

# ATM WAN tests for broadcasting applications

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IRT

***In order to evaluate the operational and technical feasibility of using standardized telecom network techniques for broadcasting applications over LANs and WANs, the IRT has set up an internal ATM-based high-speed transport network. It has also carried out tests on ATM WANs and was heavily involved in the planning and evaluation of the ARD HYBNET<sup>®</sup> field-trial network, and in other trials and demonstrations which are described here.***

***Based on these IRT tests, the author provides basic evidence as well as some general results and conclusions in favour of using ATM in broadcast networks which consist of both LANs and WANs.***

## 1. Introduction

The increasing use of computer-based TV production and distribution tools will dramatically change our existing workflow practices which, in turn, will greatly influence the utilization – as well as the structure and the technologies – of the digital networks within broadcasters' premises. This may lead to faster processing and, in consequence, to lower costs – but only if the new infrastructure (computer-based production tools, together with local computer networks and wide-area networks) can also provide cost savings.

The networks involved will need to provide integrated transport facilities to carry all the elements of our programme signals: i.e. video, audio, data and metadata. Furthermore, the introduction of new production facilities – using different compression formats as well as different (and possibly dynamically-varied) bit-rates – will require the availability of flexible networks which can easily be adapted to the changing requirements of programme contribution and distribution.

A very important issue will be the seamless combination of internal networks (campus networks) with WANs. We will want to avoid the cascading of coding processes just in order to adapt our bit-rates to the network access rates. In addition, a given network will have to be able to cope with fast file transfers as well as with real-time transmission (streaming) of video and audio signals. At the destination, the quality of the received signal will have to accord with normal studio requirements, as further processing of that signal may have to take place.

Global integrated management systems will need to be implemented in order to ease the setting up of connections and to enable a user-friendly dial-up facility for exchanging files or



even bitstreams between end terminals in broadcasting environments (including contribution, primary distribution and secondary distribution scenarios). Concepts for new networks in the broadcasting environment will have to take into account the advantages and risks of new network technologies for broadcasting applications, but also the possible improvements in functionality and economy that these networks could bring about.

Looking closer at these challenges, one of the key questions concerning the transport of compressed data streams is how to carry these streams over studio campus networks as well as over WANs. Standards are available from the EBU/SMPTE Task Force for mapping SDTI streams into different transmission techniques such as FC and ATM, but there is no evidence up to now that a common solution (e.g. based on the MPEG-TS specification) will be adopted. In consequence, flexible transport mechanisms that are able to carry different stream formats will be necessary in the future.

Furthermore, real networking solutions will be needed which enable bi-directional data transfers, based on standard computer networking techniques. Appropriate equipment interfaces, such as ATM or FC network interface cards (NICs), will also be required to enable the direct interfacing of production equipment to high-speed and high-performance networks.

Network Management Systems (NMSs) will need to be available and installed in order to set up, manage and troubleshoot these possibly very large and complex networks. Global network management tools, including not just LAN management but also the management of external connections on WANs, must also be considered. If we have to merge these requirements with economic solutions, LANs and WANs specifically designed for broadcasting applications and adapted to emerging new applications will no longer be affordable. Possible solutions in order to meet economic constraints may include the use of standardized and existing transport mechanisms such as the SDH and particularly ATM for the seamless interconnection of local studio networks as well as wide-area networks.

The standardization and availability of appropriate network adapters for the mapping of transport streams (MPEG, DVCpro etc) onto ATM is likely to be realized in the near future. But applying these basic rules to the planning and operation of new digital networks for contribution and distribution means that we will have to accept the behaviour of these standard telecom networks in LANs as well as in WANs. This includes particularly all the restrictions and disadvantages associated with the use of these networks which are optimized for telephony and data transport only, but not for the real-time transmission of video/audio signals. Any measures to be taken in order to fulfil real-time requirements will have to be applied to the network adapters or video/audio terminals.

Equipment such as frame store synchronizers or sample rate converters for audio signals are available today to provide safe operation over current networks. On the other hand, the use of such equipment in complex scenarios which involve the cascading of connections may introduce annoying delays to the signals which are perhaps not acceptable for interactive programmes or for certain interviews (e.g. combining a live studio interviewer with an interviewee who may be located at a remote site). New synchronization or re-timing concepts should be considered and applied – such as the synchronization of all the studio sites and telecommunications terminals involved using GPS, for example. It should be emphasized that these new synchronization concepts will offer potential improvements (e.g. avoiding frame slips with the associated audio alignment problems) in comparison with the existing practice of using free-running studio clocks.



