Factsheet

DAB+ digital radio: a guide to a successful field trial

Laying the groundwork for a future rollout

Motivation

When radio ecosystem members in a country become interested in establishing DAB+ digital radio, they want to explore DAB's features and capabilities and understand the process to establish DAB+ as a national broadcasting system. One of the best ways to undertake these initial steps is to establish an on-air field trial system which will provide coverage to a suitable target area.

Field trials are easily scaled depending on the proposed target area. For national planning, the field trials may start with a major city and then expand to regional areas to provide understanding of the impact of terrain and clutter in different environments. At the other end of the scale, field testing can be used to determine, or verify, the transmission power required to cover areas targeted for small-scale DAB.

A field trial usually also includes one or more workshops to explain how the DAB+ system works both technically and from a business perspective. A field trial allows local radio technical and management staff to investigate and experience several aspects of the DAB+ system including:

- Understand how DAB+ works – technical workshop during the field trial period
    - Demonstrate DAB+ features
    - Demonstrate different types of receivers
- Explore coverage and DAB+ signal propagation – field trial
    - Mobile drive testing
    - Building Entry Loss (BEL) assessment
    - Man Made Noise (MMN) characterisation
- Review / test audio quality and related settings – laboratory testing
- Feature demonstrations to stakeholders – for example, at stakeholder meetings
- Systems operational training and feature demonstrations can be at an equipment centre or a "laboratory" site
    - Multiplexer systems
    - Transmitters
    - Test and measurement equipment

DAB+ field trials can run for different periods, from a simple one-off demonstration for a few days, to months if larger scale investigations and demonstrations to multiple stakeholders are required, to long-term coverage that eventually becomes part of the final system design.

The recommended activities that follow provide guidance for those wishing to establish DAB+ digital radio. Post-technical trial activities including marketing, receiver supply chain establishment and the production of digital radio content, should also be considered prior to DAB+ launch. More information on the overall process of establishing DAB+ can be found in the WorldDAB ebook "Establishing DAB+ digital broadcast radio" available for **free** at https://www.worlddab.org/resources/establishing-dab-plus-ebook.

Radio ecosystem and stakeholder engagement

Once there is some interest in DAB+ from within the radio ecosystem, the first step is to gather like-minded people to discuss how to move forward. This process is different in every country but is a common opportunity to start the overall process. The initial interest may be from broadcasters, the broadcast regulatory body, or both. The most important aspect is gathering and forming a working group to discuss and action the various aspects of the process.

It is normal to establish a DAB+ committee with representatives from across the radio ecosystem. This committee should meet regularly to discuss progress and develop plans. In some countries this initial group is confined to the industry regulator. At least initially however, we strongly recommend that representation in such a committee includes all relevant sectors of the industry.

Once the committee has decided to undertake the important step of establishing a field trial, they need to define the requirements., These include:

- Determine where the trial will be undertaken and the availability of VHF Band III spectrum
    - The DAB+ trial should not impact any other services within VHF Band III so suitable analysis of the expected impact on existing services such as legacy ATV or new DTV should be undertaken
    - This is also an opportunity to assess the future availability of spectrum for DAB+ and to start conversations about both the importance of establishing DAB+ as the backbone of radio's digital future and beginning the process of determining a roadmap for spectrum availability
- The period of time the trial will last
    - This may be very targeted, for example one month or one year, or may be kept active as a pre-commercial coverage opportunity once the decision to move forward has been made
- What needs to be tested and demonstrated
    - Demonstrations to management, especially advanced digital features
    - Technical experience and systems knowledge building
- How much finance is available
    - The biggest capital expense will be the transmitter(s) and antenna systems and their installation.
    - Trials may also include contribution and distribution networks to deliver audio and metadata to the multiplexer site and to deliver the ETI stream to the transmitter site(s). This is usually via a Telco operator and should be budgeted for over the expected lifetime of the trial
    - Higher power trials, e.g. 4 to 10 kW ERP, provide more opportunities to study the impact of terrain and clutter on DAB+ coverage and propagation
    - Technical testing of DAB+ requires specialised test equipment

Liaising with government

Broadcasting is controlled by each country's government usually through a telecommunications regulatory body. Broadcasters should discuss with the regulator the cost benefit of establishing DAB+ digital broadcast radio, and the availability roadmap for the use of VHF Band III spectrum for DAB+ operation, preferably through a cross-industry committee.

The cross-industry committee can then make formal approaches to the government through the regulator, which should also be represented. An open approach will allow all parties to air their opinions and guide the development process.

When a decision is made to establish a trial, the details need to be documented in a joint approach to the government and the regulator with a proposal expressing the ambition to move to DAB+ digital radio, and request permission to run a DAB+ digital radio trial.

