A high bit-rate data broadcasting system using the terrestrial FM radio network

SWIFT Eureka 1197 project

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The SWIFT Eureka 1197 project aims to develop a multi-application data system using the FM radio network. This article presents a technical assessment of the various existing high bit-rate data broadcasting systems that are compatible both with the Radio Data System (RDS) and with the audio signals (monophonic or stereophonic) that are transmitted by FM radio networks.

The technical performance of each existing system is reviewed, along with the performance criteria of the system which has been adopted in the SWIFT project. Finally, three classes of application – professional, public and services for disabled people – are described.

1. *The SWIFT Eureka 1197 project*

Conventional FM radio broadcasting can offer additional services by means of a subcarrier placed in a clear part of the baseband multiplex signal. In Europe, a data broadcasting system called Radio Data System (RDS), with a transmission capacity of about 1.2 kbit/s, has been in operation for a number of years [1]. RDS has also found other wide-ranging applications throughout the world [2].

Further uses for RDS have been proposed and these can only lead to a saturation of the RDS channel resources in due course. This observation has naturally led to the consideration of alternative systems, also using the FM radio channel as a bearer, but which allow the transmission of higher bit-rates.

The SWIFT *Eureka 1197* project (System for Wireless Infotainment Forwarding and Teledistribution) aims to develop a multi-application data service for portable and mobile receivers, by using a new high bit-rate data broadcasting system carried via the existing FM network. Three classes of application will be fully demonstrated within the project, taking into account the following targeted markets:

– professional applications (e.g. E-mail broadcasting, differential-GPS correction data);

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– general public applications (e.g. still-image and traffic-information broadcasting);

– special applications (e.g. a news service for blind people).

The broadcasting network and the terminals will be designed and developed within the project. The broadcasting network will include:

– the applications and network server;

– the subscriber management unit, which comprises the subscriber management system to deal with the marketing aspects, and the subscriber authorization system to handle the access control;

– the encoder.

The access points will feature a transparent data-file transfer, so that any new applications may be readily implemented. Every terminal will use the same type of receiver, designed to be a PCMCIA unit, and will include dedicated software running on host computers.

1.1. Organization of the project

The project is organized in four stages:

1. Service definition, which includes the choice of data broadcasting system presented in this article, the service architecture, the technical and system specification as well as the subscriber management unit.

2. Development phase for the X400 and network server, the PCMCIA receiver, the encoder, the terminal application software and the access controller.

3. Preparation of the commercial aspects, carried out in parallel with stage two, and including the international standardization effort.

4. Field demonstrations in Sweden, Norway and France.

1.2. Participants in the project

SWIFT is a two-year long project and involves the two research centres of Télédiffusion de France (TDF-C2R[1], the project co-ordinator, and CCETT[2]); the Swedish national broadcast network operator, Teracom; the Norwegian national broadcast network operator, Telenor; the Norwegian governmental agency, Norwegian Mapping Authority (NMA), and the French software development company, Antigone.

1. Centre d'Etudes en Radiodiffusion et Radiocommunication.

2. Centre Commun d'Etudes de Télédiffusion et Télécommunication.

2. Choice of data broadcasting system

2.1. High bit-rate data broadcasting systems

At the beginning of the 1990s, various new high bit-rate data broadcasting systems which use the FM radio infrastructure were proposed. Several of these systems have now been implemented or are under experimentation in various countries but only three of them are of interest to the SWIFT project. These are as follows.

– *DARC system*

The DARC system has been developed mainly by NHK of Japan, in cooperation with Teracom of Sweden. Intended for mobile and stationary reception, it is now in commercial operation in Japan.

– *TDF-C2R system*

TDF-C2R has developed a dual-operating-mode system for fixed and portable receivers which uses two different bit-rates, multiplexed in time. The system is not yet commercially available, but the idea of being able to adapt the bit-rate (modulation) of the service to suit the receiving conditions is of great interest and could have a wide range of applications.

– *High-speed Subcarrier Data System*

The High-speed Subcarrier Data System (HSDS) has been developed by Seiko Telecommunication System Inc (STS) and is now deployed as a commercial paging and information service in the Seattle and Portland areas of the USA.

