TERACOM

The Swedish Digital Radio Pilot Project

Setup of the DAB+ network

Background

In 2008 the Swedish Radio and TV Authority recommended that DAB+ should be used as the future system for digital radio in Sweden. The recommendation was supported by a majority of the Swedish radio industry, including the public service broadcaster Swedish Radio, the two major commercial radio groups MTG Radio and SBS Radio, network operator Teracom and the national organization of community radios NRO.

As a result of the recommendation the government decided to propose a change in the broadcast regulation. The new legislation came into force on the 1st of August 2010, stating ground rules so that it now is possible for commercial broadcasters to apply for digital radio licenses. Some of the ground rules include the license period (eight years) and that there will only be a smaller, administrative application fee. The application process will begin early 2011.

In order to prepare for the application process and the coming deployment of networks and services, Teracom decided to establish a DAB+ test network in the three towns of Stockholm, Uppsala and Gävle. At the seminar “Radiopuls” Teracom announced that the network will be opened up for broadcasters who wish to develop know-how and create experience from the new digital services and the technology. The first DAB+ transmission were launched in Stockholm on the 14th of May 2009 and were quickly followed by Gävle and Uppsala during fall 2009.

Content

The content in the DAB+ network is constantly changing. As of October 2010 the following broadcasters have delivered content and participated in the project:

Figure 1 Content/channels in the DAB+ pilot network as of October 2010.

The content providers so far are: Public Broadcaster Swedish Radio, with audio programs such as **SR P2**, **SR P3**, **SR Metropol** and **SR P4 Stockholm**. Commercial broadcaster group MTG radio, with audio programs such as **RixFM**, **NRJ**, **Lugna Favoriter** and **Bandit**. Other local, community and commercial broadcasters, with audio programmes such as **Dansbandskanalen**, **RocketFM**, **Skärgårdsradion**, **Radio Lidingö** and **Uppsala Studentradio**. Last but not least, actors that do not have an analogue FM license and currently are only broadcasting on Internet, such as **Radioseven** and **Radio DeeJay**. All in all approx. 15 audio programs with PAD has been on air simultaneous.

Typical ensemble configuration

Service name	Sub-channel bit rate	Audio mode	SBR	PS	PAD (kbit/s)	DLS text	Slide show
SR P2 Musik	112 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
SR P3	96 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
SR P4 Stockholm	80 kbit/s	Stereo	Yes	No	8 kbit/s	Yes	Yes
SR Metropol	72 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Rix FM	72 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Lugna Favoriter	72 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
NRJ	72 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Bandit Rock	72 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Radio Deejay	72 kbit/s	Stereo	Yes	No	4 kbit/s	Yes	Yes
Dansbandskanalen	80 kbit/s	Stereo	Yes	No	8 kbit/s	Yes	Yes
Skärgårdsradion	72 kbit/s	Stereo	Yes	No	4 kbit/s	Yes	Yes
Studentradion	64 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Radio Lidingö	64 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Radio Seven	64 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No
Rocket FM	64 kbit/s	Stereo	Yes	No	1,3 kbit/s	Yes	No

Table 1. A typical multiplex configuration

Several other configurations of the multiplex were also tested. The tests included:

- comparing higher and lower bitrates for audio, typically 48-192 kbit/s
- comparing higher and lower bitrates for PAD, typically 1,3-8 kbit/s
- comparing MPEG layer II audio encoding, with HE-AACv2 audio encoding
- comparing HE-AACv2 with or without SBR and parametric stereo (PS)
- using different code rates (½, ¾) to increase the total useful bandwidth from 1,2 Mbps up to 1,7 Mbps
- transmission of service following, DAB-DAB and (when applicable) FM-DAB

Transmitter network

City	Site	Channel	ERP	Antenna height	Polarisation
Stockholm	Nacka	12D	15 kW	240 m	Vertical
Stockholm	Kaknäs tower	12D	0,7 kW	102 m	Vertical
Stockholm	Marieberg	12D	0,2 kW	92 m	Vertical
Uppsala	Vedyxa	13C	20 kW	200 m	Vertical
Gävle	Skogmur	13F	20 kW	280 m	Horizontal

Table 2. The transmitter network. Note that Gävle has horizontal polarisation.

