DAB Digital Radio — a recipe for success

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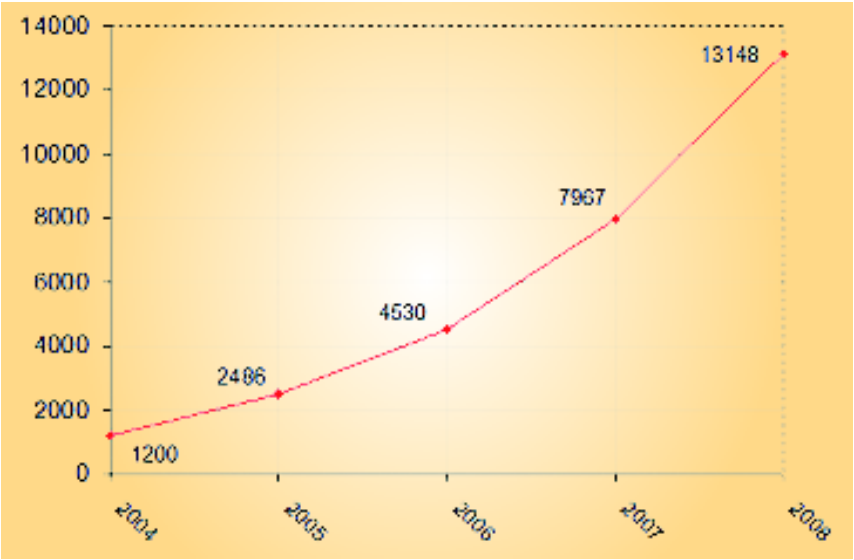
DAB digital radio began test broadcasting around ten years ago but it has not been a universal consumer success across Europe. In the UK, however, digital radio receivers are one of the fastest-selling consumer electronics products and sales have overtaken those of analogue radios. Why has the UK succeeded with DAB digital radio when other European countries have yet to see their markets take off?

This article explains what steps the UK took to make DAB digital radio a success.

By the end of 2005, around 10% of the UK's 25m households will own a DAB digital radio and high-street retailers will be selling 5,000 new digital radio receivers every day. By 2008, penetration is forecast at around 30% [1]. 85% of the population can already choose between twenty national radio stations and up to thirty local or regional stations with about half of these available only on digital radio – the rest being simulcasts of existing AM and FM stations. Some DAB digital radio receivers have an EPG, while others allow listeners to pause and rewind live broadcasting or to record programmes onto removable memory cards for listening to later. Consumers in the UK are having a love affair with digital radio, but it took a determined blend of marketing, collaboration between rivals and perhaps, most importantly, a technology intervention to create this successful market.



Caption ...

The 1996 Broadcasting Act

The UK is fortunate because, for the last 10 years, there has been a progressive government policy towards digital broadcasting. The 1996 Broadcasting Act set out a full licensing regime for both

1. Source: DRDB/DigitalOne 5 Year Forecast

digital television and digital radio. Whilst the challenges for radio and television are similar in many respects, creating a successful transition to digital radio is different because the scale of investment available is a fraction of that available to TV. Nevertheless, the 1996 UK legislation contained a number of key elements which have been cornerstones of its success. Behind this was a recognition that neither commercial radio nor the BBC could succeed in creating the digital landscape without the other. The 1996 Act introduced the concept of a ***multiplex operator*** – the holder of a spectrum licence who is able to commission or lease the transmission networks and has a free market choice over which content service providers to use.

In late 1997, before any commercial multiplex licences were advertised, the prominent receiver manufacturers announced that they would be bringing mass-market consumer receivers to the market, and simultaneously the BBC announced it would expand its DAB network to 65% national coverage.

The first and only national commercial multiplex licence was awarded to ***Digital One*** [2] in 1998 for an initial term of 12 years (renewable for a further 12) and, in return for being the sole commercial national licensee, this put obligations on Digital One to drive the penetration of DAB digital radio receivers. In effect, the commercial sector had a responsibility mirroring that of the public service broadcaster (the BBC), but with commercial freedoms unavailable to the BBC.