2.2. Technical assessment of these different systems

2.2.1. Status of FM multiplex broadcasting

The transmission parameters for frequency-modulated sound broadcasting in the VHF band are set out in ITU-R Recommendation BS.450 [3]. The RF signal comprises a main carrier which is frequency-modulated by a baseband multiplex signal. The peak carrier deviation (in Europe) is 75 kHz. The baseband signal is either a monophonic audio signal or a stereo multiplex, which occupies at least 90 % of the frequency deviation, together with supplementary signals which do not exceed 10 % of this deviation. The spectrum of the supplementary signals – which must be compatible with the monophonic signal or the stereo multiplex – must fit within the baseband frequency range from 53 to 76 kHz, according to CCIR Report 1065 [4]. RDS is one such supplementary signal; it occupies a bandwidth of 4.75 kHz, centred on 57 kHz.

Fig. 1 shows the baseband spectrum of the stereo multiplex, accompanied by the RDS signal. It is seen that there is an unused sub-band between 61 and 76 kHz. Any supplementary data system which uses this sub-band must therefore have a maximum bandwidth of 15 kHz and must be designed to be perfectly compatible with the existing programme signals, according to ITU-R Recommendation BS.450 [3].

2.2.2. Standard technical features

Several applications are currently under development, or have been implemented, using the RDS European standard or the RBDS standard in the USA, which is a slightly modified version of RDS.

The most important features of the RDS system, as given in ITU-R Recommendation BS.643 [5], are as follows:

– the RDS data signal is a differential binary phase shift keying (DBPSK) signal with a gross data rate of 1187.5 bit/s;

– the 57 kHz subcarrier is modulated by the above RDS data signal and added to the stereo composite signal;

– the chosen modulation method for RDS is double sideband AM, with the carrier suppressed;

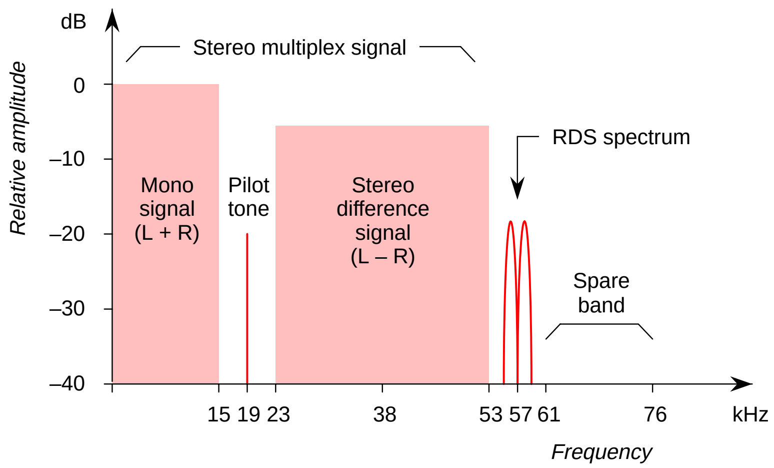


Figure 1
Baseband spectrum of the FM multiplex.

– the RDS signal occupies a bandwidth of 4.75 kHz, ranging from 54.625 to 59.375 kHz;

– the nominal peak deviation of the main FM carrier is ± 2 kHz (in France, a practical value of ± 4 kHz is used);

– the protection ratio complies with ITU-R Recommendation BS.412 [6].

In order to achieve good working of the RDS system, the maximum bit error-rate (BER) before application of the error-correcting code is 10^{-2}

A BER of 10^{-2} is achieved with the RDS system if the main FM carrier-to-noise ratio (C/N), evaluated in a bandwidth of 200 kHz, is at least 12 dB.

A bit error-rate of 10^{-2} has also been chosen within the SWIFT project to evaluate the noise performance of high bit-rate data broadcasting systems which use the FM radio infrastructure.