The objective of the transmitter network design was to

1. Achieve first-class indoor coverage in the built-up areas of Stockholm, Uppsala and Gävle with surroundings
2. Achieve good outdoor (area) coverage on the roads connecting the three cities

Several network designs were calculated and compared. The most cost efficient network was proved to be when using high power transmitters for area coverage in combination with low power transmitters in densely built-up areas.

- *High power transmitters* (ERP:s of 15-20 kW) typically uses high tower masts. The signal strengths from one of the transmitters alone are enough to achieve sufficient portable indoor coverage within a city with surroundings, or in other words a radius of approx. 40 - 50 kilometres. The main transmitters in the Swedish DAB+ network are operating in a multi-frequency network architecture, giving the possibility to add locally inserted programs and commercials.
- *Low power transmitters* (ERP:s of 200-700 W) is typically used to improve indoor coverage in densely built-up areas and to cover white spots. The low power gap-fillers are operated in a single-frequency network with their main transmitter. A receiver in the target area is subsequently in many cases reached by signals coming from different directions (different transmitters), meaning the probability of acceptable coverage is substantially increased.

Several antenna designs were used and compared.

- At one of the sites, Gävle, horizontal polarisation was used as a result of re-using the old analogue TV/VHF-antenna to broadcast DAB. The first field measurements indicate that reception of horizontal polarised signals with a vertical antenna requires slightly higher field strength. However, in most areas it seems to work well due to a good margin in field strength.
- In Uppsala a combined horizontal and vertical antenna was used. This solution showed to be a cost effective and mast space saving way to implement both DAB+ and DVB-T2 in VHF band 3.

Coverage map

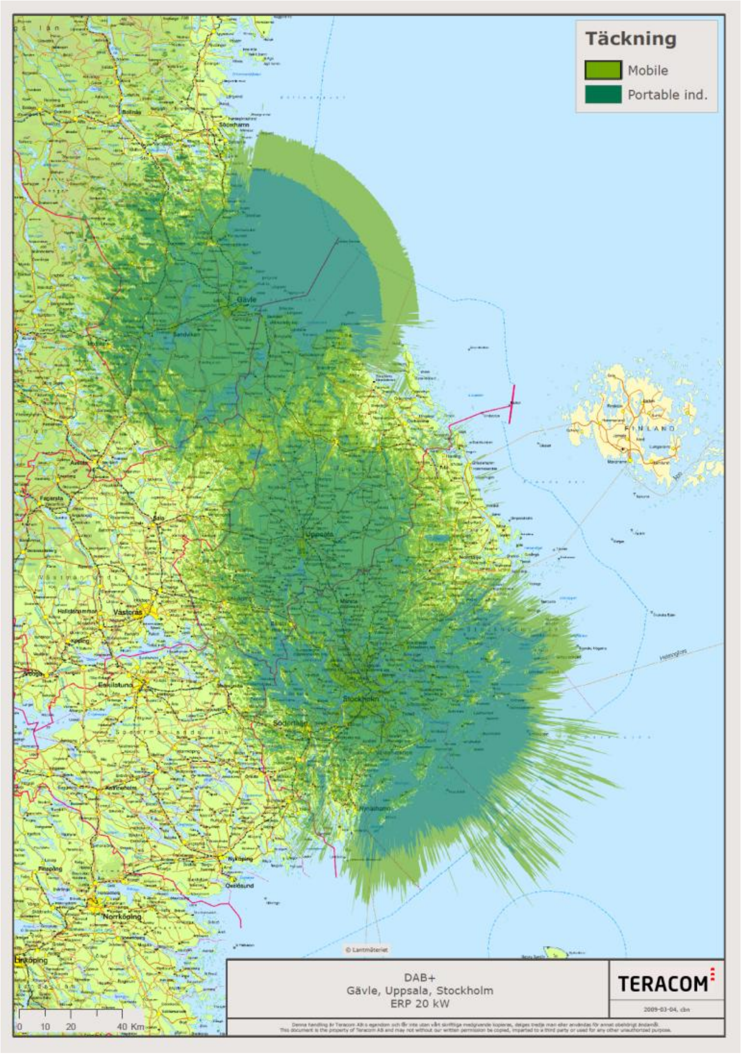

Figure 2. Coverage map. Reception conditions may vary depending on the buildings construction and how the receiver is placed. Area covered is eq. with 22% of the Swedish population.

