This part of the course ...

• ... is prepared by
  Wolfgang Leister
• ... uses material from Eureka 147
EUREKA DAB

- reliable multi-service digital broadcasting system for
- mobile, portable and fixed receivers
- with non-directional antenna
- audio programmes
- data services

EUREKA DAB

- EUREKA-147 (1992)
- ITU-R recommendation (1994)
- ETS 300401 European Standard (1997)

- useful bit rate up to 1.5 Mbit/s
- error protection (25-300 % of bitrate)
DAB Services

- MPEG 1 / MPEG 2 Audio Layer 2
- Flexible audio bit-rate 8 - 384 kbit/s
  (5-6 hq. stereo / 20 rq. mono programmes)
- Data services
- Programme Associated Data (PAD)
- Conditional Access (CA)
- Service Information (SI)

Data Services

- Programme Associated Data (PAD):
  667 bit/s - 65 kbit/s; at the end of DAB/ISO audio frame.
- Independent Data Services:
  - 24 ms logical frames with nx8 kbit/s
  - packet mode
  - part of FIC (Fast Information Channel)
Data Services

• Conditional Access
• Service Information
  – basic programme service label
  – programme-type label
  – dynamic text label
  – programme language
  – time and date for display or recorder control
  – switching to traffic reports, announcements
  – cross reference to the same service
  – transmitter identification

Generation / Reception
Channel Coding

- energy dispersal scrambling
  - add pseudo-random bit sequence to data
  - to randomize shape of data (power saving)

- convolutional encoding
  - adding redundancy to data
  - UEP: Unequal Error Protection

- time interleaving
  - reduce risk for total loss of data
  - spread data over longer time

Unequal Error Protection

- Parts of audio signal are less sensitive to transmission errors!
- Drawing shows added redundancy:
Main Service Multiplex

• encoded / interleaved data ⇒ MUX
• data gathered to sequences every 24 ms
• combined bit-stream = MSC (Main Service Channel)
• net bit-rate: 0.6 - 1.8 MBit/s (dependent on convolution rate)
• DAB signal 1.536 MHz bandwidth
• possible bit-rates ⇒ ⇒ ⇒ ⇒ ⇒
• MCI (Multiplex Configuration Info)
• MCI is part of FIC

<table>
<thead>
<tr>
<th>Audio Bit-rate kBit/s</th>
<th>Protection level incrementing protection level</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0, 5, 16, 64, 48, 24</td>
</tr>
<tr>
<td>64</td>
<td>0, 6, 20, 10, 14</td>
</tr>
<tr>
<td>128</td>
<td>13, 10, 9</td>
</tr>
<tr>
<td>192</td>
<td>9, 7, 5</td>
</tr>
<tr>
<td>224</td>
<td>7, 6, 5</td>
</tr>
<tr>
<td>256</td>
<td>6, 5, 3</td>
</tr>
</tbody>
</table>

Transmission frame

• Fixed frame structure
• Three channels:
  – Sync
    • null symbol
    • phase ref
  – FIC
  – MSC
OFDM

- Orthogonal Frequency Division Multiplexing
- divide into large number of bit-streams
- with low bit-rates each
- orthogonal carriers
- differential QPSK
- symbol duration larger than delay spread
- insert a temporal guard interval

- large number of orthogonal carriers with FFT
- signal spectrum is ~ rectangular, Gaussian noise like
- DAB block
## Transmission Modes

<table>
<thead>
<tr>
<th>System Parameter</th>
<th>Mode I</th>
<th>Mode II</th>
<th>Mode III</th>
<th>Mode IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frame duration</td>
<td>96 ms</td>
<td>24 ms</td>
<td>24 ms</td>
<td>48 ms</td>
</tr>
<tr>
<td>Null symbol duration</td>
<td>1297 ps</td>
<td>124 ps</td>
<td>158 ps</td>
<td>648 ps</td>
</tr>
<tr>
<td>Guard interval duration</td>
<td>246 µs</td>
<td>42 µs</td>
<td>31 µs</td>
<td>123 µs</td>
</tr>
<tr>
<td>Nominal maximum transmitter separation for SFN</td>
<td>96 km</td>
<td>24 km</td>
<td>12 km</td>
<td>48 km</td>
</tr>
<tr>
<td>Nominal frequency range (for multiple reception)</td>
<td>≤ 1.75 MHz</td>
<td>≤ 1.5 GHz</td>
<td>≤ 3 GHz</td>
<td>≤ 1.5 GHz</td>
</tr>
<tr>
<td>Speed/coverage trade-off</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Useful symbol duration</td>
<td>1 ms</td>
<td>256 µs</td>
<td>125 µs</td>
<td>500 µs</td>
</tr>
<tr>
<td>Total symbol duration</td>
<td>1248 µs</td>
<td>312 µs</td>
<td>130 µs</td>
<td>625 µs</td>
</tr>
<tr>
<td>No. of modulated carriers</td>
<td>13-30</td>
<td>18-4</td>
<td>192-704</td>
<td></td>
</tr>
</tbody>
</table>

## DAB Distribution Network

- DAB Ensemble
- ETI: Ensemble Transport Interface
Receiver Data Interface

- RDI: Receiver Data Interface (up to 1.8 Mbit/s)
- DAB based MM services
- Transport mechanisms:
  - stream mode
  - packet mode
  - PAD
- MOT
  (Multimedia Object Transfer Protocol)

DAB Signal Generation
Deployment

Applications

- Data management
- Traffic and Travel Information
- Text Transmission
- Electronic Newspaper
- Picture Transmission (JPEG + HTML)
- TV Transmission to Mobiles (MPEG1/2)
- Fax Printout
- Differential GPS

other than audio ...
Literature and Links

DAB:
http://www.worlddab.org

Wolfgang Hoeg, Thomas Lauterbach:
“Digital Audio Broadcasting - Principles and Applications“
Wiley, 2001

End of Part