Broadcasting and Broadband

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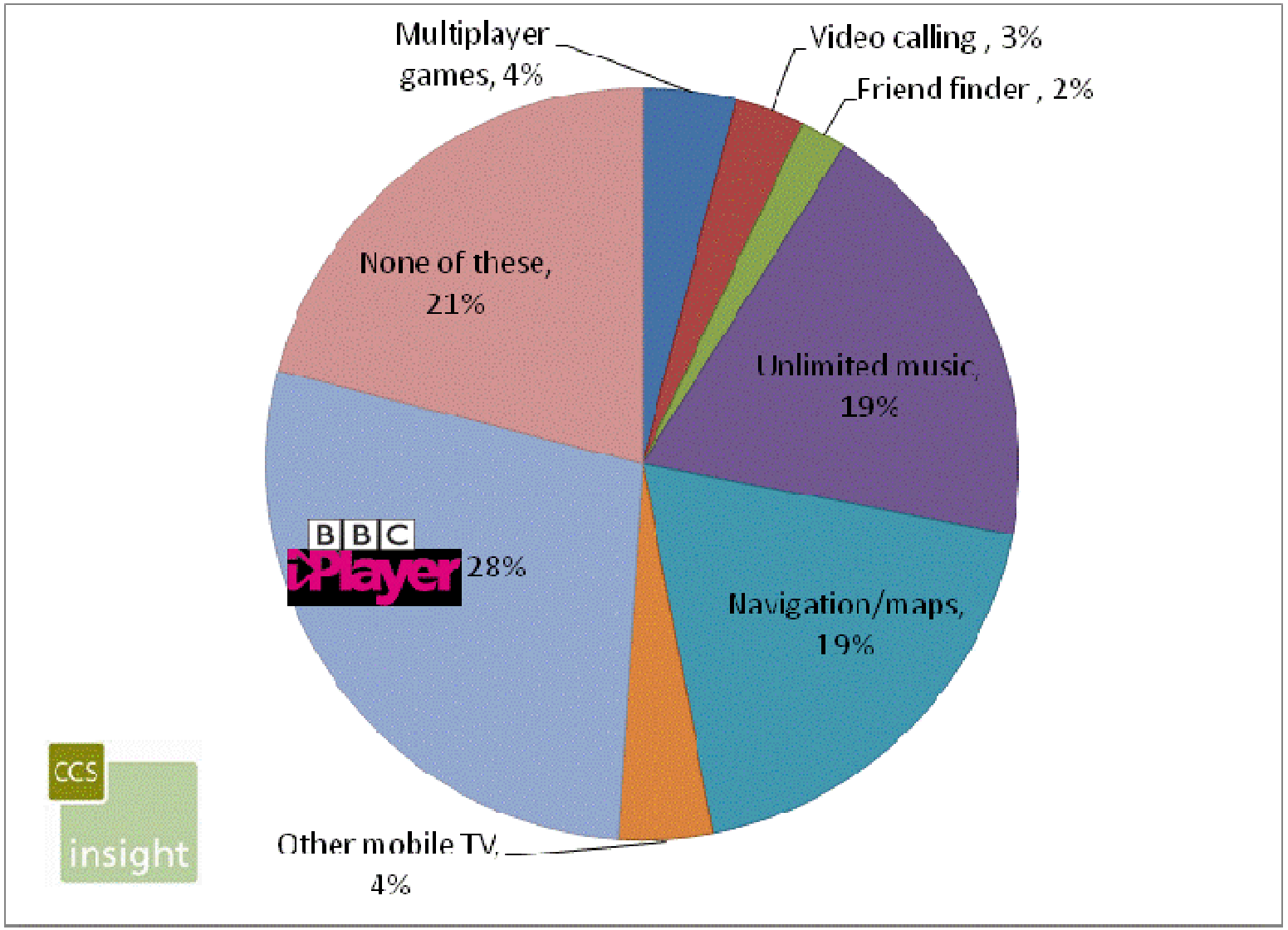
Contents

Wireless Broadband – User Requirements

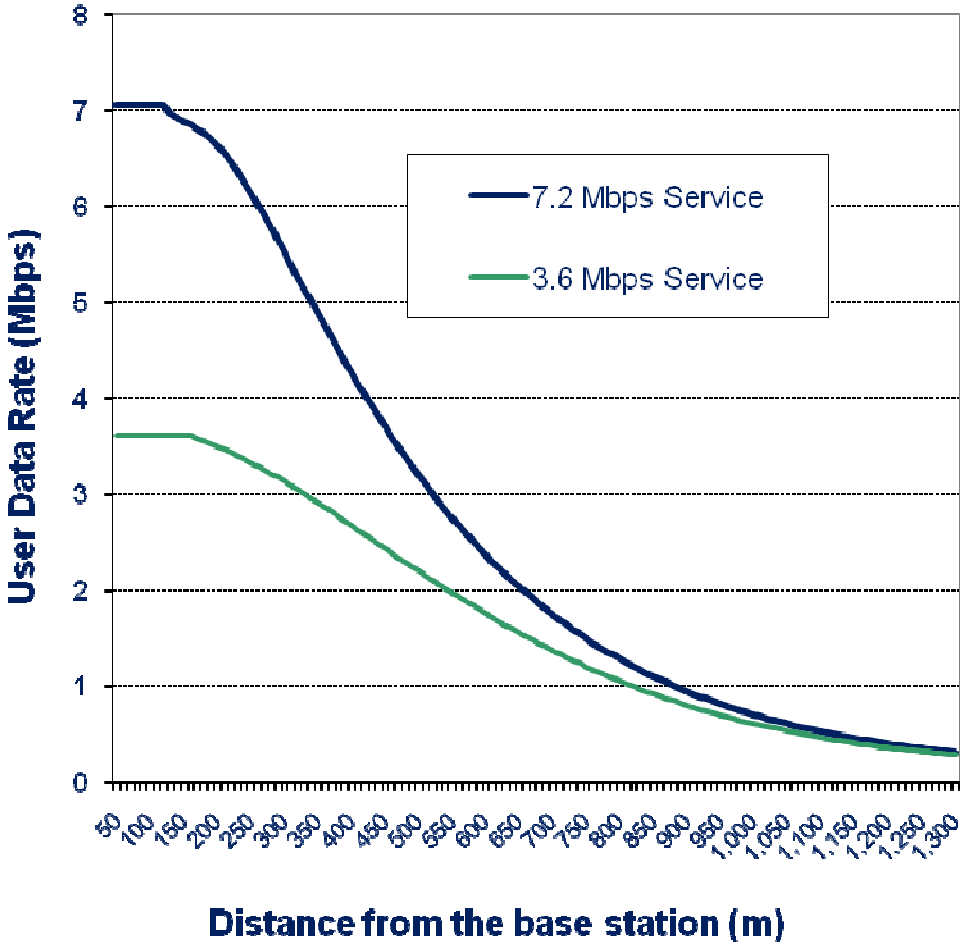
Which Service Would You Most Like to See on Your Phone?



Broadband Capacity Requirements

Application	Bandwidth	Notes
HD-TV Streaming (1280x720 pixels)	3200 kb/s	iPlayer HDTV VOD H264 video / AAC+ audio
SD-TV Streaming (640x360 pixels)	800 kb/s	iPlayer SDTV VOD H264 video / AAC+ audio
Hi-Res Mobile (480x272 pixels)	500 kb/s	iPlayer for iPhone/ iPOD H.264 video / AAC audio
Mobile Phone / PDA (320x176 pixels)	184 kb/s	H.264 video / AAC audio
Radio Streaming	128 kb/s	iPlayer AAC live radio
Web browsing (HTTP)	~150kb/s	Based on a page refresh of 300ms for a 5k page