Coverage class	**Median field strength**	**Description**
Portable Indoor (Dark green)	> 58 dBµV/m@1,5m (95% loc. prob.)	-Very good outdoor coverage. -Good or very good indoor coverage.
Mobile Outdoor (Light green)	48-58 dBµV/m@1,5m (99% loc.prob)	-Good outdoor coverage. -Limited indoor coverage.

Table 3. The minimum requirement used for network planning at Teracom.

Head-end system

The DAB+ head-end system has been provided by Factum Electronics and is based on their Ensemble Provider System concept. The system is configured to be able to carry up to 16 radio stations with additional program associated data as well as standalone data services such as EPG and TPEG.

The Factum EMX100 ensemble multiplexing system and its DBS100 data insertion server is placed in the central multiplexing site at Stockholm Nacka. At this site two Factum MAP250E DAB+ encoder units are also placed. The two encoder units provides capability to encode up to 8 DAB+ channels, which are fed to Nacka from the radio stations via Audio over IP contribution lines.

For broadcasters Swedish Radio and MTG Radio, providing four radio channels each, a distributed encoding solution is used. In this case the DAB+ encoders are placed at the studio and Teracom's IP-based WAN is used to stream the DAB+ encoded radio programmes into the central multiplexing site.

In the pilot project sub-channel bitrates of 48-112 kbit/s were allocated and tested in order to give an acceptable audio quality for services with and without Slideshow transported as PAD. With 16 channels in the multiplex the chosen bitrates are 64, 72 and 80 kbit/s which enables some capacity to be allocated for standalone packet mode services such as EPG and TPEG.

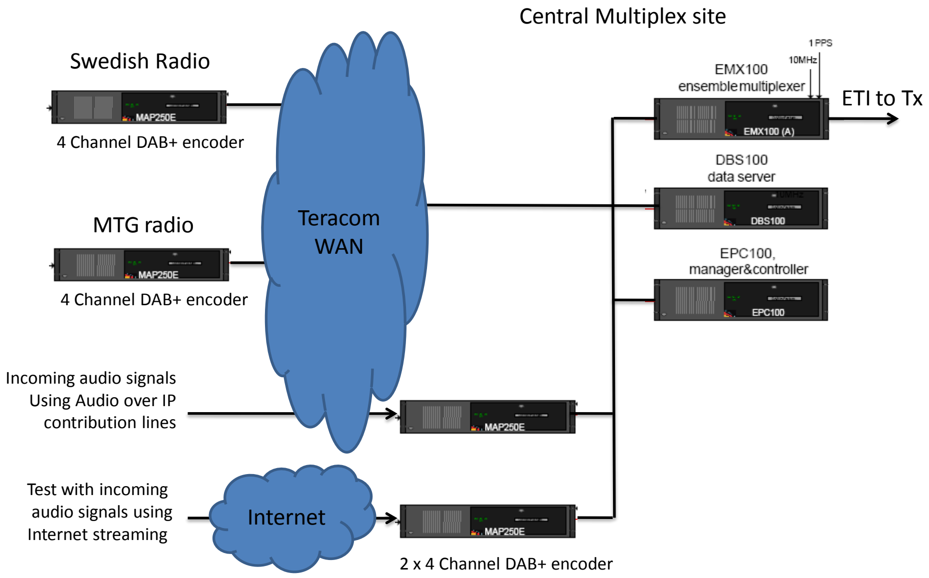

Figure 3. The head-end system used in the DAB+ network.

Additional data services

Technology like DLS (Dynamic Label Segment) and DAB Slideshow are straightforward examples of information that a radio station could provide besides the audio. When used with consideration, they are perfect tools for branding a radio station and for increasing the relevance of the program among its listeners. Below are some of the DLS and Slideshow examples being transmitted in the DAB+ pilot network.