2.2.3. DARC system

Research and development on the DARC data system has been carried out by NHK in Japan, in cooperation with Teracom in Sweden. Today there are two DARC specifications, a Japanese one and a Swedish one. Both systems are compatible with respect to the physical layer and the data-link layer. For the layer above, three different but compatible types have been specified: two by NHK and one by Teracom.

The chosen modulation is level-controlled minimum shift keying (LMSK), which is a form of MSK where the amplitude is controlled by the stereo sound signal (left minus right). The –20 dB bandwidth is 35 kHz, centred on 76 kHz (i.e. 76 kHz ± 17.5 kHz). The gross bit-rate is 16 kbit/s, hence the spectral efficiency is around 0.457 bit/s/Hz.

The subcarrier level is dependent on the level of the stereo difference signal. When the peak deviation of the main carrier, caused by the stereo difference signal, is less than 2.5 % (± 1.875 kHz), the subcarrier injection level is 4 % (± 3 kHz). When the peak deviation of the main FM carrier is more than 5 % (± 3.75 kHz), the subcarrier injection level is 10 % (± 7.5 kHz). Between these two limits, the deviation varies linearly.

In the case of mobile reception, the presence of multipath interference causes intermodulation between the audio signal and the data signal. This, in turn, causes the signal-to-noise ratio (S/N) of the received audio signal to deteriorate. By using the level control of the modulation system, the deterioration in S/N ratio is reduced and good compatibility with the audio signal is ensured. By using MSK modulation, good performance in the presence of noise is ensured, at the expense of low spectral efficiency.

To organize the data structure, three methods are specified: two are based on the product code (272,190)∗(272,190) and one method is based on the block code (272,190). The "frame" is organized in 190 information blocks and 82 parity blocks. The length of each information block is 288 bits: each one consists of a 16-bit block identification code (BIC), 176 information bits, 14 bits of cyclic redundancy check for error detection, and 82 parity bits. The three methods of organizing the data structure are identified by a sequence within the BIC. Further information on the three methods is given in [7].

The DARC system does not comply with CCIR Report 1065 [4], but the protection ratios measured in Japan and in Sweden show that they comply with ITU-R Recommendation 412 [6]. Before the system may be exploited commercially, it is vital that it accords with the recommended protection ratios; discussions to update CCIR Report 1065 have already begun.

In order to achieve a BER of 10^{-2} with the DARC system, the minimum C/N ratio of the main FM carrier, evaluated in a bandwidth of 200 kHz, is 23 dB.

2.2.4. TDF-C2R system

The C2R digital data broadcasting system has been developed by TDF-C2R. It permits the broadcasting of data at two different bit-rates (19 or 30 kbit/s) to stationary or portable receivers. The idea is to time-division-multiplex the data from different services at different bit-rates. The originality of this system lies in a transmitter which can change its bit-rate and which uses the same bandwidth to transmit the different data signals. The chosen bit-rate is adapted to the application and the receiving conditions, by choosing two different modulation schemes and error protection strategies.

To obtain two bit-rates with the same transmitter, two similar modulation systems – offset quadrature phase shift keying (OQPSK) and offset quadrature partial response signalling (OQPRS) – are used. A prototype has been developed where these two modulation systems are implemented very easily in the same transmitter, using digital techniques. The OQPSK/OQPRS channel is centred at 68.5 kHz and occupies a bandwidth of 14.25 kHz for the OQPSK system (it uses a raised cosine filter, split equally between the transmitter and the receiver) and a bandwidth of 15 kHz for the OQPRS system.

These two techniques achieve a spectral efficiency of 1.33 bit/s/Hz for OQPSK and 2 bit/s/Hz for OQPRS. The peak deviation of the main FM carrier, caused by the OQPSK/OQPRS signal, ranges from ± 4 kHz (for compatibility with RDS signal broadcasting) to ± 7.5 kHz (the maximum peak deviation permitted by ITU-R Recommendation BS.450 [3]).

The performance of the OQPSK/OQPRS system has been evaluated by computer simulation and the main results are given in [8]. By using the 15 kHz bandwidth centred on the 68.5 kHz subcarrier, the OQPSK/OQPRS system is compatible with the audio and the RDS signals and is in accordance with CCIR Report 1065 [4]. Multiple tests with signals using this same bandwidth show that the protection ratio accords with ITU-R Recommendation BS.412 [6].

