LTE and ISDB-T Coexistence Study

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Outline

- Objective
- Scope
- Key assumptions
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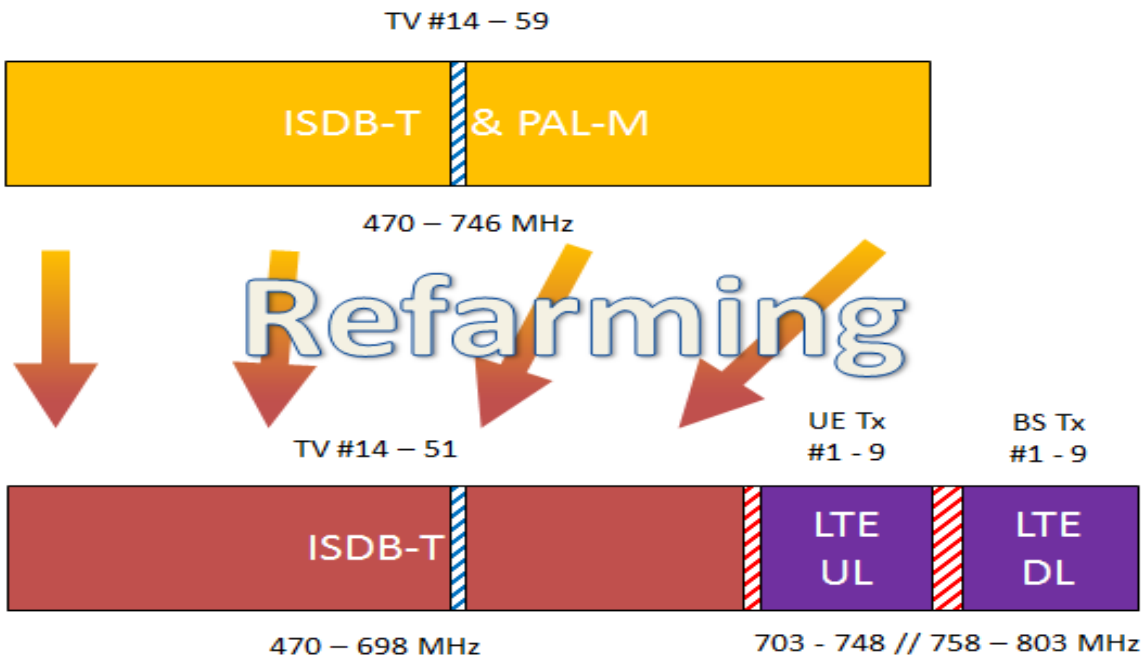
Objective

To develop evidence through realistic modelling of the compatibility of LTE adjacent to ISDB-T following a digital dividend where all analogue TV emissions cease and an equivalent service is provided by digital TV. Subsequently the modelling should support a case for the coexistence, exploring simple mitigations where necessary.

Scope

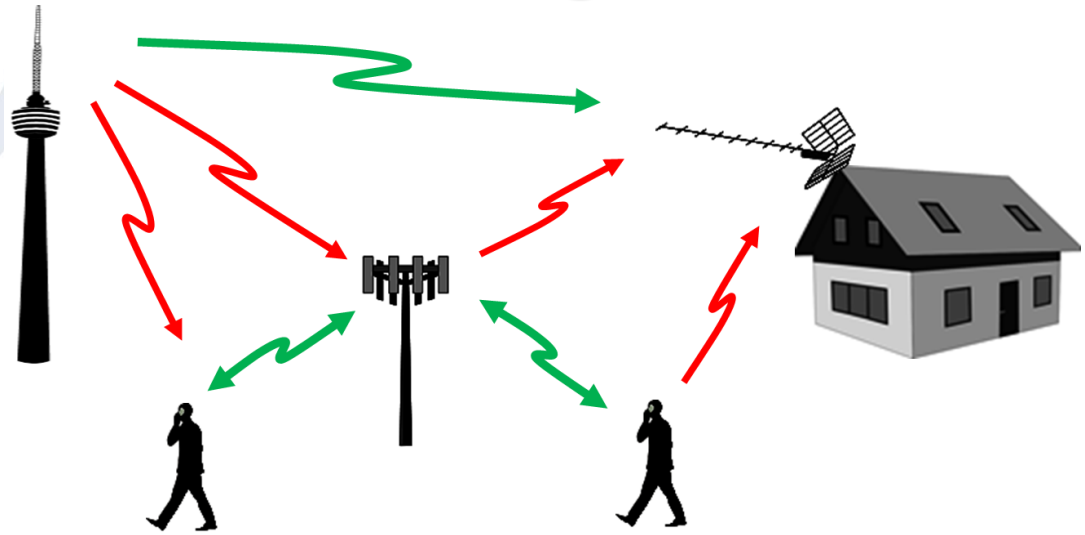


- To quantify the impact LTE stations may cause to the ISDB-T broadcasting service
- To quantify the impact that the ISDB-T services might have on the LTE cellular network
- Analogue TV considered as staggered switch off

