RF Systems and Networks (August 31, 2020)

Test tracks for evaluation of DAB car receiver performance

Objective

The FM distribution is to be replaced by DAB+ in the medium term. For this purpose, the DAB[1] roll-out proceeded at a good pace. However, a successful transition to DAB+ requires a representation of the existing FM situation to the DAB system as a minimum, in terms of program diversity as well as in terms of achievable coverage. These requirements have to be taken into account, when the planning of the future DAB networks is carried out. However, the achievable level of coverage does not depend exclusively on the transmitter network development, but also on the performance of the DAB equipment on the market.

A significant percentage of radio consumption takes place while driving. Therefore, the mobile reception is a crucial factor in terms of listener's satisfaction. High-quality radio reception is expected by the listener in almost every situation. Limitations in this respect lead to a lack of acceptance of the entire system.

For this reason, the performance of the DAB equipment, available for the automotive market, has to be evaluated. Receivers and antennas are important aspects in this regard. But the interaction of the single components in real settings are of main interest for this purpose, too. Field tests are particularly suitable for such an analysis, as they allow the evaluation of the system (antenna, receiver and car) as a whole and the performance can be assessed in real reception environment. Thus, field tests are able to provide practically oriented findings. However, the results of field tests show generally more deviation compared to laboratory tests.

DAB test transmitter

For the field tests described above, it is important to provide radiation and propagation conditions as constant as possible. This is a prerequisite for the purpose of performance checks in order to obtain reliable statements regarding the quality of the receiving equipment. Therefore, changes in the transmitter network should be avoided, as well as strong field strength fluctuations due to propagation-related conditions. SFN networks increase the complexity of receiver behavior. As a consequence, the evaluation of the receiver sensitivity may be hampered by an SFN. Since the service following is not taken into account for the time being, the use of a single test transmitter seems to be

[1] Since only DAB+ is used in Germany for the replacement of FM, the spelling "DAB" in this document always refers to "DAB+".

suitable for the intended purposes. Among other things, this will enable a specific influence on the distribution of the test signal.

With the kind support of Bayerischer Rundfunk, a DAB test transmitter on the BR site in Nuremberg (Studio Franken, 11E 01' 38.64'' / 49N 26' 02.40'') has been put into operation for this field trial. The transmitter is operating in channel 6B and the antenna has a height (center of gravity) of 97.3m. In the current test constellation, the maximum effective radiated power (ERP) is approximately 180W.

Four different programs are available in the multiplex for test operation. As a test signal, a sine wave is used for all programs, which substantially facilitates the acoustical and analytical evaluation of interference and disruption. Four different protection levels are applied to the four subchannel streams: EEP-2A, EEP-1B, EEP-3A and EEP-2B.

Requirements for DAB equipment with respect to mobile reception

For the purpose of qualitative tests, the functionality of the receiver has to be checked, based on the field strength available. The receiver should operate properly, provided that a certain minimum field strength is given at the antenna. However, this minimum field strength varies strongly from receiver to receiver and also depends on the sensitivity of the entire system. Thus, by checking the functionality of the receiver under certain field strength conditions, a qualitative statement can be made concerning the performance of the receiving equipment.

For classification, two quality levels are distinguished by the German public broadcasters with regard to the quality requirements for the DAB receiving equipment. On the one hand, a mobile reception environment with an average consumer receiving equipment should be considered. The resulting median value of the minimum field strength at 1.5m height is 48 dBµV/m [1]. As an increased quality level for mobile reception, the minimum field strength of technically feasible quality receivers is assumed. The resulting median value of the minimum field strength at 1.5m height is 41.5 dBµV/m [2]. Both values apply to the protection level EEP-3A.

	Required minimum field strength at 1.5m height (median)
Average quality	48 dBµV/m
High quality	41.5 dBµV/m

Table 1: Minimum field strengths for DAB mobile reception for EEP-3A

In order to evaluate the quality of a DAB receiving equipment, its functionality must be assessed on the basis of the minimum field strengths listed in *Table 1.* In order to meet those quality requirements, a specific receiver functionality must be guaranteed, depending on the field strengths available. The requirements to be checked for this purpose are summarized in *Table 2.* While passing through the test tracks, a rough classification of the quality can be carried out depending on the observed functionality of the car receivers.

