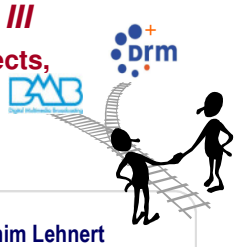
Digital Broadcasting 11th Workshop 15.-16.09.2010

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



Prof. Dr.-Ing. Andreas Steil
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► *Short review – Investigations of DRM+ in FM VHF band II (87.5 – 108 MHz)*

Lab measurements and two field trials in Kaiserslautern in 2008 and in 2009 with DRM+ in FM VHF band II successfully completed

Objectives:
- ☑ Investigations on **compatibility** between FM and DRM+
- ☑ Determination of **DRM+ coverage** for fixed and mobile reception

Positive technical results:
- ☺ DRM+ transmitters could be coordinated (**compatible with existing FM networks**)
- ☺ DRM+ transmitters show a **better coverage** than FM transmitters (equal ERPs) especially, in the service area, for mobile and portable reception
- ☺ DRM+ is **frequency economic** since SFN is possible

Negative regulatory results:
- ☹ **Available frequencies are not foreseeable** for a long time in VHF band II
- ☹ **Potential restrictions of aeronautical services** block the deployment as long as ITU-Recs for compatibility with digital systems in VHF band II are missing
- ☹ **Multinational coordination procedures** in Europe are missing

The - somewhat sad – conclusion is obvious:
- ☹ **Deploying DRM+ in FM VHF band II in Europe is impossible (mid/long term).**

► *Considerations of the deployment of DRM+ in VHF band III*

Is there another fitting broadcasting service band for DRM+ in Europe with a chance of a quicker deployment as in FM VHF band II?

VHF Band I (47- 68 MHz)	VHF Band III (174 – 230 MHz)
☹ Not a digital broadcasting services band of RRC-06	☺ Allocated to the digital sound broadcasting service in RRC-06
☹ Other services operate in VHF band I	☺ Huge amount of available frequencies without affecting the use of DAB
☹ Extensive network infrastructures, lack of clarity of the RX design (RF frontend, reception antennas)	☺ Digital radios for VHF band III are in the market for DAB reception.
☹ Propagation conditions are problematic; no frequency coordiniation agreements	☺ Coordination regulatories of RRC-06 are applicable for DRM+
☺ VHF band I is currently included in the DRM+ ETSI standard	☹ VHF band III is NOT currently included in the DRM+ ETSI standard – it's not a technical motivated border, more a fictive border to protect the DAB frontyard
☹ not feasable ☹	**☺ fitting candidate ☺**

► *Considerations of the deployment of DRM+ in VHF band III*

MOTIVATION for deploying DRM+ in VHF band III:
Acceleration of the digitalization of the sound broadcasting with DRM+ in addition to DAB+ in VHF band III, especially for local and regional sound broadcasters (DAB is uneconomical)

First: Clarifications on the technical level:

? Is DRM+ applicable with its system parameters in frequencies up to 230 MHz for **mobile reception** due to the OFDM subcarrier spacing?

? Is DRM+ **compatible to existing DAB networks**?

? Is DRM+, with its coverage and network infrastructure, an **alternative or even better solution** to **DAB/DAB+** for **local and regional sound broadcasters**?

? Can **DAB+ radios be updated for DRM+ reception** with low cost (antenna and RF frontend work in the same frequency band, audio decoding is the same, signal processing is similar) ?

► *Investigations of DRM+ in VHF band III (174 – 230 MHz)*

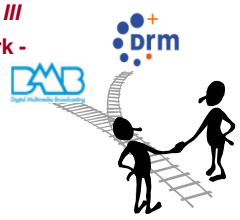
To clarify the questions regarding coverage and system parameters for a good mobile reception:
Laboratory measurements and field trials in Kaiserslautern were performed

Objectives (same as in the FM VHF band II inverstigations)**:**
☑ Investigations of **compatibility** between DAB/DAB+ and DRM+
☑ Determination of **DRM+ coverage** for fixed and mobile reception at high speed

Approach:
1.: Laboratory measurements with channel simulations
2.: Field trial under real conditions
3.: Proposals of planning parameters

► *So here we go: Outline*

DRM+, a perfect complement to DAB/DAB+ in VHF band III
- Technical results, planning aspects, and regulatory work -

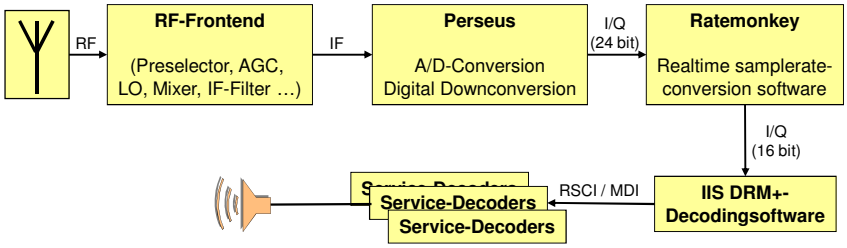


I. Selected elements of the DAB/DRM+ TX/RX chains
II. Lab measurements
III. Field trials
IV. Proposal for planning parameters
V. Outlook

Fachhochschule Kaiserslautern | University of Applied Sciences — Selected elements of the DAB/DRM+ TX/RX chains — LMK

► *DRM+ Prototype RXs: General architecture & overall parameters*

Rx-Name	Rx1	Rx2
RF-Frontend manufacturer	Maxim	Unkown
Frequency bands	VHF-II, VHF-III, L-Band	VHF-III, L-Band
IF-Frequency [kHz]	2.048	38.912
IF-Filter-Bandwidth [kHz]	133	1527
Sensitivity, 4/16-QAM [dBm]	-112 / -106	-117 / -112
Shoulder / dB (@-40 dBm)	36	37
Noise Figure [dB]	8.3	3.3
Near Carrier Phase Noise [dBc/Hz]	< -80	< -70



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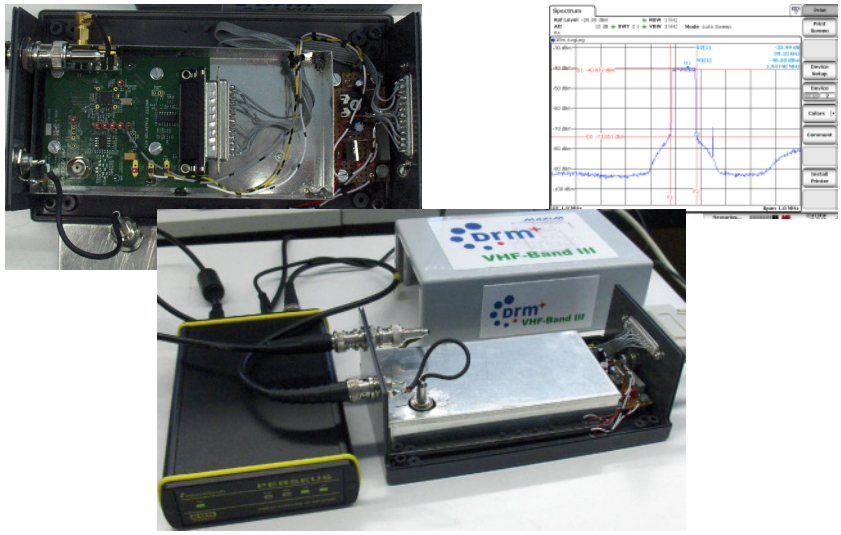
► *DRM+ Prototype Rx1: Some impressions ...*



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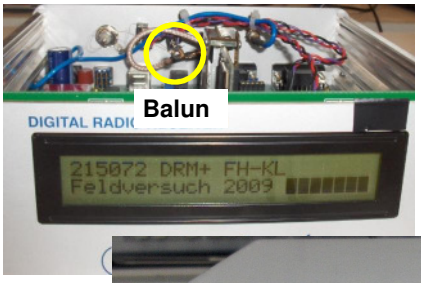
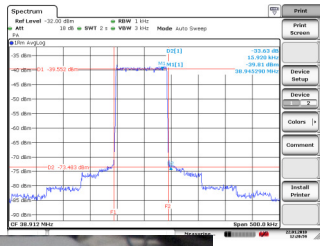
► *DRM+ Prototype Rx2 : Some impressions ...*





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► *DAB/DAB+ RX*

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Selected elements of the DAB/DRM+ TX/RX chains

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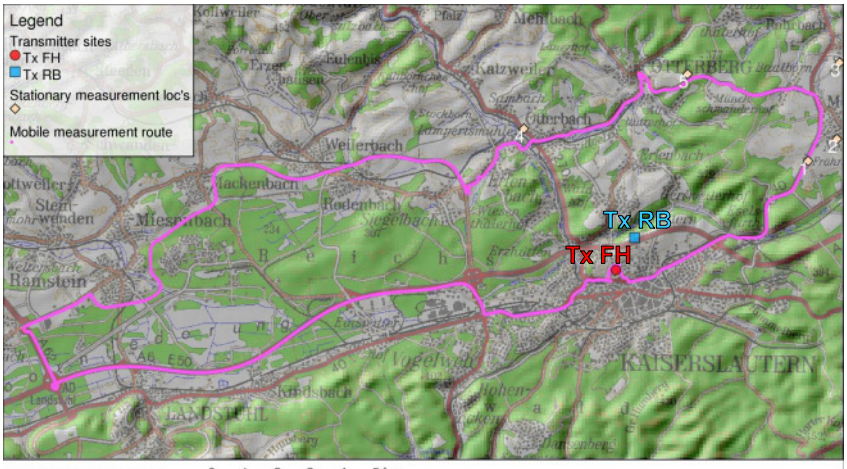
► *TX sites*



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Selected elements of the DAB/DRM+ TX/RX chains

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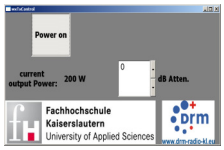
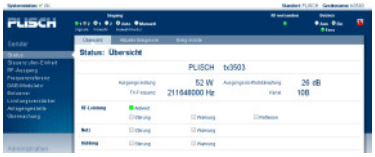
► *TX characteristics*

