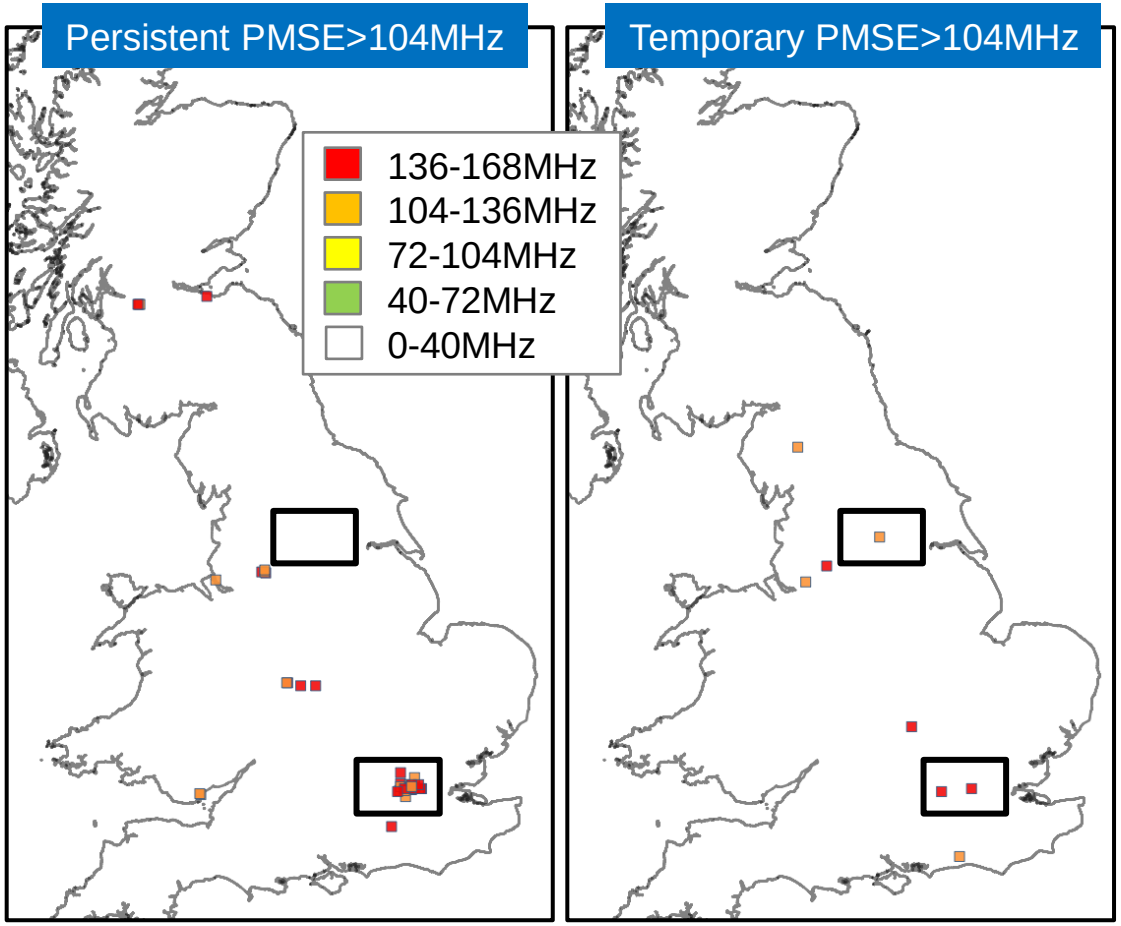
- There may be some scope for re-negotiation of bilateral agreements for early 2030's
- Could other countries also be interested in IMT600?

