The HuMIDAB project

– looking at the Human Machine Interface of digital radios

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The HuMIDAB project was born out of a belief – among EBU and WorldDAB members – that the Eureka-147 DAB standard would open so many new opportunities for receiver designs that the digital radios of the future could not just replicate the analogue radios of today. Future digital radio services would provide a package, including audio programmes, associated services – such as programme-related data – and, at a later stage, multimedia capability in the form of pictures, perhaps even moving ones!

Both the broadcasters and the receiver designers would have to rethink the requirements of digital radios. They would have to work together to formulate an intrinsic understanding of the other's role, to allow the design of new digital radios with many enhanced features.

This article reports on the work carried out within the project, which had only a one-year time frame.

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1. Introduction

During late 1996 / early 1997, the WorldDAB Project Office undertook to form a consortium of members who would co-operate in the Human Machine Interfaces for DAB (HuMIDAB) project. Partners were gathered from four European Union countries and Switzerland, with a view to seeking EC funding. The consortium eventually consisted of both broadcasters and consumer electronics manufacturers, as shown in *Table. 1*.

Whilst there was considerable support amongst the partners for such a project to be undertaken, it would be safe to say that, without some external funding, the chances of progressing the project would have been quite small. This is where the European Commission came to the rescue. Directorate General X (for Audiovisual, Information, Communication and Culture) agreed to support 50% of the project costs, while the other 50% was raised by the project partners themselves. The work undertaken by the WorldDAB Project Office was 100% funded by all.

France	Radio France (Development Department)
Germany	Robert Bosch GmbH (Corporate R&D, Hildesheim)
	Clarion Europa GmbH (European Headquarters)
	Sony Deutschland GmbH (European R&D, Stuttgart Technology Centre)
	Grundig GmbH (Advanced Research Department)
	Institut für Rundfunktechnik GmbH (R&D Institute of ARD, ZDF, ORF and SRG/SSR)
Sweden	Swedish Broadcasting Corporation (Technical Development Department)
Switzerland	WorldDAB Project Office (EBU/UER)
United Kingdom	British Broadcasting Corporation (BBC DAB)

Table 1
The HuMIDAB project partners.

It was agreed that the project would be carried out for the benefit of consumers, consumer electronics manufacturers and radio/multimedia data and programme services providers. This required a carefully-constructed project plan which would allow such an objective to be actioned in the very short time frame of only 12 months allowed by this type of funding.

2. Project plan

The HuMIDAB partners, meeting in February 1997, agreed to divide the project activity into five work packages, as follows:

- initial research and evaluation of existing "easy-to-use" radio receivers;
- outline scope of user requirements for DAB receivers;
- development of computer model HMIs linked to a DAB receiver;
- ergonomic design studies and evaluation of computer modelling results;
- project management, development of user requirements and guidelines, organization of workshops.

The partners in each work package then defined, in more detail, the scope of their work to ensure it fell within the time and budget constraints of the HuMIDAB project, which started formally in April 1997.

One of the key aspirations of this project was the intention to develop a computer model of a DAB digital radio, capable of demonstrating some of the HMI issues to non-technical users in order to obtain an insight into their reactions to such a product. With such a short time frame, it became clear that several activities would have to run in parallel and it was decided to start computer simulation modelling, before all the initial research work could possibly be completed. Thus, internally to the project, there was the possibility of taking several different approaches to the same challenge and, some would say, the luxury of having the possibility to choose a particular simulation at a later stage of the project. This did however mean that some of the evaluation of existing "easy-to-use" receivers was not available until later in the

project. Whilst those results were late, they were able to confirm our best guesses made earlier. The final critical choice, made early on in the project, was to build only a simulation of a DAB digital car radio. Time and resources were just too few for anything else.

3. Initial research and evaluation of existing "easy-to-use" radios

This work package was undertaken by BBC DAB experts and comprised two areas of work, to ensure that the project partners were given a full briefing about the latest information in the field of radio design ideas.

3.1. Initial research

Initially "desk research" was undertaken by several institutions with prior expertise in this field, including the Human Sciences and Advanced Technology Institute at Loughborough University, the Transport Research Laboratory and the University of Leeds Psychology Department – all in the UK. Additionally, earlier BBC market research was reviewed but it was found that little DAB-specific data had been collected before 1995, although some RDS information was interesting. The question of commercial confidentiality made data-gathering very difficult and endorsed the project view that data would need to be collected by the project partners themselves.

