DAB+ Coverage in Swiss Tunnels

WorldDAB Spectrum and Networking Implementation Committee

10.12.2024

SRG SSR

RSI RTR RTS SRF SWI

Agenda

- Roadmap
- Swiss proof of concept
- Stakeholders involved
- Technical concept of tunnel system
- Specification of tunnel system
- Signal reception
- Signal emission
- Voice break-in
- Lessons learned

Roadmap

Roadmap 2010 - 2024

- 2010 Concerns about feasibility of DAB+ in tunnels and voice break-in systems
- 2011 Scouting for DAB+ tunnel- and voice break-in systems by SRG SSR
- 2011 Study report “DAB+ voice break-in” by IRT Munich on behalf of SRG SSR
- 2013 Swiss proof of concept and show case for DAB+ tunnel and voice break-in system by SRG SSR
- 2014 First Swiss guideline for DAB+ in tunnels by FEDRO
- 2015 Start engineering, tendering and rollout through five regional offices of FEDRO
- 2018 Measurement campaigns by SRG SSR
- 2018 Revision of guideline for DAB+ in tunnels by FEDRO
- 2019 Formal closing of rollout project by Swiss Federal Roads Office
- 2019 to 2024 extensions for new tunnels and new DAB+ ensembles

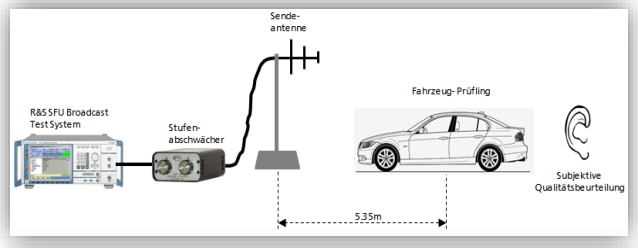
Swiss Proof of Concept

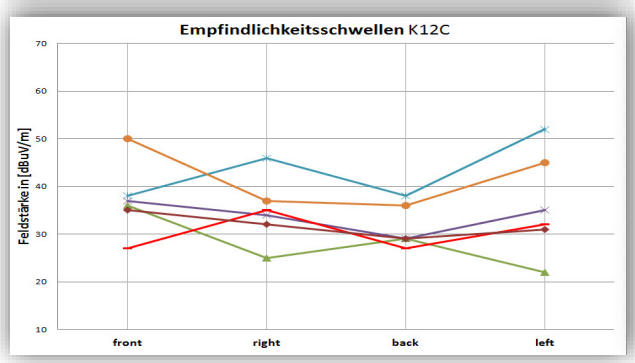
Swiss Proof of Concept

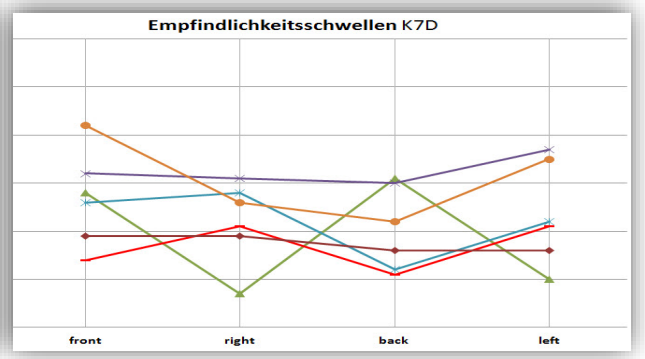
Swiss Proof of Concept









Fahrzeug	Umschaltzeiten Enkom VBI [s]		Umschaltzeiten Comlab TRS [s]		Bemerkung
	Synch.	Asynch.	Synch.	Asynch.	
VW Passat	0 - 1	k. A.	0 - 1	k. A.	Kenwood KDC DAB41U
Honda (Messauto)	0 - 1	15 - 17	0 - 1	k. A.	Pure Highway 300di
VW T5 California	2 - 3	5 - 6	k. A.	k. A.	Zenec ZE-DAB60
Mini Cooper S	2 - 5	k. A.	k. A.	k. A.	fest verbaut
BMW	3 - 5	7 - 10	3 - 5	k. A.	fest verbaut (Modelle: 116d, 318d, 320i)
Skoda Octavia	5 - 8	8 - 12	6 - 7	k. A.	fest verbaut