Tx name & location	„Am Kaiserberg“ (Tx FH) FH Kaiserslautern 07E 46 49 / 49N 27 10 [PD] 260 m asl, antenna: 30 m agl		„Am Rotenberg“ (Tx RB) KL-Rotenberg 07E 46 19 / 49N 27 39 [PD] 260 m asl, antenna: 50 m agl
System	DRM+, MSC: 4- or 16-QAM		DAB, DAB+
Frequency	211.648 MHz (10B)		211.648 MHz (10B)
Max. Power	90 W (ERP) Jan. to April	180 W (ERP) since May	135…300 W (ERP)
Antenna	Omni		5-elem. Yagi 6 dBi
Polarisation	vertical		vertical
Content	Audio (AAC+), sync. PRBS		Audio: Musicam (DAB), AAC+ (DAB+)
Equipment	Plisch ULE-Series		R&S SLA8000, Plisch TDA 3503





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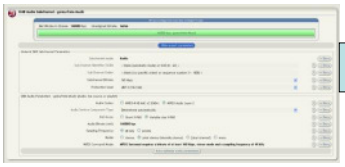
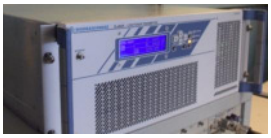
► *Transmitter KL-Rotenberg, DAB (Tx RB)*



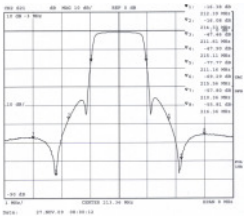
LAN — IIS DAB/DAB+-Content-Server R5 — WAN

ETI

LAN



DAB-Transmitter
R&S SLA8000 < May 2010
Plisch TDA3503S >= May 2010



DAB-Maskfilter;
Spinner; Ch. 10B

DAB / DAB+
135 … 300 (ERP)

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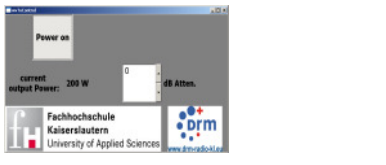
► *Transmitter KL-Kaiserberg, DRM+ (Tx FH)*

WAN

LAN — Spark+ DRM/DRM+ CS — SPARK+ OFDM-Modulator

LAN — IIS DRM/DRM+-CS

MDI/Ethernet



SMU 200A

GPIB

LAN — Controlling Computer

El. Atten.

Minicircuits ZX60-30LN

Plisch SDA730

+

Plisch ULE820

Plisch ULE820

+

DRM+
0 … 180 W (ERP)

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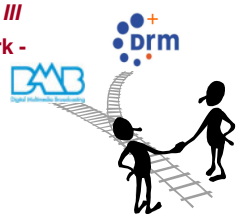
► So here we go: Outline

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



I. Selected elements of the DAB/DRM+ TX/RX chains

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DRM+, a perfect complement to DAB/DAB+ in VHF band III

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► Part II: Lab measurements

1. DRM+ mobile reception performance

2. Protection ratios DRM+/DAB

Mobile reception with DRM+ in VHF band III ?

Q: Why should mobile reception in VHF band III be a problem?

A: Since the received signal is subjected to a Doppler shift!

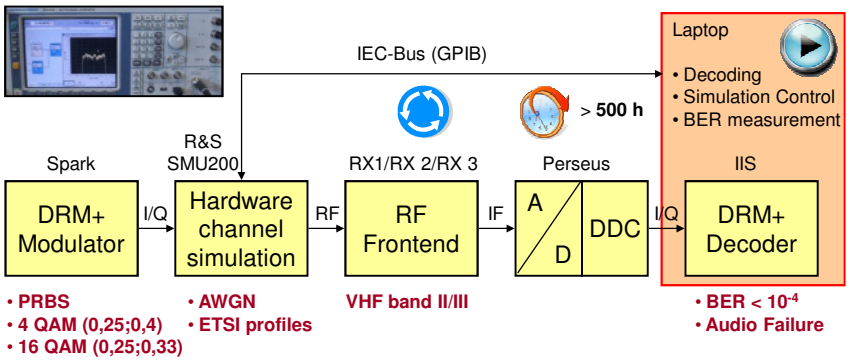
$$f_D = \frac{v}{c_0} \cdot f_0 \cdot \cos(\alpha) \quad \overset{!}{<<} \quad \Delta f$$

f_D	Doppler frequency
v	speed
c_0	speed of light
f_0	carrier frequency
α	angle of incidence
Δf	OFDM subcarrier spacing

Assuming a speed of 200 km/h, we have (roughly)

	DRM+		DAB
	VHF band II	VHF band III	VHF band III
Δf [Hz]	444	444	1000
$f_{D,max}$ [Hz]	20	42	42
$f_{D,max} / \Delta f$	0.045	**0.082**	0.042

► *Setup to assess the mobile performance by lab measurements*



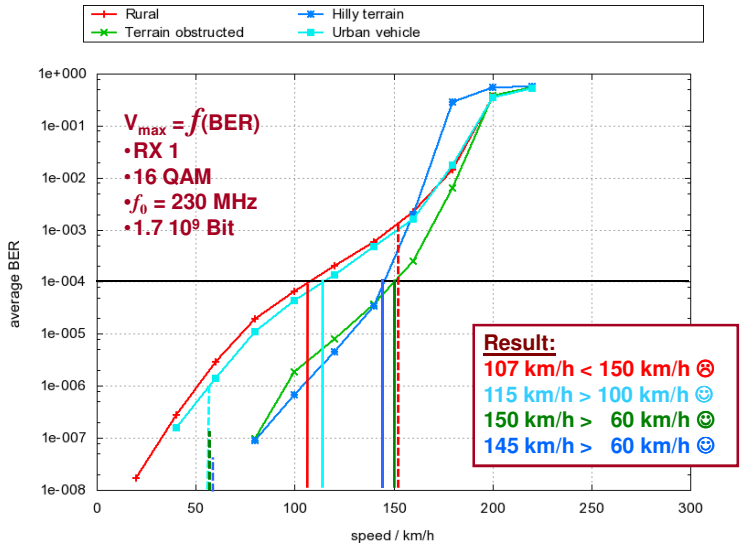
Types of measurements:

(1) **with ETSI fading profile, without AWGN** → v_{max} @ {BER = 10^{-4}}

(2) **without ETSI fading profile, with AWGN** → S/N_{AWGN} @ {BER = 10^{-4}}

(3) **with ETSI fading profile, with AWGN** → S/N_{Profil} @ {BER = 10^{-4}}

► *Example: Measurement result of type (1): v_{max}*



► *Measurement results of type (1): v_{max}*

ETSI profile	$v_{Profile}$ [km/h]	v_{max} [km/h] RX 1		v_{max} [km/h] RX 2	
		4 QAM	16 QAM	4 QAM	16 QAM
Urban	60	169	115	157	129
Rural	150	168	**107**	161	**125**
Hilly terrain	100	165	145	162	146
Terrain obstructed	60	174	150	173	153

Does this mean, that the ETSI-profiles can not be met by DRM+?

No, since the

- ***AGCs of the RF frontends used***
  - ***expect a DAB signal (larger bandwidth!)***
  - ***have no software parts controlling the A/D conversion***
- ***decoder software (channel estimation, ...) could further be optimzed***

For more details: Visit the project homepage

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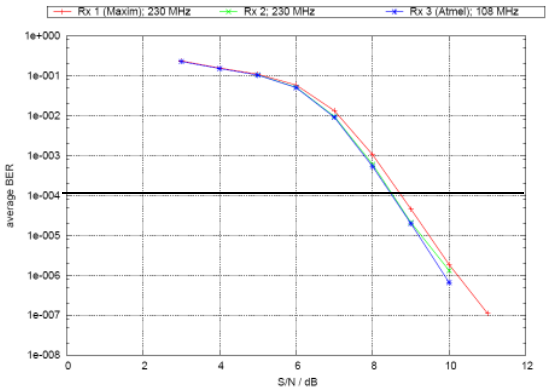
► *Measurement results of type (2): S/N_{AWGN}*



- 16 QAM
- f_0 = 230, 230, 108 MHz
- 10^9 Bit
- Input Level > -45 dBm

S/N_{AWGN} [dB]	RX 1 (230 MHz)	RX 2 (230 MHz)
4 QAM	3.3	3.3
16 QAM	8.7	8.5

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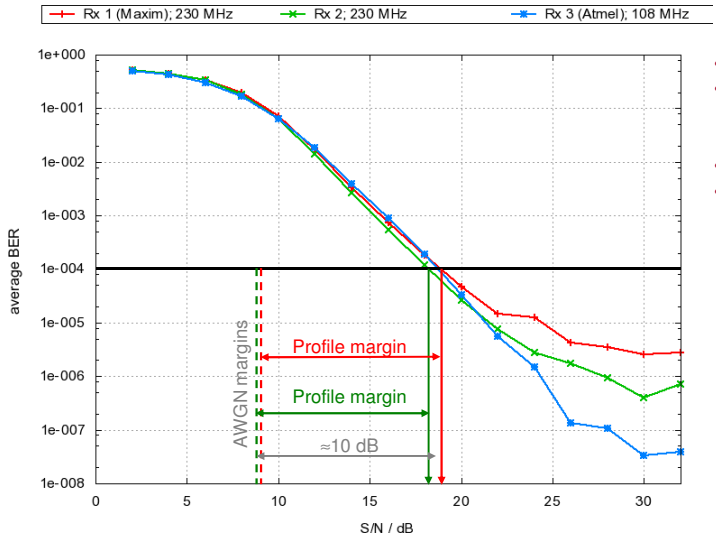
► *Example: Measurement result of type (3): S/N_{Profil} for 16 QAM, urban vehicle*