DLS examples

Figure 4. DLS dynamic text displaying "this song" and "next song" on a PURE EVOKE FLOW.

Figure 5 DLS dynamic text displaying "this song" and "next song" on a SONY XDR-S16 .

Slideshow examples

Figure 6. A listener takes a picture of the first spring flowers and emails it to the studio. The photo is published by the editor on the stations website. The Teracom platform is constantly polling the RSS-feed of the stations website. Subsequently, the photo is broadcasted as slideshow in DAB+ digital radio.

Figure 7. One of the participating radio stations is targeting listeners in the Stockholm archipelago. By using public webcam pictures, the archipelago weather is being broadcasted as DAB+ slideshow along with the audio.

Figure 8. The weather pictures from the archipelago are sponsored by Gill, a clothing manufacturer specialising in garments suitable for sailing. Gill is the radio stations main sponsor. Every fifth or so slideshow picture shows the Gill company logo and a sign "sponsored by".

Figure 9. One of the participating radio stations is targeting listeners in the car. By using public available webcam pictures, the traffic situation is being broadcasted as DAB+ slideshow along with the audio.

Figure 10. One of the participating radio stations broadcasts live from Sweden's many dancehalls .Teracom developed an application allowing their listeners to upload pictures to the digital radio platform, using their MMS enabled mobile phone. The pictures are being reviewed by the radio station and, if approved, published as a DAB+ slideshow along with the audio. The cost of sending the MMS, approx. 1 Euro, is charged to the listener's mobile phone bill and the revenues are split between mobile phone operator and the radio station.

Measurements and testing

Test Receivers

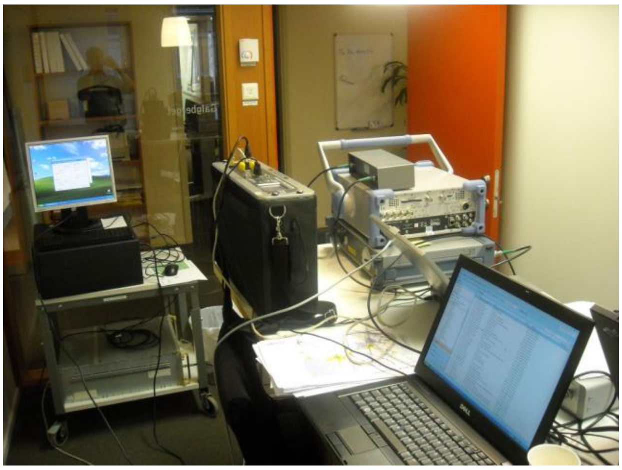

Figure 11. Teracom test bench.

For planning and operation it is essential to know the propagation and interference conditions in the area to be covered. Teracom uses a precision field-strength measurement receiver (ESVB) which is highly suitable for measuring signal and interference field strengths. The measurement data from the ESVB were compared with that of specific DAB+ test measurement receivers. To some extent, the comparison could be used to assess which DAB+ test measurement receiver has the best performance.

Consumer Receivers

Figure 12. Some of the consumer receivers tested.

Most important, the DAB+ transmissions gives necessary opportunities for trying out the end consumer product in means of receiver-listener interface. Several receivers were tested and the results were confidentially shared with the respectively manufacturer. As a result, some lack in basic functionality (and in very rare cases even hardware failures) could be corrected. All in all, the receiver performance was good, in some cases very good, in the models Teracom tested.

Field measurements

Figure 13. The Teracom field measurement vehicle.

To plan a broadcast network, a software field-strength "prediction tool" is used.

- The input data to the calculations are parameters such as number of transmitters, ERPs, antenna heights, site locations, antenna patterns, receiver performance including antenna gain, RF channel characteristics, man-made noise, building penetration loss, mean value and the field-strength location variation, etcetera.
- The output from the prediction tool gives good indication on how to build the most cost efficient network, given that the reception quality should meet a defined criteria. To verify some of the assumptions made in the prediction it is often necessary to perform field measurements.

