Applied Digital Broadcast Planning and Implementing
Essential in planning Maps

Aerial View

DEM View
Essential in planning Maps

Clutter View

Solutions in Radiocommunications
Clutter definable options

<table>
<thead>
<tr>
<th>Clutter Code</th>
<th>Name</th>
<th>Attenuation (dB)</th>
<th>Clutter Height (m)</th>
<th>Reflection Factor</th>
<th>Surface Factor</th>
<th>Diffusion Factor</th>
<th>Station Width (m)</th>
<th>Station Height (m)</th>
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* Used for coordination  ** Used for sub-layer

Clutter parameters include:
- Clutter Code
- Name
- Attenuation (dB)
- Clutter Height (m)
- Reflection Factor
- Surface Factor
- Diffusion Factor
- Station Width (m)
- Station Height (m)

ATDI
Solutions in Radiocommunications
Coverage View 3D/2D
Percentage Layer
Full 3D navigation
Case in planning digital Broadcasting

BBC DAB
Planning for Mauritius Island
Planning France Digital Broadcasting
DAB with FM Broadcasting

The BBC Network
- 4 Radio Channels in Stereo coded with 192kbits/s
- 1 Radio Channel in Mono coded with 96kbits/s
- Speech-based programs at lower rates (typ. <96kbits/s)
- 12.5MHz of Band III allocated to DAB (217.5-230MHz)
BBC network availability

Key Concept

- MUSICAM - MPEG Layer 2
- OFDM
- FEC CODING
- GAP FILLERS
- SFN
- FLEXIBILITY

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<td>(192 Kbit/s)</td>
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BBC Implementation

4 MODES OF OPERATION (I TO IV):

- Mode I: for terrestrial SFN (greater site spacing)
- Mode II: for single-station broadcast and hybrid networks up to 1.5GHz
- Mode III: satellite broadcast and earth dispatch, up to 3GHz
- Mode IV: for optimal SFN in L band

SEVERAL FREQUENCY RANGES (UHF/VHF/L Band)
Feasibility of SFN and gap fillers
Simple Quasi-Omni RX Antennas
BBC DAB Network

Radio freq properties

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode I</th>
<th>Mode II</th>
<th>Mode III</th>
<th>Mode IV</th>
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<tr>
<td>Bandwidth</td>
<td>1.536MHz</td>
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<tr>
<td>Number of carriers</td>
<td>1536</td>
<td>384</td>
<td>192</td>
<td>768</td>
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<tr>
<td>Guard Interval</td>
<td>246µs</td>
<td>62µs</td>
<td>31µs</td>
<td>123µs</td>
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<tr>
<td>Distance between TX in SFN</td>
<td>&lt;=60km</td>
<td>&lt;=20km</td>
<td>&lt;=10km</td>
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<tr>
<td>Carrier spacing</td>
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<td>4kHz</td>
<td>8kHz</td>
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</table>

MUSICAM Audio Coding (8 to 384kbits/s), sampling @48 or 24kHz

Scrambling

FEC + Time & Frequency interleaving

COFDM up to 1536 carriers, spaced 1kHz
Example of DVB-T network planning
Mauritius island (Indian ocean)
Planning a new digital broadcast
(Step 1/4)

- One of the existing analog network is « duplicated »:
- Same sites:
  - 14 sites for the analog program
  - Only 7 for the digital multiplex
- Same transmitting antennas
- Same powers
- Same frequencies
Planning a new digital broadcast
(Step 2/4)

- The coverage of the digital transmitters are computed.
- The powers of the digital transmitters are adjusted to ensure the coverage of the whole island.
- A lower power is required:
  - Typically 1000 W for the analog program.
  - Only 100 W for the digital multiplex (lower thresholds).
Planning a new digital broadcast
(Step 3/4)

- A channel N-1 or N+1 is randomly attributed per site.
- Analog program:
  - channel 27 of the analog frequency plan
- Digital Multiplex:
  - channel 26 or channel 28 of the digital frequency plan
- Digital signals are extremely robust
- Hence interferences caused by digital signals on analog signals
Planning a new digital broadcast
(Step 3/4)

- The digital transmitters causing interferences are isolated.
- They are transferred from channel N-1 to channel N+1 or vice versa.
- It is then possible to avoid almost any harmful interference.
- The new network is now being tested.
CSA’s requirement in France

- 6 multiplex (= 6 frequencies)
- 5 or 6 programs per multiplex

33 programs

Reserved for state and local channels

22 programs left to be attributed to the candidates
CSA’s requirement in France

- 29 sites located around the main cities in France
- On each site, 6 transmitters (1 per multiplex)
- For each one of the 174 transmitters, the main technical characteristics:

For each one of the 174 transmitters, an antenna pattern
CSA’s requirement in France

- 28 sites + 1 in Corsica
- 6 transmitters on each site
- Sites located around the main cities
- The East and North parts of France have few transmitters
- Problems of coordination with neighboring countries
Present Analogue Network

- The existing analog network
  - 1,000 mains transmitters
  - 11,000 sub or re-transmitters
Response to technical specifications