- 16 QAM
- f_0 = 230, 230, 108 MHz
- v_{Profil} = 60 km/h
- 1.7 10^9 Bit

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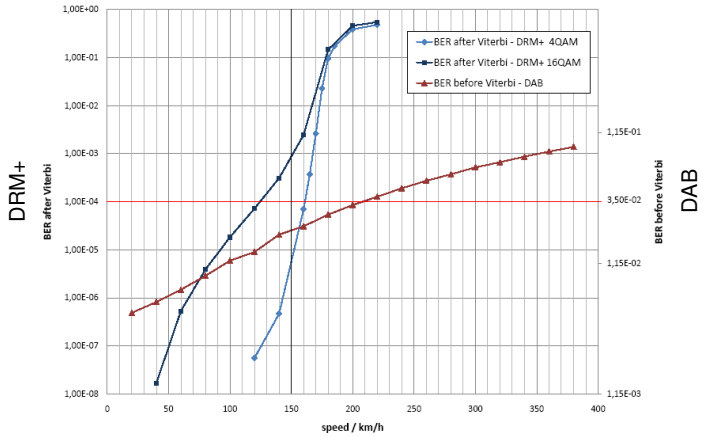
► *Measurement results of type (3): S/N_{Profil}*

		S/N_{Profil}	
DRM+ channel model ETSI ES 201 980	**velocity**	**Rx_1 (230MHz)**	**Rx_2 (230MHz)**
Channel 7 (AWGN)	0 km/h	3,29 dB	3,32 dB
		8,75 dB	8,50 dB
Channel 8 (Urban)	60 km/h	12,50 dB	13,89 dB
		18,84 dB	18,26 dB
Channel 8 (Urban)	2 km/h	23,01 dB	23,94 dB
		28,07 dB	27,50 dB
Channel 9 (Rural)	120 km/h	14,86 dB	16,63 dB
		BER > 10^{-4}	BER > 10^{-4}
Channel 10 (Terrain obstructed)	60 km/h	12,04 dB	11,96 dB
		17,18 dB	16,90 dB
Channel 11 (Hilly terrain)	100 km/h	11,97 dB	11,96 dB
		18,41 dB	17,64 dB

DRM+ 4QAM
DRM+ 16QAM

► *Complement: A comparison with DAB mobile reception performance*



v_{max} [km/h] RX 2	DRM+		DAB
ETSI profile	4 QAM	16 QAM	
Rural	161	**125**	209

► *Mobile reception of DRM+ in VHF band III: Summary*

✓ **DRM+ passes all ETSI profiles except for the `rural profile`**
All measurements were based on

- **the upper fringe of VHF band III**
  → **Using a frequency < 230 MHz relieves this profile constraint even with the prototype RXs used!**
- **prototype receivers (intended for the use with DAB).**
  → **Need to optimize RF frontends, esp. AGC, for DRM+**
- **The VHF band II Rx prototype operated at 230/108 $f_{D,max}$ did comply with the `rural profile`**

→ **DRM+ could comply with the ETSI profiles tested**

? **The hardware channel simulation did not support SFN**
→ **SFN performance is not yet clarified**
→ **There *might* be constraints, this is an open issue**

For more details: Visit the project homepage

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -

► *Part I: Lab measurements*

1. DRM+ mobile reception performance

2. Protection ratios DRM+/DAB

Compatibility issues DAB/DRM+ in VHF band III ?

Q: Could DAB/DAB+ and DRM+ technically co-exist in VHF band III ?

A: Well, this depends on the protecion ratios (PRs).
Once these are established,
- *a qualified answer can be given*
- *Model network planning exercises can be done*

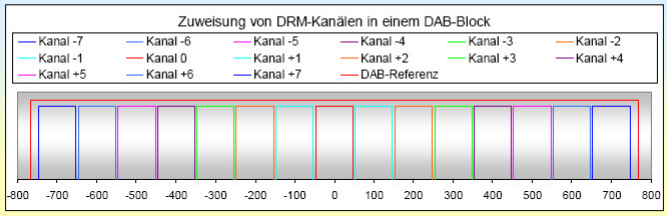
Our approach:

1. *Lab measurement of PRs:*
   - *DRM+ interfered with by DAB*
   - *DAB interfered with by DRM+*
2. *Verification of PRs with field measurements:*
   - *Stationary measurements (10 m antenna hight agl)*
   - *Mobile measurements (2m antenna hight agl)*

► *Channel definitions: Dr. Kühn's proposal*

DRM-Übertragung im VHF-Bereich

Vorschlag: Zuweisung von DRM-Kanälen in einem DAB-Referenzblock

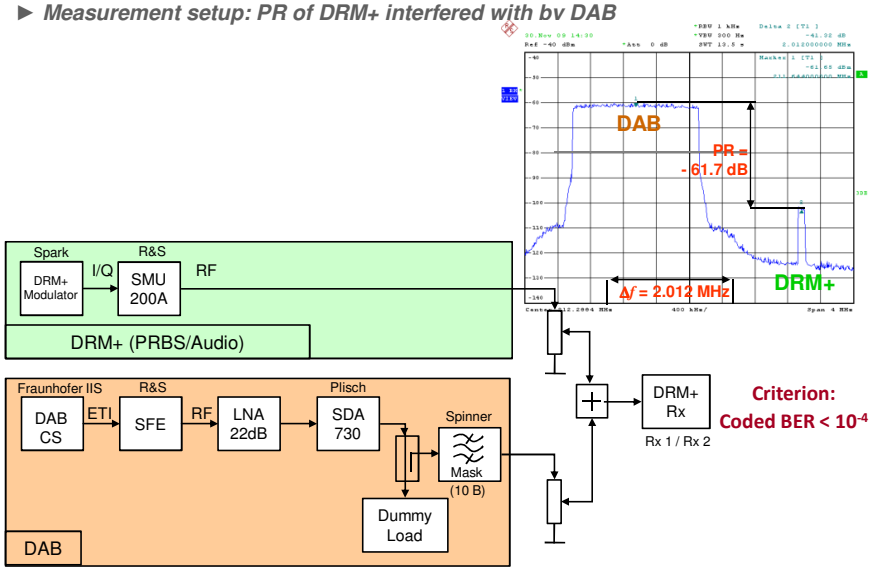


Zuweisung der DRM-Kanäle in den fiktiven DAB-Blöcken

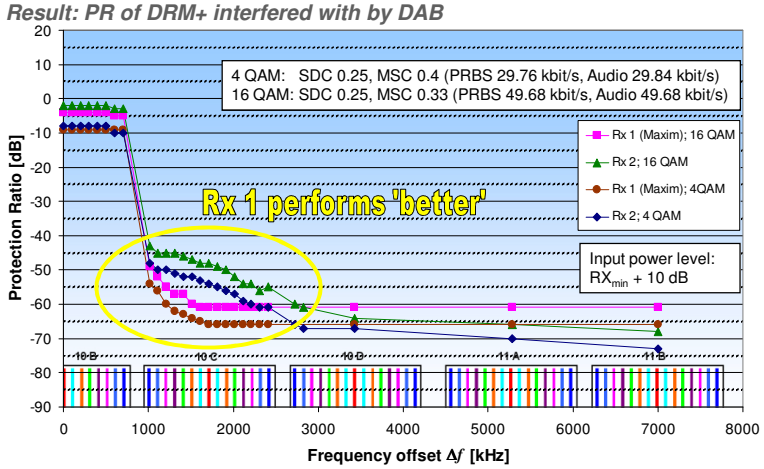
- Jedem DAB-Block werden 15 DRM-Kanäle symmetrisch zugeordnet
- Der Mittenfrequenz f_0 des DRM-Bezugskanal entspricht $f_{center\ DAB}$
- Die Mittenfrequenzen der Kanäle –7 ... –1 und +1 ... +7
  ergeben sich zu $f_{n0} = f_0 \pm n*100$ kHz
- DRM-Kanalabstand 5,8 kHz
- Randabstand zur DAB-Blockgrenze 21 kHz

MOBILE BROADCAST CONSULT DRM im VHF (v0-1) Dr.-Ing. Manfred Kühn Seite 10

► *Measurement setup: PR of DRM+ interfered with by DAB*



► *Result: PR of DRM+ interfered with by DAB*



PRs for DAB → DRM+:
- **Co-Channel: Difference 4/16 QAM ≈ 5 dB (cf. AWGN-performance!)**
- **Adjacent channel: PR < - 60 dB (Rx 1)**
- **Similar performance with RX_{min} +10/20 dB input power level / DAB TX**

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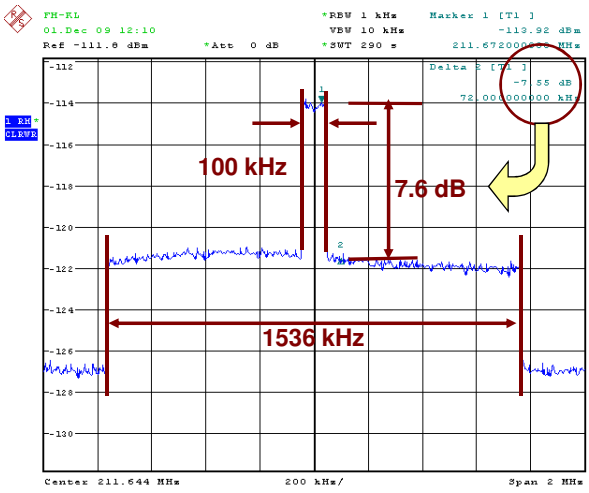
► *Uhps ... panic on board ... negative PRs???*