The proposal to government should outline the benefits of digital radio for broadcasters and listeners, manufacturers and suppliers of both domestic and automotive products and services, and advertisers and marketing agencies.

Obtain a trial licence

The proposal to government should include a request for a trial licence for a minimum period, such as two years, to trial DAB+ digital radio in unused VHF Band III spectrum. If VHF Band III is still used for ATV or DTV, then the location and/or power of the trial may be limited.

It is important to plan for in-building coverage, not just vehicular coverage, so aim for a suitably high transmission power, typically 4 to 10 kW ERP. We note that some countries opt for very high powers even at trial stage, such as South Africa with 100 kW ERP at two sites which allowed extensive testing including Single Frequency Network (SFN) studies.

Equipment for the trial

For a trial, seek a loan of equipment or a very low-cost lease or purchase. Suppliers should see helping with your trial as an opportunity to demonstrate their equipment and to build a relationship with broadcasters and the regulator. This particularly applies for software-based systems such as multiplexing and encoder networks but will be more limited for physical systems such as high-power transmitters and antenna systems. The cost of installation may also need to be included, particularly when a new transmission antenna is required.

The trial transmission should be located at a suitably high site, usually a broadcast site. It is important that stakeholders understand the expected coverage of the trial before the system is constructed. This can be determined using modern propagation planning tools and services.

It is very important to be able to demonstrate the full suite of DAB+ features and capabilities, and the software and other equipment used at this stage must be specified for this. There will be opportunities for cost savings in the system design phases.

The wide range of activities possible once the trial is on-air are explored below.

Coverage drive testing

One of the most important activities in trials is the measurement of coverage. This allows comparison with coverage predicted by modern radio propagation tools, as well as the “tuning” of the propagation models to maximise the prediction accuracy. We typically seek to obtain a correlation between the prediction and measurements of over 95%.

The field testing will allow the clutter that is used in the prediction to be updated to improve accuracy, for example, building heights of suburbs as well as the inclusion of very tall buildings. This may require a drive-by study campaign to estimate the heights of buildings. For example, in the Bangkok DAB+ trial, the antenna was 196 m AGL, however there are over 30 buildings in Bangkok which are taller than this and which create significant shadowing effects to a large area of the city. Those very tall buildings had to be included in the clutter map to ensure suitable prediction accuracy, see Figure 1.

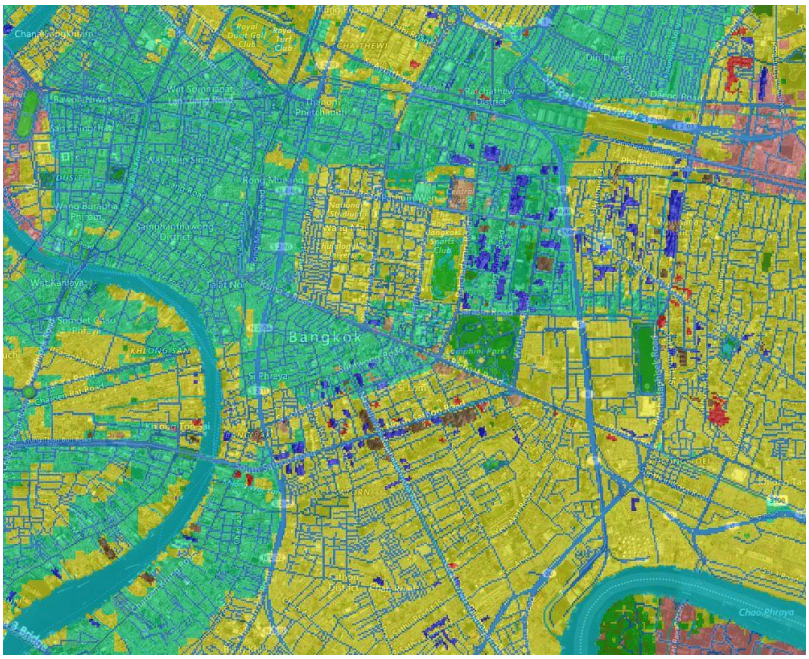
To ensure accuracy, we suggest that the Digital Terrain Map (DTM) has a resolution of 20 m or less. The clutter that is often provided lacks specific building details, so there are usually two choices:

1. Update the building clutter manually by identifying specific buildings and estimating their size and height, or

2. Purchasing a high resolution DTM along with an up-to-date building layer clutter map.

The former typically takes between one and five staff days per city, while the latter has a financial cost. An example clutter map of the Bangkok CBD is shown in Figure 1.

