The DAB adoption process, Part 3: DAB+ requirements and allotment planning

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ABSTRACT

In this article we discuss planning for the implementation of DAB+ systems within a country. It has three major steps: planning requirements determination, RF transmission planning and network implementation planning. In this article we look at service, coverage and spectrum requirements and allotment planning. The stakeholders that should be involved in this part of the planning process include broadcasters and regulators and in some countries network providers/operators.

PREREQUISITES

The prerequisites to starting the detailed planning process are:

- The broadcast industry has decided to move forward and implement DAB+
- The Regulator is agreeable to developing (or has developed) the licencing framework
- There is (or will be) VHF Band III spectrum available

The overall process to be undertaken is shown in the flowchart in ***Figure 1***, which starts with the determination of the service requirements and concludes with the allotment plan being complete.

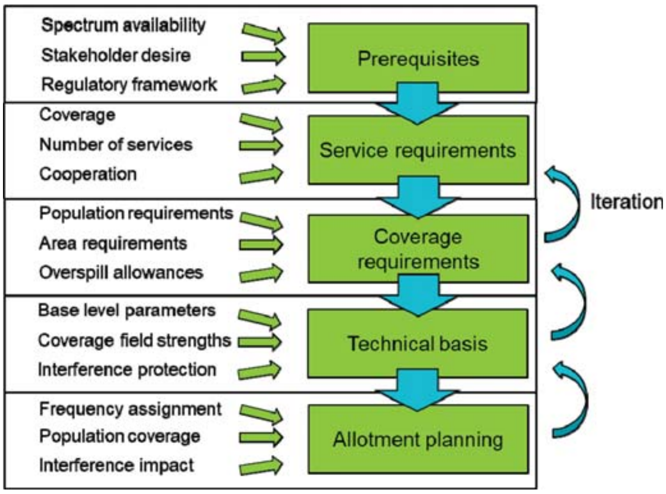

Figure 1: *Requirements planning steps*

The overall goal is to determine the allotment plan which will achieve the best long term benefits for the country. The process is generally iterative and requirements may need to be refined on an area basis, for example the number of services that can be delivered in a specific area will be impacted by the spectrum that is available, the coverage requirements and ultimately the technical basis which will define the coverage field strength targets and interference protection ratios.

In some cases the process flow will have existing constraints, such as when a number of transmission sites have already been constructed and are operational providing DAB+ services to the public. This was the case for the Allotment planning in Australia which was undertaken some years after the initial five main cities had established DAB+ transmission services.

SERVICE PLANNING

The starting point for DAB+ system planning is the number and types of services which already exist and the expectations for future new services. The development of DAB+ across Europe during the last 20 years has shown that where spectrum is available services will follow. The result is an expansion in the number of services that are available to the public, with typical increases in mature DAB+ countries being between 3 and 6 times the number of pre-DAB+ analogue services. It is therefore very important to factor into the planning requirements; not only the digitisation of existing services, but an allowance for new services in the future.

Services are planned by their coverage area or cell. National services are those provided consistently across an entire country, regional services cover a significant part of the country or multiple local or licence areas, and local services provide content only within a single local licence area. In many cases the number of national, regional and local services provided in an area have similar numbers, as shown in ***Table 1*** where the current service numbers are derived from www.wohnort.com. We see that each area has a significant number of services, all having more than 60, with London having the most, with 126. Overall the services by area type are reasonably balanced, however we see the UK examples showing relatively more national services due to the UK's small size and reasonably evenly distributed population, while Australia has relatively few national services due to its large size and population distribution being focused on urban centres.

	Service types		
Location	**National**	**Regional**	**Local**
Sydney	11	30	33
London	57	47	22
Bristol	57	12	20*
Munich	27	22	20
Oslo	17	20	23

Table 1: *Example number of services in an area*

Services are also divided by the content and licence types, where we often see Public Service Broadcasters (PSB), Commercial Broadcasters and Community broadcasters.

COVERAGE AREAS

Coverage by area is generally separated into National, Regional and Local layers, where regional includes several local areas and national covers all regional areas and in many cases most of the country. Figure 2 shows an example of the 34 commercial licence areas in the state of New South Wales in Australia.

Community licence areas tend to be smaller and more focused on individual communities, however some may be the same as commercial licence areas particularly in the metro cities. PSB coverage areas are typically regional and encompass multiple commercial licence areas.