Let's shift the dBs …

$$\left.\frac{C}{I}\right|_{100\,\mathrm{kHz}} = 7.6\,\mathrm{dB}$$

$$I|_{100\,\mathrm{kHz}} = C - 7.6\,\mathrm{dB}$$

$$I|_{1536\,\mathrm{kHz}} = I|_{100\,\mathrm{kHz}} + \underbrace{10\log_{10}\left(\frac{1536}{100}\right)}_{11.9\,\mathrm{dB}}$$

$$= C - 7.6\,\mathrm{dB} + 11.9\,\mathrm{dB}$$

$$= C + 4.3\,\mathrm{dB}$$

$$\mathrm{PR}|_{\mathrm{dB}} = C - I|_{1536\,\mathrm{kHz}} = -4.3\,\mathrm{dB}$$

Theory

Measured: ≈ - 5 dB

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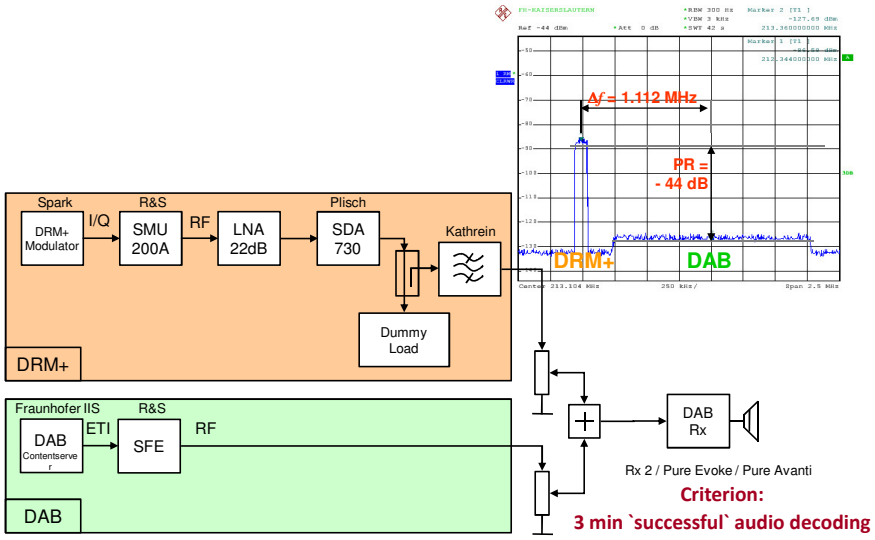
► *Measurement setup: PR of DAB interfered with by DRM+*



Criterion:

3 min `successful` audio decoding

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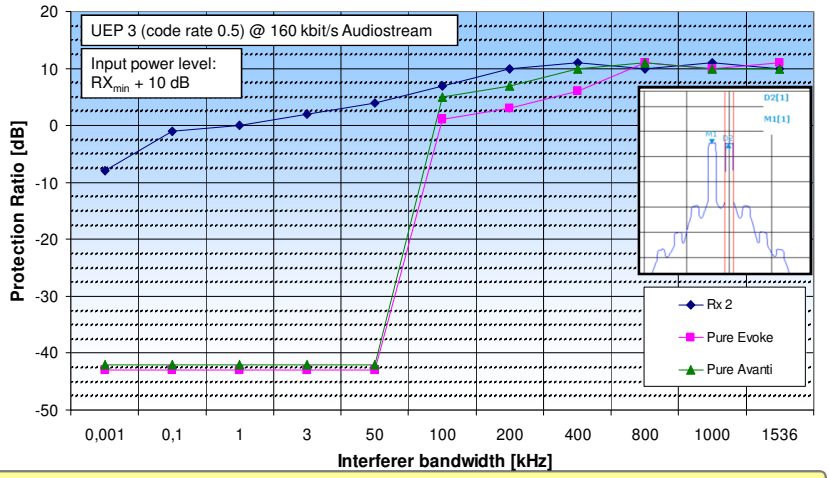
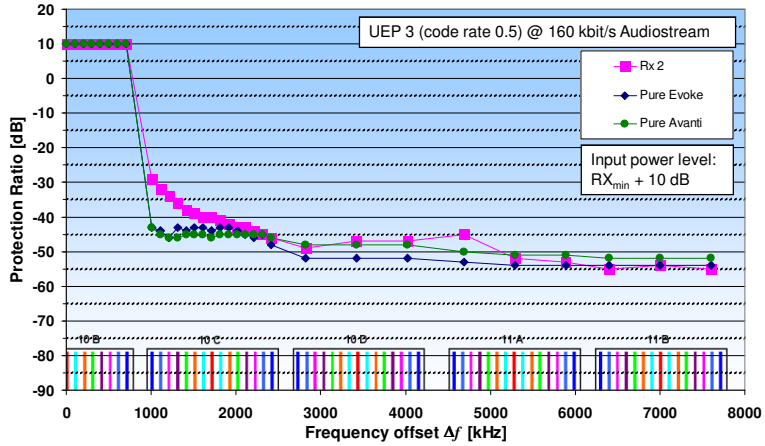
► *Example: PR of DAB interfered with by DRM+ (Cochannel, multiple DRM+ interferer)*



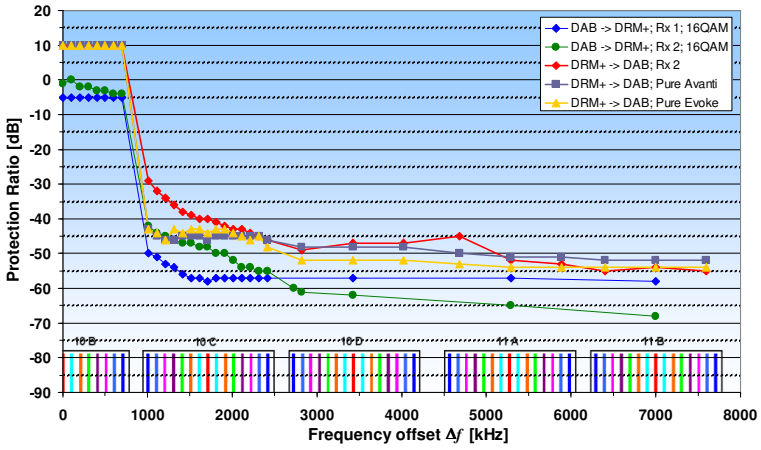
PRs for DRM+ → DAB
• Co-Channel: ≈ 7 … 10 dB (1 … 15 DRM+ interferer)

► *Result: PR of DAB interfered with by DRM+*



PRs for DRM+ → DAB
• No influence of DRM+ modulation (4/16 QAM)
• Co-Channel: ≈ 7 … 10 dB; adjacent Channels < -40 dB

► *Comparision of PRs (DRM+ 16QAM; DAB)*



PRs (esp. in Co-Channel!) are quite different due to different
- **bandwidth (→ definition of PR)**
- **error protection schemes and audio coding schemes**

► *Lab measurements of PRs: Summary*

✓ **DAB channel spacing:**
- **Co-Channel:**
  - **PR of DAB interfered with by DRM+:**
    - **≈ 7 ... 10 dB (1 ... multiple DRM+ interferer)**
  - **PR of DRM+ interfered with by DAB:**
    - **≈ -7 dB (4 QAM)**
    - **≈ -2 dB (16 QAM)**
- **Adjacent channel case: `uncritical`, i.e. < - 40 dB**

✓ **DRM+ channel spacing:**
- **Co-Channel:**
  - **DRM+ interfered with by DRM+:**
    - **≈ 4 dB (4 QAM)**
    - **≈ 10 dB (16 QAM)**

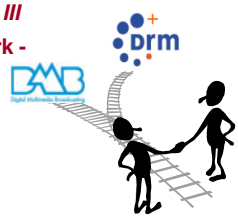
DRM+ and DAB/DAB+ could coexist in VHF band III

For more details: Visit the project homepage

► *So here we go: Outline*

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



I. Selected elements of the DAB/DRM+ TX/RX chains

II. Lab measurements

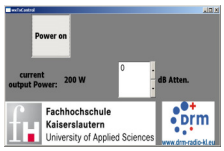
III. Field trials

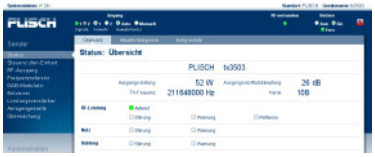
IV. Proposal for planning parameters

V. Outlook

► *Transmitter setup (reprise ☺)*

Tx name & location	„Am Kaiserberg“ (Tx FH) FH Kaiserslautern 07E 46 49 / 49N 27 10 [PD] 260 m asl, antenna: 30 m agl		„Am Rotenberg“ (Tx RB) KL-Rotenberg 07E 46 19 / 49N 27 39 [PD] 260 m asl, antenna: 50 m agl
System	DRM+, MSC: 4- or 16-QAM		DAB, DAB+
Frequency	211.648 MHz (10B)		211.648 MHz (10B)
Max. Power	90 W (ERP) Jan. to April	180 W (ERP) since May	135…300 W (ERP)
Antenna	Omni		5-elem. Yagi 6 dBi
Polarisation	vertical		vertical
Content	Audio (AAC+), sync. PRBS		Audio: Musicam (DAB), AAC+ (DAB+)
Equipment	Plisch ULE-Series		R&S SLA8000, Plisch TDA 3503





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Field trials DRM+/DAB

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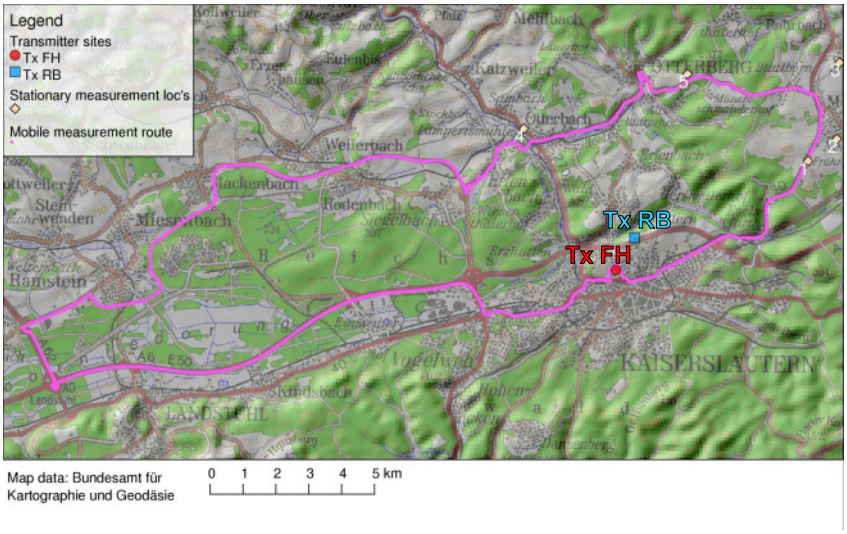
► *The scenario (reprise ☺)*