There are several models used within propagation prediction tools. These include ITU recommended propagation models such as P.525/526 and P.1812, as well as customised models such as CRC-Predict. These are deterministic models and should be used for a receiver height of 1.5 m AGL. Other models such as ITU P.1546 are mainly used for interference assessment and are empirical models which usually have less accuracy. An example coverage map showing the impact of very tall buildings is shown in Figure 2.



Clutter code		Name	dB/km	Atten (dB)	Clutter height
0		open	0.0	0.0	0
1		Extreme urban	0.0	0.0	200
2		suburban	0.0	0.0	8
3		urban	0.0	0.0	15
4		dense urban	0.0	0.0	30
5		forest	0.0	0.0	12
6		hydro	0.0	0.0	0
7		high urban	0.0	0.0	50
8		park/wood	0.0	0.0	4
9 *		very high urbar	0.0	0.0	100
10		rail	0.0	0.0	0
11		road	0.0	0.0	0
12		airport	0.0	0.0	0
13		port	0.0	0.0	0
14		open rural	0.0	0.0	0
15 *		vv high urban	0.0	0.0	150

Figure 1: Example clutter in the Bangkok CBD area along with the clutter heights by colour

Figure 2: An example coverage prediction showing shadow lines caused by very tall buildings in Bangkok including drive test results track and the field strength pallete

The development of accurate coverage predictions is critical to the eventual cost of establishing a DAB+ transmission network as it ensures the most accurate assessment of the ERPs required at transmission sites to meet the coverage field strength targets of each coverage area type. The field strength requirements are developed using the model provided in EBU Tech 3391 [1]. Field testing can help establish a number of the parameters used in the development of field strength targets such as Building Entry Loss (BEL) and Man-Made Noise (MMN), the details of which are discussed below. The incorrect selection of transmission ERPs and associated transmitters and antennas can incur considerable cost if over-designed and result in poor coverage and large black spots if under-designed, so it is vital to ensure maximum accuracy. To this end, the training provided by field trials can deliver significant cost savings during the DAB+ network design and implementation stages.

Field testing can also be used to explore the impact of technical settings used for transmission. This includes the trade-off between the Forward Error Correction (FEC) code rate and the data capacity of the transmitted ensemble. The usual code rate used is EEP-3A, which is considered to provide a good balance between error correction and payload capacity. It has a code rate of R=1/2 and is used for the vast majority of DAB+ transmissions around the world. There are however situations where other FEC code rates may be useful, for example when multiplex capacity demand is high, some services could employ EEP-4A, R=3/4 coding, to provided additional payload capacity at the expense of a smaller coverage area. Regulators and system designers may wish to measure the impact of different FEC code rates to better understand the impact on coverage and service delivery performance.

Other planning parameter tests

The measurement and processing of field strength reception allows assessment of Building Entry Loss and Man-Made Noise values which are usually included in the field strength target calculations in [1]. Both parameters vary depending on the reception environment and the country to be covered. Every country is slightly different, for example in Europe each country has determined its own target field strengths, see [2] §7.5. The reception environments are usually defined as mobile outdoor, suburban indoor, urban indoor and dense urban indoor, see [1].

Building Entry Loss (BEL) can be assessed by comparing measured field strengths outside and inside the building under test. Care needs to be taken to ensure suitably accurate results and like-for-like comparisons. Outdoor measurements are usually taken at ground level, while indoor measurements can take into account ground and higher levels. It can be useful to measure at different distances inside the building, particularly for non-domestic buildings such as offices, to assess how far indoors the DAB+ signal can propagate. Also, measurements on higher floors will generally have a higher value, with field strength typically increasing by 2 to 3 dBµV/m per floor until Line of Sight (LOS) to the transmitting antenna is achieved. When undertaking BEL measurements, it is important to have a suitable statistical basis with multiple measurements for each “class” of building, where the class is determined by the building materials used for construction. See [1] Annex E for an example.

Man Made Noise (MMN) is gradually increasing as we use more and more electronic devices. This is the case inside homes and workplaces, as well as the general environment where in cities we have many additional contributors in the form of cars, power grids, mobile and other communications devices. Consequently, the values used in the target field strength calculations are gradually increasing, particularly for urban and dense urban environments.

The measurement of MMN requires the use of additional equipment, typically a RF spectrum analyser. In this case we measure the field strength or power density (for example, dBm/Hz) of the wanted DAB+ signal, as well as the MMN in the adjacent channels, upper and lower if not used for DAB or another system such as DTV.

For BEL analysis, this is a statistical exercise and the more measurements and environments that can be captured the better. In some cases, the resulting values may differ from the typical values shown in [1]. It is the regulator’s choice as to what values are used to define the target planning field strengths in each country.