DAB rollout – Phase I ... and the dot.com bubble

For the next two years, the UK broadcasters committed heavily to DAB digital radio, confident that the manufacturers would deliver on their 1997 commitment. When Digital One launched in November 1999, 69% of the population could receive its transmissions, with the BBC not far behind. But the receivers did not come, or at least if they did it was at a price of €800 - €1000. Consumers appeared interested, but not at this cost, and it has been said that the only people buying them were radio executives.

In 2000, the year after Digital One commenced broadcasting, things didn't look much brighter. The dot.com bubble had burst, terrestrial subscription DTV was foundering and the BBC was not sounding as positive about DAB digital radio as it had been. By now we all realized that the manufacturers were not producing the mass-market digital radios they had promised and, moreover, the retailers were not going to stock them despite our best efforts to convince them otherwise.

It was clear that a "wait for the other guy" strategy was not going to work and I set out to discover why the market had stalled ... and which levers could be pushed or pulled to get it going again.

DAB was never positioned as a subscription-based service like TV which meant that receiver hardware would not be subsidised, nor could the end design be controlled or influenced to any great extent by the broadcaster. DAB suffered from the high cost of early silicon technology and, without subsidy from subscriptions to deliver a volume of receivers, the production costs would remain locked at a high level. Silicon manufacturers and tier-one consumer electronics manufacturers (often the same companies) had seen no R&D returns on their early-generation DAB processor chips and consumer receivers, and were not about to invest in the third-generation silicon to enable price reductions.

Add to this the immense complexity of early DAB designs – which necessitated extensive engineering support to make any DAB radio implementation work – and it was not hard to appreciate that low cost, mass-market DAB from second- and third-tier Chinese manufacturers was a pipe dream. Yet it was precisely these manufacturers (who make the vast majority of consumer electronics goods) and their importer/wholesaler customers (who badge them up with familiar brand names) that could be crucial to the success of DAB digital radio.

2. Website: **http://www.ukdigitalradio.com**

Despite this apparent setback, the DAB receiver market wasn't completely dead – there is always a consumer sector willing to pay several hundred pounds for a radio receiver, but these are hi-fi enthusiasts and the very earliest adopters who together account for less than 1% of the market. The other 99% of the market had to be converted. Critics and doomsayers were quick to point out that an analogue radio could be bought for €30 but that view was then (and continues to be) naïve. It is like saying an iPod is too expensive compared to a cassette Walkman, or perhaps that a PDA will never sell because a diary is cheaper.

Driving the receiver costs down

The answer lay somewhere in achieving a reasonable price that matched consumers' expectations of DAB digital radios – more choice, better quality and ease of tuning. Achieving this price point quickly would mean taking new risks, breaking through the *laissez-faire* and undoubtedly upsetting some manufacturers.

A typical DAB receiver circuit board in 2000

As my understanding of manufacturing and retailing grew, I learned the first rule of thumb that each one dollar of material cost translates to three to four dollars in the retail price. There's no magic in this, simply that every stage from raw silicon though product manufacture, import and wholesaling to retailing is a daisy chain and at each stage a percentage margin, taxes and duties are added to the previous cost in the chain. A product whose Bill of Materials (BoM) manufacture cost is $100 will retail for between $300 and $400 (manufacturing currency is always talked of in dollars). It also became evident that there was no point trying to take on manufacturers or retailers at their own game, or finding ways to cut out intermediate margins – that's how the system works and for most CE products it will always be that way.

Fundamental problems for digital radio were the complexity, size and cost of the component

Table 1 – Typical "cost-up" of a £99 DAB radio

Item	Cost	RUNNING TOTAL
DAB Module BoM $35		
Other Materials $20		
Manufacture $10		
Factory FOB price $65	£40	£40
Shipping and Duty	£10	£50
Importer Margin	£10	£60
Retailer Profit	£25	£85
VAT on £85 @ 17.5%	£14.90	£99.90 = Consumer Retail Price

boards – and at the heart of this was a moribund generation of DAB baseband chips with no prospect of operating from portable battery power.

In 2000, a typical component circuit board for a DAB receiver product consisted of over 300 separate components and cost around $100 to buy in. To turn it into a DAB digital radio required other components including a display, audio stages, loudspeakers, a power supply, connectors and a case. No wonder the cheapest DAB radio cost €800 in the shops.

We knew from research that the acceptable end consumer price for a DAB digital radio had to be £99. To achieve this we had to understand the maximum sustainable cost of a DAB circuit board module. This turned out to be $35 *(see Table 1)*. This was the magic price to achieve ... but still a formidable challenge.