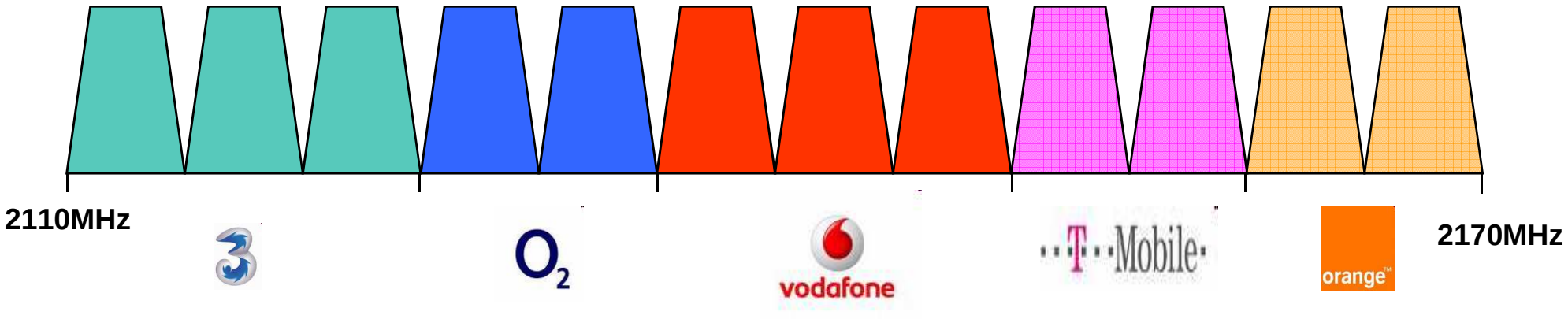
3G HSDPA Mobile Broadband Capacity



Modulation	Coding Rate	Capacity in Mbp/s		
		5 codes	10 codes	15 codes
QPSK	1/4	0.6	1.2	1.8
	2/4	1.2	2.4	3.6
	3/4	1.8	3.6	5.4
16-QAM	2/4	2.4	4.8	7.2
	3/4	3.6	7.2	10.8
	4/4	4.8	9.6	14.4

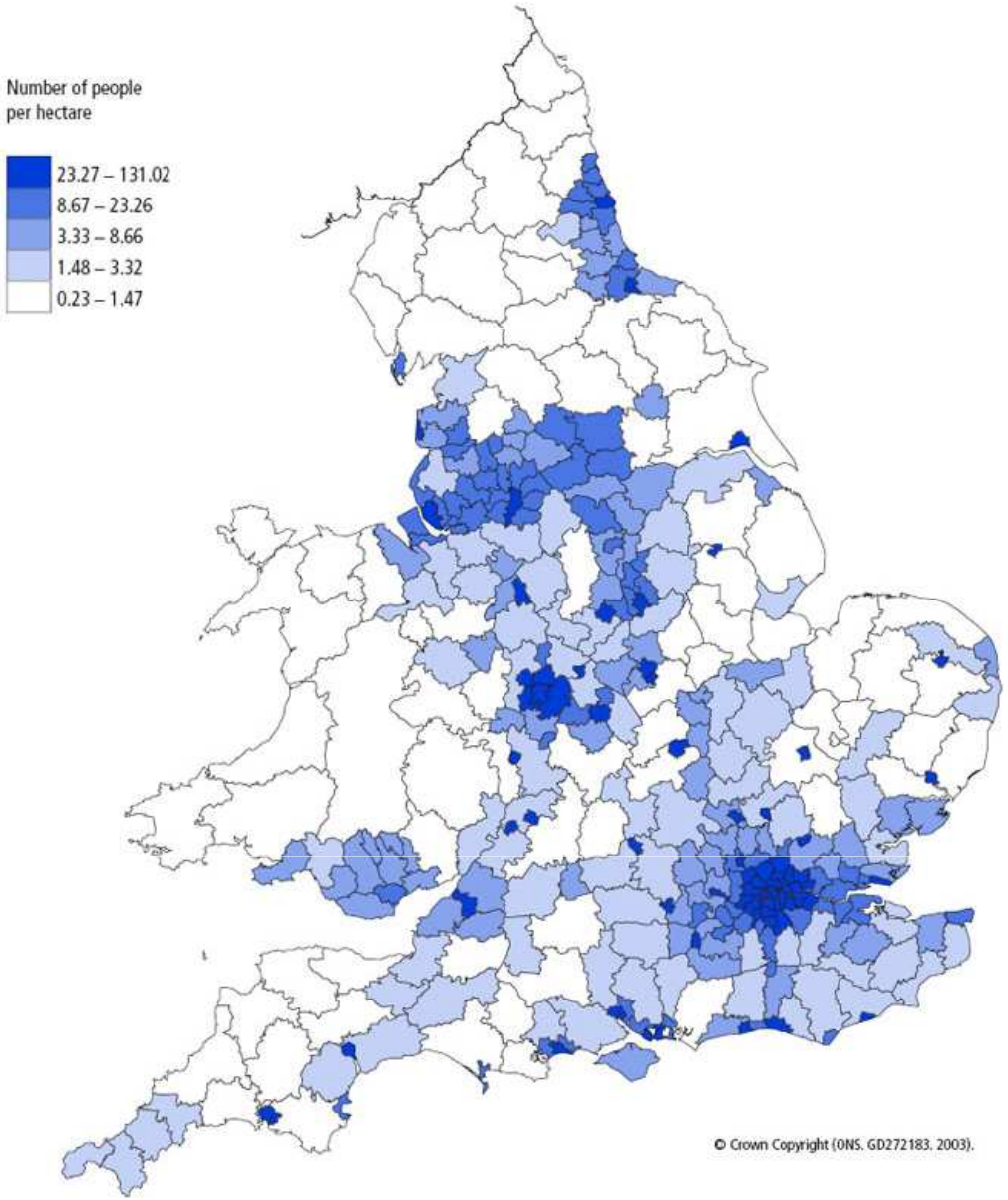
- Adaptive Modulation & Coding (AMC)
  - Fixed DL Power
  - Capacity falls with distance
  - Use robust modes for distant UE
- Typically 3 sectors / cell
  - Up to 40Mb/s /cell /carrier

Estimating 3G Network Capacity (2110 -2170MHz)



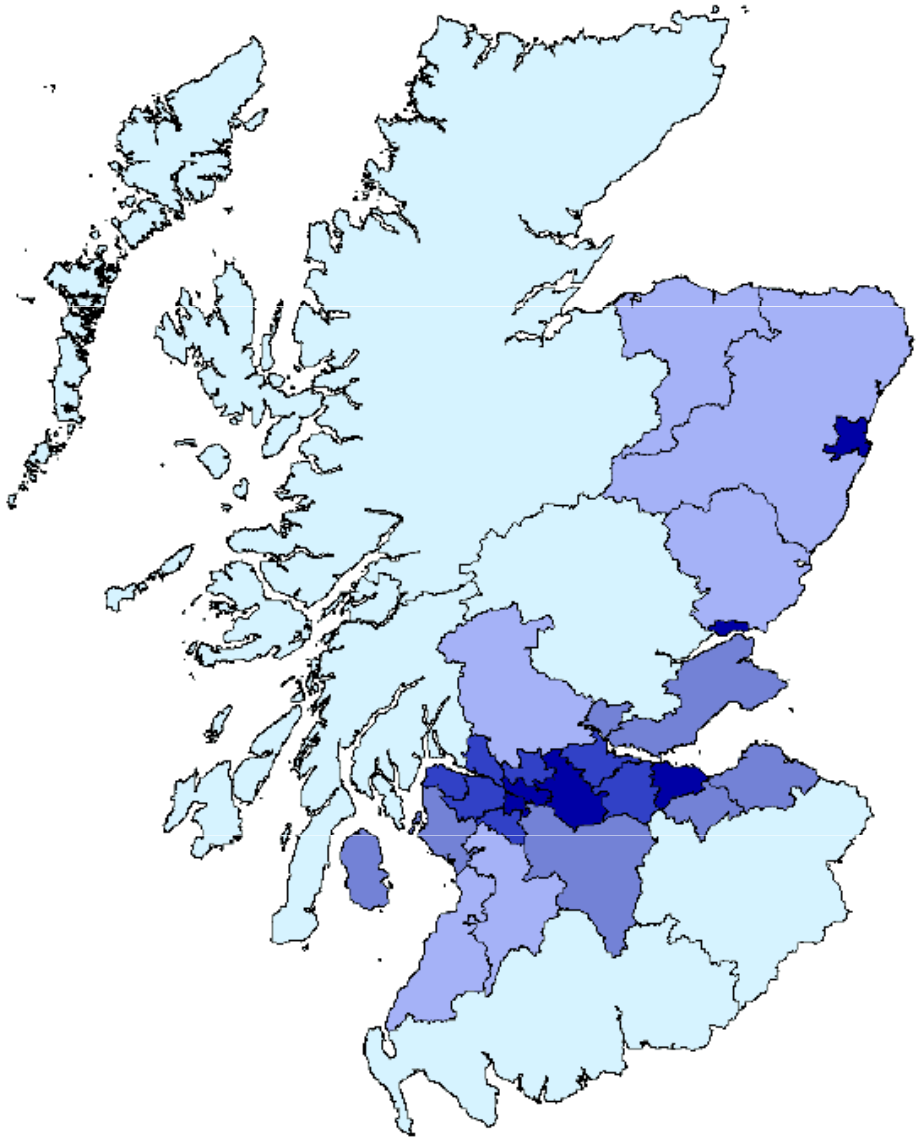
- 40Mb/s / cell / carrier
- 12 x 5MHz carriers (5 operators)
- 500 Mb/s /cell (1 km^2)
  - 5Mb/s/ha

Population Density & Network Contention Ratio



- Population density defines contention ratio for a 5Mb/s service (1km cell pitch)
- Dense urban areas
  - 23 to 130 people/ha
- 3G capacity reduced
  - Interference at cell edge
  - Imperfect spectrum reuse
  - Operator partitioning
- Capacity improvement options
  - Smaller cells (pico, femto)
  - More efficient modulation
  - More spectrum

Population Density & Network Contention - Scotland



- Population density much lower
- Urban areas <33 people /ha (Glasgow)
- Average density 0.66 people / ha
- Lower contention ratios
  - Permitting parser networks

Improving Spectrum Efficiency - 4G LTE vs 3G UMTS

- Can improved Coding and Modulation increase network capacity?