Audio quality testing

When establishing a new market, broadcasters and regulators may wish to assess the impact of the service bit rate on the resulting audio quality. It is well known that different audio types including classical, folk, pop, rock, or other music, as well as speech, require different sub-channel bit rates and audio settings to deliver the preferred audio quality. The perceived audio quality is also impacted significantly by the audio delivery system and the listening environment. There is a big difference between listening using professional headphones or in modern cars with multi-speaker sound systems, compared with using a table-top radio in a kitchen environment.

The ITU provides guidance on subjective audio quality testing, see [3] in the first instance and references therein to additional ITU Recommendations as needed.

Also note that the actual audio stream bit rate is not the service’s sub-channel bit rate, as both the additional FEC coding of AAC+ based sub-channels and the PAD bit rate need to be considered, see [4] for details. The audio bit rate may be calculated using the following equation:

$r_{audio} = 0.9\, r_{sub-channel} - r_{PAD}$ (kbps)

where the 0.9 accounts for the approximately 10% overhead of the Reed-Solomon FEC code used to protect the audio stream.

The knowledge gained from subjective listening tests allows broadcasters to understand the impact of the settings used for their services on the audio quality experienced by their listeners. This in turn allows them to adjust those settings to best serve their audience.

While most countries leave the decision of service bit rate to the broadcaster, some regulators may wish to set minimum performance standards, such as Slovenia which requires a minimum service bitrate of 48 kbps, parametric stereo and FEC code rate EEP-3A.

Audio quality testing is particularly useful when it is conducted as an industry exercise, as it then allows common understanding between the various stakeholders. It can however be complex and time consuming.

Feature testing

This provides a demonstration of the features of DAB. Some features are easily demonstrated, such as DL text, SLS images, language support and announcements, but others are more difficult as the feature requires a specific environment and parameters to perform the required changes, for example Service Linking and hybrid features.

The DL text, SLS and language features can be tested and documented visually in a report, however the Announcements and Service Linking features are dynamic and are usually captured in a video clip.

The Announcements feature is usually only available in car receivers and hence testing may require drive testing for factory fitted vehicles or bench testing for aftermarket products. Recently a domestic receiver was produced as a test device by Keystone Semiconductors and Sangean manufacturing, please contact WorldDAB for further information.

Service Linking testing also requires vehicle-based testing, both DAB to/from FM and DAB to DAB testing should be undertaken if possible.

System operations training

In some cases, vendors are keen to show potential customers the details of their systems, this can be for both multiplexing and transmitter systems. This generally involves detailed training and provides the delegates with the skills and knowledge of how the equipment works and how to operate it.

The training may be limited in initial trials; however such training is encouraged from multiple vendors to provide a broad view of the features and operating approaches that different vendors provide. This will provide valuable input to the system requirements at equipment tendering time when a DAB+ rollout is being planned.

Stakeholder feedback

The tests above provide useful feedback to technical and management staff. It is important to report the results to all stakeholders to allow a full discussion of what the market needs and how to provide the necessary services.

Undertaking field trials and the subsequent learnings should provide the DAB+ system development team with information to ensure efficient system designs and the minimisation of the overall Total Cost of Ownership (TCO).

It is important to create and maintain relationships with stakeholders throughout the DAB+ system establishment. The retailer and the automotive sectors should also be kept informed.

What to do with the DAB+ trial after the initial tests are completed

Once the initial set of tests are undertaken, analysed and the results disseminated, it is not unusual that further information and related tests are planned. Trials and experiments can take several years and be conducted in parallel to national system designs and coverage planning exercises.

While the initial trial may use some borrowed equipment, it is often useful to purchase the equipment to allow for longer-term experimentation.

When trials are established at working broadcast sites, the trial may be upgraded in the future to become part of the fulltime operational network.

Conclusions

Field trials provide opportunities for the various radio stakeholders to experience DAB+. Different stakeholders will have different perspectives where the focus may be audio quality for broadcasters and listeners, transmission planning parameters for network operators, and capacity and interference requirements for regulators.

Overall, such trials provide an invaluable opportunity to gather the radio community in an immersive and productive experience. This in turn helps all stakeholders understand the other's perspective and should result in a smoother and faster DAB+ system rollout.

References

[1] EBU Tech 3391, "Guidelines for DAB network planning", May 2018
[2] WorldDAB ebook, "Establishing DAB+ digital broadcast radio", L. P. Sabel, 2023
[3] ITU-R BS.1284-2, "General methods for the subjective assessment of sound quality", 01/2019
[4] ETSI TS 102 563, "Digital Audio Broadcasting (DAB); Transport of Advanced Audio Coding (AAC) audio"

Further support from WorldDAB

For full information on setting up a DAB+ trial and for equipment supplier details, visit: www.worlddab.org or contact projectoffice@worlddab.org.