Tabelle 5: Empfängerreaktionszeiten von Autoradios beim Einsprechen

Output – Reports, Measurements and Guideline

IRT study report

project report incl. car receiver measurements

ASTRA 13006 | Funksysteme in Strassentunneln - admin.ch

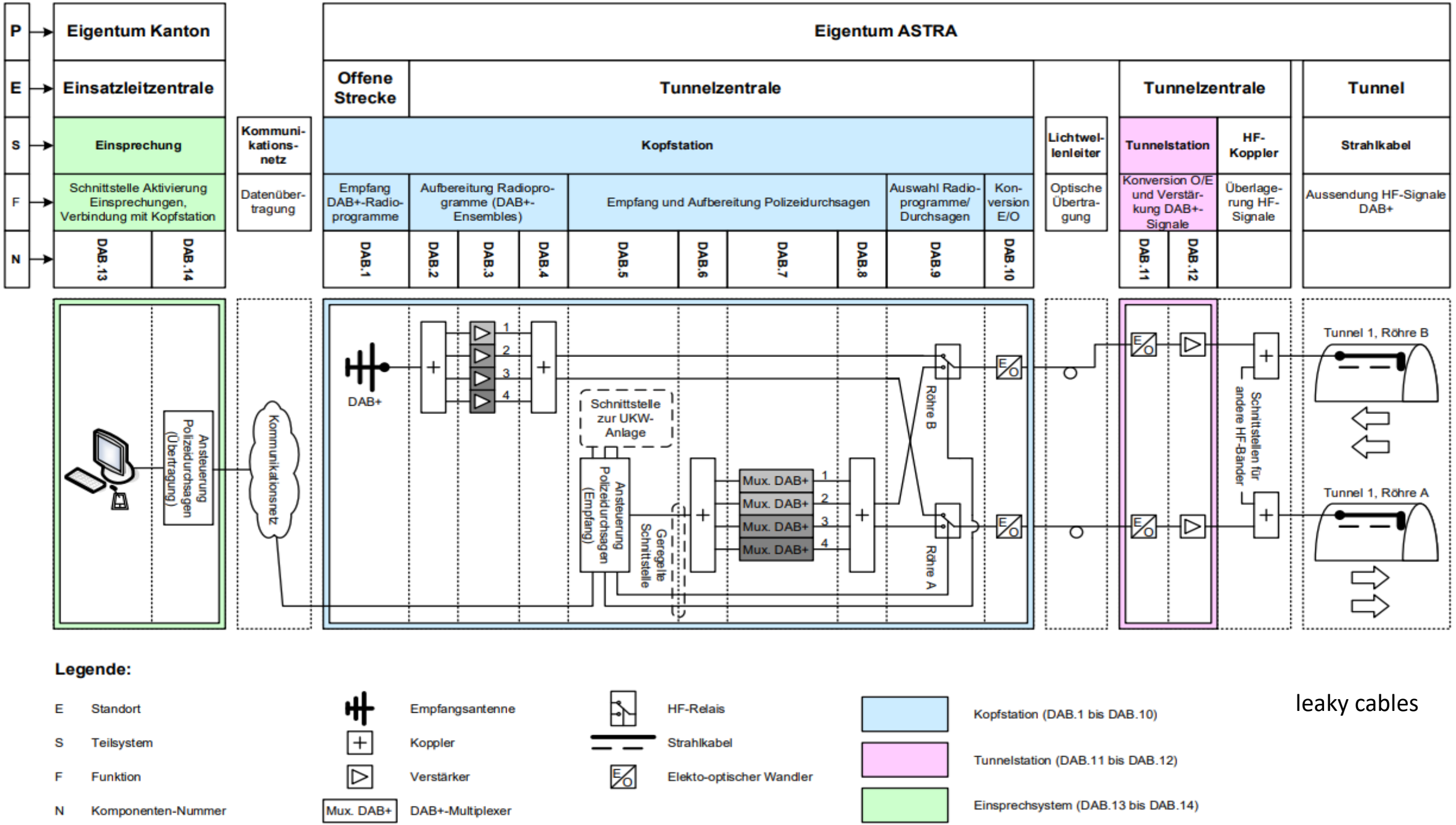
Stakeholders

Stakeholders

- Swiss Federal Roads Office, incl. regional Offices
- Swiss Federal Office of Communications
- DAB+ Ensemble Providers: SRG SSR, Swissmediacast, Romandie Medias, Digris, Dabcom