In the case where the main FM carrier has a peak deviation of ± 4 kHz due to the RDS signal and ± 4 kHz due to the OQPSK/OQPRS signal, the minimum carrier-to-noise ratio to insure a BER of 10^{-2} is 24.5 dB for OQPSK modulation and 31.5 dB for OQPRS.

2.2.5. HSDS system

The HSDS system is fully developed and is being deployed in parts of the USA by Seiko Telecommunication System Inc (STS). Applications which are currently being marketed include paging and information services to digital-display wristwatch receivers, and to pocket pagers.

HSDS permits a high bit-rate of 19 kbit/s by using an AM-PSK modulation scheme. This modulation system uses a double-sideband suppressed carrier, amplitude-modulated by a duobinary-coded data signal. Pre-encoding of the data is performed to prevent error propagation. The standard channel is 19 kHz wide, centred on a subcarrier frequency of 66.5 kHz. The bandwidth of the modulated subcarrier is 19 kHz, in the 57 to 76 kHz frequency range.

The RDS signal spectrum lies between 54.6 and 59.4 kHz, so the HSDS signal interferes with the RDS signal. To remove this incompatibility, STS has proposed another version (for Europe) which uses the same subcarrier at 66.5 kHz, but the spectrum of the modulated subcarrier from 57 to

61 kHz is cut off, inverted, and added to the spectrum in the 57 to 76 kHz frequency range. This modification is implemented in the finite-impulse-response (FIR) filter in the HSDS subcarrier generator; an input filter in the receiver eliminates the RDS signal before the data from the HSDS signal is decoded. The spectral efficiency is 1 bit/s/Hz for the standard version and 1.27 bit/s/Hz for the European version. The peak deviation of the main FM carrier, caused by the HSDS signal, varies from ± 3.75 kHz (for compatibility with RDS signal broadcasting) to ± 7.5 kHz (the maximum peak deviation permitted by ITU-R Recommendation BS.450 [3]).

The data structure of the HSDS system is described in [9]. Three levels of error protection are used:

- the first level is realized by an error-correcting code (Hamming code with 4 redundant bits per byte), which corrects one false bit in every twelve bits;
- the second level is an interleaved data transmission, which corrects an error burst of up to 20 bits in 240 bits;
- the third level uses a cyclic redundancy check (CRC) in each packet, which allows error checking after the first two levels of correction.

Additionally, for the paging service, the transmission strategy is based upon space, frequency and time diversity (i.e. the system uses multiple transmitter sites, multiple frequencies, and deploys a different time delay at each transmission site). This broadcasting strategy ensures a good paging service for a BER, before error correction, of 2.10^{-2}.

The performances of the HSDS system have been evaluated by experimental test for the standard version and computer simulation for the European version. As already mentioned, the standard version is not compatible with the RDS system. The European version, on the other hand, will be compatible with the RDS signal, provided that the filters in the transmitter and in the receiver are changed.

STS will change the filters in the transmitter but the filter changes at the receiver are not carried out in practice. In this case, the experimental tests and the computer simulations have shown that the RDS compatibility is considered acceptable if a peak deviation of at least ± 6 kHz is chosen for the HSDS subcarrier, and a maximum peak deviation of ± 2 kHz is used for the RDS subcarrier. Measurements of the protection ratio comply with ITU-R Recommendation BS.412 [6] and the bandwidth of the baseband multiplex FM signal is in accordance with CCIR Report 1065 [4].

In the case where the main FM carrier has a peak deviation of ± 4 kHz due to the HSDS subcarrier, and there is no RDS signal, the minimum C/N ratio necessary to ensure a BER of 10^{-2} is 29 dB. The same performance is obtained for the European version, in the presence of an RDS signal, with the same peak deviation of the HSDS subcarrier.