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► *Stationary measurements: Setup*

VHF-Directional antenna
10m agl.
k = 8.9 dB

Frontend

Perseus
- A/D-Conversion
- Digital Downconversion

Spectrum Analyzer
R&S FSP30
- Channel power measurement

Laptop
- UMTS-Connector for Transmitter Control
- DRM-Decoder
- Decoder Monitoring (BER, Audio)

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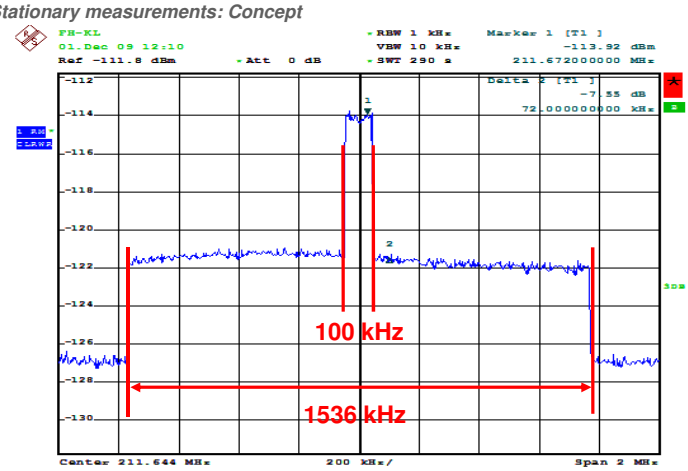
► *Stationary measurements: Concept*



- **Measure** DRM+ / DAB signal power within respective bandwidths (separate measurement; turn on/off the Tx's before…)
- **Decrease** DRM+-Tx-Power until mean BER ~ 10^{-4}
- **Calculate** $PR_{field} = P_{DAB} - (P_{DRM+} - \text{Tx Attenuation})$

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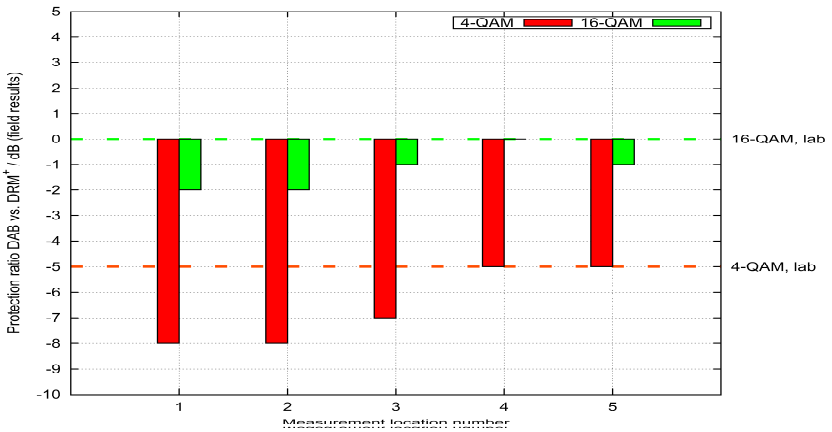
► *Stationary measurements: PR Results*



- Field results tend to confirm laboratory results → Influence of non-flat channel ...
- Measurement uncertainity ≈ ± 1dB, esp. critical in 4-QAM-Mode due to the steep gradient of mean BER vs. S/N
- Measured PR difference (4-/16-QAM) similar at each location

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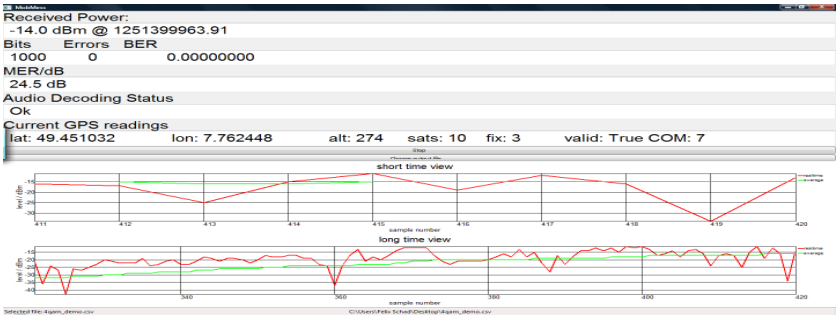
► *Mobile measurements: Monitoring software*



- Realtime-monitoring of
  - location, time, ...
  - RF-Power, BER, MER, … (DRM+)
  - RF-Power, audio status, Rx-Sync., CRC-Frame-Errors, … (DAB)
- RF-Power sampled in equal intervals at 0.8λ (~ 1.14m)
- Sub-(consumer) GPS-Resolution achieved by equalizing via the known measurement distance
- Vector-data output to various GIS-tools for analysis

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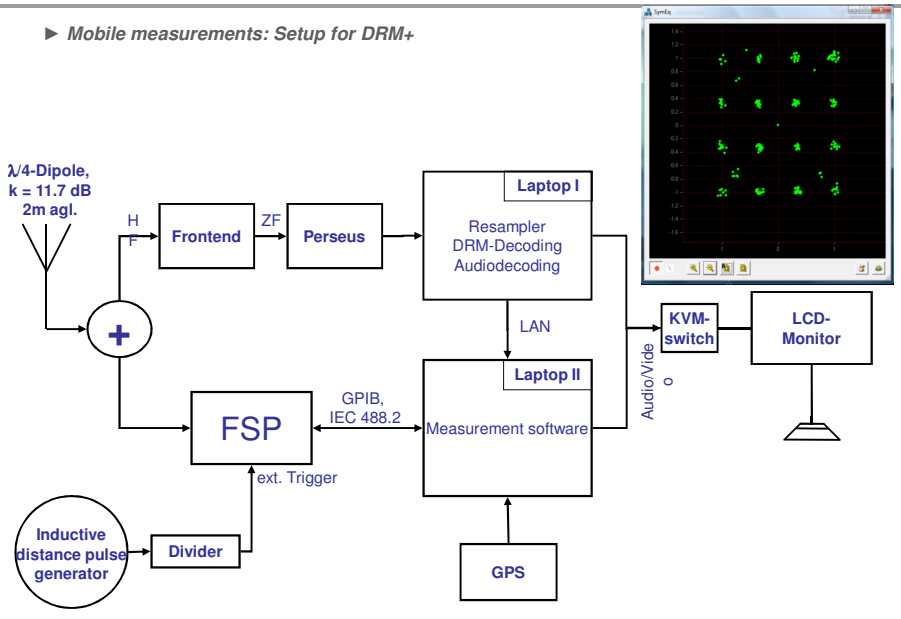
► *Mobile measurements: Setup for DRM+*



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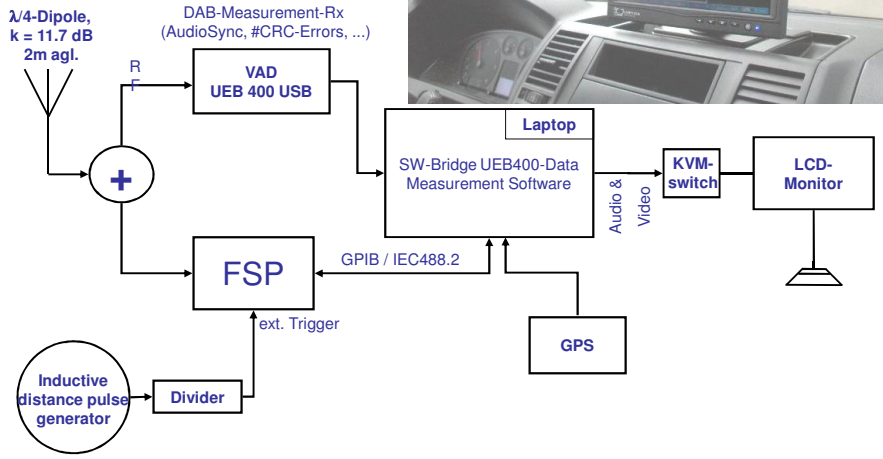
► *Mobile measurements: Setup for DAB*



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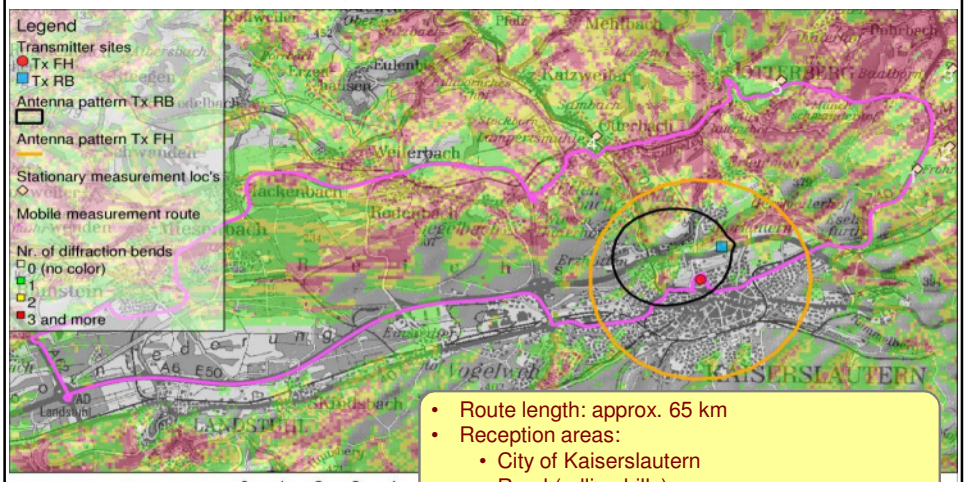
► *Mobile measurements: A topographic look around (LOS-Conditions)*



- Route length: approx. 65 km
- Reception areas:
  - City of Kaiserslautern
  - Rural (rolling hills)
  - Motorway (max. speed: 120 km/h)
  - Light industrial and residential zones
- LOS-Rating based on DEM only (i.e. no buildings)