System (#UE Cat)	Modulation	Number of Codes (CDMA)	FEC Code Rate	Data Rate [Mb/s]
3G HSDPA #6	16-QAM / SISO	5	0.76	3.6
3G HSDPA #8	16-QAM / SISO	10	0.76	7.2
3G HSDPA #10	16-QAM / SISO	15	0.97	14.0

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3G HSDPA #10	16-QAM / SISO	15	0.97	14.0
4G LTE (20MHz)	64-QAM / SISO	-	1.00	100.0
4G LTE (20MHz)	64-QAM / MIMO	-	1.00	172.8
4G LTE (20MHz)	64-QAM / MIMO 4x4	-	1.00	326.4

- LTE “marketing” bit rates higher than 3G systems (>100Mb/s)

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3G HSDPA #6	16-QAM / SISO	5	0.76	3.6	0.72
3G HSDPA #8	16-QAM / SISO	10	0.76	7.2	1.44
3G HSDPA #10	16-QAM / SISO	15	0.97	14.0	2.80
4G LTE (20MHz)	64-QAM / SISO	-	1.00	100.0	5.00
4G LTE (20MHz)	64-QAM / MIMO	-	1.00	172.8	8.64
4G LTE (20MHz)	64-QAM / MIMO 4x4	-	1.00	326.4	16.32
3G HSDPA #14	64-QAM / SISO	15	0.98	21.1	4.22

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- Normalised efficiency similar (20MHz LTE bandwidth vs 5MHz 3G bandwidth)

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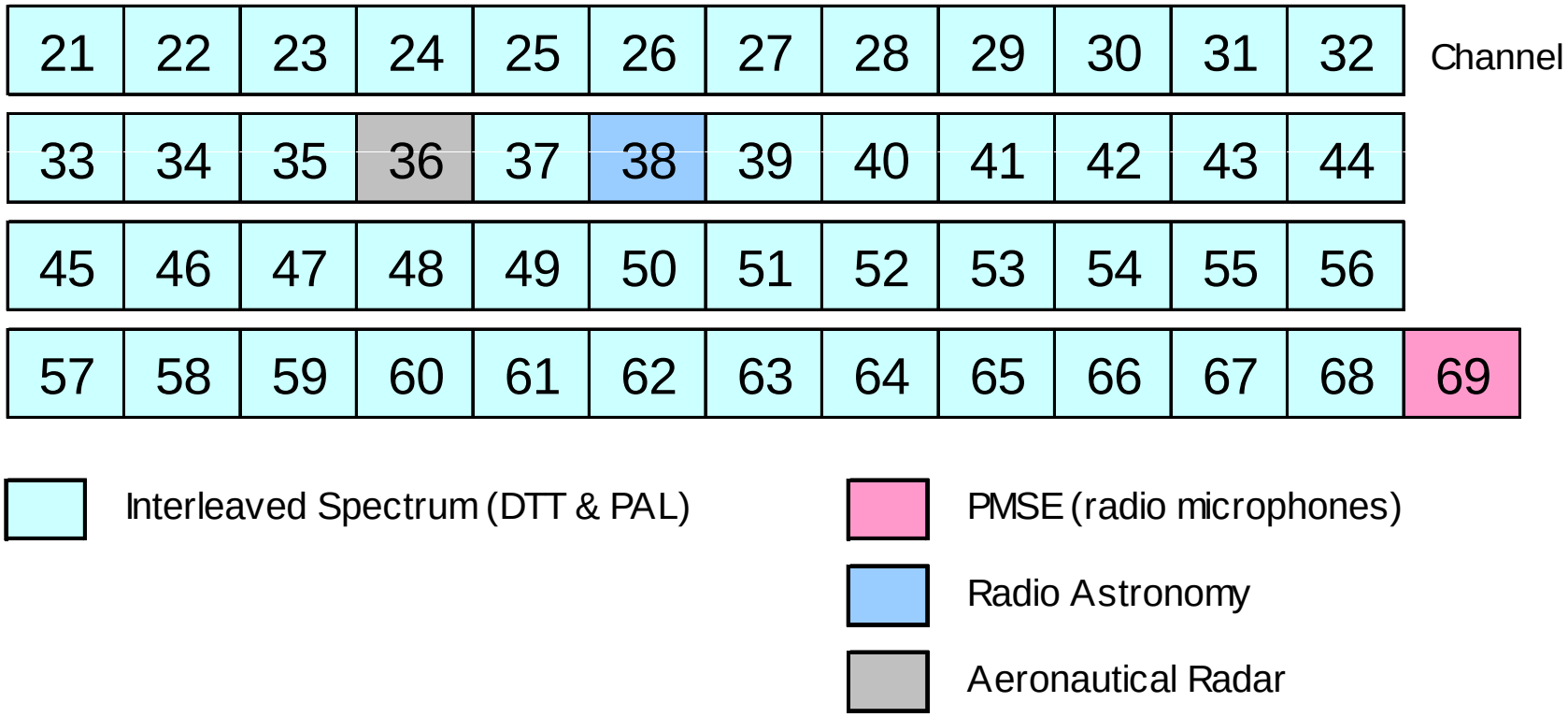
3G HSDPA #14	64-QAM / SISO	15	0.98	21.1	4.22
3G HSDPA #20	64-QAM / MIMO	15	1.00	42.2	8.44

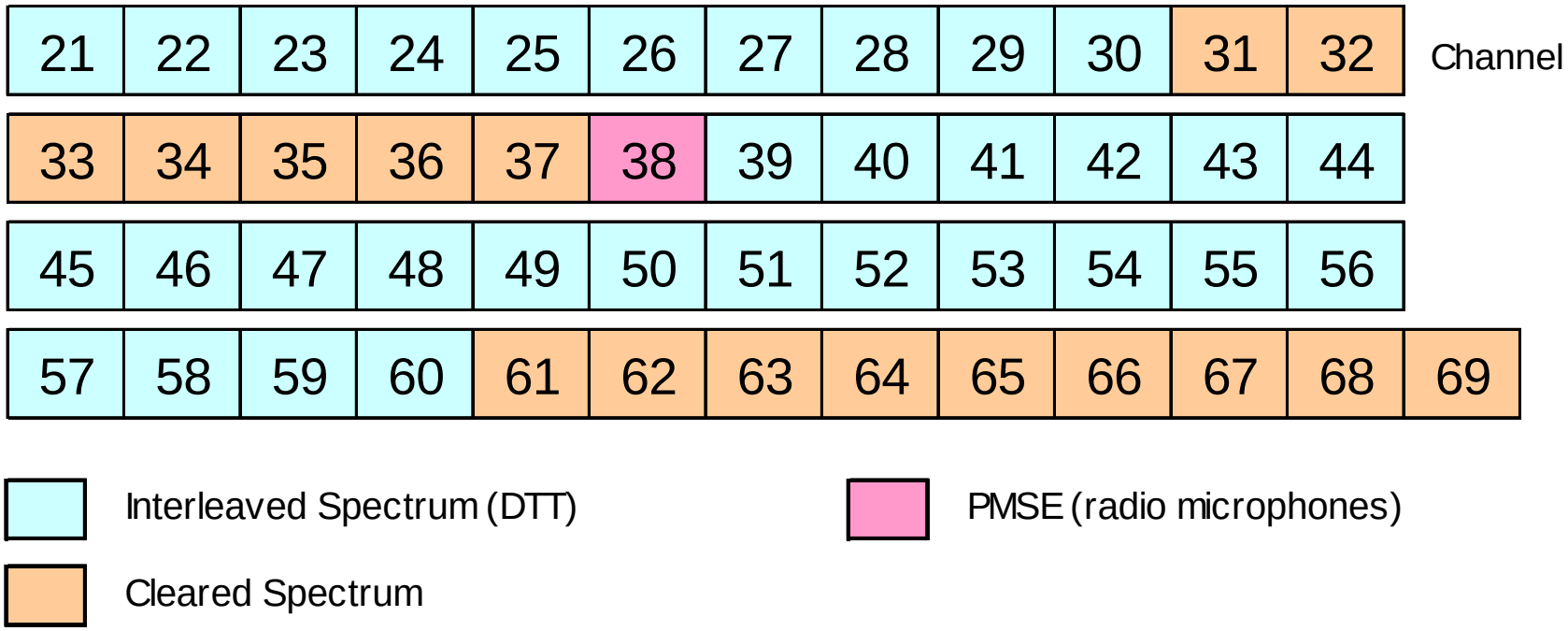
- LTE “marketing” bit rates higher than 3G systems (>100Mb/s)
- Normalised efficiency similar (20MHz LTE bandwidth vs 5MHz 3G bandwidth)
- Options for MIMO with 3G (HSDPA evolved)
- 3G/4G re-farming offers limited benefits
  - New spectrum required to support mobile multimedia