2.3. Which choice for the SWIFT project?

The SWIFT project aims to provide a multi-application data service for mobile and portable reception. The chosen system will be a precursor to future services which will use digital data broadcasting systems (e.g. DAB for mobile reception, digital television for reception on fixed or portable receivers). Consequently, the SWIFT project can provide a good marketing test for these future digital services. The criteria and technical performances of the systems studied within the SWIFT project must be analysed to choose the optimal data broadcasting system. These different criteria are presented in *Table 1*.

HSDS has proved to function well as a paging service and for general information broadcasting in the USA. The equipment is already available, with a large amount of integration in the receiver. The chipset which is currently incorporated in the digital-watch receiver is very small, it has minimal energy consumption and is not expensive, thus ensuring speedy deployment at either a technical or an operational level. In the European version, HSDS is compatible with the RDS system – on condition that a limited peak deviation for the RDS subcarrier is chosen. However, the fully-compatible system that is described in *Table 1* is not currently available; it is based on the premise that the input filter in the receiver has been changed.

By using a 35-kHz bandwidth centred around a 76-kHz subcarrier, the DARC system does not comply with CCIR Report 1065 [4]. Nevertheless, the protection ratio measured in both Sweden and Japan complies with the ITU-R Recommendation BS.412 [6]. For countries which have a high density of programmes, this system can be introduced on the FM radio network with an appropriate choice of frequency planning. Today,

System	RDS (reference)	HSDS	DARC	C2R	SWIFT EU 1197 System choice
Modulation	DPSK	AM-PSK	LMSK	OQPSK / OQPRS	L(OQPSK / MSK)
Gross bit rate (kbit/s)	1.1875	19	16	19 / 30	38 / 16
Occupied band (kHz)	54.625 – 59.375	61 – 76	60 – 95	61.4 – 75.6 / 61 – 76	61.75 – 90.25 / 60 – 95
Subcarrier (kHz)	57	66.5	76	68.5	76
Protection ratio	YES	YES	YES	YES	YES
Audio, RDS compatibility	YES	YES	YES	YES	YES
C/N (dB)	12	29	23	24.5 / 31.5	28 / 23
Receiving conditions	Mobile, portable, fixed	Portable, fixed	Mobile, portable, fixed	Portable, fixed	Mobile, portable, fixed
Available	YES	NO*	YES	NO	NO

* Based on the premise that the input filter in the receiver has been changed (see *Section 2.3.*).

Table 1
Main criteria and technical specifications of the data broadcasting systems studied by the SWIFT project.

this system is fully developed for mobile applications. It gives the best coverage area with the best performances in the presence of noise. However, it has the lowest spectral efficiency which means that the transmission bit-rate is the lowest of the systems under consideration.

The C2R system, which is not currently available, has been developed for reception on fixed and portable receivers. It is expected to provide a relatively good performance with a good coverage area for the services it will offer. The idea of having two bit-rates which can be adapted to suit the required services and the receiving conditions is of great interest.

The DARC system – which uses an MSK modulation system that is very similar to OQPSK and OQPRS – also offers adaptable bit-rates. For example, a bit-rate of 16 kbit/s can be chosen for use with mobile receivers and the transmission of certain services; alternatively, a bit-rate of more than 35 kbit/s can be chosen for use with portable receivers and for the transmission of other services such as still images in news information broadcasting.

The ideal parameters for the proposed SWIFT system are given in the last column of *Table 1*. By combining the control-level technique adopted in the DARC system with the OQPSK modulation technique used in the C2R system, better compatibility with the audio signal can be achieved. The performance of this composite system in the presence of noise can be obtained by computer simulation of the OQPSK modulation and experimental tests on the MSK modulation. As this system is not yet available, it is therefore planned to start with the DARC system alone during the development of the SWIFT high bit-rate data system.

3. Applications developed in the SWIFT project

The DAB system has been designed to replace FM radio in the long term; it will also offer a significant extension of the data services already available today on RDS. The prospective new data services which may be carried on future DAB channels are discussed in [10].