Available field strength	Quality requirements: Car receiver…
< 41.5 dBµV/m	*does not have to work*
41.5 - 48 dBµV/m	*should work*
≥ 48 dBµV/m	*must work*

Table 2: Quality requirements for DAB car receivers for EEP-3A

If a minimum field strength of less than 41.5 dBµV/m is found to be sufficient for operation of the receiver, this indicates a high quality of the equipment. If it requires a higher minimum field strength, but still works at least at less than 48 dBµV/m, an average quality of the equipment can be assumed. If functional capability of the receiver is only given at even higher minimum field strengths, this can be an indication of insufficient quality of the equipment.

The minimum field strengths in *Tables 1* and *2* refer to protection level EEP-3A. In the multiplex of the test signal, there are four subchannel streams with different protection levels. The two system variants with EEP-1B and EEP-2A are more robust than the EEP-3A protection level due to their lower code rate and therefore, the reception should be more stable compared to this one. The system variant with protection level EEP-2B has a higher code rate than EEP-3A and is therefore more vulnerable in its reception properties. It is to be expected that the signal with EEP-2B will fall slightly behind the requirements of *Table 2.*

Proposed test tracks

Several test tracks are proposed, which seem suitable both in terms of the expected field strengths and in terms of the available infrastructure. An appropriate distribution of the field strengths is important for the choice of the test tracks. The values should ideally range around the minimum field strengths to be tested. There should be sections below the minimum field strength for high quality as well as above the minimum field strength for average quality for the evaluation of extreme operating conditions. All the test tracks introduced below are fairly close to the transmitter, the maximum distance of the test points to the transmitter is 22km. This will minimize the influence of propagation-related field strength variations.

Figure 1 gives an overview of the four introduced test tracks, in particular with regard to their position relative to the transmitter.

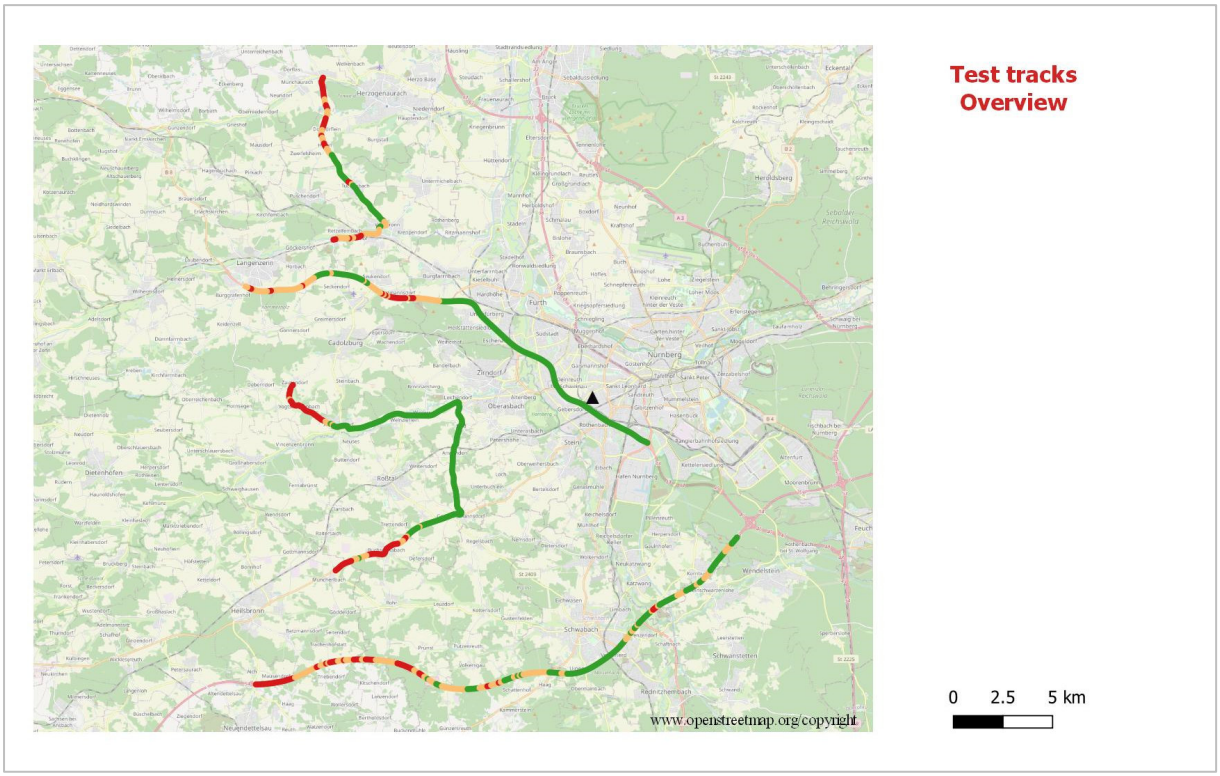

Figure 1: Overview of the introduced test tracks

Measurements were carried out to specify the expected field strengths on the proposed test tracks. Thereof, the functionality of the receivers in order to fulfil the quality requirements from *Table 2,* can be derived.