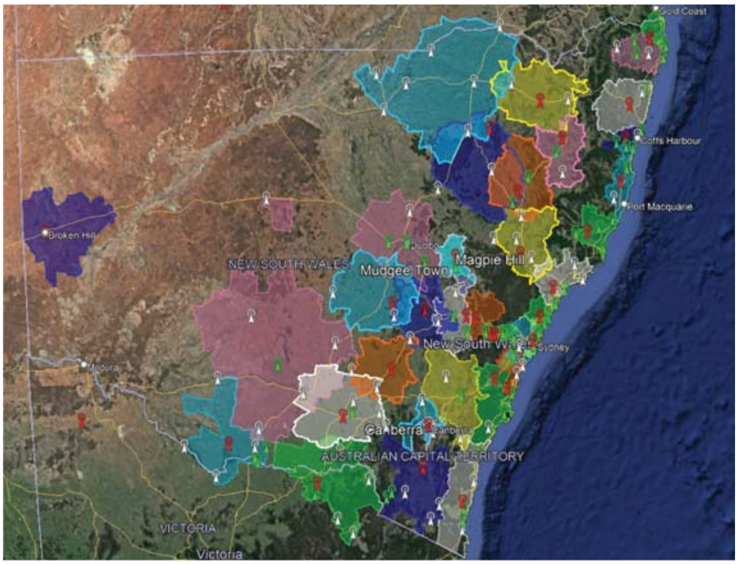

***Figure 2**: Commercial licence areas in the state of NSW in Australia*

LICENCE TYPES

The main licence types used are public service, e.g. for the BBC or NRK, commercial e.g. stations from networks like Bauer and Global, and community. Each has its own allowances, restrictions and costs defined through legislation The number of services in an area will be a mixture of these basic types. The type of licence often also impacts the likelihood of additional DAB+ services. We find that PSBs typically increase their number of services by 2 to 3 times, commercial by 4 to 6 or more times and community generally less than 2 times. This demonstrates the value of DAB+ to commercial radio broadcasting. In some countries new services may be new market entrants after the introduction of DAB+ rather than the expansion of services from exiting radio networks.

COVERAGE REQUIREMENTS

Regulators will often require network providers to comply with coverage targets in terms of both the percentage of people who can receive DAB+ and the percentage of the country's area where DAB+ can be received at specific grades of service. This is to fulfil Universal Access and Service (UAS) obligations that ensure that no one is disadvantaged.

While coverage is critical, when planning DAB+ networks it is also critical to control interference, to ensure the correct grade of service can be delivered. Most countries have land or sea borders with other countrie, which will require cross border coordination to ensure that cross border interference is limited to acceptable levels.

SPECTRUM REQUIREMENTS

DAB+ operates in the VHF Band III spectrum band, which has traditionally been used for analogue television (ATV). The clearing of ATV from this band with its DTV replacement being made in the UHF bands IV and V allowed band III to be used for DAB+. Band III was extensively cleared and planned for DAB+ in Europe in the late 1990s and early 2000s, including the landmark ITU planning conference GE06.

The conversion of ATV to DTV is still underway in the Asia Pacific region with some countries having completed the conversion and ASO process and many still in progress. To start the DAB+ planning process Band III spectrum does not necessarily need to be available but a date for its availability is needed for industry certainty. The availability date of spectrum, or even the start of the ASO process, provides target dates for system rollout. DAB+ can be established before ATV switch-off however due to high Protection Ratios (PRs) the DAB+ power may be reduced relative to planned ERP levels.

In some countries Band III spectrum will also be used for DTV, e.g. Australia and South Africa due to its ability to deliver signals over longer distances than at UHF for the same ERP. This requires spectrum sharing plans which will determine how many frequency blocks will be available for DAB+ across the country. As we have seen in both Australia and South Africa the provision of only two TV channels, or eight DAB frequency blocks, is the absolute minimum for most countries to ensure suitable range of regional services. When cross border coordination is required flexibility with their positioning will be necessary.