Scenario 3 post 2030
DTT Interference into IMT600 - mitigation



- French HPHT DTT to a UK IMT600 Uplink would be worst case interference
- Argued by many as the reason against co-primary when IMT is FDD
- 37dBuV/m represents 1% Time interference for V-Polz IMT Uplink at 30m height & 0dB I/N
- Further mitigation afforded by:
  - BS Heights at 15m (typical for UK)
  - BS Antenna Tilting and Azimuth
  - OEM 4R IRC at Base Station
  - Proprietary 4R IRC at Base Station (Examples in US demonstrated >20dB)
- IMT600 band n71 could be used in n28+n71 CA and have n71 Uplink CA disabled too. Possible co-ordination tool for Europe?

Scenario 3 in early 2030's PMSE demand needing >104MHz



- 216MHz UHF Spectrum today
- IMT600 would need 80MHz
- Means that 136MHz remains for DTT
- 4xDTT Channels = ~32MHz
- 104MHz spectrum for PMSE remains

- Analysis of Ofcom PMSE licence data
- PMSE licences over 1 year in 470-703MHz
- PMSE Intermodulation considered too

- 40 unique locations with persistent demand seen in licences
- 8 unique location with temporary demand seen in licences

- The data implicitly includes the effects of DTT overlap regions too, as the locations for the 6x (today) and 4x (IMT600) Mux cases will be the same

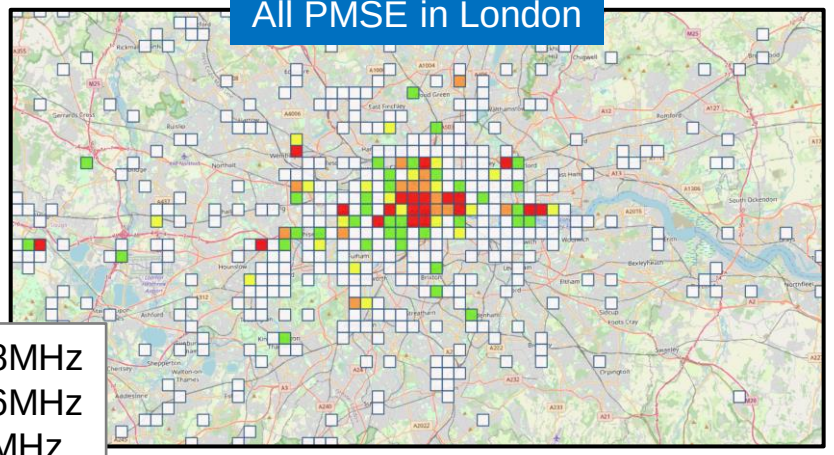
Scenario 3 post 2030
PMSE demand needing >104MHz

- Strong correlation with West End
- Clearly see festivals, special events, etc.

- West Yorkshire (>2M Pop) had one location needing >104MHz for 2 days
- This implies that West Yorkshire could benefit from IMT600

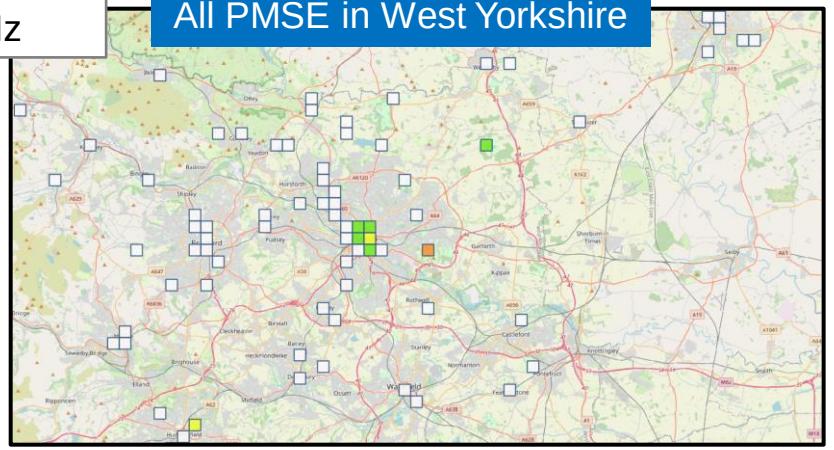
- Similarly, if IMT600 is not deployed in West/Central London then these areas (West End) can benefit from
- Another 16MHz of Pro PMSE spectrum plus another 5MHz of unlicensed spectrum