The SWIFT data system is an intermediate scenario, implemented in a short time-scale to achieve a smooth changeover from FM radio to DAB. It will offer bit-rates of 8 or 10 kbit/s for reception on portable or mobile receivers, allowing a new generation of data applications to be launched [11]. For demonstration within the *EU1197* project, three classes of application will be fully demonstrated: professional applications, general public applications and applications for disabled people.

3.1. Professional applications

Several important factors are contributing to the development of electronic mail (E-mail) services. In particular, X400 – an E-mail software program for the Windows environment – allows a client's desktop PC to be connected to the Atlantic X400 server.

Electronic mail represents a major new business opportunity for both the computer industry and the public service providers. On the one hand, the computer industry sees electronic mail as the principal application of networking and distribution principles, aimed at the general public. On the other hand, public service providers see the development of electronic messaging services as a way to introduce new value-added services and as a new source of income, given the relative saturation of the telephony market and related services. Equipment manufacturers will benefit not only from supplying the public service providers, but also from the existence of a world-wide backbone messaging network, which will make it easier for them to focus on the development of products for the very lucrative end-user market.

Many users of messaging systems will find advantages in the broadcast method of sending messages, which is the most eagerly-awaited extension to message-sending technology. With a broadcast E-mail service, a user can send a single message to an unlimited number of receivers at one time. The messages are stored in the receiver and retrieved at the recipient's convenience. If the receiver is connected to a traditional network (e.g. telephone modem, X25, LAN), the recipient can also create and send mail.

A summary of the main features of a broadcast E-mail service is given below:

– *User interface*

  This will feature an in-tray, out-tray, message creation software, a distribution list, a transfer log, an indication of connection status, secure access and background file-transfer facilities.

– *Message management*

  This will offer facilities for linked applications, text editing, filing into folders and the export of file attachments and distribution lists.

– *Message sending (with traditional access only)*

  This will offer facilities to create forms, carbon and blind copies, multiple acknowledgements and multiple file attachments. It will also provide delayed or immediate sending facilities, and message compression and encryption facilities.

– *Message receiving*

  This will provide notification of new mail messages, an indication of message attributes, whether there are any files attached to the message, facilities for forwarding/replying to a message (with traditional access only), anti-virus facilities and the means to decompress and decrypt messages.

– *Data communications*

  This will offer a receive-only link, an RS232 link with script language, a modem connection and a PAD link with script language, TCP/IP.

Another area of professional application is the Differential Global Positioning System (DGPS). The Global Positioning System (GPS) is a constellation of 21 satellites maintained by the US Department of Defense. From any three satellites, users equipped with the appropriate receiver can determine their position anywhere in the world. Due to ionospheric delays and an error deliberately added by the Department of Defense, GPS can only be relied upon to give accuracies to the nearest 100 metres. However, if a GPS receiver is installed in a known, surveyed location, then the error which is inherent in the GPS-position reading can be determined mathematically. This correction can then be broadcast in real time by the SWIFT system to other GPS receivers, to provide an accuracy in the 1 to 10 metres range. The combination of GPS and SWIFT technologies will allow delivery of a high performance service at a very modest cost to the end user.

3.2. General public applications

The adaptation of teletext standards for RDS transmission (i.e. radiotext) does not cause any technical problems. However, due to the maturity of multimedia technology and coding standards today, it may be opportune to develop a multimedia extension to teletext, which would allow it to carry geometric and photographic images as well as some degree of sound or speech coding. It appears that the transmission of radiotext, intended mainly for portable receivers that are equipped with a suitable display device, is subject to a need to compromise between the quality of the text and the transmission time.

The broadcasting of a daily information magazine – comprising about 30 pages of 4 kbyte each, with alphageometric characters for remote learning schemes – takes about 54 minutes via an RDS channel. With a high bit-rate data broadcasting system (e.g. 30 times faster than RDS), the transmission time reduces to around 2 minutes. Moreover, a photographic image – represented by 64 kbyte of data – could be received in about one minute, instead of 30 minutes when using RDS. The inclusion of image-compression schemes would permit the transmission of even higher-quality images in the same time-scale.