TECHNICAL BASIS

It is very important that the field strengths used for planning in different reception scenarios are suitable for the country planning DAB+. As shown in Figure 3 there are variations in the required minimum median field strength targets for different reception scenarios. This is due to variations in the 'base level parameters' used to calculate the coverage target field strengths. The physical equations are well known and example calculations are shown in the EBU document Tech 3391. Typical examples of variations are:

- Building entry loss: the amount of building entry loss is dependent on the type of building and the materials used for its construction. Radio frequency waves are attenuated more by steel reinforced concrete than timber, so areas which are dominated by high-rise buildings will need higher external field strengths to ensure suitable indoor reception than timber homes.
- Man Made Noise: The rise of electronic devices ensures that the background MMN level is higher in dense urban areas than in rural settings. This can become a sensitive issue when trying to receive DAB+ inside a building which has a significant quantity of electronic equipment, such as radio studios, PC dominated office environments and industrial sites.
- Vehicle antenna characteristics: Vehicle antennas have evolved from roof mounted whip antennas which have good omnidirectional gain characteristics, to in-glass antenna lines which have lower gain and often non-omnidirectional patterns. This has occurred due to the aesthetics of modern vehicles becoming more important than radio performance. Some countries have elected to redefine their vehicle antenna gain values to lower values to ensure that the required probability of reception in vehicles is achieved.

The establishment of the correct values for such parameters is essential to ensure that suitable reception probabilities can be achieved.

It is also important to select suitable values for the Protection Ratios (PRs) for both Co-Channel Interference (CCI) and Adjacent Channel Interference (ACI) however these are well understood and the values used quite universal (see EBU Tech 3391).

The issue of minimum service quality should also be considered. Most countries allow the market to decide what service characteristics are delivered though a listener acceptance approach where if the quality of a service is too poor then people will not listen to it and hence the viability of the service will be questionable. This is more the case for commercial broadcasters than PSBs who tend to prefer higher quality. Some countries however prefer to define the minimum service quality