UK TV Spectrum 2009



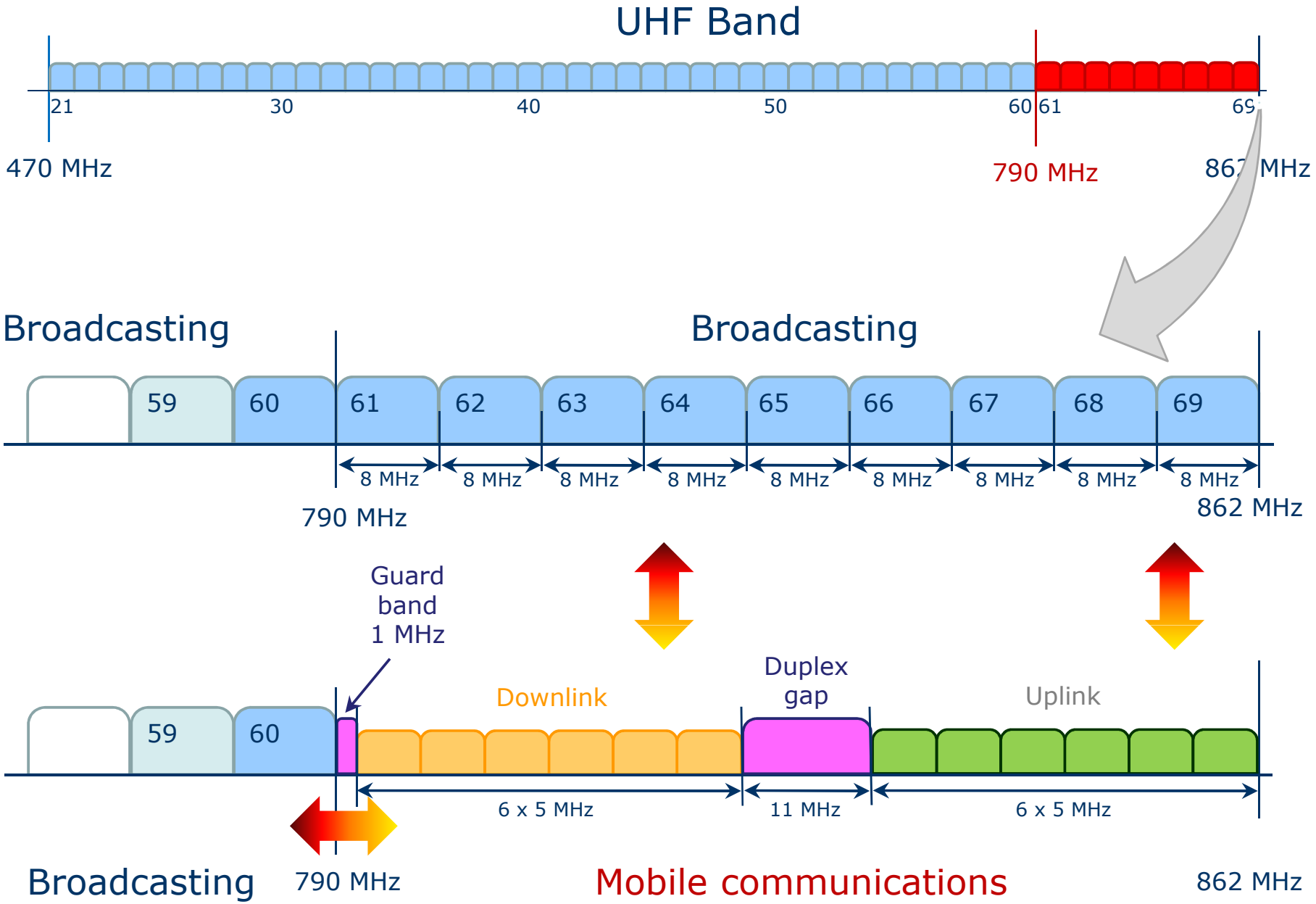
- MFN using 46 UHF channels (368MHz total)
- 11 TV Services (5xPAL + 6xDTT multiplexes)
- Licensed radio microphones (PMSE in interleaved white space spectrum)

UK TV Spectrum 2012 – The Digital Dividend



- 16 channels (128MHz) cleared for auction
  - Upper cleared (9 channels) for ECNs (LTE)
  - Lower cleared (7 channels) use to be determined
- 32 channels (256MHz) retained for 6 x DTT multiplexes and interleaved whitespace (licensed PMSE + licence-exempt WSDs)

4G WRC07 Harmonized Band & DTT Compatibility



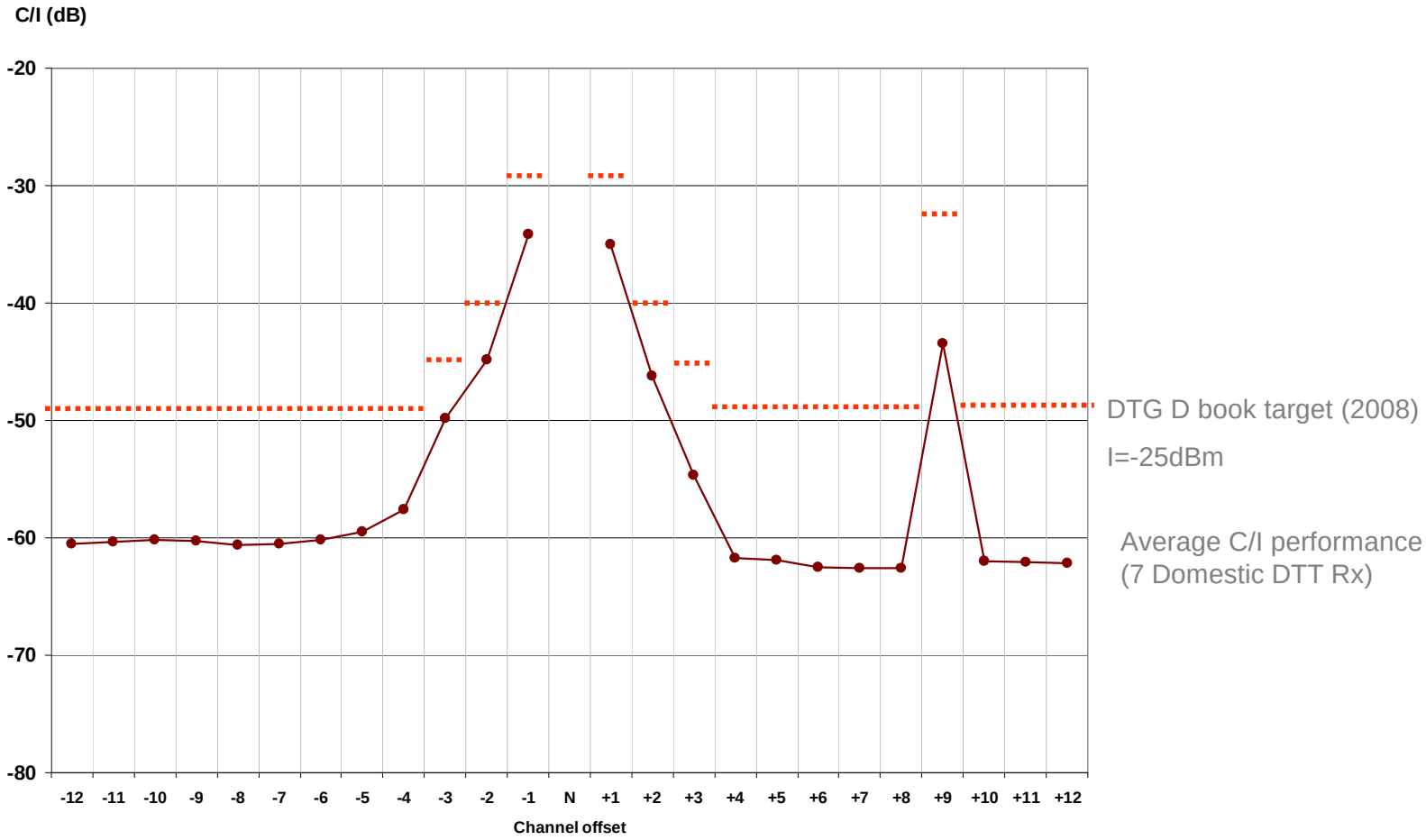
Predicting Interference – DTT Receiver C/I Targets

What signal level from the 4G ECN can be tolerated by a TV tuner ?