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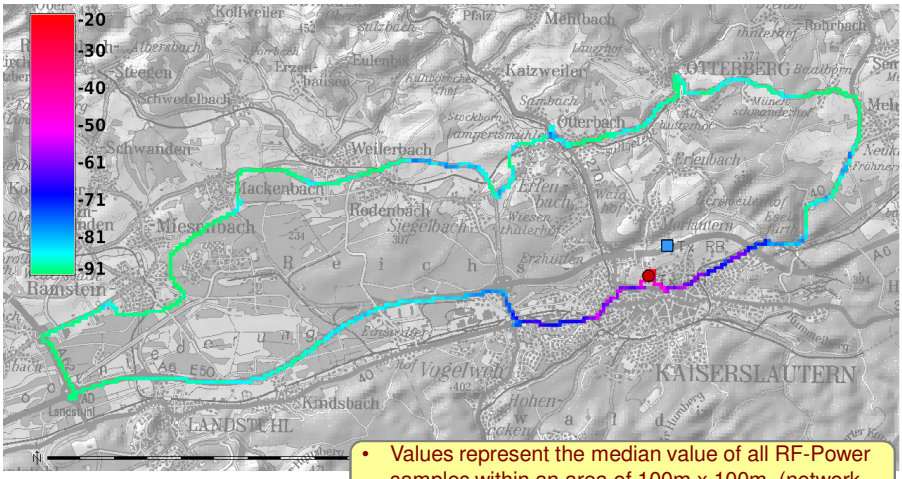
► *Mobile measurements: Received power [dBm] of Tx FH@180W ERP*



- Values represent the median value of all RF-Power samples within an area of 100m x 100m (network planning!)
- Sensitivity (min value: -93 dBm) limited by spectrum analyzer; no measurement receiver available ☹

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Field trials DRM+/DAB

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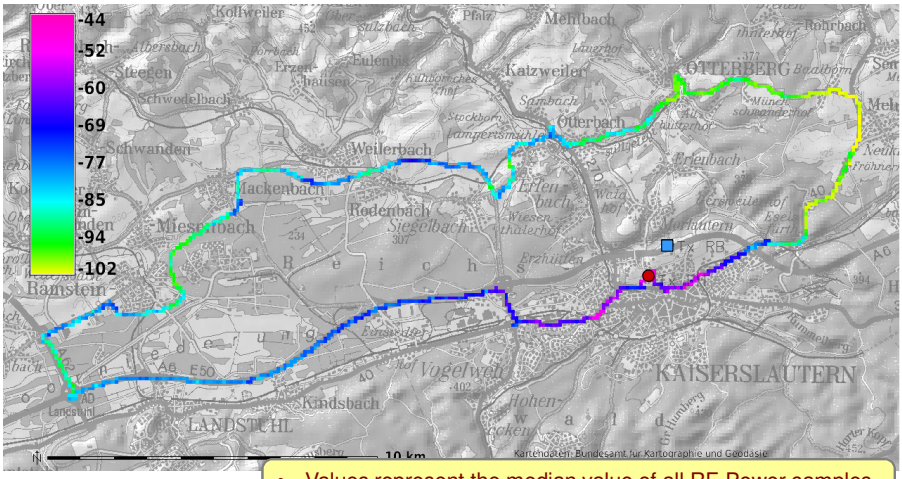
► *Mobile measurements: Received power [dBm] of Tx RB@135W ERP*



- Values represent the median value of all RF-Power samples within an area of 100m x 100m
- Same color-scale as before
- Higher sensitivity due to usage of VAD-Rx (slower)

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Field trials DRM+/DAB

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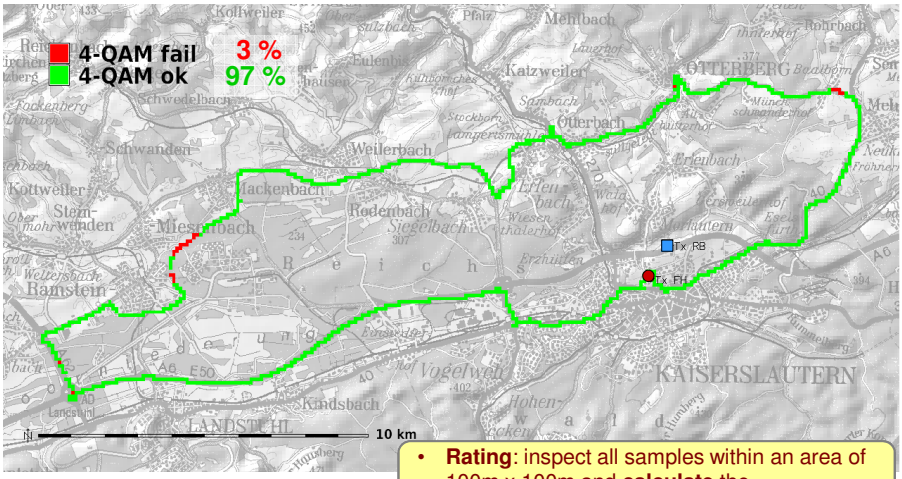
► *Mobile measurements: Coverage for DRM+, 180W ERP*



- **Rating**: inspect all samples within an area of 100m x 100m and **calculate** the (instantenous-) BER's 75%-percentile q
- $q <= 10^{-4}$ → **Green**
- **Green**: Implies succesful audio-decoding!

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Field trials DRM+/DAB

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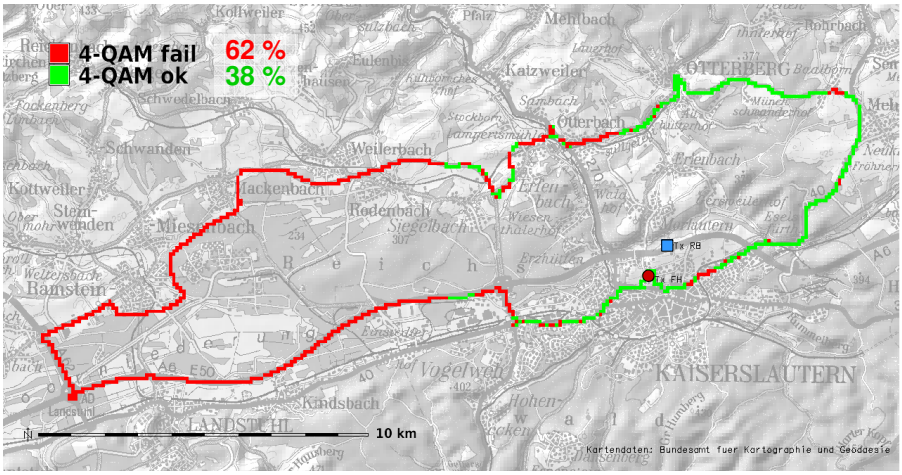
► *Mobile measurements: Coverage for DRM+, 180W ERP interfered by DAB, 135W ERP*



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Field trials DRM+/DAB

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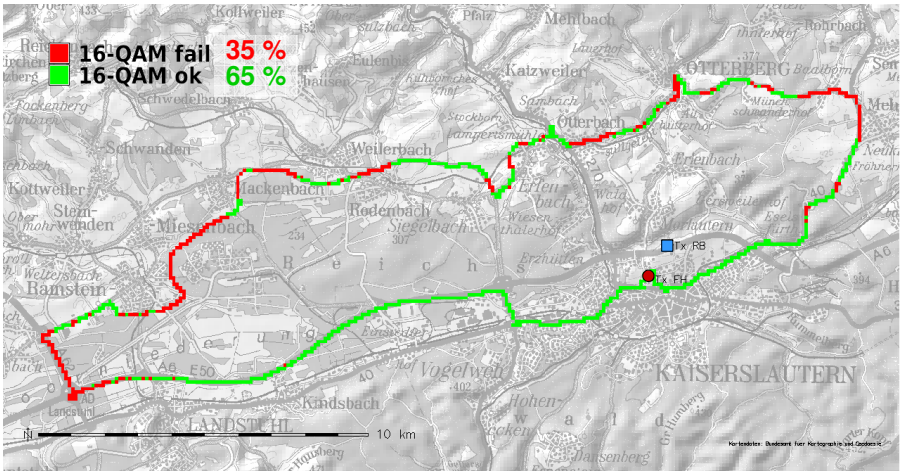
► *Mobile measurements: Coverage for DRM+ (180W ERP)*



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Field trials DRM+/DAB

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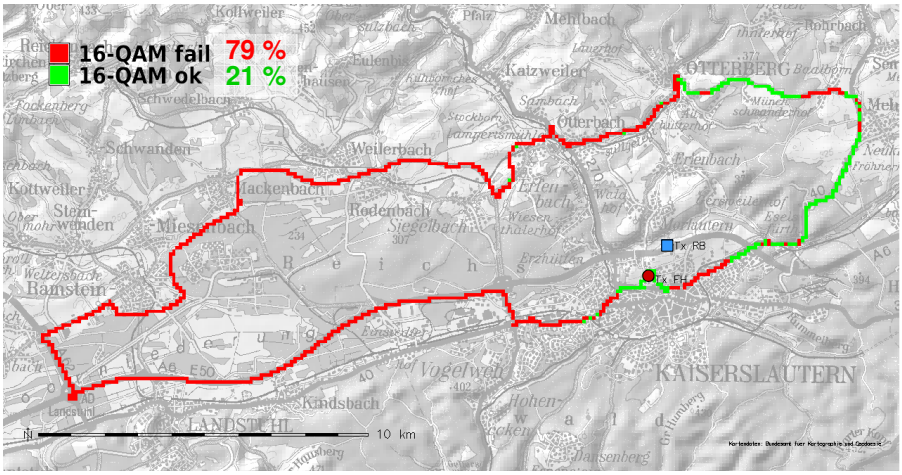
► *Mobile measurements: Coverage for DRM+ (180W ERP) interfered by DAB(135W ERP)*