Even at this stage, interesting indicators were observed. For example:

- vehicle driver safety should not be compromised by the need to interact visually with a radio receiver more than is necessary;
- icon recognition showed up as a helpful solution as did the use of audio commands for a receiver.

Market research had also revealed that there are a number of radio user types based not on demographics, as had previously been supposed, but more on psychographic and behavioural dimensions. Thus the term *Fearful Tuner* was coined and, throughout the project, the partners hoped to be making life better for them. It was interesting to note that the reviewed BBC survey had suggested that some 74% of the UK population was favourable towards DAB, but 21% were rated as *Fearful Tuners*. From the earlier data gathered about user reactions to RDS receivers, the project partners learnt that acronyms, such as AST, TA and EON [1], were generally considered confusing to the user.

Conclusions of this initial phase [2] were, briefly stated, as follows:

- the HMI must look simple;
- displays should provide explicit confirmation feedback;
- a "tell-me-more" function is helpful;
- DAB should enhance existing radio rewards (not turn into a different medium);
- text displays are likely to appeal to early adopters;
- broadcasters should use text carefully to enhance audio programmes and should be very careful about using scrolling text.

3.2. Evaluation of existing "easy-to-use" radio receivers

This work package undertook a small-scale evaluation of some existing receivers thought to be "easy-to-use". The intention was to collect information on user preferences and needs for the HMI in order to inform the project members. Immediately the partners hit upon a problem: there was almost no published data for the attribute "easy-to-use" and it appeared that no manufacturers had ever nominated their receivers with any specific statements about their ease of use. However some broadcast engineers, including the author, had been studying recent receivers and eventually suggested three facilities-rich RDS car radios for the expert assessment. An expert panel, comprising a physical ergonomist, a cognitive ergonomist and a consumer interests expert, evaluated these car radios [3].

The first radio was recognized to have a clear display and "uncluttered" front panel which supported the quick learning of functionality. The traditional rotary control knob for sound and tuning control was particularly appreciated. But the experts noted that some icons used on the display were not intuitive and some abbreviations used to label buttons were far from clear. They noted that buttons with more than one function were difficult to use.

The second radio had a consistent menu structure which promoted ease of learning for the user, and the control feedback was good in providing obvious distinction between a short and a long button press. The experts particularly liked one-touch keys for radio station storage and recall. However, many controls were poorly labelled and minor function keys (e.g. "Attenuation") were given undue prominence.

The third radio had a large LCD display which could show well-formed alphanumeric characters associated with a soft-key selection capability. Other controls were well spaced and the "hidden cassette slot" allowed maximum space for front-panel controls. Nevertheless, the menu structure was difficult to navigate because the abbreviated labelling was not easy to follow. The experts found it difficult to attach consistent meanings to the "+" and "–" keys versus the "up" and "down" keys.

Despite the hopes for these three car radios, the experts found a number of "hard-to-use" aspects. From the user point of view, redundant information was evident, some information was hard to use – because, for example, the menu trees were too "deep" – and human-error tendencies were not well considered, especially through the use of very small buttons which are not easily used in a vehicle environment. They noted that description-belief errors can occur where a button "looks" like it will perform a certain function but actually performs another function. Automatic mode change in some radios is not indicated and this leads to user confusion.

This work package was able to make a number of straight-forward recommendations, as follows:

- ⇨ future designs should optimize the controls, displays and icons;
- ⇨ future designs should reduce the potential for cognitive error by reducing unhelpful information;
- ⇨ mistaken use from description-belief errors should be reduced by a better use of acronyms (for example, the acronym TIM has virtually no meaning to a user and its functionality has to be learnt);
- ⇨ documentation for products needs to be very simple and should show *all* the menu structures that will be encountered;

⇨ as the complexity increases, an “Undo” or “Home” button is very necessary to allow the user to return to a simple recovery mode.

4. Identifying the HMI elements of DAB receivers

This work package, led by the Swedish Broadcasting Corporation, allowed the partners a “brain-storming” approach. There was general agreement that DAB radios should be characterized by *abstraction from technical details* and that service access should be *content based*, so that a listener can “forget” the technical delivery mechanism. The work package [4] gathered an array of non-unified ideas which would be the subject of a selection process for the simulation modelling, to be undertaken later.