	Interferer Level (dBm)	C/I (failure)	C/I (QEF)	
DTT ACI (N±1) protection (dB)	-25	-29	-27	dB
DTT Non-ACI (N±2) protection (dB)		-40	-38	dB
DTT Non-ACI (N±3) protection (dB)		-45	-43	dB
DTT Non-ACI (N±M) protection (dB), M≥4, M≠9		-49	-47	dB
DTT (N+9) Protection (dB)		-33	-31	dB
DTT Simultaneous non-ACI (N+2) & (N+4) protection (dB)	-25	-30	-28	dB

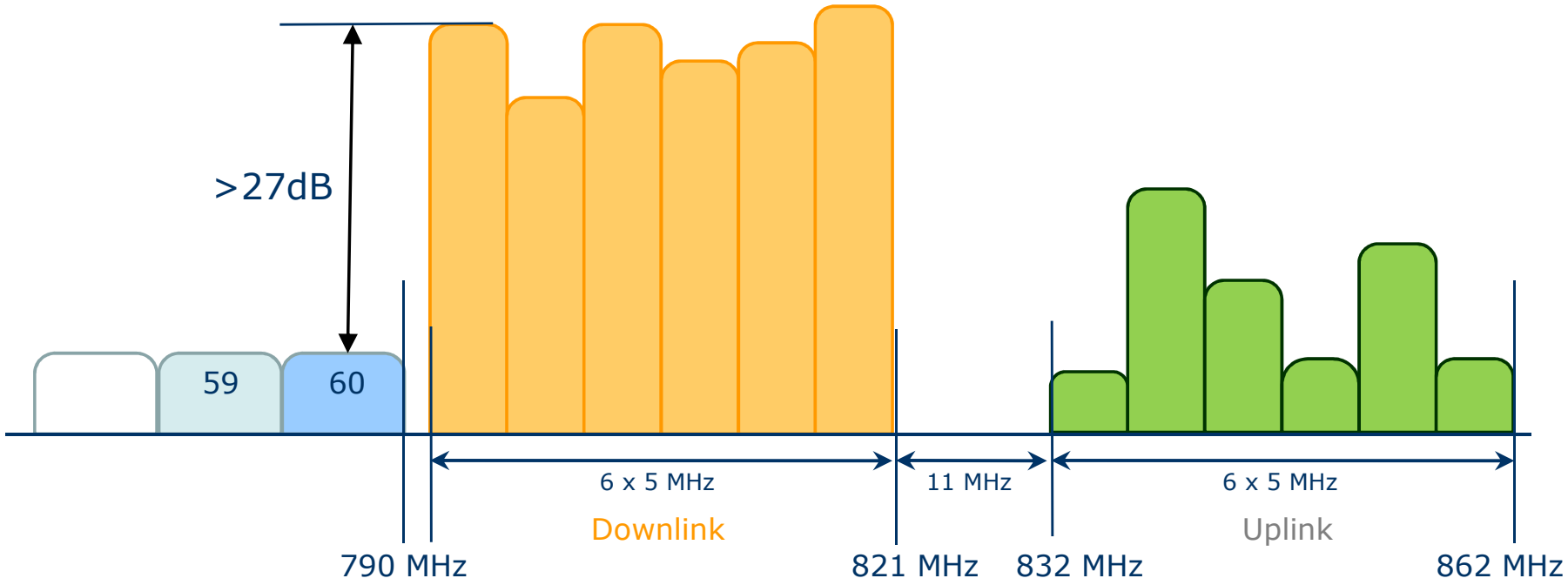
- DTG-D Book “Requirements for Interoperability V5.02”
  - New targets for DSO mode 64QAM Rate 2/3 8k FFT (November 2008)

Measured DTT Rx C/I vs. DTG target (7 Receivers)



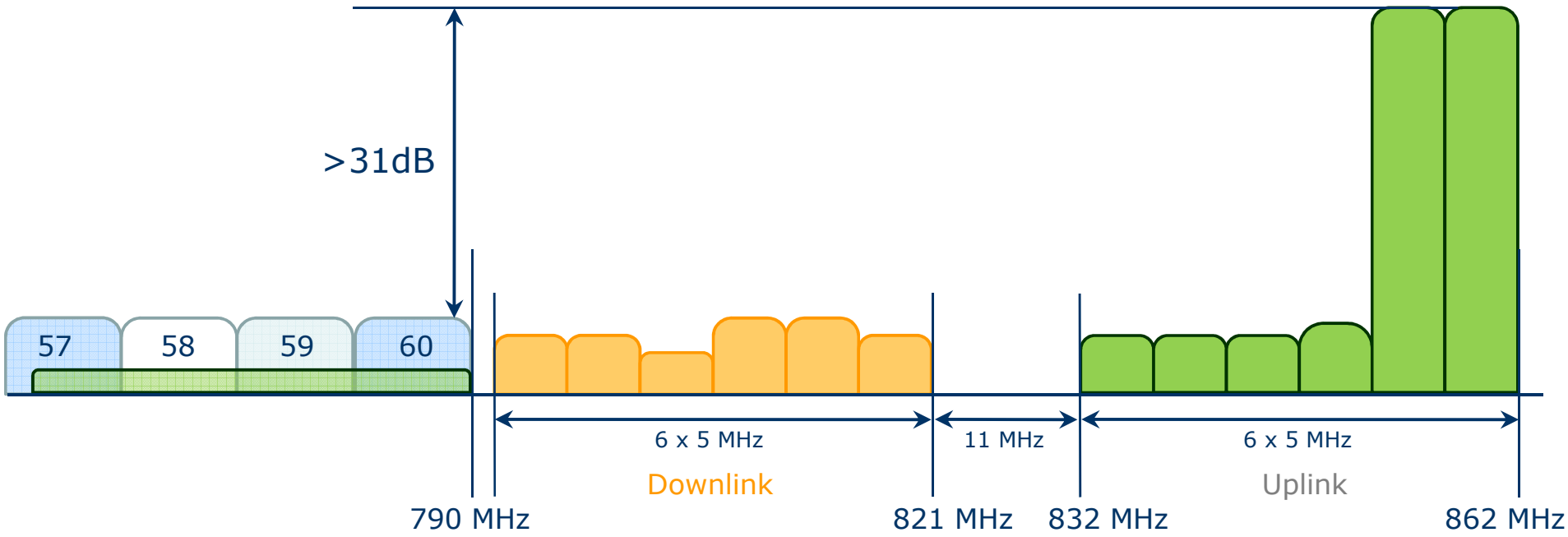
- Some margin on DTT target values for current STBs (typically 5dB)
- Value-engineered receivers using silicon tuners may perform closer to target