- Regional companies for engineering, tendering and projects
- Suppliers for systems and system integration
- Suppliers for subsystems for DAB+ and voice break-in
- Further stakeholders interested in Swiss DAB+ tunnel coverage
- WorldDAB, EBU

Technical Concept

Abbildung 5.1: Struktur der DAB+-Anlage (für einen Tunnel mit zwei Röhren)



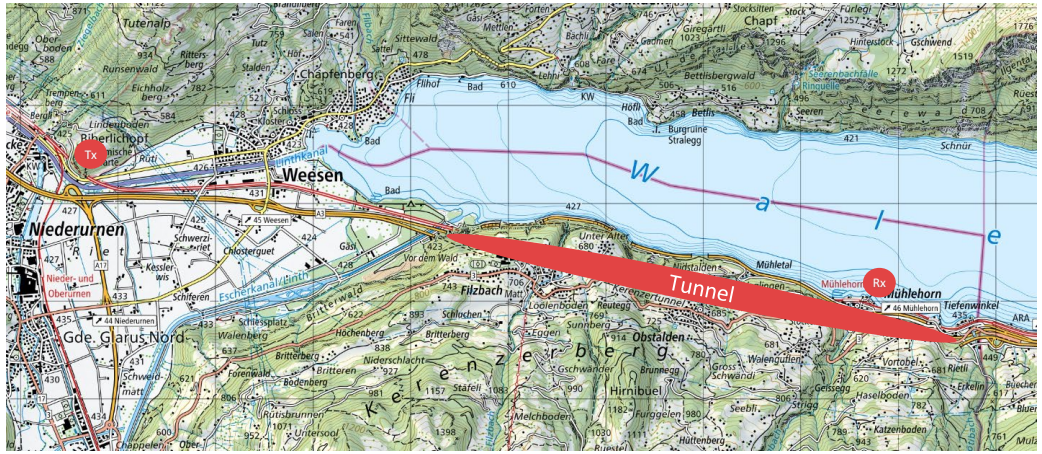
Legende:

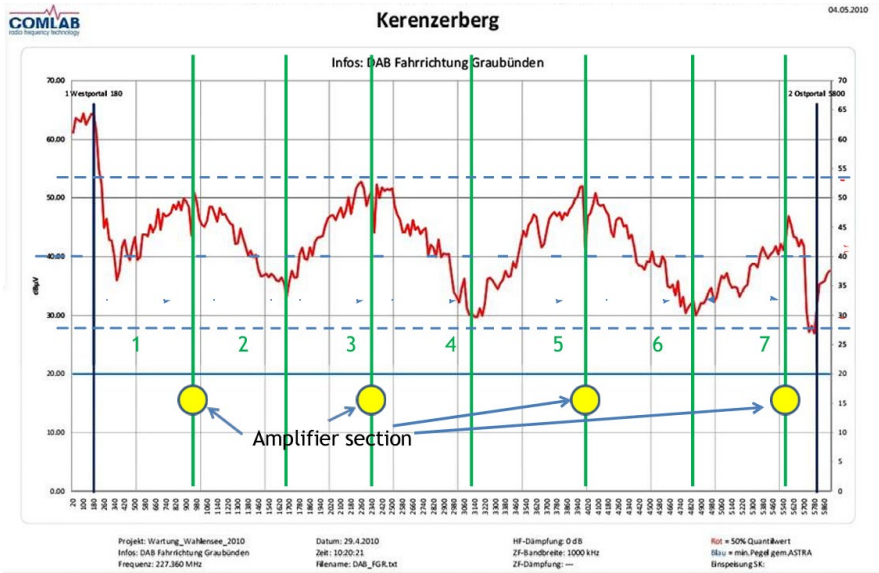
E	Standort
S	Teilsystem
F	Funktion
N	Komponenten-Nummer