Figure 14. DAB antenna mounted on the roof of the vehicle.

With this in mind Teracom conducted comprehensive DAB+ field-strength measurements in Band III in the target area of Stockholm, Uppsala and Gävle.

The measured field strength was compared with the statistically-based predictions (the calculated field strength in the same pixel).

Some of the conclusions from the measurement campaign are:

- A very good, almost perfect, match between predicted and received field strength
- High power transmitters proven to enable good indoor coverage over large areas.
- In the areas predicted as mobile outdoor coverage, measurements show that to a large extent indoor reception was also possible

Also, a number of DAB+ consumer receivers were given out to Teracom personal, to take home and use on a regular "radio listening" basis. A simple, non-scientific, survey was conducted with the purpose of getting their views and opinions on reception quality and on the receiver itself. The results show that the listener experience within this group was very positive.

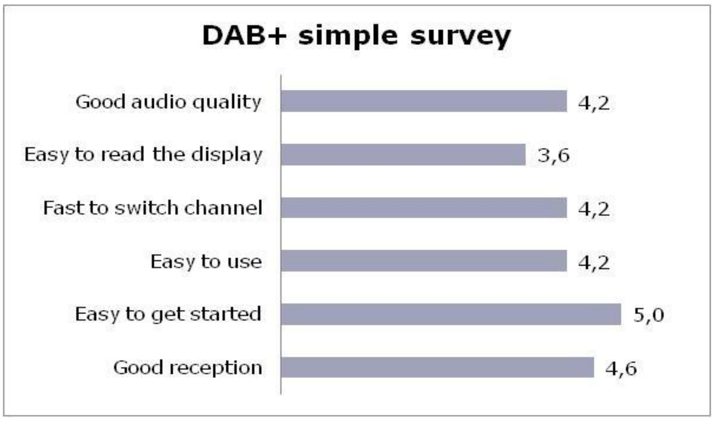

Figure 15. Results from the simple survey conducted among Teracom personal. Answers were given on a 1-5 scale when 1 is "I totally disagree" and 5 is "I totally agree".