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Field trials DRM+/DAB

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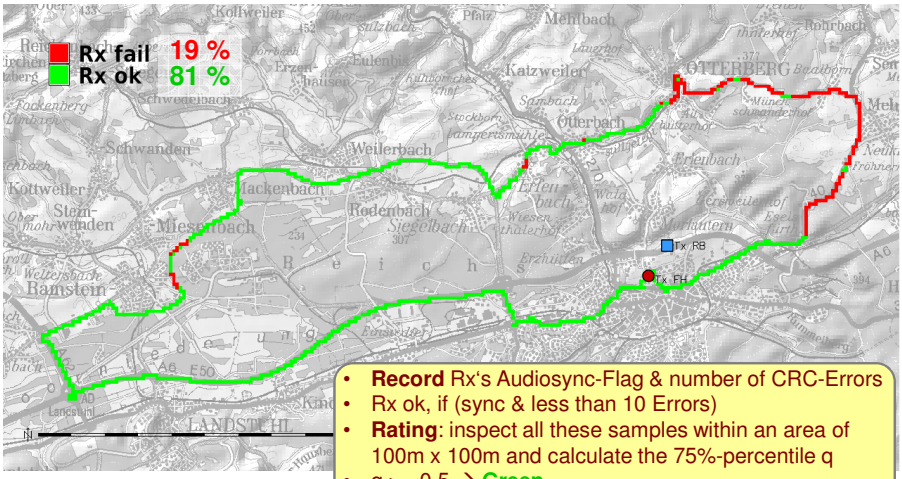
► *Mobile measurements: Coverage for DAB (135W ERP)*



- **Record** Rx's Audiosync-Flag & number of CRC-Errors
- Rx ok, if (sync & less than 10 Errors)
- **Rating**: inspect all these samples within an area of 100m x 100m and calculate the 75%-percentile q
- q >= 0.5 → **Green**
- Rating matches the listener's **subjective perception**
- **Note**: less than 2% more ‚red pixels' when inspecting the 90%-Percentile

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Field trials DRM+/DAB

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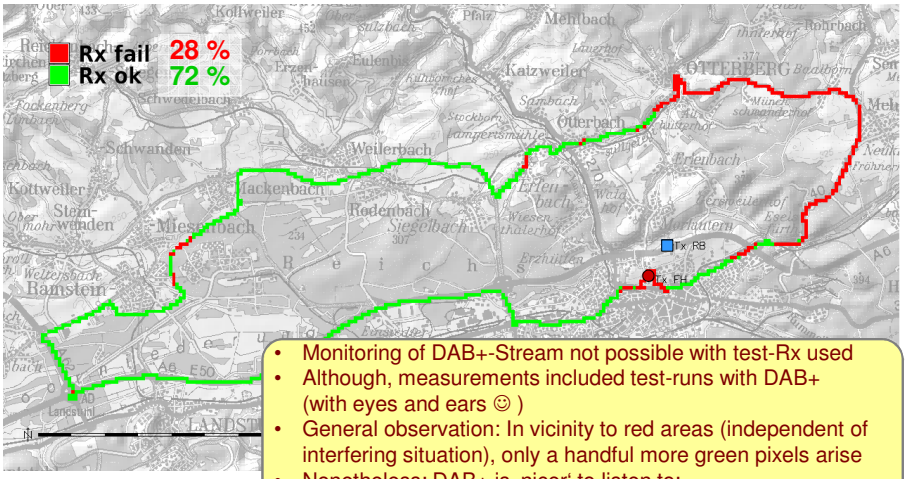
► *Mobile measurements: Coverage for DAB (135W ERP) interfered by DRM+ (90W ERP)*



- Monitoring of DAB+-Stream not possible with test-Rx used
- Although, measurements included test-runs with DAB+ (with eyes and ears ☺)
- General observation: In vicinity to red areas (independent of interfering situation), only a handful more green pixels arise
- Nonetheless: DAB+ is ‚nicer' to listen to:
  - higher quality & error tolerance
  - No more gargling sounds, hard muting of the audio stream in case of bad reception

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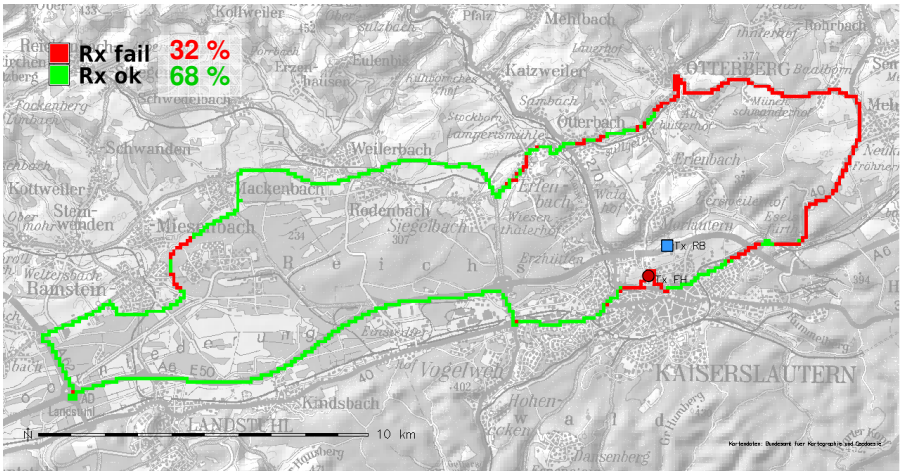
► *Mobile measurements: Coverage for DAB (135W ERP) interfered with 2 DRM+-Blocks (90W ERP)*



Only very small differences as compared to 1 DRM+ interfering block observed…

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► *Field measurements: Summary*

✓ **PR lab measurements (DRM+/DAB)**
- **Validated by stationary measurements in 10m height**
- **Notes:**
  - Channel not `flat` → Slight PR difference to lab
  - Adjacent channel measurements not possible (limited dynamics)

✓ **Mobile reception along measurement route**
- **Simulations confirmed**
- **DRM+ mobile reception as compared to DAB/DAB+ ok within coverage area!**
- ***Subjective* audio quality comparable to DAB+, in any case superior to DAB (*muting* instead of *tweeting*)**

DRM+ DAB DAB+

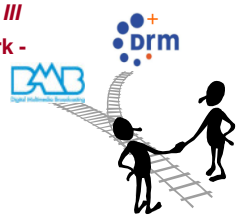
DRM+ and DAB/DAB+ could coexist in VHF band III

For more details: Visit the project homepage

► So here we go: Outline

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



I. Selected elements of the DAB/DRM+ TX/RX chains

II. Lab measurements

III. Field trials

IV. Proposal for planning parameters

V. Outlook

► *Proposal for reception modes for DRM+ in VHF band III*

type of reception	*fixed*	*portable outdoor*		*portable indoor*		*mobile*
reception situation	(RRC-06)	portable (RRC-06)	handheld (EBU)	portable (RRC-06)	handheld (EBU)	(RRC-06)
receiver type						
antenna pattern / gain	D +4dBD	ND -2.2 dBD	ND -19 dBD	ND -2.2 dBD	ND -19 dBD	ND -2.2 dBD
man made noise	2 dB		1 dB	2 dB	1 dB	2 dB
location probability	70 %	95 %				99 %
antenna height	10 m	1.5 m				
feeder loss	1.4 dB	0 dB				0.28 dB
building penetration loss	0 dB			9 dB (σ=5,5 dB)		0 dB

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► *Proposal for minimum receiver input power level for DRM+ VHF band III*

type of reception		*fixed*	*portable outdoor*	*portable indoor*	*mobile*
Receiver noise figure (F) [dB]		7			
Bandwidth (B) [kHz]		100			
Receiver noise input power level [dBW]		-147			
ETSI DRM channel model +3dB implementation margin		7 - AWGN	8 - urban		11 - hilly terrain
Representative minimum C/N level [1] [dB]	4QAM	4.3	10.3		8.5
	16QAM	10.9	18.4		15.8
Minimum receiver input power level P_s [dBW]	**4QAM**	**-142.7**	**-136.7**		**-138.5**
	16QAM	**-136.1**	**-128.6**		**-131.2**

[1] These values are taken from ETSI ES 201 980.
Out from the lab measurements of the FH Kaiserslautern the values are
13.1 dB /18.5 dB (4QAM/16QAM) for channel 8 – urban
12.0 dB / 18.0 dB (4QAM/16QAM) for channel 11 – hilly terrain

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► *Proposal for median field strength levels for DRM+ in VHF band III*

type of reception		*fixed*	*portable outdoor*		*portable indoor*		*mobile*
reception situation		(RRC-06)	portable (RRC-06)	handheld (EBU)	portable (RRC-06)	handheld (EBU)	(RRC-06)
receiver type							
antenna pattern [D/ND] / gain dBD		D / +4	ND / -2.2	ND / -19	ND / -2.2	ND / -19	ND / -2.2
feeder loss [dB]		1.4	0				0.28
effective antenna aperture [dB]		4.7 dB	-1.5 dB	-18.3 dB	-1.5 dB	-18.3 dB	-1.5 dB
minimum field strenght level @ receiving antenna [dBµV/m]	**4QAM**	**3.4**	**16.6**	**27.4**	**16.6**	**27.4**	**15.2**
	16QAM	**10.0**	**24.7**	**35.5**	**24.7**	**35.5**	**22.5**
Correction factors for reception modes [dB]		5.9	26.3	29.5	38.3	42.1	31.4
min. MEDIAN field strenght level @ receiving location [dBµV/m]	**4QAM**	**9.3**	**42.9**	**56.9**	**54.9**	**69.5**	**46.6**
	16QAM	**15.9**	**51.0**	**65.0**	**63.0**	**77.6**	**53.9**