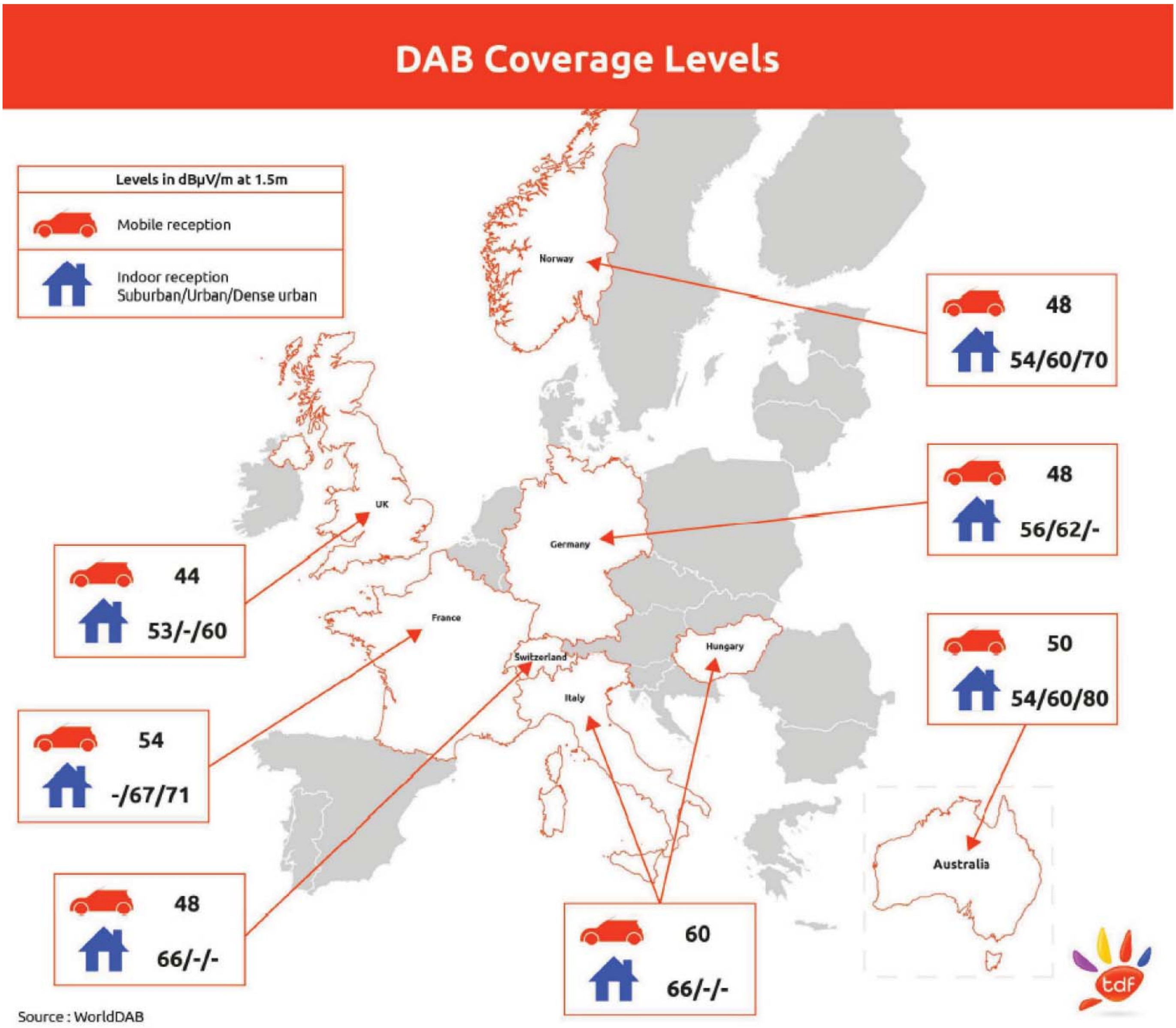

Figure 3: Example field strength targets, *Source: Jerome Hirigoyen, TDF*

through minimum service bit rates and Forward Error Correction (FEC) capability. Slovenia is an example where they have recently defined the minimum sub-channel delivery requirements of a bit rate of 48 kbps and FEC = EEP3A for stereo services. Services can be delivered at lower bit rates e.g. 32 kbps however the quality of the audio reproduction, particularly in new vehicles which tend to have excellent sound systems, can be quite poor for some types of content, especially when pure tones are delivered in music such as classical, jazz, folk and some modern styles.

ALLOTMENT PLANNING

ROLE OF THE REGULATOR

Regulators are responsible for a wide variety of technical and licencing aspects for radio system design and operation. Those responsibilities include the allocation of frequencies to broadcast areas, Allotment planning, and the allocation of frequencies to transmission apparatus, Assignment planning.

In ITU region 1, Europe, Africa and East and North Asia the ITU undertook a detailed planning exercise for the planning of VHF and UHF broadcasting in 2006, known as GE06. That conference resulted in the assignment of frequencies for broadcasting, largely throughout region 1, as well as a set of procedures to be used for variations, additions and cross border coordination. The Asia-Pacific is ITU region 3 which has no regional plan for broadcasting.

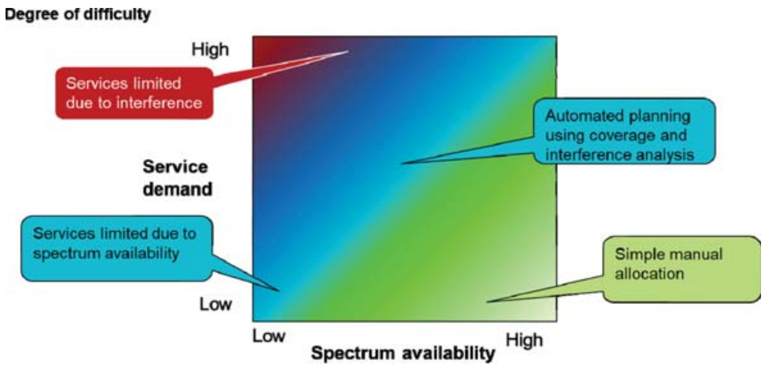

***Figure 4**: Allotment planning complexity*

Currently planning for DAB+ in ITU region 3 is done on a country by country basis with cross border coordination being done directly between the regulators of the involved countries who need to agree the allotment planning process, which is typically based on ITU recommendations. The complexity of that process is dependent on the demand for services, which is usually driven by the population and regional radio areas of the countries, and the amount of Band III spectrum that is available. As Band III has been extensively used in the past for ATV, existing cross border channel agreements may still exist.

When spectrum is not limited and demand for services is low the allotment planning can often be done manually. If the demand is moderate and the amount of spectrum is reasonable, then it is often necessary to use automated allotment planning methods based on agreed planning principles. If the demand for services is high but the available spectrum is low, interference issues will cause either the number of services and/or the served areas to be limited.

PLANNING PRINCIPLES

The approach to Allotment planning should be agreed between the major stakeholders usually the broadcasters and the Regulator. This ensures an agreed approach for all types of broadcaster. This is particularly important when spectrum is scarce and demand is high (Also see ITU-R BT.2140-12).

