A summary of the Stratix Report; “Digitisation of Wireless Microphones”

APWPT session, IBC, Amsterdam 2018

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Birthplace of
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1. Overview on STRATIX Report
Overview on STRATIX Report

Basic data

Contractual
- AT Agentschap Telecom NL (Spectrum regulator) contracted STRATIX Analysts to conduct study
- Contracted as a reaction on discussions with APWPT
- FAU Prof. Fischer approached by STRATIX to assist in studies
- STRATIX located in Hilversum, NL – near media park…

Timelines
- Studies mainly conducted Feb – April 2017
- 2nd May 2017 presentation of draft to AT, some iterations followed
- Report (73 pages) finalized 24th January 2018
- Presented to CEPT in Jan 2018

Interviewed parties
- Eric Pierens, NEP Worldwide
- Roland Mattijsen, Daniel Kee, Audio Electronics Mattijsen
- Massimo Polo, Wisycom
- Prof. Herre and Prof. Edler, Audiolabs of FAU and Fraunhofer
- Edgar Reihl, Wolfgang Bilz, Mark Brunner, Shure
- Axel Schmidt, Sennheiser
- Kees Heegstra, Camel-co
Overview on STRATIX Report

Main questions for study

**First Question**
- What type of PMSE applications that make use of the UHF band can be digitised and what types of applications cannot?

**Second Question**
- How much spectral savings could be obtained from digitisation of the applications that can be digitised, given the demands and constraints at large media event?
Overview on STRATIX Report

Research method

- **Interviews**
  - Dutch PMSE sector
  - Suppliers of equipment for the PMSE sector
  - Typical 'large scale events' and 'bottleneck events', scenario candidates
  - The ideal situation for audio
  - Current constraints

- **Desk research**
  - Constraints of analogue and digital audio encoding
  - Commercial availability of solutions
  - Near future solutions for audio encoding
  - Scenario parameters for 'analog' and 'digital' cases

- **Analysis**
  - Final selection of scenario
  - To what extent can market demand be met?
  - What are the constraints?
  - Will digitisation deliver a saving

- **Feedback and reporting**
  - Communicating intermediate results
  - Presentation PMSE sector
  - Finalising report
2. Expectations on Digitisation
Expectations on Digitisation
Views

Expectations
• There was large expectation that digitization of PMSE will lead to large savings on spectrum
• More efficient use of spectrum was expected
• There was also the view that mainly the total amount of spectrum for PMSE is key regardless where it is located, although focus of study was UHF
• The number of links per 8 MHz channel would raise significantly
3. Report findings
Report findings
Digital transmission system

Transmitter

Information source
Microphone
Capsule

A/D Converter

Source Coding, compression

Channel Coding protection

Modulation

Radio
Upconversion

Power Amplifier (PA)

Antenna

Receive

Information sink
e.g. mixing console

Antenna

Radio Downconversion

Low Noise Amplifier
LNA

Demodulation
and detection

Channel Decoding

Source Decoding,
Decompression

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Report findings
New challenge, the “digital cliff”

Notes
• Only in a small window digital does much better, but above signal is totally lost, consequence additional margin needed for digital, as collapse might trigger lengthy resync
• Digital allows for easy scalability, however also present by narrow band analog PMSE
Report findings
Compression in analog versus digital

Notes
• Analog PMSE Compander equivalent 2:1 compression
• Digital PMSE compression 2:1 for high quality, 4:1 for robustness in dense packing of radio links
• No real difference on compression between analog and digital

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Report findings
Audio quality levels

Codec quality & datarate

Today’s digital PMSE does not provide Studio quality, prepare for the future?

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Report findings
Shannon bound – what comes on top?

Notes
- The high SNR operating point of PMSE is inherent to PMSE application and cannot be overcome by digitisation
- Fade margin due to narrowband and latency hit comes on top of Shannon bound
- So where can we win something?
Report findings
Circulators/Isolators inside wireless mic

Notes
- Circulators/Isolators prevent signals getting backwards into wireless mic
- Forward and backward waves intermodulate and lead to IM products spreading into neighboured frequencies
- Spectrum fragmentation implies bank of iso-/circulators, not cost efficient
- The IM problem is relaxed mainly by better radio HW, not whether analog or digital PMSE
Report findings
HW innovation by electronic circulator?

Notes
• Funding for HW research needed!
• Large Chip developments too costly for a PMSE equipment supplier
Report findings
Dense packing of links

Overlap of spectrum mask with today’s equidistant spacing of 23 Ch/8MHz for spectrum @ <1GHz

Overlap of spectrum mask with today’s equidistant spacing of 23 Ch/8MHz for spectrum @ >1GHz

• Spectrum mask also is a limiting factor for more dense packing of PMSE links
• Very difficult to tighten in real HW

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Report findings
Dense packing of links

<table>
<thead>
<tr>
<th>Number of IM free channels</th>
<th>noIM</th>
<th>IM3</th>
<th>IM3.IM5</th>
<th>Shure Info for digital mics</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>11</td>
<td>10</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>

Max number of IM free frequencies in 8 MHz, assuming min spacing of 300 kHz with 25 kHz steps

Notes
- IM problems significantly reduce packing of links
- Due to spill over by spectral mask there is strong interference
- Large SNR operating point not possible
- Due to “Near-far-problem” dense packing only possible with comparable RF levels at RX
- To keep levels approx. the same, movement must be restricted
Report findings
Techniques for robustness of transmission

Notes
• Space Diversity → RX Diversity (SIMO) → MIMO in future?
• Frequency diversity → not present today, narrowband 200 kHz, regardless analog/digital
  PMSE → Wideband PMSE in future?
• Time Diversity → not possible in PMSE due to latency constraints → this is the gain other
digital systems catch
4. Conclusions & recommendations
Conclusions & recommendations

wrap up

Conclusions

• Benefits from digitisation were overestimated
• Latency hit in digital, Mics go digital, but IEM stay analog, risk of irritating artist
• Analog also uses compression techniques (Compander), compression not new in digital
• Benefits in digital mainly come from:
  – Large compression → due to quality constraints restricted 2:1…max 4:1, not a lot to
    catch for digital PMSE in comparison to analog compression
  – Channel coding → these gains do not show up under low latency constraints as in
    PMSE, other digital systems make large use of time diversity, implies large latency,
    not applicable to PMSE
• Packing PMSE links more dense is facilitated by improved Radio HW
  (Isolators/circulator), only present in High End Equipment due to additional costs
• Rec for dense packing are more likely a consequence of improved radio HW than of
digital transmission
• Spectrum fragmentation for PMSE is contrary to Isolators/circulators as they have
limited bandwidth (banks of circulators needed)
• As regulators do - simply summing up spectrum pieces here and there is no answer to
the HW challenge
• Spectrum mask also a limiting factor for packing more dense
Conclusions & recommendations

wrap up

Recommendations

• As regulators, please allow for large contiguous spectrum chunks, not small pieces here and there

• Do not simply use the Shannon bound to compute spectrum demand, low latency and high quality demands by PMSE need to be quantified in

• Innovations in Radio Hardware needed, eg. Electronic tunable circulators, Switch mode PAs are more robust to TX Intermodulation

• With Digitisation of PMSE the narrowband nature of 200 kHz was kept, new PMSE systems should be wideband to explore frequency diversity for overcoming fading, necessary fade margin will disappear

• PMSE hasn’t looked into MIMO yet, so far only SIMO

• Opportunities for mm wave?

• PMSE community must prepare for the future

  3D Audio wireless?

  Studio quality 24 bit @ 192 kSa/s wireless?