Another area of public service information is the transmission of traffic information. This type of service is designed to provide road users with any relevant information that might improve the security, efficiency or enjoyment of their journey [10]. In this case, the objective of SWIFT is to improve on the services currently provided by the German traffic system, ARI, or the TP-TA facility of RDS, which have well-known limits. Improvements to the traffic information service are commonly felt as one the most urgent applications of data broadcasting to mobile receivers.

3.3. Applications for disabled people

Progress made in the computer sciences has led to applications such as news information for blind people. As an example, IBM sells a software package for the PC called "Screen Reader" which allows the automatic reading of information displayed on the computer. News broadcasting for blind people is not a new application and several services have already been developed in Sweden and France. Some newspapers like *Le Monde* and *The Times* also sell floppy disks which contain news stories and articles in the form of text files. A computer can store the text files for later reading by the user, either on the screen or via a printout. This application is of particular interest to blind people who are equipped with a speech synthesizer.

In the SWIFT proposal, a data receiver (in the form of a PC extension board) would be connected to a computer via an RS232 interface. The broadcast text files provided by the press agency would be organized in articles and pages, just like a classical newspaper, to be stored in the computer for reading later. In the case of visually impaired people, the received information could be transformed into vocal messages via a blind person's dedicated user interface.

4. Conclusion

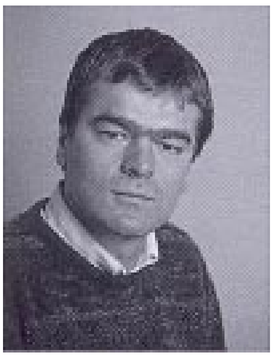
The SWIFT project aims to develop a flexible and transparent multi-application data channel, based on a high bit-rate data broadcasting system for portable and mobile receivers, implemented on a PCMCIA card. By using the infrastructure of the existing FM network, which is used in all European countries, the SWIFT system will be easy and inexpensive to implement, and will provide good area coverage. The system could be implemented over a short time and could thus provide an interim data service during the transition period from RDS to DAB data broadcasting. The SWIFT system could also act as a good marketing test for future data broadcasting services.

This article has reviewed the existing high bit-rate data systems which use a subcarrier in the baseband of the FM stereo multiplex. From an analysis of the technical aspects of each system, the SWIFT project team has chosen a data system based on the DARC system, developed jointly in Sweden and Japan. By means of a technical adaptation, the DARC system offers the possibility of having two bit-rates: 16 kbit/s, or more than 35 kbit/s for reception on mobile or portable receivers.

Market analysis in France has shown a demand for SWIFT technology in the next seven years. The results of this study assume the introduction of SWIFT services in the next two years. The feasibility of a PCMCIA receiver must be demonstrated in this time period.

Acknowledgements

The authors wish to thank their partners in the SWIFT *EU1197* project (see *Section 1.2.*) for the valuable information they have provided.



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***Roland Andersson** graduated from Luleå Technical University, Sweden, in 1984.*

He is now a research engineer in the Teracom Research & Development department at Luleå, and is currently working on the development of new data broadcasting systems.

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Montreux Award for Ulrich Reimers

The Montreux Achievement Gold Medal for 1995 was awarded to Professor Ulrich Reimers – Chairman of the Technical Module of the European Digital Broadcasting (DVB) Project – for his outstanding contributions to the establishment of technical standards for the delivery of digital television services by satellite and cable.

Montreux '95

The award was presented by the Chairman of the Medal Award Committee, Mr John Forrest, Executive Chairman of NTL Ltd.

Ulrich Reimers studied Communications Engineering at the Technical University in Braunschweig, Germany and graduated in 1977. He stayed on at the University as an Assistant Professor until 1982 when he joined the BTS company to work on advanced HDTV studio systems. In 1989, he was appointed Director of Engineering for Norddeutscher Rundfunk (NDR) in Hamburg. Since 1993, Dr. Reimers has been Director of the Institute for Telecommunications at the University of Braunschweig.

In addition to his Chairmanship of the DVB Technical Module, Ulrich Reimers is President of the Fernseh- und Kinotechnische Gesellschaft (FKGT).