Brief descriptions of the four test tracks are given in the following section. All suggested test routes are available as high-resolution JPEG images using OpenStreetMap (source: www.openstreetmap.org). Alternatively, they can be made available as kmz-files for the purpose of presentation in Google Maps or Google Earth. The representations indicate the expected functionality of the receiver, which must be guaranteed in order to meet the quality requirements set out in *Table 2.* The test routes can also be provided in shape format for further analysis in GIS tools.

Test track 1:

Location: Motorway A6 between the junction Neuendettelsau (49° N 18' 17.16'' / 10° E 47' 38.97'') and the junction Nürnberg-Süd (49° N 22' 15.40'' / 11° E 07' 38.57'')

Length of the test track: approx. 27.5km

Distance to transmitter (Min / Max): approx. 10km / 22km

Note: motorway route, therefore also well suited for trucks

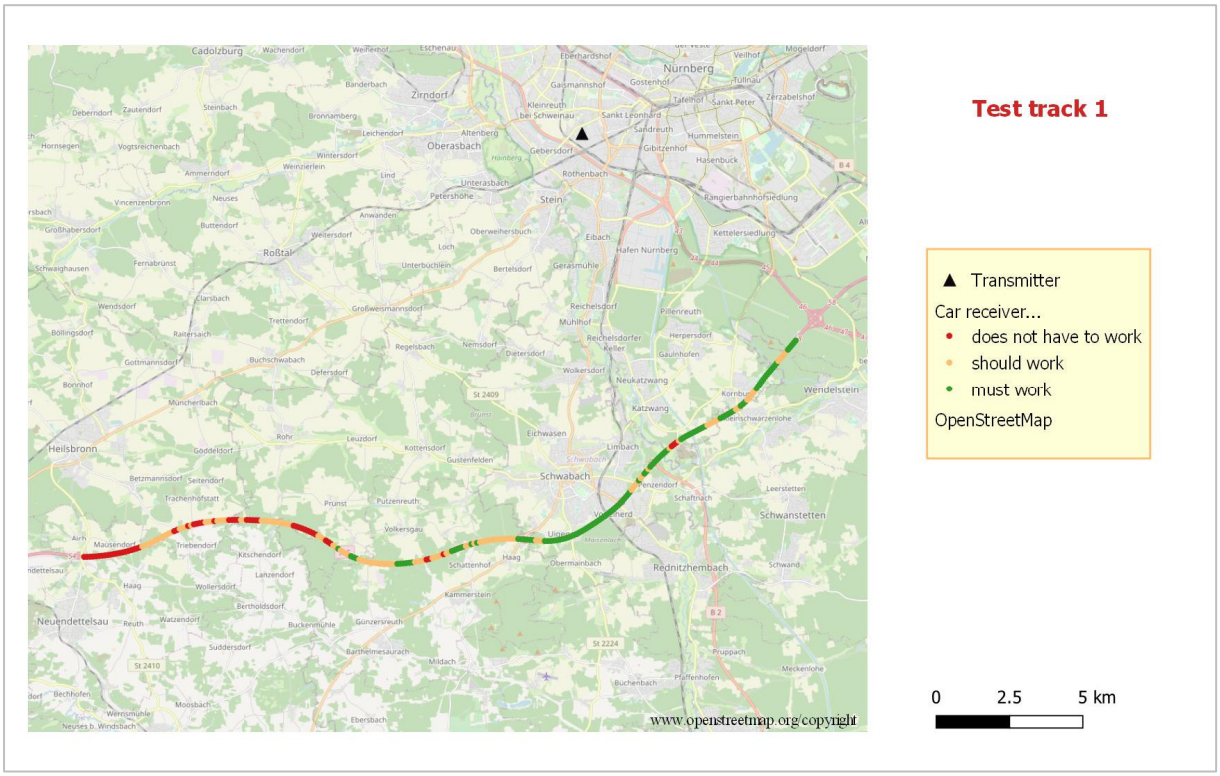

Figure 2: Quality requirements test track 1

Percentage of the route	**covered**	< 39 %	39 % … 80 %	> 80 %
	not covered	> 61 %	61 % … 20 %	< 20 %
Quality of the receiving equipment		**insufficient**	**average**	**high**