The Australian Digital Radio Planning Committee developed a set of planning principles, due to only 8 frequency blocks being available across Australia and the demand for two frequency blocks to be available in each commercial radio licence area. Those blocks were, one for the PSBs, and one for the commercial and community broadcasters. The Planning Principles can be summarised as:

- 1 – Overall planning approach
  - Plan for all areas in advance of any implementation to ensure balanced opportunities for first movers and late adopters.
- 2 – Proposed frequency allotment planning approach
  - Define and agree how much spectrum will be available for each broadcasting sector.
  - Initial main site transmission powers may need to be limited to ensure an overall solution.
- 3 – Licence area aggregation
  - When there are specific coverage licencing areas for commercial and community broadcasters it may be necessary to combine some to achieve a realistic overall plan.
- 4 – Transmitter site selection
  - Use existing sites where possible, this will minimise costs and interference between any DTV which may exist in VHF Band III.
- 5 – RF planning parameters
  - Select the planning parameters appropriate to your country in each class of reception.
  - This includes minimum coverage field strength to be protected, CCI and ACI PRs.
  - This may require some testing and experimentation especially with respect to vehicle antenna gains and patterns, in-building entry losses and man-made noise in cities.

The Planning Principles should result in a Balanced Allotment Process. We start with the general requirement of the maximum interference that one coverage area cell is allowed to cause into another cell in terms of people affected. The coverage requirements are generally considered secondary as they can be increased by adding low power transmitters later. The overall process is:

1. The stakeholder team define the baseline ERPs and antenna patterns (HRP/VRP) for each cell
   a. Use only one main transmitter site in a cell is provided with typical ERP of 5 to 10 kW, with some exceptions for remote and very dense areas. The ERP must be low enough to be able to obtain a solution for frequency allotments for all coverage areas.
   b. Typical antenna HRP is omnidirectional, VRP down tilt = 0°.
   c. Antenna locations are usually chosen from existing broadcast transmission sites with antenna tower height being the same as previous/existing ATV antennas.
   d. NOTE at this stage we are not interested in the transmitter systems themselves, only the radiated power and pattern.
2. For a set of assigned powers calculate the field strength coverage for all areas using the same frequency
   a. Typically use the centre frequency of the available frequency band
3. Determine the CCI between all sites
   a. The initial planning is done for CCI, ACI is considered as a secondary issue.
   b. CCI is generally assessed as the number of people in the affected cell who will lose reception due to interference.
4. Assign candidate allotment frequencies to each area
   a. Typically using a cellular approach where co-channel assignments have maximum distance between them. This can be done manually or using an automated approach.
5. If the interfered population in each cell is less than the target, then finish, else reduce/adjust the ERP and HRP of sites which cause the most interference.
   a. Higher elevation sites will radiate further due to larger areas of Line of Sight coverage.
   b. Problematic main sites may need to be significantly reduced in power and have low power repeaters added to ensure suitable area coverage.
   c. Repeat from step 2 where coverage and interference is reassessed for sites with changed ERP/HRP.
   d. If the initial interference is too high it may be necessary to reduce most/all site ERPs.

This process can be quite complex when there are a lot of individual coverage area cells and will often mean that it is not feasible to manually select the set of frequency assignments which meets the local interference limits. The complexity of allotment planning can be reduced by using a few rules:

- Limit the number of cells in the area to be planned to limit the number of possible combinations.
- Use large pixel sizes when running coverage and interference simulations, e.g. 100 m x 100m or larger.
  - The impact on the initial analysis of clutter will be small
  - Higher resolution analysis can be done for specific cases when the allotment plan is starting to converge to an overall solution, i.e. all cells have interference of less than the target when using a selected set of Allotment Frequencies.
- Some cells may have preassigned frequencies, e.g. cells which have already been planned/implemented or in a set of adjacent cells whether in country or across borders.
- Do not allocate the same frequency in adjacent blocks, have at least one intervening cell between co-channelled cells.

Once a set of allotments has been successful planned the coverage in each cell can be assessed and adjusted through the addition of low power repeater sites to ensure that over time adherence to population and area coverage targets can be met.

CONCLUSION

The development of the requirements for the deployment of a new radio system can be a complicated process. It is essential that all stakeholders are engaged in the process and that all have a flexible position to ensure an overall positive result.
In our next article we will cover the details of the coverage and interference analysis aspects that are used in both allotment planning and any subsequent adjustments to the initial transmission parameters.

AUTHOR

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Les has over 30 years of experience in communications systems, including broadcast digital radio (DAB/DAB+ and DRM), mobile communications, wireless broadband and satellite communications. Les founded S-Comm Technologies Pty. Ltd. in 2008 to work with the radio industry on DAB+ digital radio. S-Comm provides independent engineering consultancy to WorldDAB, the ITU and broadcasters, regulators, network operators and equipment suppliers in Australia, South East Asia and around the globe. ■