Digital One teams up with Imagination Technologies

I spent time visiting the main suppliers of DAB silicon chips and boards (which at that time meant Panasonic, TI/RadioScape and Bosch). All of them had roadmaps for next-generation devices and shared the ideal of achieving mass-market products. Yet despite apparent enthusiasm, plans for third- and fourth-generation DAB chips seemed destined to remain on paper until existing R&D costs had been recouped, and a plan to engage the mass-market manufacturers was missing.

To remove this barrier, Digital One decided to invest directly in a third-generation chip design and to take the concept of ready-made DAB modules a step further. We took the idea to other UK digital broadcasters to see if we could share the investment risk but, to my amazement, none of them was interested. Despite their ongoing heavy investment in DAB networks and programming, there was an almost blind faith that low-cost receivers would somehow arrive on the market by themselves.

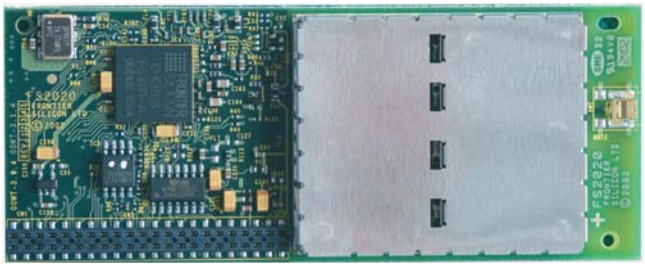
The mainstream silicon companies were not interested in the sort of partnership which I was convinced was necessary to make DAB successful. One company was keen but didn't do joint ventures (JVs), another was happy with the money but not our vision of low-cost receivers, and yet another couldn't guarantee a consumer product without other partners (and, as anyone knows, the difficulty coefficient of a partnership is proportional to the square of the number of partners [3]).

Generally, the view seemed to be that you can't advance consumer electronics faster than it naturally wants to go. The manufacturers offered similar advice and one even warned me off from creating a £99 retail price point because this would "erode profits and kill the business". This last piece of advice made the challenge all the more dangerous and I chose to ignore it because, frankly, there was no receiver business and I wasn't prepared to wait whilst others killed my business.

Meanwhile, ***Videologic*** a new DAB hi-fi receiver manufacturer (later known as ***Pure Digital*** [4]), had entered the market with the first £300 DAB tuner. Their tuner used a Panasonic DAB component board and they managed to sell the radio for under £300 by keeping a tight control of their costs and margins. It was the cheapest DAB set on the market and it had created a good deal of consumer and trade attention, but Videologic wanted to go further. And so did I.

Videologic's parent company ***Imagination Technologies*** [5] made chip designs for computer graphics and games consoles. Co-incidentally, Imagination had just acquired ***Ensigma*** [6], a specialist in chip design and DSP, who happened to have prior experience in designing DAB circuitry for the BBC and Hitachi.

3. Howard's "Partnership Theorem"!
4. Website: **http://www.pure-digital.com**
5. Website: **http://www.imgtec.com**
6. Website: **http://www.ensigma.com**



Caption ...

Imagination thought that if they could design a new DAB chip, it would reduce the component count, circuit size and power consumption and would deliver increased in-built functionality to make DAB receivers easier to manufacture. The BoM cost of the entire DAB electronics could be reduced to around $35 – my magic price! But DAB wasn't their core business and they would not take such a risk alone. So we agreed to co-fund the new chip development on a 50/50 basis in return for a royalty on every DAB chip produced. In early 2001 our JV deal was signed and over £3m was committed to develop a brand new, better-featured, third-generation DAB chip. I was now in the silicon business!

Strategically for Digital One, the investment made sense for several reasons. Success would be measured by the return on investment in royalties, but competitive stimulation of other chip suppliers would be a bonus and good for the DAB market overall. It would provide a more secure basis for my shareholders' continuing investment in transmission networks, content and marketing. On the other hand, if our investment didn't produce the desired outcome for DAB, then we reasoned there would probably be little point in continuing as we were. If we failed, then both BBC and commercial radio DAB in the UK would also fail and along with it the government's whole digital strategy. Not much to lose sleep about, really!