UMTS/ DTT Interference Scenario – N+1 C/I limited



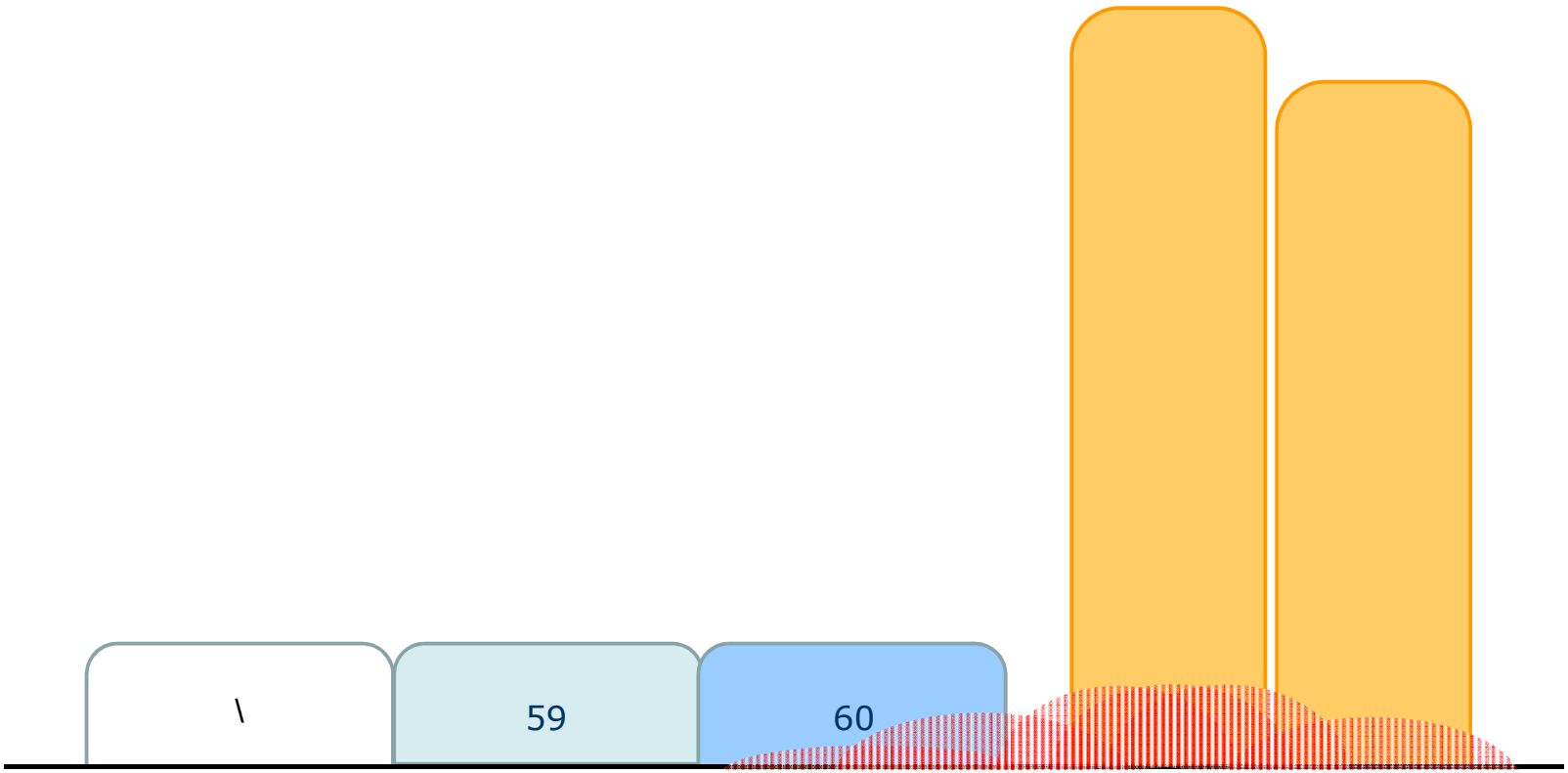
- Adjacent channel C/I performance exceeded (BS D/L into DTT Rx)

ECN/ DTT Interference Scenario – N+9 C/I limited



- Proximity of handsets operating in CH69 exceed C/I N+9 performance
- Problem extends down to CH57
- 25dBm EIRP UE Power
  - For DTT -72dBm => UE <-41dBm => Isolation >66dB => d>50m

ECN/ DTT Interference Scenario – OOB pollution



- Base station is non-linear
- Up to 0dBm OOB permitted into CH60 from ECN D/L

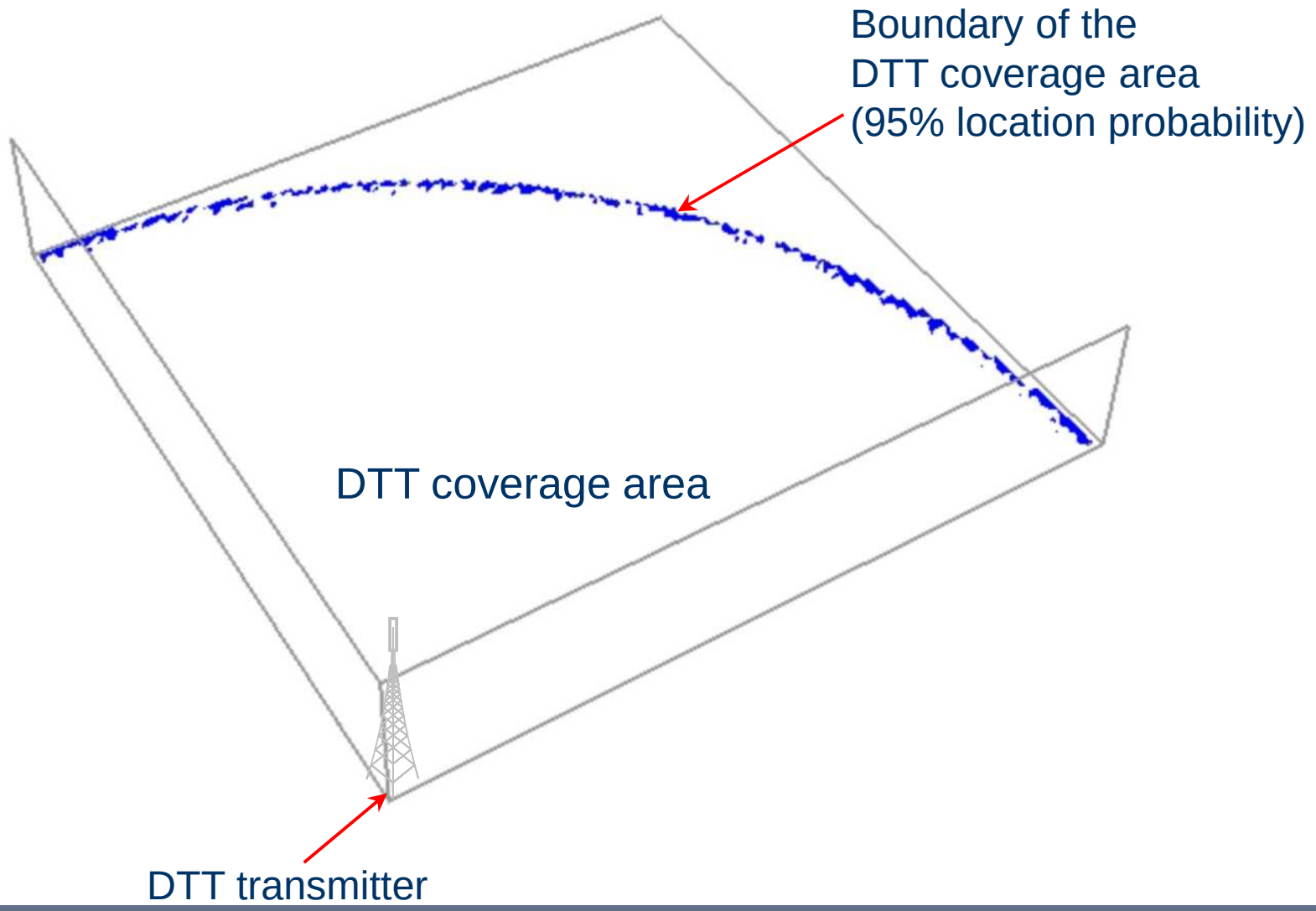
CEPT Report 30 Proposal

OOB Block Edge Masks for ECN base stations:

Situation	Description	Condition on base station e.i.r.p. P (dBm/10MHz)	Maximum mean out-of-block EIRP	Measurement bandwidth
A	For DTT frequencies where broadcasting needs to be protected	P ≥ 59	0 dBm	8 MHz
		44 ≤ P < 59	(P-59) dBm	8 MHz
		P < 44	-15 dBm	8 MHz
B	For DTT frequencies where broadcasting requires an intermediate level of protection	P ≥ 59	10 dBm	8 MHz
		44 ≤ P < 59	(P-49) dBm	8 MHz
		P < 44 dBm	-5 dBm	8 MHz
C	For DTT frequencies where broadcasting does not need to be protected	No condition	22 dBm	8 MHz