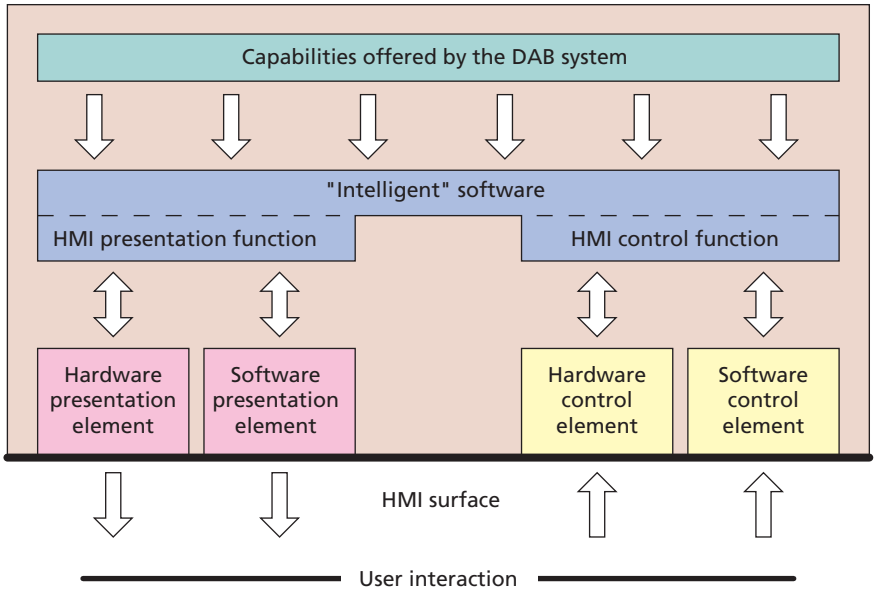

Figure 1
HMI concept for a generic DAB receiver.

Amongst the many ideas proposed, a conceptual model of a generic DAB radio was considered to help the project partners separate a number of interrelated aspects. This is shown in *Fig. 1* which illustrates generic HMI elements in terms of *HMI functions*, implemented in software, and *HMI surface elements*, consisting of hardware or software (computer-generated) control and presentation elements.

5. Development of a computer-model DAB receiver for allowing HMI evaluations

This work package, led by Robert Bosch GmbH, took the ideas gathered from the previous work package and synthesized them into a number of features to be evaluated through computer simulations of a front panel surface for a DAB radio. Due to the very short time frame of this project, a limited selection of features had to be made and the project also had to select a single simulation from the four available. The final simulation would have to be presented to a sample of users and would need to be a stable simulation, if possible capable of emulating a relatively real-world scenario.

Whilst very advanced in the concepts addressed, the Radio France simulation (see *Fig. 2*) was only available on a Website, so it could not be used in the subsequent market research environment.

In many ways the Swedish Radio simulation (see *Fig. 3*) had similar limitations, when considering the project requirement to undertake market research with the public. But we must give both these broadcasters their dues. Their objectives were to demonstrate ideas to the car-radio manufacturing industry, not to the general public; in both cases this was done with huge imagination, and stimulated a very successful debate about the HMI issues that needed to be addressed.

The simulations of the consumer-electronics partners were more product-oriented. Both the Bosch (*Fig. 4*) and Sony (*Fig. 5*) simulations would be able to address Service Access, PTy and Announcements features, as well as the common user-based settings for station memory, etc. It is interesting to note that Bosch used the conventional "DIN-slot" size that is utilized by most car radios, whereas Sony used a 1/4 VGA screen format which is beginning to be used in car navigation systems that are line-fitted when a car is initially manufactured.

Eventually the project partners unanimously, although by a narrow margin, selected the Bosch simulation to serve their purposes [5]. The Bosch simulation software was further developed after the ergonomic study, described in the next section, had been designed.

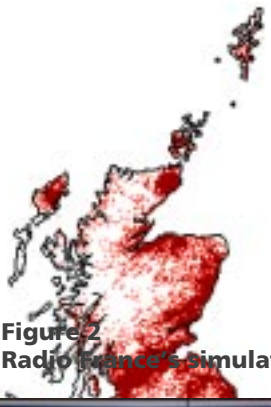

Figure 2
Radio France's simulation of a car radio front panel.

Figure 3
Swedish Radio's simulation of a car radio front panel.

Figure 4
Bosch's simulation of a car radio front panel.