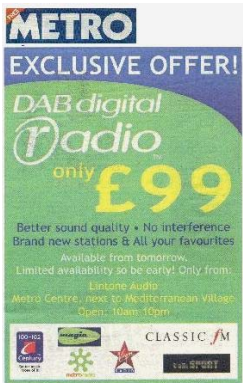
Our DAB chip, codenamed DBX1, took nine months to design and produce and it worked first time – a remarkable achievement, and about half the time a traditional silicon company takes to produce a new chip. There were many reasons for the chip's quick success but I believe these are down to a close working relationship between the broadcaster and silicon designer, having a complete view of DAB digital radio as both a content service and as a consumer product which ensured the consumer experience would be better than each working in isolation (which has been the case for AM and FM radio, for example, where the radio receiver has barely changed since the transistor).

Much careful thought went into the design of the chip features (including how displays would look, easy tuning and labelling features, the user interface, onboard USB and memory support) and also in the design of the entire DAB circuit module which would feature in the first £99 consumer radio. One of the critical successes was the ability to run the module from battery power which would open the market to portable and personal DAB digital radios for the first time. From successful chip to finished radio production would take another six months and not be ready until mid-2002 – in all, a 16-month timeline from chip to radio.

The consumer price point – £99

The remaining hypothesis was the consumer price point. Would £99 prove to be the magic price and, if retailers devoted shelf space, would anyone buy them? The only way to find out was to try it for real. In December 2001, to co-incide with the 100th anniversary of Marconi sending a signal across the Atlantic, Digital One devised a consumer market test with a specially-designed kitchen DAB receiver. It looked and worked like a typical portable radio but it was DAB only. Inside was the same Panasonic chipset and circuit board used in Videologic's £300 tuner plus a loudspeaker and telescopic whip antenna, all housed inside a smart looking case.

Although these radios cost more than £150 to make, with support from other UK broadcasters through the Digital Radio Development Bureau (DRDB) [7], these special radios were wholesaled to selected retailers at about £65 to give them a typical profit margin and would go on sale for £99 until all of



them sold. Point-of-sale promotional material was produced, together with radio commercials and some print advertising, and we geared ourselves for up to five days of sales – which is how long we thought they would take to sell out.

On 12th December 2001, 100 years to the day since Marconi's achievement, to our great surprise we found people queuing outside the retailers before the doors opened – all eager to buy a DAB radio for £99. In 23 minutes, every single digital radio had sold out. We could have sold 3,000 more on that one day, such was the demand. It was a test marketing success beyond anyone's dreams and remains the one and only time that Digital One has ever subsidised a DAB receiver.

Now we knew that £99 was the right consumer price and, with our brand new DBX1 chip and circuit designs, we could cut DAB production costs to 30% of the existing price. Other DAB chip competitors were beginning to respond as expected and the price of a complete DAB module was already falling to around $40 - 45. Moreover, other silicon vendors were announcing next-generation chipsets. But having a low-cost DAB reference design is a far cry from having a radio manufactured, an importer on board and a product being sold by the retailers.

Our joint venture with Imagination Technologies included the chip being turned into a £99 consumer receiver for sale without subsidy. This became the famous ***Pure Evoke 1*** DAB digital radio which first went on sale in July 2002 and, like our Marconi test radio, sold out immediately. The Evoke has gone on to become the best selling radio of all time – outselling any other model of radio – including analogue – and the Evoke family of DAB radios recently surpassed 500,000 unit sales [8].

Diversification – the Chorus chipset

One receiver does not make a consumer market. The other important part of this story centres on the other routes to market which Digital One foresaw for DAB. This involved bypassing the tier-one CE brands in favour of tier-two and tier-three manufacturers with the capability to move quickly and offer keener prices. A usual assumption is that world-leading electronics brands provide all the innovation in new products and the tier-two brands always follow with cheap copies. My experience, particularly in relation to DAB, was different. Whilst the big brand names undoubtedly innovate, they only lead the market with expensive first-generation products and it is not in their interests to see prices fall. Sometimes they miss a product entirely and then spend a couple of years playing catch-up (the mp3 portable player is a good example of this).