The DDR Interference Issue

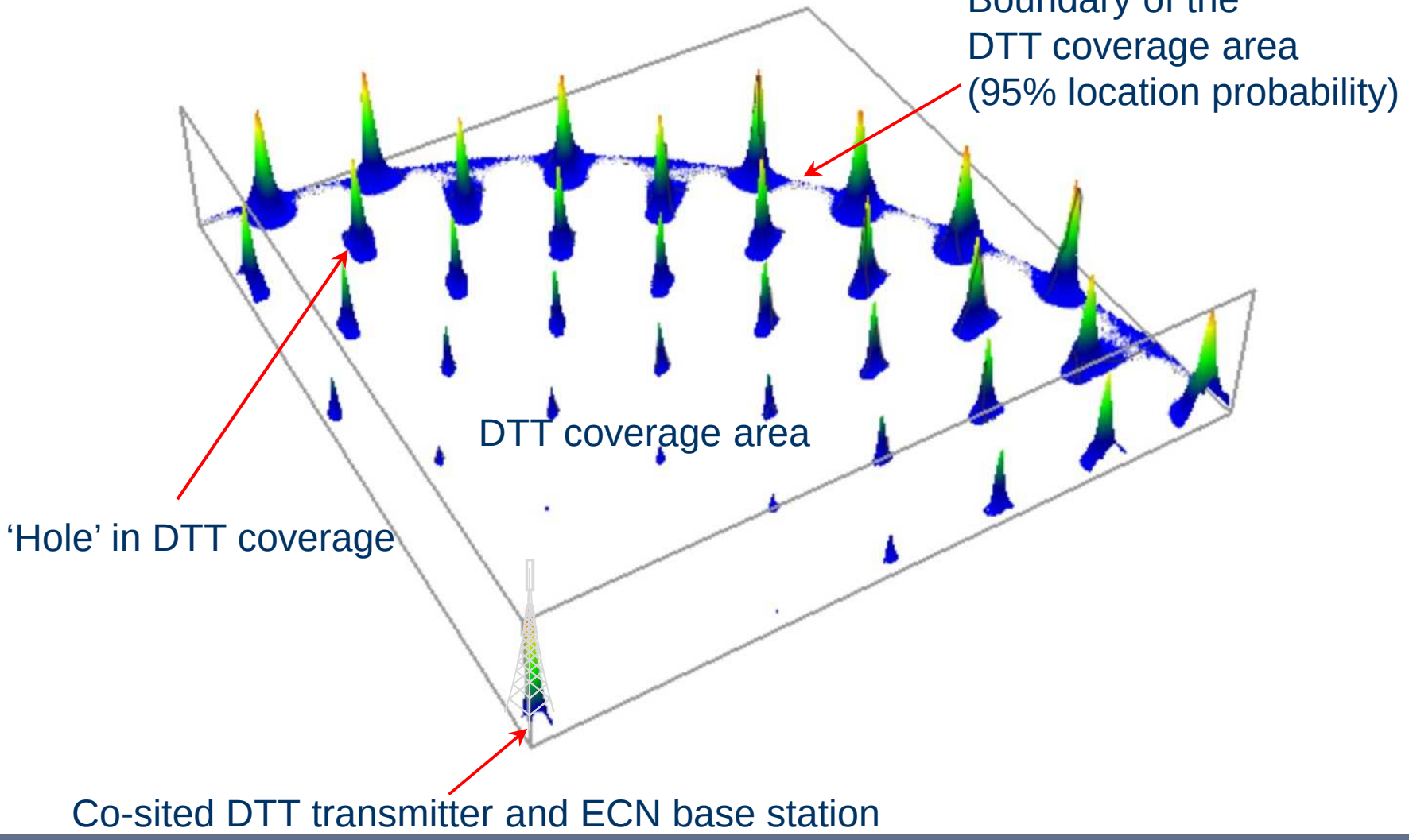
Illustration: Interference from ECN base stations



The DDR Interference Issue

Illustration: Interference from ECN base stations

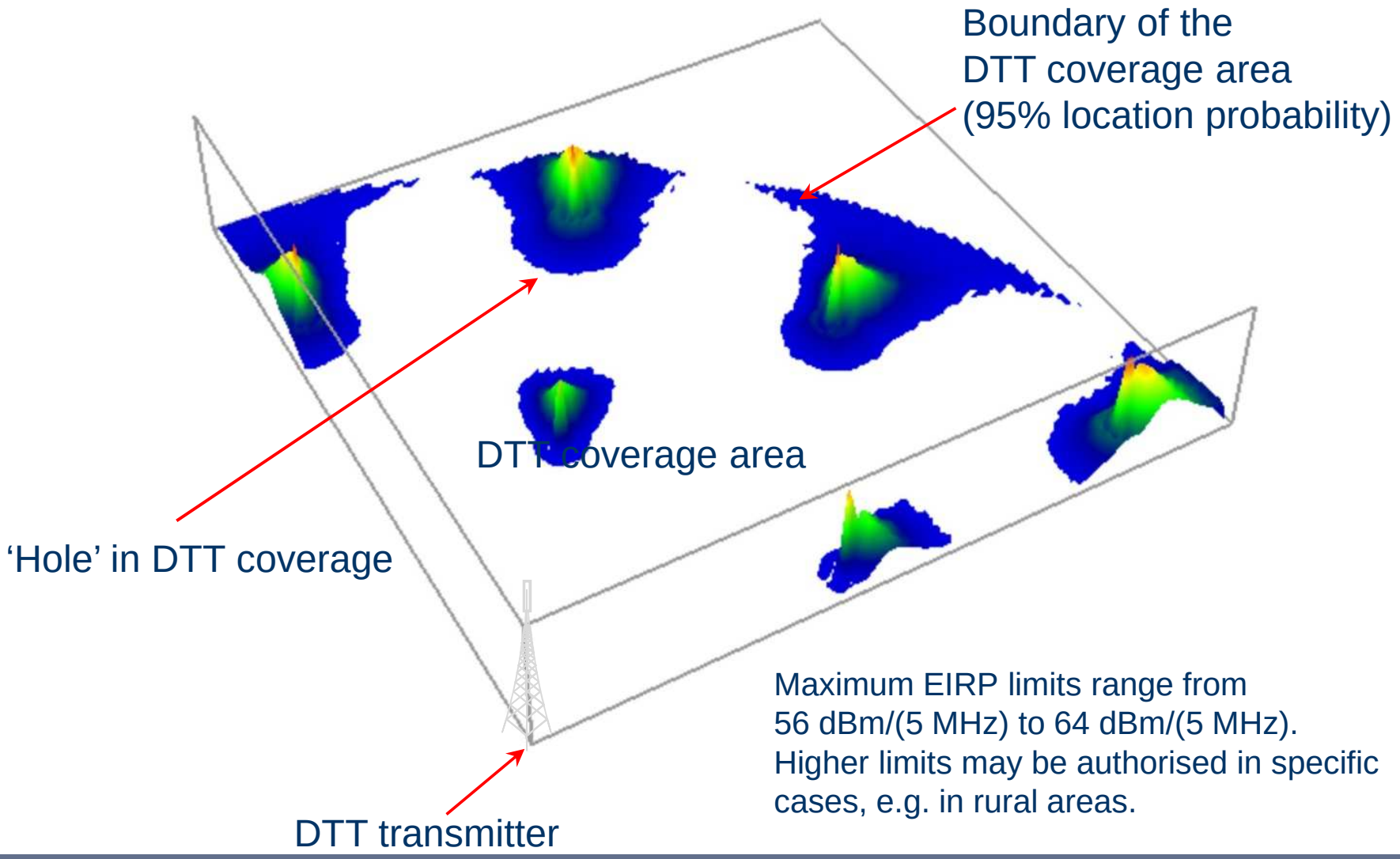
Low-power dense ECN network



The DDR Interference Issue

Illustration: Interference from ECN base stations

High-power dense ECN network

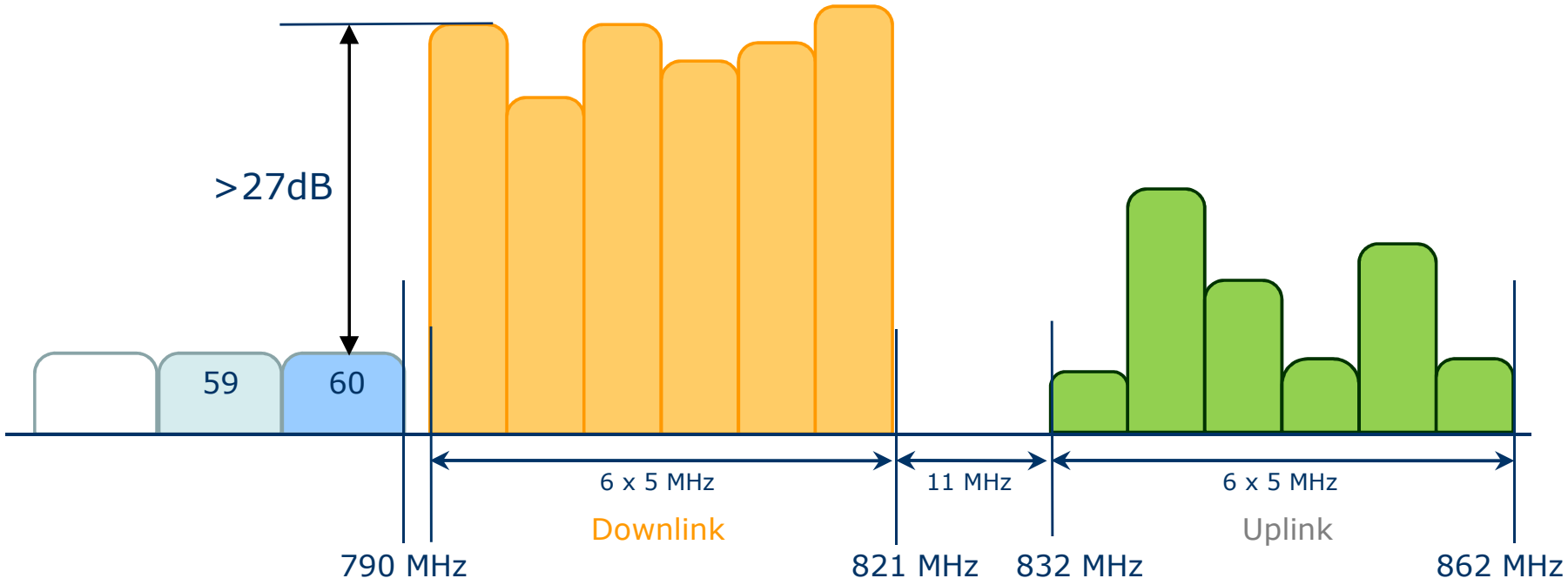


Maximum EIRP limits range from
56 dBm/(5 MHz) to 64 dBm/(5 MHz).
Higher limits may be authorised in specific
cases, e.g. in rural areas.