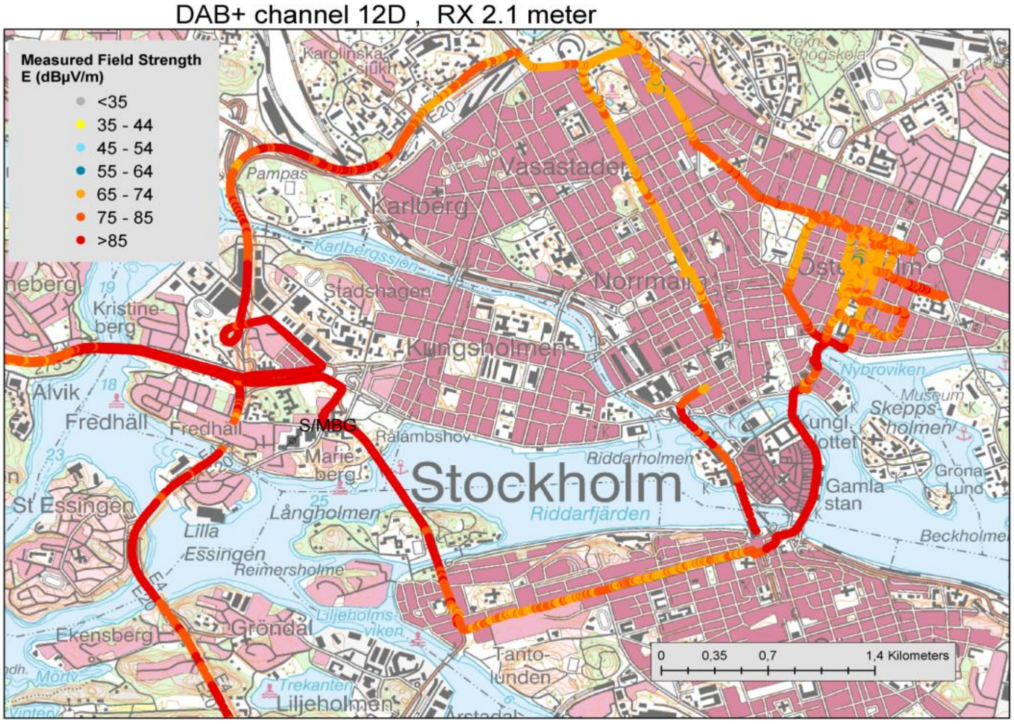

Figure 16. Measurement results from the Stockholm inner city. A field strength of 35 dBµV/m is the minimum receiver sensibility, equal to the min. requirement for mobile outdoor reception. For indoor (outdoor) reception a measured minimum value of 47 dBµV/m on street level is required to compensate for the building penetration loss.

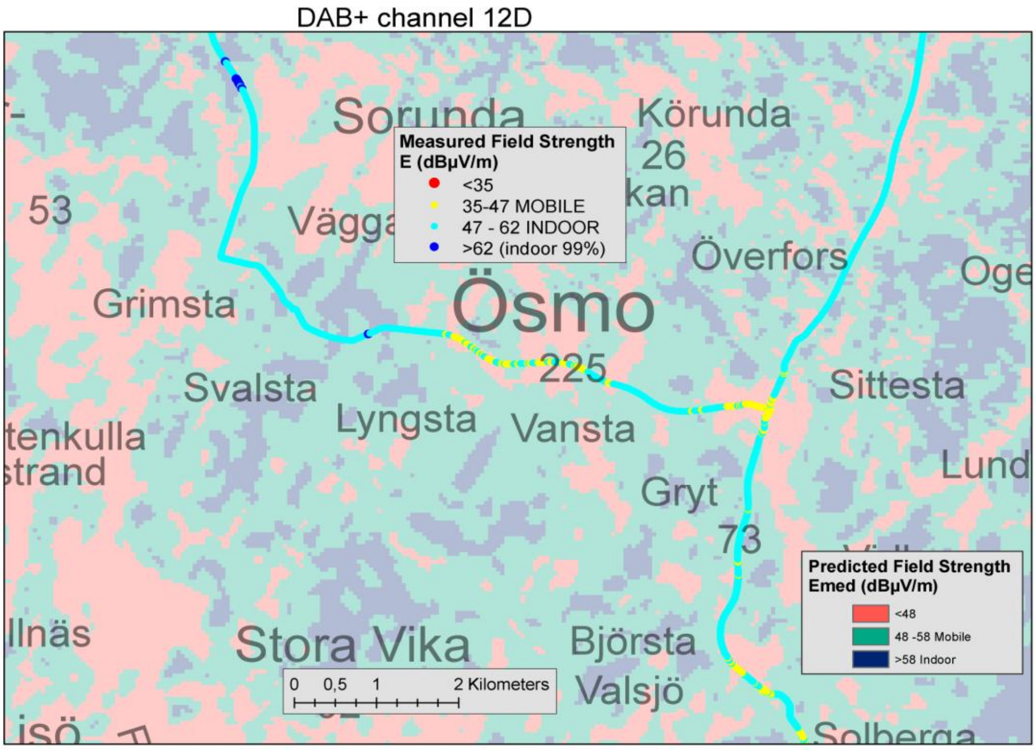

Figure 17.Measurement results from rural area in the surroundings of Stockholm. For comparison, the measured field strength is plotted on the same map as the predicted field strength. The measured spots with lower field strengths are due to obstacles in the terrain. These spots are also predicted in the computer calculation.

Further works

Among further work, in the planning phase for coming periods, are:

- Audio levels (in FM and) DAB+, with reference to EBU R 128
- Audio reference material, coded and broadcasted in DAB+ at different bitrates, for practical (live) audio quality evaluations
- Indoor measurements
- Further analyses of building penetration loss and man-made-noise
- Further application development for data services such as EPG, TPEG, broadcast recording services, etcetera
- Further evaluation on using IP networks for audio collection (and distribution)

Contact us

We hope this document provided you with relevant information about the Swedish DAB+ digital radio pilot, the network and the testing.

Should you want to know more, don't hesitate to contact us:

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Figure 18. A typical radio listening moment.