Current trends in manufacturing appear to favour those suppliers who are nimble, adaptable, have a low cost base and are not afraid to win new customers with new products. DAB fits this profile and Digital One together with Imagination Technologies wanted to ensure the widest use of our new chip design by these manufacturers. The result was ***Frontier Silicon*** [9], a new UK company created in late 2002 to market and sell our DAB chip solution, now renamed "***Chorus***", together with the complete module designs created for products such as the Evoke family.

Frontier was well placed to sell the Chorus DAB solution into a number of household consumer electronics brands and, with their far-east manufacturing partners, this combination of skills had a major

7. Website: **http://www.drdb.org**
8. See: **http://www.pure-digital.com/Releases/Release.asp?ID=231**
9. Website: **http://www.frontier-silicon.com**

Abbreviations

AAC	(MPEG-2/4) Advanced Audio Coding
AM	Amplitude Modulation
BoM	Bill of Materials
BSAC	Bit Sliced Arithmetic Coding
CE	Consumer Electronics
COFDM	Coded Orthogonal Frequency Division Multiplex
DAB	Digital Audio Broadcasting (Eureka-147)
DMB	Digital Multimedia Broadcasting
DRDB	(UK) Digital Radio Development Bureau
DSP	Digital Signal Processor / Processing
DTV	Digital Television
DVB	Digital Video Broadcasting
DVB-T	DVB - Terrestrial
EPG	Electronic Programme Guide
FM	Frequency Modulation
JV	Joint Venture
OEM	Original Equipment Manufacturer
R&D	Research & Development / Design
UEP	Unequal Error Protection
WM9	(Microsoft) Windows Media Series 9

impact on the market. The company also developed a strategy which recognized that DAB remained too complex for some tier-two and tier-three manufacturers. Instead of just a selling a chip or reference design, complete DAB modules are offered as an OEM component, together with the necessary engineering integration, test and support services to customers and their manufacturing facilities. Frontier today has a family of complete DAB modules using the Chorus chipset and various RF designs including single Band III, dual Band III / L-Band, tri-Band (including FM), automotive and a complete new generation of even more powerful DAB chipsets and RF components.

An interesting combined DVB-T and DAB chip from this company today appears in a number of UK Freeview set-top boxes. The twin technology makes duplication of radio channels on DVB-T multiplexes unnecessary and frees up the increasingly valuable DVB-T spectrum which is now being sought for HDTV.

Digital One's intervention in creating new DAB silicon has been highly successful. There is healthy competition from major silicon vendors with Atmel recently announcing a new DAB chipset and Sonarics entering the DAB product market last year. TI and RadioScape continue to innovate and compete whilst Panasonic's DAB products proved to be one of the top sellers in the UK last Christmas. Bosch equipment appears in the ever-popular Blaupunkt car radios with Siemens making use of it for line-fit DAB radios in GM Vauxhall cars in the UK.

Currently there are over 150 DAB digital radio products on the market in the UK with high street prices starting at below £40 (€60) – 70% of all receivers sold use the Chorus chip.

Regulation is key

Elsewhere is Europe, DAB is meeting with mixed success. Denmark is performing similarly to the UK thanks to the innovation of the public broadcaster but where DAB is not so strong, the problem can usually be pointed at the lack of enabling regulation. The UK's example, whilst not appropriate everywhere, has valuable lessons including licensing incentives for existing analogue commercial broadcasters, the multiplex licensing model (rather than channel by channel) and a market-building obligation on the national multiplex licensee.

It is this latter point that caused Digital One to think far beyond the confines of a traditional broadcaster's role. It led to Digital One working closely with the public broadcaster on marketing (followed by formation of the DRDB) and collaboration on co-sited transmitter rollout (now at 85% for the BBC and 87% for Digital One). The need for effective consumer marketing encouraged Digital One to create powerful and consistent consumer branding for ***DAB digital radio*** which is now used by the majority of manufacturers and retailers on products and point-of-sale material, clearly identifying DAB digital radio products and services without the confusion of acronyms and inflexible logos. Perhaps, most importantly, it resulted in Digital One doing what no other radio broadcaster was even

willing to contemplate – investing in a chip to stimulate the entire DAB market which has now transformed the industry.

Meanwhile, Eureka-147 DAB is taking off in Korea with ***Digital Multimedia Broadcasting (DMB)*** already available to mobile phones, powered by the same chips used in the Evoke and many other DAB radios. DMB is likely to appear in Europe next year with the T-Systems/Samsung tie-up for Euro 2006 football whilst, in the UK, Digital One's multiplex will soon be carrying video services to mobiles through its partnership with BTLivetime.