Figure 5
Sony's simulation of a car radio front panel.

6. Ergonomic design studies and evaluation of market research

This work package was led by the BBC DAB market research expert who made the project partners realize that a user evaluation is a highly complex piece of work, and that a very pragmatic approach is needed when dealing with members of the public. Accordingly, a very detailed analysis of the functionality of the Bosch simulation was undertaken. The user evaluation would involve market research techniques requiring a sample size of several hundred people. Although the time to obtain comments from members of the public would be severely limited, we still wanted to arrange as near a real-world simulation as possible. This required the project partners to understand the market research methodology and to be prepared to concentrate only on a few key issues.

This led to an apparently limited evaluation, but market research techniques are designed to have applicability beyond the self-evident. So the project was able to construct a pragmatic test scenario, undertaken at three locations in the UK during June 1998. Having received "wish-lists" for these tests from the partners, it was agreed to eliminate lengthy research methods and avoid questions that had already been answered through previous research activities. This left five areas for evaluation, as follows:

- ⇨ the appeal of various facilities;
- ⇨ dealing with complexity;
- ⇨ button preferences;
- ⇨ performance on specific tasks;
- ⇨ how opinions and behaviour differ according to the respondent type.

This implied a core quantitative research method, plus an ancillary observational study. The last piece of work was to provide "realistic" audio sequences that were matched to the user expectation of the tests. Since all the tests would be conducted in the UK, audio sequences which matched typical programme content in the UK were prepared; these sequences could be selected on the computer simulations by the test subject. This would give the subject a fairly realistic feeling whilst following the questionnaire about the simulation.

In all, 553 respondents assisted the project, ranging in age from 18 to 64 years and with a male/female split of 48%/52%. These people were selected on the basis that they admitted to being regular radio listeners.

In terms of consumer attitudes towards the simulated DAB radio, the results[6] were fairly positive – it was generally considered to be easy to use overall, and the ease of performing each of the tasks was rated "above average". However, making the process of choosing a programme by type more intuitive than at present, and labelling the buttons used to change ensembles, would undoubtedly improve the ease of performing these more difficult tasks.

Both a touch screen interface and, in particular, a voice recognition system would be popular methods of operating a DAB radio; however, each of these methods would also deter relatively high proportions (around one in five people). As respondents were least likely to be averse to a small number of buttons, which would allow the user to step through the various functions, it was suggested that, if practical, voice-recognition DAB radios should be developed which can also be operated using a small number of buttons. This would then offer the novelty and advantages of voice recognition along with the reassurance and security of current technology (which was found to be of particular importance to the subcategories of

women and older people). The case for voice recognition is further strengthened by the fact that respondents would be prepared both to learn standard spoken commands and to teach the receiver to recognize their own speech.

From the research, it emerged that consumers who listen mainly to the radio in the car would prefer to receive help by means of a built-in voice, activated by a spoken command, whilst home radio listeners tended to favour help text on a display screen. This would suggest that separate systems have to be developed for the car and for the home (the in-car DAB radio would offer voice-recognition help capabilities, while radios designed for the home would provide information on a display screen).

If the radio were to be button-operated, it would be essential that preset stations could be selected with just one button press. Respondents requested equal simplicity in choosing a programme by type, for switching service components and, in the case of in-car DAB radios, for setting the traffic announcement facility. A scan up and down button, which would allow the user to step through a list of functions and select the desired one, would be the most popular method of choosing the remaining facilities.

In overall conclusion, consumers tended to embrace the new digital radio technology, which is particularly encouraging when considering that almost half of the respondents claimed not to be up-to-date in terms of Information Technology, only buying the latest equipment when it becomes really necessary. This bodes well for DAB as it suggests that even when first launched, it will have an appeal which extends beyond the niche "early adopter" market.

7. Workshops as the project progressed

This project had a second objective: that of informing professional contacts as the work progessed. Consequently, three highly successful workshops were held during the year [7]. The partners fully participated in these workshops, which included presentations of work undertaken and "hands-on" demonstrations for the participants. Participants were asked to assess the usefulness of these workshops to their professional interests and, in summary, their responses were very favourable.

The project was very fortunate to have enthusiastic partners and particular mention must be given to the Swedish Broadcasting Corporation who facilitated a thesis [8] by Patrik Werle, Stockholm University, Department of Computer and Systems Sciences. This work on "agent-based user interface architectures" was described during the second workshop.