## 2. ARD HYBNET field trials

### 2.1. Why HYBNET field trials?

Taking into account the changing requirements for new production and distribution scenarios, as well as the possible benefits from a developing competition between network providers in an opening telecommunications market, the ARD has considered replacing the existing contribution and distribution network for its member organizations by a new network called HYBNET<sup>®</sup>. This new network is based on standardized and commonly-used telecom technologies such as SDH and ATM.

The ARD HYBNET project group had the task, among other things, of evaluating all networking concepts which could offer the functional and technical options needed today in the broadcasting environment. A new flexible approach will be required for adapting the chosen type of network to the requirements evolving from the introduction of computer-based production and distribution techniques, including real-time streaming and high-speed file transfers between member stations. Furthermore, independence from any one network and service provider is an essential goal in the planning and configuration of this new network.

In the framework of the project, WAN tests have been carried out to prove that the functional requirements as well as all the technical parameters – and particularly the signal quality for contribution and distribution applications – can be met by the standard telecommunications technologies that are planned for the new ARD network. The tests included audio and video transmission over SDH and ATM, as well as audio and video file transfers between servers, via ATM. The IRT was charged with the testing of all these broadcast applications in a HYBNET field-trial network.

### 2.2. The HYBNET field-trial network

The HYBNET field-trial network included transparent transmission segments from different network providers, interconnected via network elements (SDH) to form a complete WAN which can be managed by a service provider. Via this fibre-optic-based network with a length of 1400 km, the ARD sites at Frankfurt (FFM), Hamburg (NDR), Munich-Freimann (M1) and Munich-Funkhaus (M2) were interconnected. The topology of the network and the transport capacity of the different segments are shown in Fig. 1. Deutsche Telekom AG (DTAG) and a local Citynet carrier in Munich (M<sup>n</sup>net) provided connections with bit-rates

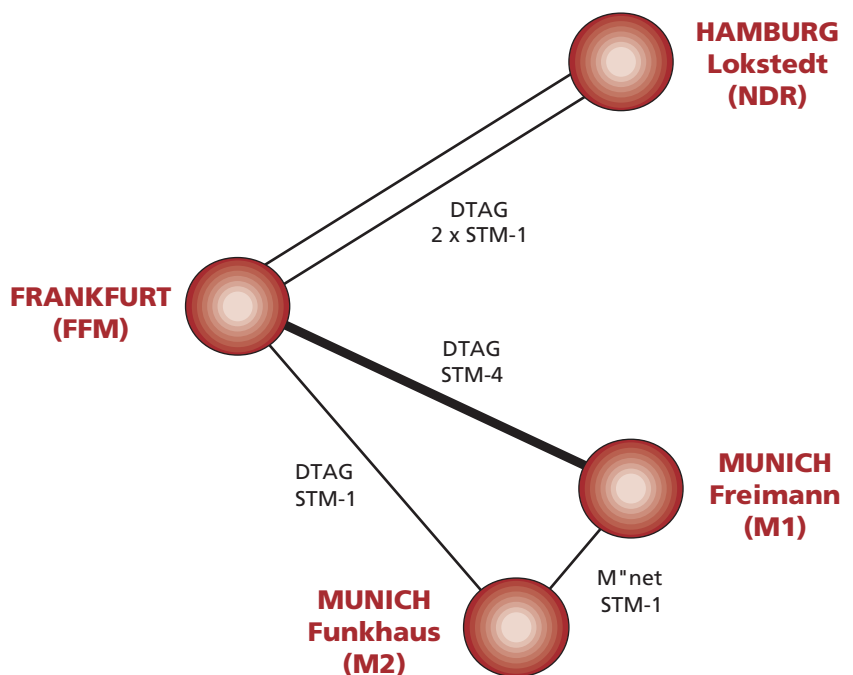


Figure 1  
Topology of the ARD HYBNET field-trial network.

of 155 Mbit/s (STM-1) and 622 Mbit/s (STM-4). These connections were available over a period of about six months.