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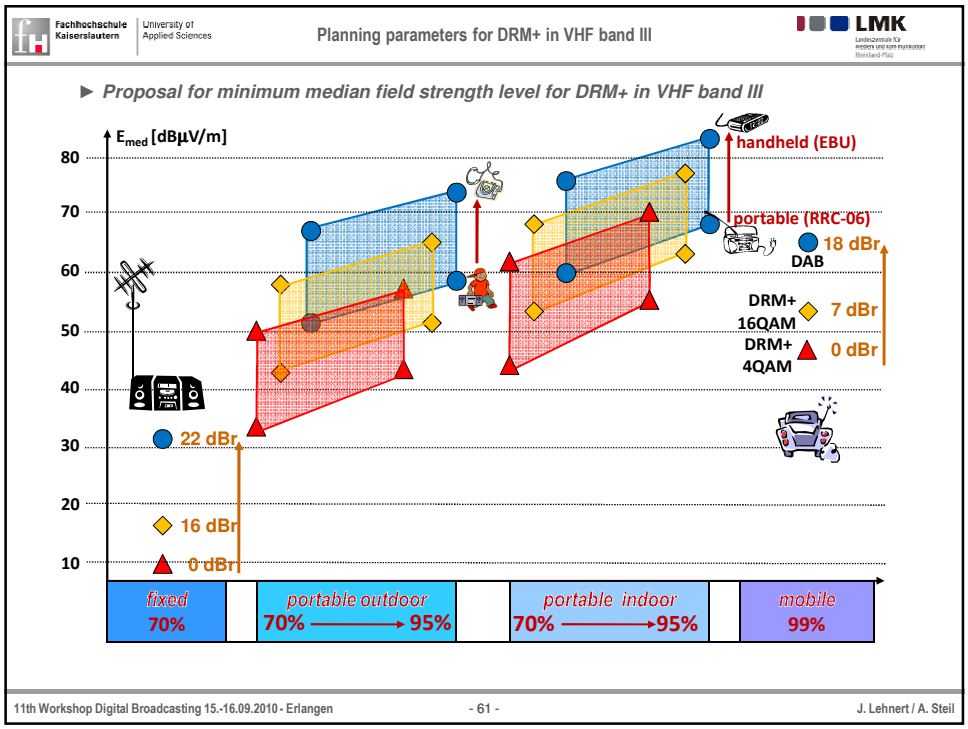
Fachhochschule Kaiserslautern
University of Applied Sciences
Planning parameters for DRM+ in VHF band III
LMK
► Proposal for minimum median field strength level for DRM+ in VHF band III
E_med [dBµV/m]
80
70
60
50
40
30
20
10
handheld (EBU)
portable (RRC-06)
18 dBr
DAB
DRM+ 16QAM
7 dBr
DRM+ 4QAM
0 dBr
22 dBr
16 dBr
0 dBr
fixed 70%
portable outdoor 70% → 95%
portable indoor 70% → 95%
mobile 99%
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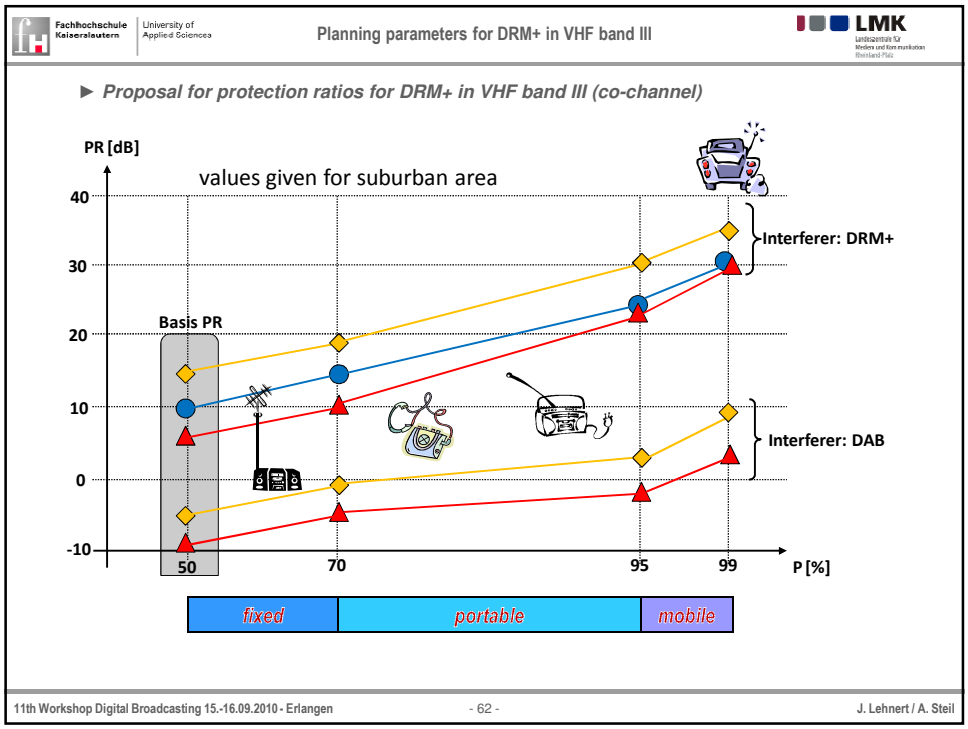
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Planning parameters for DRM+ in VHF band III
LMK
► Proposal for protection ratios for DRM+ in VHF band III (co-channel)
PR [dB]
values given for suburban area
40
30
20
10
0
-10
Basis PR
Interferer: DRM+
Interferer: DAB
50
70
95
99
P [%]
fixed
portable
mobile
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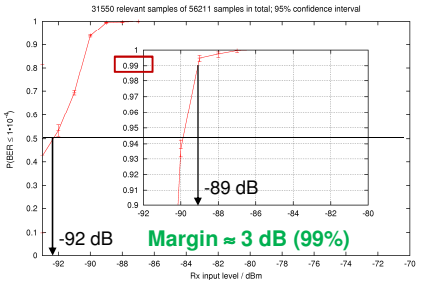
J. Lehnert / A. Steil

► *Example: Margins for mobile reception (useful signal) out of the mobile recordings*

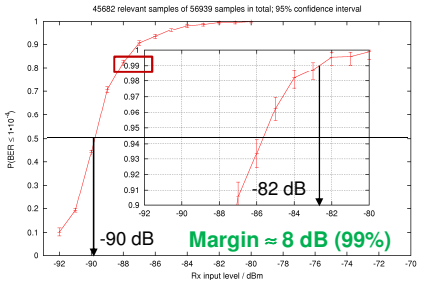
Coverage validation by , e.g., determining the
RX margin from 50% (median) to XX %

Example:

4 QAM



16 QAM



Remark: On base of ITU-Rec. P.1546 the margin for DRM+ in VHF band III for 99% location probability are given by: $C_l(99\%) = 17{,}4$ dB for suburban areas

Fachhochschule Kaiserslautern | University of Applied Sciences
Planning parameters (peliminary)
LMK Landeszentrale für Medien und Kommunikation Rheinland-Pfalz

► *Example: Margins for mobile reception (useful signal) out of the mobile recordings*

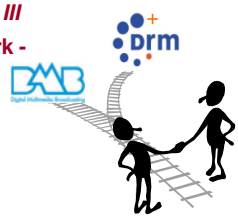
Algorithm (symbolic code):

```
FORALL vector data points IN RXLEVEL DO {
    IF (RXLEVEL > RX_50 + MARGIN_XX ) THEN
        RF_XX = True; ELSE RF_XX = False;
}
FORALL vector data points IN RF_XX DO {
    RF_XX_RASTER = RasterizeToPixel(RF_XX,1x1);
} % Only 1 value per pixel
AUDIO_Prediction = RESAMPLE(RF_XX_RASTER,100x100, value = XX%);

FORALL vector data points IN BER DO {
    BER_RASTER = RasterizeToPixel(BER,1x1);
} % Only 1 value per pixel
AUDIO_Measured = RESAMPLE(BER_XX_RASTER,100x100, value = 75%); %Subjectivly OK

COMPARE(AUDIO_Prediction, AUDIO_Measured);
```

► So here we go: Outline

DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



I. Selected elements of the DAB/DRM+ TX/RX chains

II. Lab measurements

III. Field trials

IV. Proposal for planning parameters

V. Outlook

► Outlook

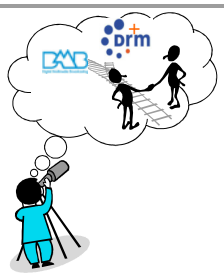
If there is a strong will to push DRM+ into the market [?] what has to be done as from now?

- **A lot of lobby work**
  (nationwide, DRM-Consortium, WorldDMB, ETSI, ITU, EU)
- **A lot of technical work**
  (SFN-tests, high-power-tests,
  development of network infrastructures and market fitting receivers,
  frequency and network analyses)
- **A lot of standardization work**
  (proposals for system and planning parameters for ECC, ETSI, ITU)
- **A lot of marketing work**
  (public information, convincing the market partners,
  esp. the broadcasters and the „users“, development of interesting
  radio programmes and services)
- **A lot of regulatory work**
  (offering easy legal conditions and support
  for network operators and broadcasters)

► *Outlook*

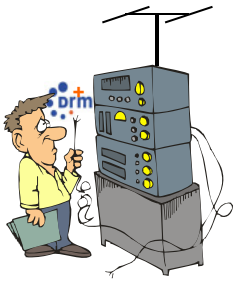
Preconditions to reach this objective:

- a lot of **communication and networking** is needed in the next years
- and last but not least:
  a **common action plan** [for Europe] is needed to digitize the whole sound broadcasting **together with the DAB family and the DRM family**
  Motto: **„We are Family“**



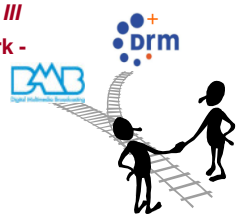
We will keep in touch with DRM+!

- Frequency plannings and analyses
- Proposals for planning parameters
- Support of further essential SFN field trials (by request)
- Cooperation in the process of standardization and regulation matters for DRM+ in the VHF bands
- Publication of results and proposals



DRM+, a perfect complement to DAB/DAB+ in VHF band III

- Technical results, planning aspects, and regulatory work -



Thank you for your attention …

… further information on www.DRM-Radio-KL.eu