Gauge specified by the CSA

Mast simulation

Pattern matching the gauge

Solutions in Radiocommunications
## Site Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Area</th>
<th>Code</th>
<th>Site</th>
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Site found in the European coordination file

All areas specified by the CSA already contain an existing site

**Solutions in Radiocommunications**
Why were the existing sites privileged?

Existing analog site

Planned digital sites

Today

Tomorrow?
Expected Problem

• Digital broadcasters will probably be obliged to rent the existing analog sites to TDF, sole owner of all existing analog sites

• Problem of fair competition:
  • the new broadcasters will be clients & competitors of TDF
The Maps

2D map sample (image)  Corresponding 3D map (MNT)

Solutions in Radiocommunications
Resulting coverage

Coverage of 1 out of the 6 multiplex
- Partial coverage of the country, smaller than the analog coverage
- Global analysis of the covered surfaces
- Global analysis of the covered populations
- Detailed analysis, city per city
Economic model

- The new programs are supposed to be financed by advertisement only
- It requires to cover a large population
- It is necessary to simulate and to compare the performances of the multiplex
Differences between the multiplex

- Some multiplex are slightly better than others.
- All in all, they are fairly equivalent.
- Technical parameters have been adjusted so that no multiplex is privileged.
User’s advantages

- Already pointing towards an analogue transmitter
- Re-orientation should be avoided as far as possible
- This orientation allows to receive with a single antenna all the digital multiplex and all the analogue programs

Multiplex R1

Multiplex R2

Solutions in Radiocommunications
Conclusion of the migration

- **Advantages**
  - Availability of these sites
  - Limitation of the problem of initialization for the receiving antennas
  - Easier to determine an adequate frequency plan of the network

- **Disadvantages**
  - Problem of fair competition between existing and new broadcasters
  - Sometimes, for historical reasons, the sites locations are not optimized
Market issue

Key issue to ensure the success of the new programs

- to concentrate around the main cities
- To adjust the technical parameters so that all multiplex cover a sufficient and equivalent population
- to perform intensive calculations considering
  - The coverage's of the transmitters
  - The population figures
Recording a station parameter

- Spectrum allocation
- Channel assignment
- Video system used
- Signal input
Single Frequency Networks Overview

What are they?
Terminology
Simple technologies
Complex modulation SFN
ATDI Modelling tools
SFN Principle

- Multiple transmitters
- Shared channel
- Same information
- Common modulation
- Simultaneous launch
Advantages

- Increased availability
- Can be spectrally efficient
- Single channel receivers (e.g. paging)
Disadvantages

- Symbol rate / audio band must be less than DS
- Destructive interference if DS or flight times are too great
- Synchronised emission
- Frequency stability
- Generally limited to broadcast or low capacity traffic delivery systems
Technologies

- AM spaced carrier
- FM offset carrier
- Complex modulation (Broadcast OFDM)
AM Spaced Carrier

- Carriers spaced within channel.
- Heterodyne outside audio passband
- Not as efficient due to large offset of carriers
- Limited number of tx possible
- Used in Airband

Tx1

Tx2

Tx3

fc
narrowband channel
FM Offset Carrier

- Carriers slightly offset to avoid static nulls
- Heterodyne below audio passband
- Receiver captures strongest signal
- Large number of tx possible
- Used in Paging (data), PMR (voice)
Complex Modulation (OFDM)

- Channel split into narrowband bins
- Information rate high overall but slow symbol rate in each bin
- DSP equalises delay spreads over channel.
- Guard interval approx $\frac{1}{4} t_{\text{symbol}}$ to prevent ISI
- Tolerant to selective fading & multi-path if DS less than $t_{\text{guard}}$
- SFN’s are a case of multi-path
- Network possible gain due to decorrelated paths
- Used in DVB, DAB.
ATDI Modelling Tools

- Composite coverage plans
- Frequency offset plans
- SDS interference assessment
- Launch delay optimisation
- Network gain areas
- Network gain calculation
SDS Interference Assessment

- Power delay protection mask
- Quantify interference over populated zones

\[ \begin{align*}
A & \xrightarrow{t_1} C/I_1 \\
& \xrightarrow{t_2} C/I_2 \\
& \xrightarrow{t} \text{Tx1, Tx2, Tx3}
\end{align*} \]
Launch Delay Optimisation

- Interference optimised by shifting into unimportant regions using launch delay
- Areas specified with % importance
- Other optimisations
  - Power reduction
  - Antenna height drop
  - Antenna pattern change (e.g. downtilt)

Launch delay optimised

>125
>100
>75
>50 usec
Network Gain Areas

- Simple tool to analyse no of servers
- Maximum gain can added to server areas
Network Gain Calculation

- SFN gain up to 14dB for 99% locations
- Depends on relative levels and delays and number of servers
- T-DAB model

Composite field strength

Effective field strength = composite + network gain
Conclusion

- Overall aim: increase network availability
- 2 simple examples and an example of a complex scheme.
- Suite of planning tools to help for examples above