PLANNING CHALLENGES

LTE Forum
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ATDI in a few words

ATDI is a French company with more than 20 years of experience in the industry.

Provides software and services in radio communication:

- Radio network planning & optimization (civil & military)
- Spectrum management
- Digital cartography

Composed of engineers with high level of expertise.

A significant number of clients: around 1,000 references.

Close to the customer with 10 local ATDI offices and a network of local distributors.
**ICS telecom**
The most comprehensive software for any kind of radio network planning: broadcasting, microwave, WiMax, LTE, mobile, PMP, etc., allowing coexistence analysis.

**ICS manager**
The most complete and efficient spectrum management platform for national regulators.

**HTZ warfare**
The Infrastructure and tactical electronic warfare radio network planning tool, adapted for new military concepts.

**ICS map server**
Advanced software system designed to produce and manage digital cartography.
LTE planning challenges

Today’s presentation focuses on one of the major challenges around LTE:

The coexistence LTE ↔ DVB-T

Numerous other challenges are associated to the proper deployment of LTE networks and are also addressed by ATDI’s solutions.
LTE Planning Considerations

Through a relevant use case, ATDI shows some of the key challenges of planning LTE networks in order to avoid:

• Interferences
• Unsecured network
• Reduced quality of service
• Unsatisfied customers

These radio planning techniques provided by ATDI are addressed to:

• Mobile operators deploying LTE networks
• Broadcasters co-existing with LTE networks
• Regulation authorities overseeing the technology transitions
Coexistence LTE ↔ DVB
Digital broadcast switchover under way

| Launch of the Digital Terrestrial Television (DTT) |
| Switch from analogue services |
| Release of a significant amount of spectrum: |
| The Digital Dividend |
| Allocation of part of the released spectrum to LTE |
| Cohabitation of Digital Television (DVB-T) and Mobile communication (LTE) within the same band |
| Coexistence issues with significant technical and economical impact |

LTE planning challenges

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Coexistence LTE ↔ DVB
Digital broadcast switchover under way

Multi-technologies technical coexistence studies have to be performed by the operators and the broadcasters in order to:

• Quantify the impact of each technology over the other
• Analyze the affected population and services
• Estimate the cost of such deployment

LTE planning challenges
ATDI has helped numerous operators, broadcasters and regulation authorities to assess the impact of LTE800 onto existing DTT services:

• Auction slots in the 790-862 MHz range to operators for LTE mobile networks

• Identify any potential interference problems

=> Description of case studies follows
Challenge was that the lowest block of spectrum due to be auctioned was immediately adjacent to the allocation for digital broadcasting.

Small guard band between the two services.
Coexistence LTE ↔ DVB: Case study

Objectives:

• Inform stakeholders of any technical constraints prior to auction of the dividend spectrum

Selected key assumptions:

• Interference from LTE network into DVB-T network to be analysed
• Channels FDD1 and FDD2 were considered as sources of interference and studied for every interference case
• The three highest DVB-T channels were studied for adjacent channel interference
• All DVB-T receiver channels were considered to suffer interference
• The DVB-T service for fixed rooftop antennas was modelled at 10m above ground level using directional antennas
• All of the receiving antennas were directed towards the best server

LTE planning challenges
Coexistence LTE ↔ DVB: Case study

Methodology

Consider LTE signal interference only into the upper three DVB-T channels (58, 59 and 60)

In case of blocking of the DVB-T receiver by an LTE signal, all UHF DVB-T channels are considered

- Accurate Digital Terrain Model (DTM)
- Recent clutter model
- Population data
Coexistence LTE ↔ DVB: Case study

Recent clutter data:
- Rural
- Industrial Area
- Urban 30m
- Water
- Airport
- Etc.
- Suburban
- Urban 15m
- Vegetation
- Forest
- Inland Water
Coexistence LTE ↔ DVB: Case study
Out of band interference and Protection Ratio

Out of band interference:

- Occurs when unwanted LTE signals from an adjacent channel to the DVB-T channels are received by the DVB-T receiver and interfere with the receiver preventing it from decoding the DVB-T signal correctly

Protection Ratio (PR):

- The minimum ratio between the wanted (DVB-T) and the unwanted (LTE) signal to ensure error free reception
Coexistence LTE ↔ DVB: Case study

**Blocking:**

- Occurs when a strong unwanted signal prevents the receiver from detecting a wanted signal.
- This interference can occur even when the wanted signal is high and the effect is not as frequency selective as adjacent channel interference.
- Likely to occur only in close proximity to the LTE base stations.
Coexistence LTE ↔ DVB: Case study
Out of band interference

Protection ratio between wanted signal (green solid line) and unwanted signal (red dashed line)
Coexistence LTE ↔ DVB: Case study

Service area calculation:

Best server (yellow arrow) calculation model

DVB-T transmitter

70 dBµV/m

DVB-T receiver

66 dBµV/m

E_{med} = 56 dBµV/m

DVB-T transmitter

68 dBµV/m

LTE planning challenges
Coexistence LTE ↔ DVB: Case study

Antenna discrimination

Using directional antennas to reduce unwanted signal strength from other directions.
Coexistence LTE ↔ DVB: Case study

LTE network modeling

Depending on the location, study and scope of work, various simulation conditions have been used:

- Antennas height
- Propagations models
- Antennas characteristics

ICS telecom can model and simulate any configuration based on the environment and end-customer’s requirements
Coexistence LTE ↔ DVB: Case study

Flexibility in terms of modeling

Propagation Models

LTE planning challenges
Coexistence LTE ↔ DVB: Case study
Flexibility in terms of modeling

Antenna Modeling

LTE planning challenges
Coexistence LTE ↔ DVB: Case study

Interference calculations

- The assessment focused on interference in each of the broadcast channels (58, 59 and 60) caused by the LTE channels (FDD1 to FDD2).