It was possible to test asynchronous network interconnections in this trial network, as the SDH network segments from both providers were based on different network clock-distribution concepts (DTAG used a caesium clock generator, while M'net used a GPS-based clock). The HYBNET network elements in Frankfurt and Munich were clocked from a GPS receiver whereas the NDR HYBNET network element was genlocked to one of the Deutsche Telekom STM-1 links. The management centre, with management systems for the SDH layer as well as for the ATM layer of the HYBNET field-trial network, was implemented at the IRT. Operation of the network and applications was carried out with the co-operation of the ARD stations involved, after a very short introduction to the systems by staff from the IRT.

The evaluation of network and signal parameters was dedicated mainly to the measurement of network-related parameters of SDH, PDH and ATM, as well as to critical video and audio signal parameters influenced by asynchronous network operation (e.g. wander, jitter, phase drift, impact from bit errors, etc.). Also included in the evaluation process was the impact that emergency re-routing over the network would have on the performance of the application signals.

### 2.3. The HYBNET WAN test set-up

A series of broadcast applications was tested using the HYBNET field-trial network as shown in Fig. 2. The applications implemented on the test network were chosen in line with the most

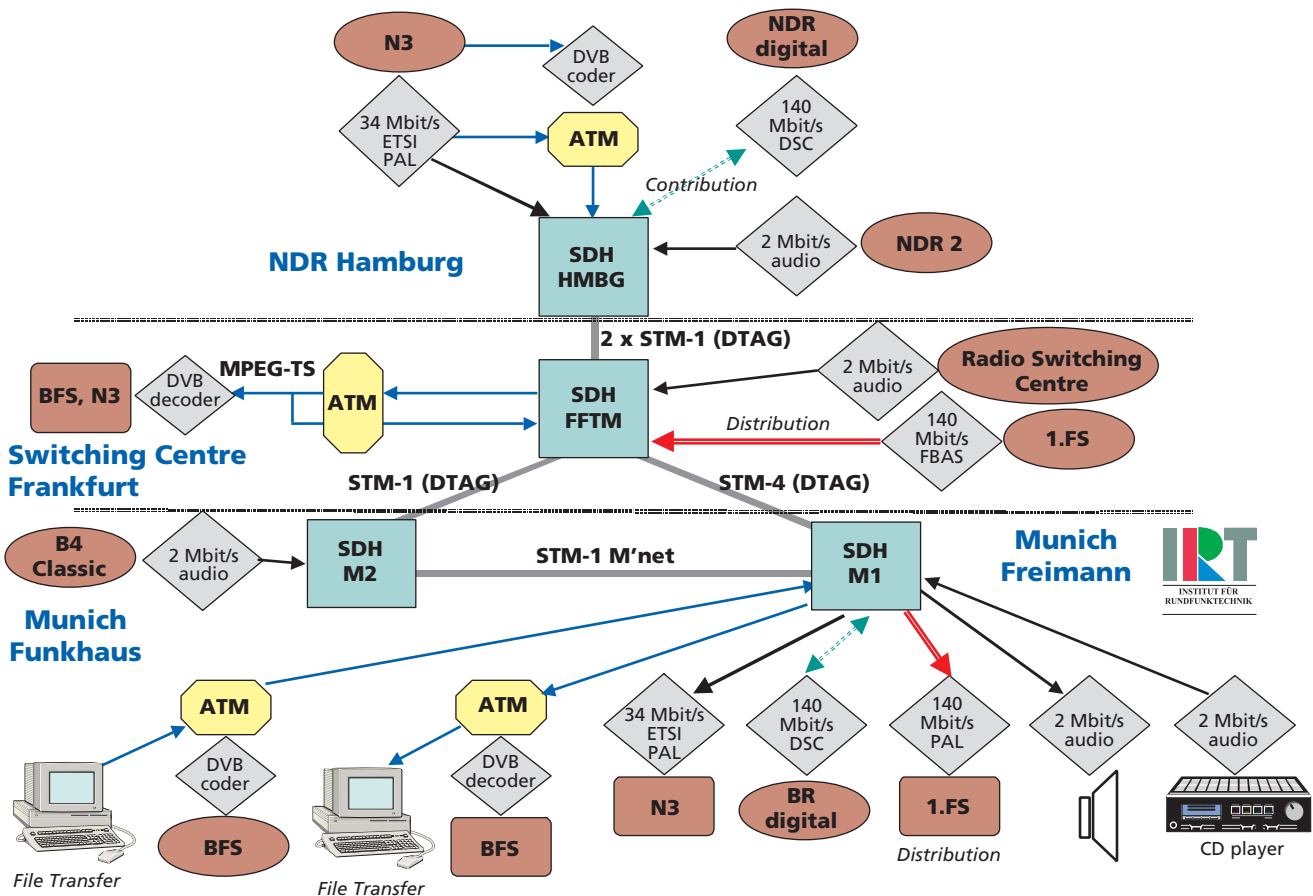


Figure 2  
HYBNET WAN test scenario for broadcasting applications.