Table 3: Reference values for quality on test track 1

Test track 2:

Location: between Südwesttangente G109 junction Nürnberg-Hafen (49° N 24' 48.83'' / 11° E 03' 55,32'') and interstate road B8 connection point Langenzenn-Süd (49° N 29' 3.5'' / 10° E 47' 13'6'')

Length of the test track: approx. 23.5km

Distance to transmitter (Min / Max): approx. 0.5km / 18km

Note: highway and interstate road, therefore also well suited for trucks

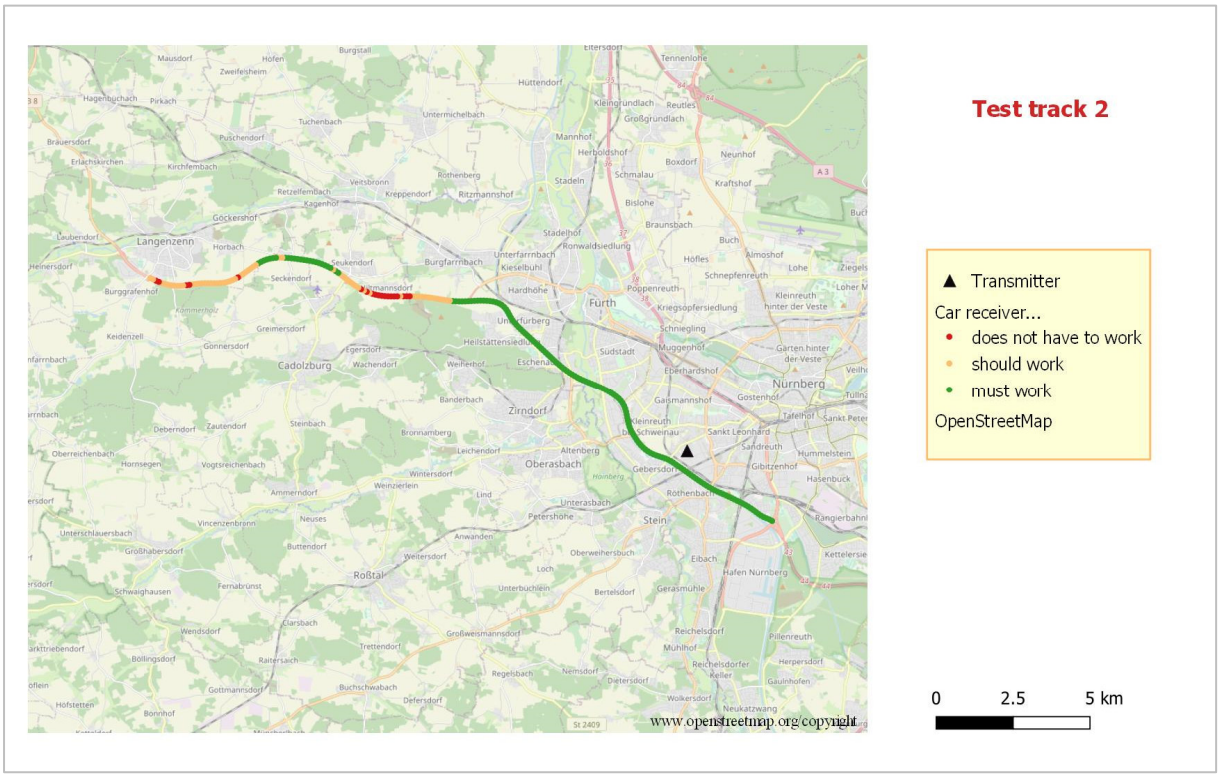

Figure 3: Quality requirements test track 2

Percentage of the route	**covered**	< 67 %	67 % … 92 %	> 92 %
	not covered	> 33 %	33 % … 8 %	< 8 %
Quality of the receiving equipment		**insufficient**	**average**	**high**

Table 4: Reference values for quality on test track 2

Test track 3:

Location: country road between Falkendorf (49° N 34' 40.51'' / 10° E 50' 26,38'') and Raindorf (49° N 30' 18.94' / 10° E 50' 52.53'') via Veitsbronn

Length of the test track: approx. 11.5km

Distance to transmitter (Min / Max): approx. 13.5km / 21km

Note: small roads through villages, underpass in Siegelsdorf, therefore only partially suitable for trucks

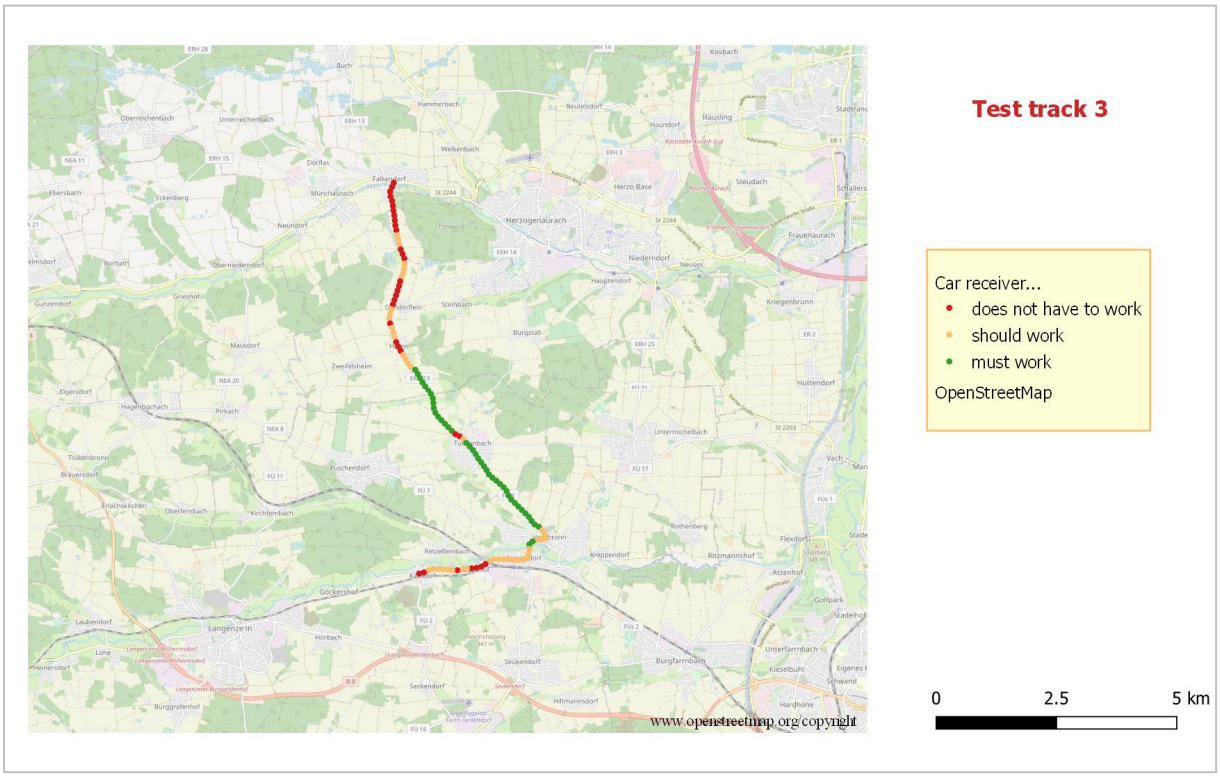

Figure 4: Quality requirements test track 3

Percentage of the route	**covered**	< 36 %	36 % … 72 %	> 72 %
	not covered	> 64 %	64 % … 28 %	< 28 %
Quality of the receiving equipment		**insufficient**	**average**	**high**

Table 5: Reference values for quality on test track 3

Test track 4:

Location: from Zautendorf (49° N 26' 23.97'' / 10° E 49' 11,22'') via Leichendorf and Großweismannsdorf to Müncherlbach (49° N 21' 22.08'' / 10° E 50' 58,11'')

Length of the test track: approx. 23km

Distance to transmitter (Min / Max): approx. 6.5km / 15.5km

Note: between Zautendorf and Ammerndorf small roads through villages, underpass before Anwanden, therefore only partially suitable for trucks; interstate roads starting at Großweismannsdorf, also well suited for trucks