All PMSE in London



136-168MHz
104-136MHz
72-104MHz
40-72MHz
0-40MHz

All PMSE in West Yorkshire



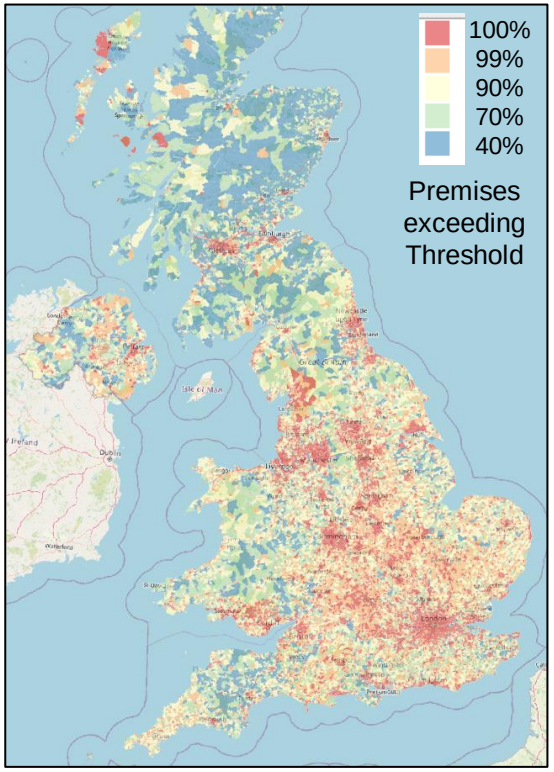
Scenario 4 post 2030
DTT Maximises Payload until IPTV is ready

Access to Superfast services (>30Mbps)	Sept 2021	Jan 2022	May 2022
UK	96%	96%	96%
England	96%	97%	97%
Northern Ireland	91%	92%	93%
Scotland	94%	94%	94%
Wales	94%	95%	95%

Access to services (>10Mbps)	Sept 2021	Jan 2022	May 2022
UK	98%	99%	99%
England	99%	99%	99%
Northern Ireland	95%	96%	96%
Scotland	97%	97%	97%
Wales	97%	98%	98%

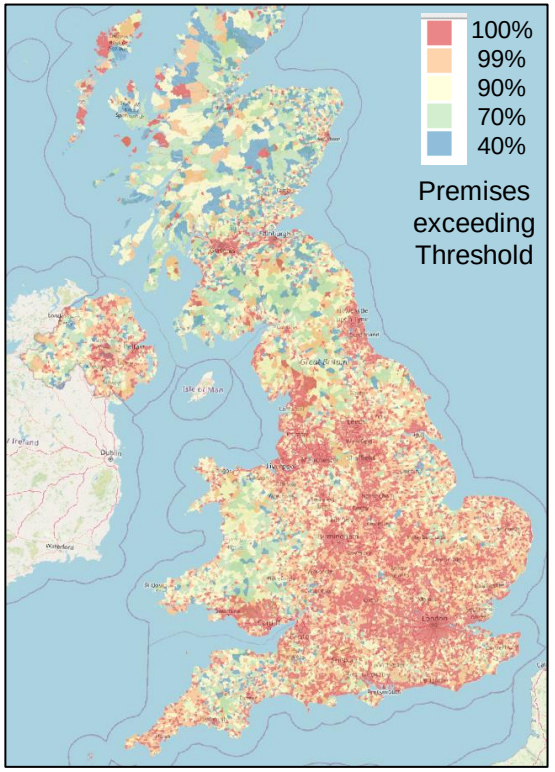
Source: Ofcom Connected Nations 2022

>30Mbps



>96% Pop

>10Mbps



>99% Pop

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