important applications in the ARD contribution and distribution environment, with the aim of reflecting as far as possible all the operational functions to be handled day by day. Furthermore, new applications which will probably be used to an increasing extent in the coming years were also selected and implemented.

The broadcast applications which were used for those tests and mapped directly onto the SDH layer were:

- ⇒ 140 Mbit/s (PAL) TV contribution / distribution between NDR – FFM – M1;
- ⇒ 140 Mbit/s (DSC) TV contribution between NDR – M1;
- ⇒ 34 Mbit/s (ETSI-DSC, ETSI-PAL) TV contribution between NDR – FFM – M1;
- ⇒ 2 Mbit/s (J.57, AES/EBU) radio contribution between NDR – FFM – M1/M2.

Via the ATM network (based on an STM-1 connection between the test sites), synchronous distribution/contribution applications were realized between NDR – FFM and M1 – FFM together with asynchronous file transfers via M1 – FFM – M1 at the same time.

## 2.4. ATM broadcast applications

The anticipated increasing use of ATM for the transport of real-time signals as well as for high-speed file transfers was taken into account in the tests, as shown in Fig. 3. DVB-coded TV programme signals were mapped onto the ATM transport layer, via ATM adapters provided by different manufacturers (Cellware and ATEcom) with bit-rates of up to 15 Mbit/s, using the ATM adaptation layer, AAL1. The same adapters could be used to map MPEG-2 4:2:2 Profile@ML signals onto the ATM network with bit-rates of up to 55 Mbit/s.

Video servers equipped with FC disc arrays provided very demanding file transfer rates to the network at bit-rates of up to, for example, 85 Mbit/s. By using special transfer protocols provided by the company *ATMedia*, the transfer performance could be evaluated. Audio adapters allowed the mapping of AES/EBU audio signals onto ATM (not being bound to SDH access rates).

Of course, the interconnecting of local-area computer networks (LANs) is part of the new network scenarios for broadcasters. Therefore LAN emulation, as well as new MPOA standards for optimizing the traffic between computers within ATM network domains, were part of the test scenario.

A very important issue for the future operation and handling of ENG applications is the inter-operation between public ATM networks and broadcaster's ATM networks. For this reason,

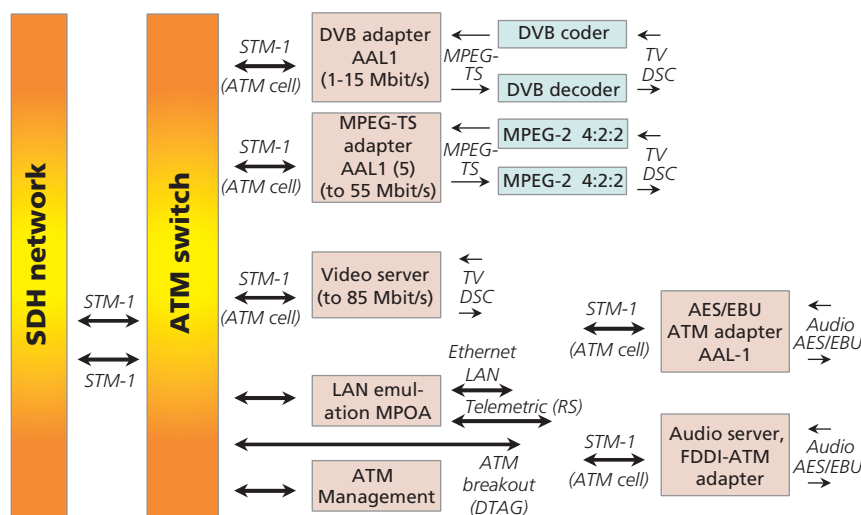


Figure 3  
HYBNET ATM test scenario for broadcasting applications.

the ATM breakout from and to the HYBNET field-trial network was also tested via a public ATM network (DTAG) including SVC-based ATM connections.