Key Assumptions

- ISDB-T service for fixed rooftop antennas will be modelled at 10m AGL using directional antennas based on Recommendation ITU-R BT.419-3
- LTE will only be considered at existing cellular sites with a single common 3 sector radiation pattern.
- Protection ratio data for LTE and ISDB-T will be taken from ITU document 4-5-6-7/146-E
- In the absence of digital TV data existing analogue site and antenna details will be used and are assumed to be representative of digital TV post switchover. The power of the analogue transmitter will be reduced by 13dB to give a representative digital transmit power.
- Omni directional antennas on TV broadcast stations
- The analogue TV and LTE services are considered to be geographically separated, rather than serving the same area, and so blocking is not considered.

Modelling Scenarios Overview



Digital

- LTE base station (BS) interferes with ISDB-T fixed rooftop receivers
- LTE user equipment (UE) interferes with ISDB-T fixed rooftop receivers
- ISDB-T interferes with LTE UE
- ISDB-T interferes with LTE BS

Analogue

- LTE BS interfering with analogue TV
- LTE UE interfering with analogue TV
- Analogue TV interferes with LTE BS
- Analogue TV interferes with LTE UE

Method

Digital

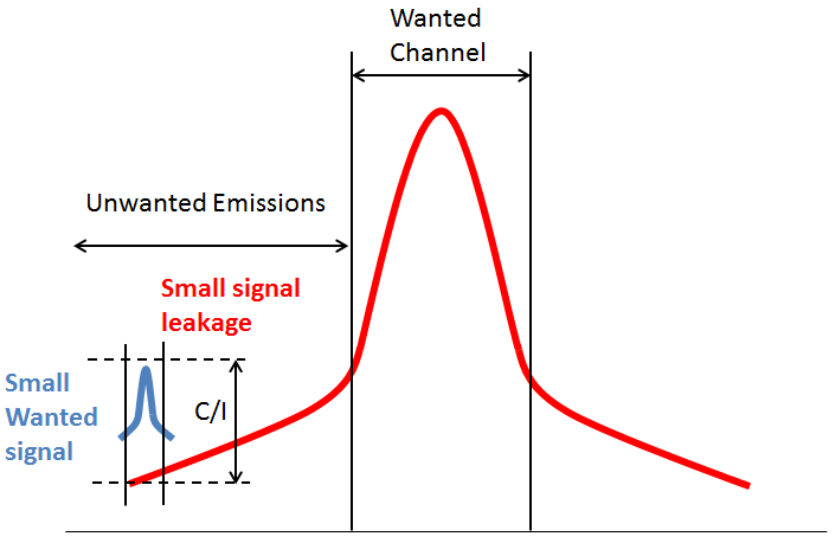
- LTE base station (BS) interferes with ISDB-T fixed rooftop receivers
  - Planning tool to model interference and population affected.
  - Sample Areas - Sao Paulo, Brasilia and Campinas.

- The remaining scenarios used the minimum coupling loss (MCL) approach to determine the minimum separation that would be required so as not to suffer interference.