- The maximum frequency offset is between DVB-T channel 58 and LTE FDD2, which is 22 MHz.
• To calculate the interference between DVB-T and LTE, the protection ratio is calculated.

• Table shows protection ratio versus frequency separation between the channel edges of the wanted and interfering signals.

<table>
<thead>
<tr>
<th>Channel edge separation (MHz)</th>
<th>PR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-33</td>
</tr>
<tr>
<td>6</td>
<td>-37</td>
</tr>
<tr>
<td>9</td>
<td>-40</td>
</tr>
<tr>
<td>14</td>
<td>-39</td>
</tr>
<tr>
<td>17</td>
<td>-39</td>
</tr>
<tr>
<td>22</td>
<td>-45</td>
</tr>
</tbody>
</table>
Coexistence LTE ↔ DVB: Case study

Blocking

DVB-T transmitter blocking by LTE signal

green - wanted DVB-T signal,
red - unwanted LTE signal

LTE planning challenges
Can be presented in various ways:

- By region, counties, cities, nation wide
- Impact by MUX, channel from FDD1/2/3, etc.
- Many maps or views are made available
- By population
- Coordination at borders (in/out bound) as ICS telecom also handles coordination aspects
Coexistence LTE ↔ DVB: Case study

Interference map (C/I) of the LTE network on a specific DVB-T Allotment
(interference zones highlighted in pink)
## Out of band interference:
Number of people affected by out of band interference

<table>
<thead>
<tr>
<th></th>
<th>FDD1</th>
<th>FDD2</th>
<th>FDD3</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUX1</td>
<td>14,949</td>
<td>4,182</td>
<td>1,800</td>
</tr>
<tr>
<td>MUX2</td>
<td>1,576</td>
<td>739</td>
<td>596</td>
</tr>
<tr>
<td>MUX3</td>
<td>3,208</td>
<td>1,180</td>
<td>741</td>
</tr>
<tr>
<td>MUX4</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>MUX5</td>
<td>2,025</td>
<td>692</td>
<td>348</td>
</tr>
</tbody>
</table>
Coexistence LTE ↔ DVB: Case study

Interference results for MUX 1 by LTE FDD1, FDD2 and FDD3 on DVB-T channel 60 (by county)

<table>
<thead>
<tr>
<th>County</th>
<th>Channel 60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FDD1</td>
</tr>
<tr>
<td></td>
<td>Pop #</td>
</tr>
<tr>
<td>Østfold</td>
<td>3,447</td>
</tr>
<tr>
<td>Akershus</td>
<td>160</td>
</tr>
<tr>
<td>Buskerud</td>
<td>3,977</td>
</tr>
<tr>
<td>Vestfold</td>
<td>5,900</td>
</tr>
<tr>
<td>Telemark</td>
<td>1,327</td>
</tr>
<tr>
<td>Aust-Agder</td>
<td>105</td>
</tr>
<tr>
<td>Nordland</td>
<td>28</td>
</tr>
<tr>
<td>Troms</td>
<td>5</td>
</tr>
</tbody>
</table>
• For reference, a specific project showed one of the most efficient mitigation techniques was found to be to limit the interfering LTE base stations to only vertical polarisation.

• Cross-border analysis between countries need to be also processed in terms of mutual impact LTE ↔ DVB.
Coexistence LTE ↔ DVB: Case study
Coordination at the border

LTE planning challenges
LTE Planning Considerations

Focus of this presentation was co-existence LTE ↔ DVB

Additional and fundamental considerations for proper LTE planning supported by ATDI:

• A key challenge is to support high data requests from the users (web browsing, video share...). ICS telecom allows to analyze not only the worst coverage but also according to different traffic scenarios (depending of number of resource blocks allocated to each cell, number of users by cells...)

• ICS telecom allows via “LTE throughput calculator” to determine what the best e-nodeB configuration is in order to achieve a given throughput
LTE Planning Considerations

Focus of this presentation was co-existence LTE ⇔ DVB

Additional and fundamental considerations for proper LTE planning supported by ATDI:

- The usage of MIMO antenna is a very important scheme: The spectrum efficiency is closely depending of the usage of MIMO antennas

- Inter-system analysis (handovers, traffic, interferences...) between LTE and 2G/3G/3.5G and WiMAX systems

- Generation of LTE users and parenting between this population and the LTE network

- ICS telecom support the LTE broadcast system (MBSFN) for SFN analysis
Advanced radio-planning solutions

In order to optimize existing and emerging networks in terms of:

- Performance (coverage, QoS)
- Interference
- Co-existence (today and tomorrow)
- Cost of ownership

Comprehensive and advanced radio-planning solutions need:

- To support all radio technologies
- To manage interference and coexistence considerations within and between competing technologies in the frequency spectrum
Advanced radio-planning solutions

LTE planning challenges