Abbreviations

AST	Auto-store tuning	**LCD**	Liquid crystal display
DAB	Digital Audio Broadcasting	**PTY**	Programme type (RDS feature)
EON	Enhanced other networks (RDS feature)	**PTy**	Programme type (DAB feature)
		RDS	Radio Data System
HMI	Human-machine interface	**TA**	Traffic announcement (RDS feature)
HuMIDAB	Human Machine Interface for DAB	**TIM**	Traffic information memory

These workshops also allowed the project partners to discover other issues from participants. In fact, two items were revealed which should be the subject of further consideration:

- one consumer electronics company operates a "Barrier-free Charter" which addresses the concept of designing products that will allow physically-handicapped people –for example those with impaired hearing or sight – to use them readily;
- a screen font, called Tiresias, has already been designed to maximize the visual acuity of such numerals as 6, 8 and 9 as well as characters such as l and i.

Conclusions

The project has demonstrated that DAB, like many new digital technologies, has far more to it than the simple matter of delivering a digitally-encoded audio signal to the end-user. Multiplexed services bring the challenge of showing the user an array of ever-present choices, which can also be changed. Thus a simple and clear display is required. For the car radio, this represents the single most tantalizing issue: much more text than previously seen on car radios will be needed but a very real safety issue – not distracting the driver – must be considered at all times.

Broadcasters will wish to encourage the user to stay tuned to digital radio services, so changes to the detail of services will become vital too. Thus the PTy feature of DAB, whilst simple to specify, still requires clever implementation in a digital radio, in order to be really user-friendly. Simplicity of button presses and their functionality is still recognized by the users as an area needing more improvements; indeed the request for an "Undo" button is a clear indication of past user experience and should be heeded by designers, particularly now that each button tends to provide several layers of nested functions.

Whilst not originally sought by this project, the requirement for voice control should clearly be given further study, in view of the high level of user interest in it.

Apart from the detailed HMI issues exposed and now better understood, this project has shown that, with sensitive management, it is possible for consumer electronics manufacturers and broadcasters to work together in a partnership for the common good of the user, and to distribute their results openly through workshops.

Bev Marks *trained at the BBC and qualified as a broadcast and communications engineer in 1968. He pursued a varied career with the BBC, in both radio and television engineering, and now works as a freelance broadcast engineer, specializing in DAB, RDS and TTI matters.*

Mr Marks is very involved in the work of the RDS Forum, having recently been elected the Secretary/Treasurer. He has been extremely active in upgrading the RDS specifications, and developing the Universal Encoder Communications Protocol. He chairs the RDS Guidelines Working Group and is Organizer of the RDS Registrations Office, for ODA AID management. He has worked for the last three years as a broadcast systems expert, working for the EC's EPISODE project and representing the broadcast sector in CEN TC 278 WG 4, dealing with RDS-TMC standardization. Over the last 18 months he has been active in the work of the EBU B/TPEG Project Group, developing new Traffic and Travel Information protocols.

Bev Marks has been an Adviser to Modules 1, 2 and 3 of the WorldDAB Forum, studying DAB Services, Equipment, Regulatory Matters and Satellite matters. He recently completed a one year Project Manager assignment for the HuMIDAB Project described in this article.

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Bibliography

[1] B. Marks: **The development of RDS standards**
3rd Montreux International Radio Symposium: Engineering Record, June 1996, pp 133 - 142.

[2] Work package 1 (Deliverable 1): **Review of Existing Research – A Summary Report**
HuMIDAB 97/016, December 1997.

[3] Work package 1 (Deliverable 2): **Evaluation of existing "easy-to-use" receivers**
HuMIDAB 98/031, July 1998.

[4] Work package 2 (Deliverable 3): **Identification of HMI elements of DAB receivers**
HuMIDAB 97/014, November 1997.

[5] Work package 3 (Deliverable 4): **DAB Specific features to be tested**
HuMIDAB 97/029, July 1998.

[6] Work package 4 (Deliverable 6): **Consumer testing of DAB computer simulated car receiver**
HuMIDAB 97/032, July 1998.

[7] **HuMIDAB Workshop shows results and fires debate on HMI issues**
WorldDAB Newsletter, September 1998.

[8] Work package 3: **An Agent-based user interface Architecture for DAB**
HuMIDAB 97/021, March 1998.