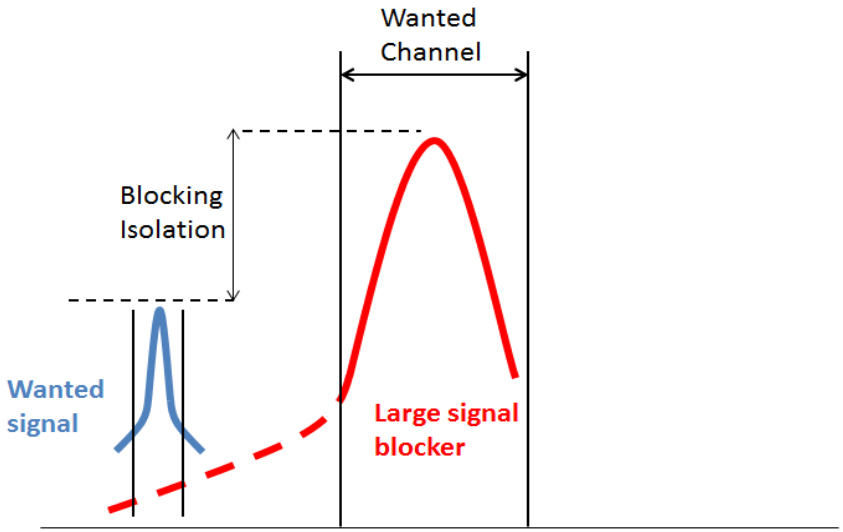
Method

Digital

Two mechanisms considered:



Out of Band Emissions



Blocking

Method

Analogue

- No protection criteria available for LTE and analogue TV.
- Equivalence modelling approach used
  - Compute the difference between the protection ratio from digital TV into digital TV and from digital TV into analogue TV, which gives an equivalence correction figure.
  - Take digital figures for LTE into digital TV and add the equivalence correction figure.
- Minimum coupling loss determined
- Systems assumed geographically separate so blocking not considered.

Mitigation

- **Options considered**
  - Limit emission power in top TV broadcast channels
  - LTE BS emission and receiver filtering
  - Broadcast emission filtering
  - Use of orthogonal polarisation
  - Domestic TV receiver filtering
  - Improved domestic antenna
  - Good quality TV receivers
- ➢ **Applying emission and receiver filters to the LTE base station and emission filters to the ISDB-T transmitter combined with limiting the emission power in the top TV broadcast channels are the most beneficial**

Results - LTE into ISDB-T

	Probability of interference	
	Out of band emissions (modelling tool approach)	Blocking (modelling tool approach)
LTE BS (30m antenna) into ISDB-T (10m fixed rooftop antenna)	Medium	Low
LTE UE (1.5m) into ISDB-T (10m fixed rooftop antenna)	Low	Low

- **The population interfered (LTE BS into ISDB-T) is relatively low with typically less than 50,000 for Sao Paulo and less than 10,000 for Brasilia and Campinas for out of band interference.**
- **For LTE UE into ISDB-T the separation distances required are typically below 50m.**

Results – ISDB-T into LTE

	Probability of interference	
	Out of band emissions (MCL approach)	Blocking (MCL approach)
ISDB-T (150m antenna) into LTE BS (30m antenna)	High	High
ISDB-T (150m antenna) into LTE UE (1.5m antenna)	Low	Low

- **For ISDB-T into LTE BS the separation distances required are typically greater than 10km.**

Results - LTE into Analogue TV

	Probability of interference
	Out of band emissions (MCL approach)
LTE BS (30m antenna) into ATV (10 fixed rooftop antenna)	Medium
LTE UE (1.5m antenna)into ATV (10m fixed rooftop antenna)	Low

- **For LTE base station into analogue TV the separation distance required is typically a few kilometres. For the uplink the separation distance required is generally less than 100m.**

Results - Analogue TV into LTE

	Probability of interference
	Out of band emissions (MCL approach)
ATV (150m antenna) into LTE BS (30m antenna)	High
ATV (150m antenna) into LTE UE (1.5m antenna)	Medium

- **For analogue TV into LTE base station the separation distance required is greater than 10km. For the LTE mobile the separation distance required is of the order of 10km**

Results (mitigation applied) – LTE into ISDB-T

	Probability of interference			
	Out of band emissions (modelling tool approach)		Blocking (modelling tool approach)	
	Before mitigation	After mitigation	Before mitigation	After mitigation
LTE BS (30m antenna) into ISDB-T (10m fixed rooftop antenna)	Medium	Low	Low	-
LTE UE (1.5m) into ISDB-T (10m fixed rooftop antenna)	Low	-	Low	-

- **The population interfered (LTE BS into ISDB-T) is relatively low with typically less than 50,000 for Sao Paulo and less than 10,000 for Brasilia and Campinas for out of band interference. With mitigation applied those numbers can be virtually eliminated**

Results (mitigation applied) – ISDB-T into LTE

	Probability of interference			
	Out of band emissions (MCL approach)		Blocking (MCL approach)	
	Before mitigation	After mitigation	before mitigation	After mitigation
ISDB-T (150m antenna) into LTE BS (30m antenna)	High	Low	High	Low
ISDB-T (150m antenna) into LTE UE (1.5m antenna)	Low	-	Low	-