The Eureka-147 standard is very flexible in providing ***multimedia services*** and the current generation of DAB chipsets is capable of decoding them now. The next generation of DAB chips (available later this year) will provide even greater efficiency with a power consumption of around 50 mW which is appropriate for extended use in mobile phones, personal media players and for DAB's simple integration into a variety of other consumer products to deliver radio, TV and multimedia at any location.

Despite the obvious success of DAB, it would be an omission to leave some of the continued criticisms unanswered, whether of its slow start or the underlying technology. True, there was much over-optimism in the mid-1990s, coupled with unrealistic promises and expectations of receiver pricing and consumer take-up.

Governments across Europe have legislated for DAB digital radio in a variety of ways but few as successfully as the UK. It is essential that both public and private broadcasters are encouraged equally to participate in digital radio. Too often the barriers for commercial radio are simply too high and unattractive, yet the commercial players are more likely to have the incentive to compete with the public sector and promote receivers with innovating ideas. More choice is the top consumer reason to go digital, yet commercial players erroneously think this means more commercial competitors and they prefer their existing closed market. In reality, more digital channels means more opportunity for the existing players to broadcast additional choice, always provided the regulator realizes the benefit of multiple channel ownership. The multiplex licence model, whilst radical for many countries, ensures that commercial matters such as coverage, transmission costs, choice and marketing costs achieve the necessary economic balance against commercial benefits.

Spurious claims from some quarters that MPEG-1 Layer2 audio is outdated or inefficient is a failure to understand the beauty of the way the frame length of MPEG and COFDM co-exist and the benefit of UEP which together deliver a very robust audio experience. Eureka-147 allows for other audio coding, of course, with BSAC being used in Korea, AAC+ and WM9 in other applications and an enhanced Reed-Solomon layer of error correction available for these more fragile encoding algorithms. Moreover, the bit/Hz efficiency is as good in DAB as anything else in real-world implementations, but the difference is that DAB chips and receivers are not mere prototypes or mere manufacturer roadmaps, they are available now in all form factors, including mobile phones and are

Quentin Howard, an electrical and electronics graduate, has worked in UK commercial broadcasting since the mid 1970s. He was chief engineer at a number of radio stations before joining GWR Group at its formation in 1982. At GWR, he was Director of Engineering with responsibility for all broadcasting and IT systems and was also responsible for the technical implementation of Classic FM and its national network of transmitters. He also held the position of Programme Director and is a radio presenter with several Sony Radio Awards to his credit. Whilst presenting The Classic Quiz for Classic FM, he pioneered the use of ISDN to broadcast from home and became the first radio presenter in the UK to enjoy this comfort on a regular basis!

Quentin Howard is acknowledged as the author of Britain's world dominating position in commercial DAB digital radio broadcasting. He is a member of the WorldDAB Forum Steering Board, is on the Board of the UK's Digital Radio Development Bureau (DRDB) and on the Board of Frontier Silicon. He created Digital One which was awarded the sole UK National DAB Multiplex licence in 1998 and began transmission to 70% of the UK population in November 1999 - making it the largest digital radio network in the world. Digital One broadcasts eight national digital radio services, five of them brand new and exclusive to digital.

already power efficient. The 1.5 MHz bandwidth of DAB leads to less dense transmission networks and fewer receiver processing MIPS than other wide-bandwidth COFDM solutions. But perhaps the biggest advantage offered by DAB is that spectrum allocations and complete networks already exist in most of Europe, so whether DAB is used solely for radio, or for multimedia (as in Korea and the UK) is merely a matter for the regulators.

Conclusions

The historic reality is that DAB receiver technology was incapable of supporting mass-consumer products until the advent of the Chorus DAB chipset, and similar products from its competitors. In consumer terms, Year Zero for DAB was less than four years ago and, on that basis, the take-up curve for DAB is easily matching or exceeding that of other new technologies such as colour TV, the Internet, mp3 players or DVD equipment.

The mistake by broadcasters was in not understanding that “build it and they will come” is no longer practical in this integrated technological age. Perhaps the truth of DAB technology is that it was years ahead of its time ... and for that, we should applaud its creators.