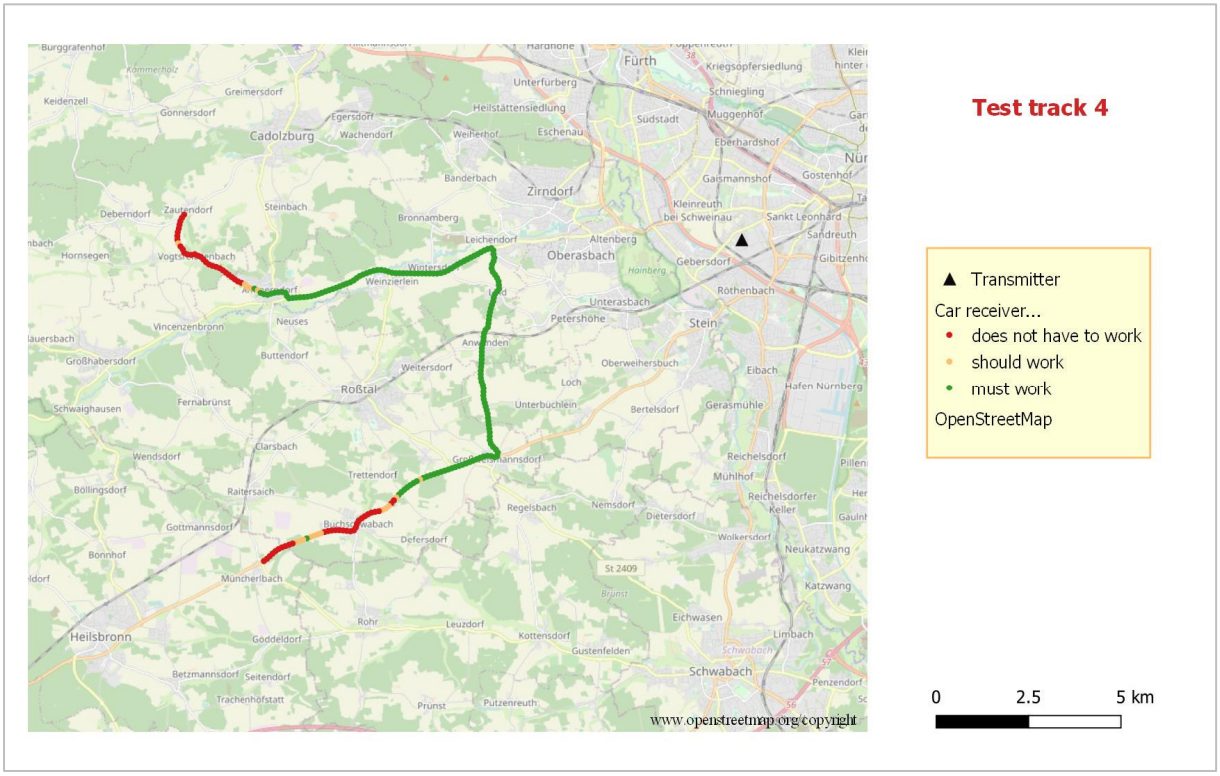

Figure 5: Quality requirements test track 4

Percentage of the route	**covered**	< 67 %	67 % … 75 %	> 75 %
	not covered	> 33 %	33 % … 25 %	< 25 %
Quality of the receiving equipment		**insufficient**	**average**	**high**

Table 6: Reference values for quality on test track 4

Information on the organizational procedure

The frequency allocation for the DAB test transmitter is limited to experimental and test transmission only. Therefore, the transmitter is put into operation solely if required. In order to ensure a smooth process, we kindly ask you to register your request for a test operation informally at the following e-mail address:

dab-testsender@rbt-nbg.de

Please make a note in your registration regarding your preferred timeframe for the test rides. If you need to make any time changes afterwards, please inform us as soon as possible to ensure a running test operation.

For further questions and suggestions, please feel free to contact:

ARGE Rundfunk-Betriebstechnik
Kerstin Pfaffinger
RF Systems and Networks
e-mail: kerstin.pfaffinger@rbt-nbg.de
phone: +49 (0)911/6573-180

References

[1] AFM/DAB-Expertengruppe, *DAB/DMB/DAB+ Planungsparameter 003rev-DAB,* December 2013

[2] Technische Richtlinie Nr. 5/9.4, *Messtechnische Beurteilung der DABplus-Versorgung,* Munich, February 2016