Interference Mitigation Options

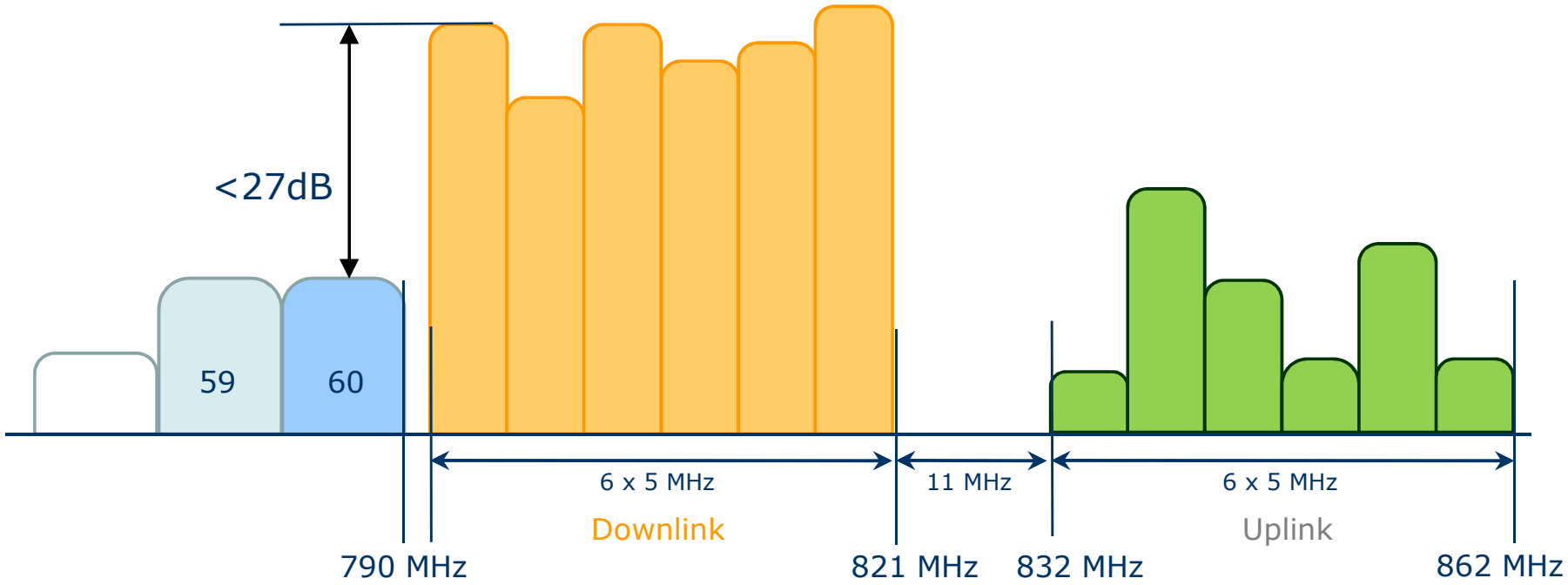
- Network coordination
  - Reduce ECN EIRP at DTT coverage boundary
- Improve DTT receiver performance
  - Retrofit band stop filters
  - Revise DTG C/I targets
- Network repair and enhancement
  - Install DTT repeaters at ECN bases
  - Facilitate portable device TV reception
  - Reduce multimedia traffic on ECN

DTT Network Repair



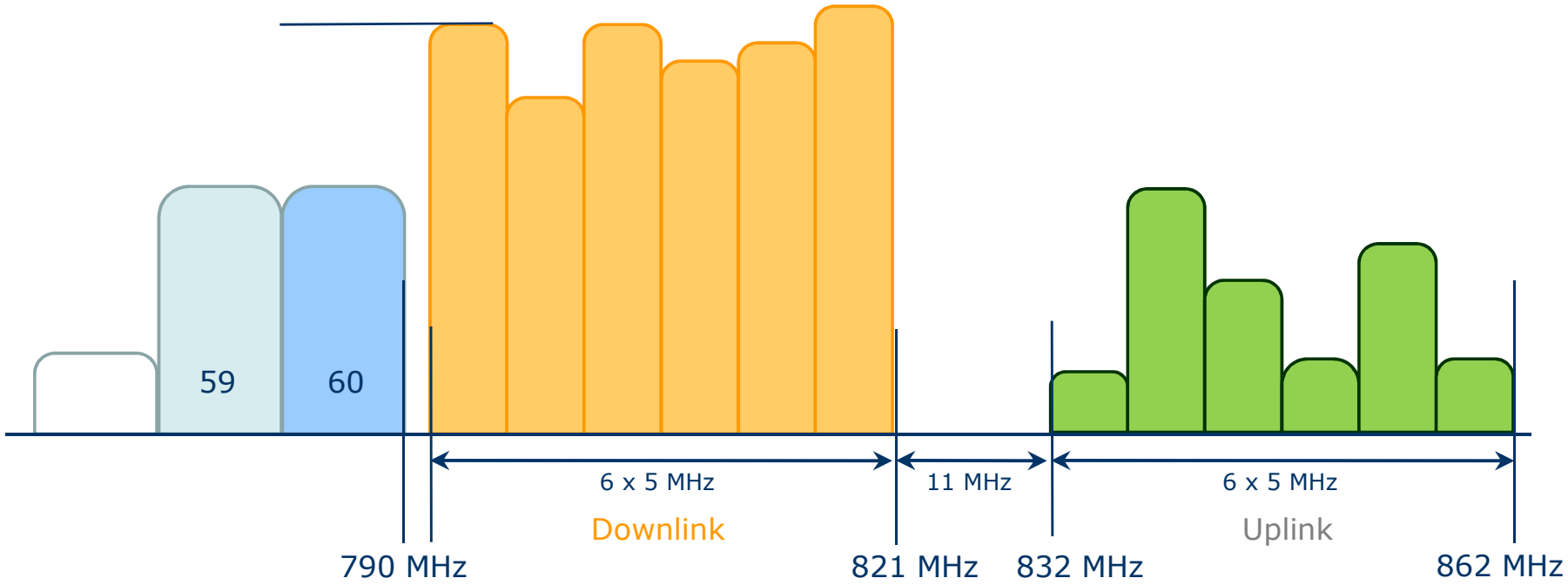
- Receiver C/I Exceeded – DTT network broken

DTT Network Repair



- DTT service re-radiated at increased power
  - Can use OCR to implement local SFN

DTT Network Enhancement



- Further increasing DTT signal enables portable reception on mobile device
- Potentially reduces traffic on mobile network
- Improved use of spectrum below 1GHz (fixed and portable)

Conclusions

- Multimedia services are increasingly popular and require improved broadband networks
- LTE offers some improvement over 3G, particularly with MIMO modes
- Additional spectrum required
- UHF TV Channels 61-69 will be cleared to improve mobile broadband

Conclusions

- DTT/ECN interference is a major concern
  - All current DTT receivers are vulnerable
    - Insufficient C/I performance to reject base stations
  - Proposed BEMs also result in Co-channel OOB interference
  - Channel 60 may effectively become sterilised

- Additional measures are required to mitigate interference
  - Reduce EIRP at DTT coverage boundaries
  - Retrofit band reject filters to existing DTT installations
    - But very difficult to engineer protection of CH60 with only 1MHz guard band.

- A better option might be to repair DTT network using local repeaters
  - Enables some relaxation of BS OOB parameters
  - Network enhancement potentially allows live unicast traffic to be offloaded to the broadcast network

Thank you for your attention!

Questions ?