- **For ISDB-T into LTE BS the separation distances required can be reduced from more than 10km to less than 600m following mitigation.**

Results (mitigation applied)- LTE into Analogue TV

	Probability of interference	
	Out of band emissions (MCL approach)	
	Before mitigation	After mitigation
LTE BS (30m antenna) into ATV (10 fixed rooftop antenna)	Medium	Low
LTE UE (1.5m antenna) into ATV (10m fixed rooftop antenna)	Low	-

- **For LTE base station into analogue TV the separation distance required is typically a few kilometres. For the uplink the separation distance required is generally less than 100m.**

Results (mitigation applied) - Analogue TV into LTE

	Probability of interference	
	Out of band emissions (MCL approach)	
	Before mitigation	After mitigation
ATV (150m antenna) into LTE BS (30m antenna)	High	Medium
ATV (150m antenna) into LTE UE (1.5m antenna)	Medium	-

- **For analogue TV into LTE base station the separation distance required is greater than 10km but reduces to below 10km with mitigation. For the LTE mobile the separation distance required is of the order of 10km.**

Conclusions

- As a general rule the edges of the wanted service area are the most vulnerable to out of band interference and blocking is generally confined to areas in close proximity to the transmitters.

1a) LTE BS into ISDB-T

- Areas of interference predicted
- Mitigation required (e.g. filter on LTE BS to provide additional attenuation)
- Applying mitigation would reduce/prevent interference problem

1b) LTE UE into ISDB-T

- Some interference may be experienced but low probability – no mitigation suggested and would be difficult to implement on UE

Conclusions (2)

2a) ISDB-T into LTE BS

- Out of band interference and blocking problem
- Mitigation of ISDB-T critical mask and LTE BS Filter
- Low transmitter TV power on top (2) channels prevent blocking problem and reduces problem of out of band interference with ch51 only potential problem
- Careful planning required to reduce impact of ISDB-T on LTE BS.

2b) ISDB-T into LTE UE

- Blocking is limiting
- Mitigation of avoiding high power TV transmitter in top (4) channels.
- Some small areas close to ISDB-T remain where blocking may occur

Conclusions (3)

3a) LTE BS into Analogue TV

- Analogue emission in channel 51 or lower coordination distance is less than 6 km. If higher, then longer coordination distance need to be applied up to a maximum of 31 km (co-channel).

3b) LTE UE into Analogue TV

- Distances are much reduced compared BS due to the lower emissions.
- Co-channel operation in the uplink requires 1.2km. Drops rapidly in the first three adjacent channels to something of the order 50m and <10m beyond.

Conclusions (4)

3a) Analogue TV into LTE BS

- Separation distances are high >10km
- With mitigation (filter) this drops typically below 10km

➢ Frequency and geographic separation required to reduce interference during switchover

3b) Analogue TV into LTE UE

- Separation distances relatively high
- With 20MHz separation distance required significantly reduced but still ~10km .

➢ Frequency and geographic separation required to reduce interference during switchover.

Recommendations

- **The following recommendations should be considered:**
  - **Apply an emission filter to the ISDB-T transmitter to achieve, and ideally exceed the critical transmission mask.**
  - **Apply an emission filter to the LTE base station to reduce out of band interference**
  - **Apply a receiver filter to the LTE base station to reduce blocking interference.**
  - **Adopt post dividend plans that avoid high power emissions in the upper TV channels (especially channels 48-51).**
  - **Have a frequency separation of at least 20MHz between the analogue TV and the LTE receivers to help reduce the separation distances required to an acceptable level during the analogue to digital transition period.**
  - **Apply mitigation at the domestic TV receiver on a case by case basis to overcome any local interference issues.**
- **The general conclusion is provided suitable mitigations are applied that coexistence between LTE and ISDB-T is possible.**

Further improvement

- **Additional mitigation techniques:**
  - Detailed analysis of the areas where the co-existence is not satisfactory.
  - In such areas low-power ISDB-T gap-fillers can be considered.
  - Using highly directional MIMO antennas at LTE BS can be very efficient.
- **Higher accuracy of predictions and analysis:**
  - Using high-resolution terrain-based modelling for coverage predictions of both the ISDB-T and LTE services.
  - Monte-Carlo dynamical analysis of the population coverage by LTE services.
  - Closer look into the impulsive interference by the LTE UE, especially in the indoor mode.

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