	Empfangsantenne
+	Koppler
▷	Verstärker
Mux. DAB+	DAB+-Multiplexer
	HF-Relais
	Strahlkabel
E/O	Elekto-optischer Wandler
	Kopfstation (DAB.1 bis DAB.10)
	Tunnelstation (DAB.11 bis DAB.12)
	Einsprechsystem (DAB.13 bis DAB.14)

leaky cables

DAB+ Signal in Tunnel «Kerenzerberg»



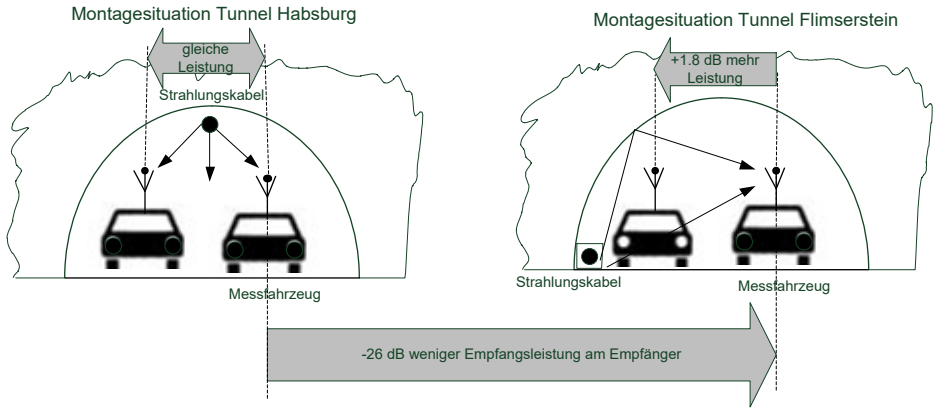


Sample measurement for minimum coverage criteria for DAB (courtesy of Comlab AG, measurements performed with a rooftop quarter wave antenna with k factor of 16 dB/m). DAB+ block 12C, 29.04.2010, red line: 50% quantil, blue line minimum signal level set out in 2010.

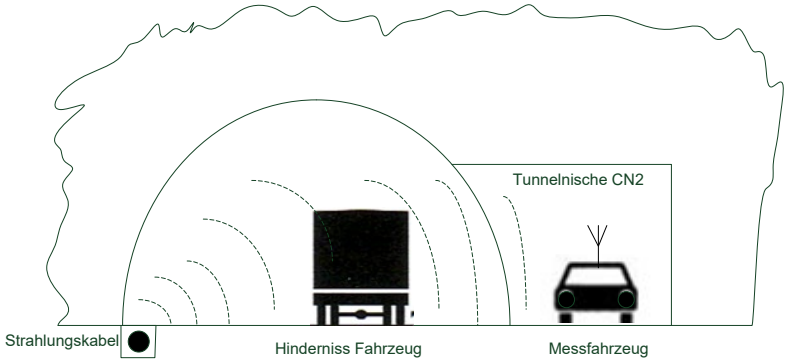
Source: measurements performed by Comlab AG Switzerland

Analysis of Influencing Factors

Impact of place of leaky cable



Impact of obstacles



measurements showed that the field strength of passenger cars briefly drops 3dB below the nominal level. For lorries, this drops briefly by up to 12dB.