Furthermore, all the Fore ATM switches involved in the HYBNET tests could be managed via a Fore ATM management system installed at the IRT. Even the set-up and control of the ATM adapters could be performed via this management system. It should be mentioned that ATM switches from Fore as well as from Newbridge (together with a Newbridge management system) were installed during the test phase for setting up a HYBNET ATM layer.

## **2.5. Test results**

Summarizing the results from the HYBNET ATM tests, we can state that all the ATM applications were demonstrated and evaluated successfully. Even the co-existence of very demanding real-time applications together with fast file transfers on the same connection between ATM switches caused no problems in the test network. Of course if we are to use standard telecommunications network techniques, we will have to accept the network as it is. That implies that the network adapters will have to cope with pointer actions caused by the SDH network as well as with increased cell delay variation caused by the ATM transmission. The pointer actions and the wander caused by SDH can be reduced substantially by genlocking the network elements at the edge of the network to a common clock such as GPS. If the adapters are designed properly, even the demanding signal-quality requirements to be met for the contribution of audio and video signals can be realized on ATM connections based on an SDH network layer.

The transfer rate achieved for fast file transfers with the *ATMedia* protocols was limited due to the transfer rate of the FC disc array controller, rather than by the transfer capability of the network connections.

## **3. EBU/IRT ATM test**

### **3.1. Connecting HYBNET with the Eurovision network**

A test was arranged on 29/30 September 1998 to check the interworking between the ATM layer of the ARD HYBNET field-trial network and the *Eurovision* network, using ATM for the transport of MPEG 4:2:2 television signals. The test configuration is shown in *Fig. 4*. The HYBNET field-trial network provided the connection between IRT Munich and the Switching Centre (ARD Stern) in Frankfurt. The main items to be tested were:

- ⇒ the interworking of the networks involved and, particularly, of the ATM equipment connected to the satellite channels (which inevitably caused a rather high round-trip delay of about 0.5 seconds);
- ⇒ the delivery of SDI signals with signal parameters which accorded with the studio requirements, as well as the behaviour of the network/codec combination in the case of (forced) high error rates on the satellite link.

In Frankfurt, HYBNET was connected to the *Eurovision* network via an ATM switch: the test set-up included the appropriate interfaces (34 Mbit/s PDH) for the *Eurovision* up-link and down-link stations.