Transition zone terrestrial vs tunnel signal

- Short zone due to limited propagation

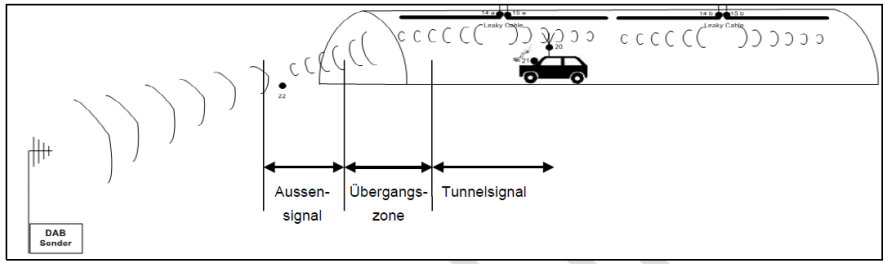


Abbildung 3: Schematische Darstellung möglicher Übergangszone am Tunnelportal

Impact analysis of DAB+ on Swiss Tetrapol PPDR radio service

- No impact detected, due to limited spectral density of DAB+ signal

Tunnelsystem Specification

Tunnel Specification

Reception

- Minimum received Signal per ensemble -65dBm (typical threshold -80dBm to -70dBm)
- Minimum received Carrier-to-Noise Ratio 15dB (some margin to be provided for tunnel system)
- Minimum receiver antenna gain +8dBi
- Polarisation vertical
- Frequency Range 174 – 230 MHz
- Error Protection referenced EEP-3A

In-Tunnel Coverage

- Minimum received signal 36 dBuV for 50% of measurement points per 1m
  - measured with quarter wave with antenna factor k=16dB/m (min. fieldstrength 52dBuV/m)
  - respecting SRG measurements of cars and potential man-made noise
- Minimum received carrier-to-noise ratio12dB
- Maximum allowed intermodulation -36dBm (to other radio services)
- Maximum delay to terrestrial signal 60us (before the need aligning the terrestrial timing)

Signal Reception

Signal Reception

- Input criteria for in-tunnel signal quality
- Needs more fieldstrength compared to a car driving along the same place
- Channel impulse response CIR is replicated 1:1 into the tunnel
- CIR to be improved by directive reception antenna
- Reception of many different ensembles needed
- Reception location sometimes challenging for some or all ensembles
  - line of sight to broadcast transmitter is not always given
  - transmitters of ensembles are not always collocated
  - existing tunnel reception station not feasible for DAB+ in some minor cases
- Small Scale networks are crucial for a vibrant DAB+ market however critical to be received with enough signal at the tunnel reception station, they need some special care.
- Blockwide filtering and amplification but no decoding.

Signal Emission

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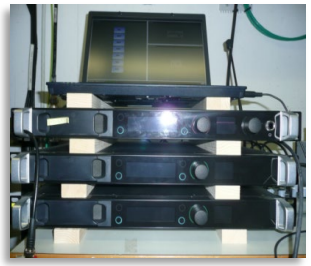
In Tunnel Signal Emission

- Tunnel infrastructure based on existing radiating leaky cables for all radio systems (FM, DAB+, PPDR Tetrapol)
- Minimum criteria for DAB+ coverage was aligned with ETSI Standards, guidelines and measurements for minimum receiver and antenna sensitivity respecting some margin.
- Some margin was added for potential man-made noise from tunnel-systems or from other cars.
- Margin is helpful for cars which do not fulfil minimum sensitivity as well.

Voice Break In

Voice Break In

- Voice break-in was one motivation for DAB+ in tunnels for Swiss Federal Roads Office
- However, voice break-in is not the only way to warn car drivers and less relevant today
- Voice break-in is not in the perimeter of Swiss broadcasters
- Complex for DAB+ (like a playout with many ensembles and audio codecs)
- Voice break-in is enforced by just replacing audio content. No signalisation, not supported by WorldDAB / ETSI standard functionality
- Steep learning curve by means of system integration, size and costs during past 14 years
  - Rack level integration (discrete per ensemble and audio codec)
  - Equipment level integration (some ensemble and audio codecs)
  - Silicon level integration (many ensembles and audio codecs)



Lesson Learned

Lessons Learned

During Planning and Specification Phase

- Understanding minimum field strength needed (measurements of cars)
- Understanding voice-break-in
- Swiss proof of concept and show casing of feasibility was successful

During Rollout Phase

- Receiving small scale ensembles could be a challenge
- Impressive learning curve for voice break-in systems

During Operational Phase

- According FEDRO and its regional offices all tunnel systems are running stable and reliable.
- However, it is not their main business and not the only way to inform car drivers within tunnels. It is seen as a service to provide excellent user experience for DAB+ driving within Switzerland.
- Different receivers with different receiver performance is seen as a challenge for drivers and FEDRO
- WorldDAB automotive working group and UX working group are very helpful

Thank you

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