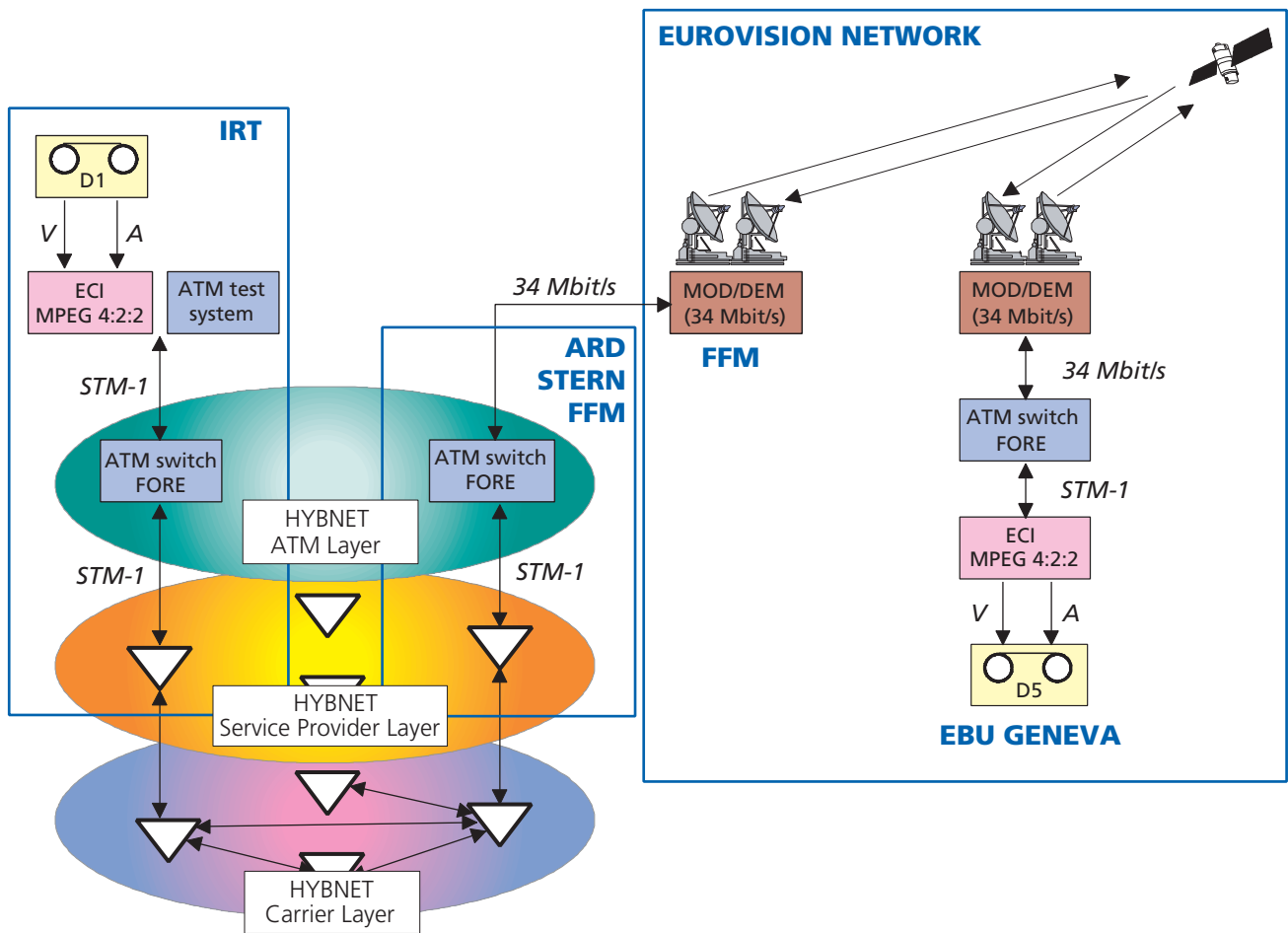


Figure 4  
EBU/IRT ATM test configuration.

### 3.2. Network configuration

The video/audio signal (SDI, AES/EBU) from a D1 studio VTR was fed to an MPEG 4:2:2 codec (HiTV from the company, ECI) which included the mapping/demapping of the MPEG-TS onto/from ATM and which delivered the ATM signal to an optical STM-1 port. During the trial, the bit-rate for the coded video signal was chosen as 18 Mbit/s while 21 Mbit/s was chosen for the MPEG Transport Stream. The STM-1 port of the codec was connected to an ATM switch (ForeRunner ASX 200 BX) which was the access switch to the ATM layer of the HYBNET field-trial network.

At ARD Stern in Frankfurt, the signal left the ATM layer of HYBNET via another ATM switch (ForeRunner ASX 200 BX, equipped with 34 Mbit/s ATM ports). The 34 Mbit/s signal was then fed into the *Eurovision* network using an up-link in Frankfurt. At the EBU operations centre in Geneva, the demodulated 34 Mbit/s satellite signal was sent to an ATM switch (also a ForeRunner ASX 200 BX with 34 Mbit/s ports) where it was routed to an STM-1 port connected to the second MPEG 4:2:2 codec (ECI HiTV). The routing was remote-controlled from the IRT using a Fore ATM management system.

A return link (34 Mbit/s) was established between Geneva and Frankfurt for the exchange of control information within the ATM network and for a possible bi-directional video/audio transmission. Using other ports of the ATM switches in Munich and Geneva, the capacity not



used by the MPEG-TS transmission on the satellite link could be used for other data transfers including file transfers etc. but, due to the limited availability of the transponder time, these tests had to be dropped. The decoded video/audio signal (SDI, AES/EBU) was recorded on a D5 VTR for further examination and to check for possible sync problems with the restored video and audio signals.

### **3.3. Test results**

The ATM connections (local and remote) were set up via the Fore ATM management system without any problems. Even rather high round-trip delays of about 0.5 seconds (due to the satellite connections) had no impact on the management of the ATM connections routed between the IRT and EBU Geneva via the HYBNET network layers. An ATM loop test, with the use of an ATM generator/analyser at the IRT and a 34 Mbit/s loop at EBU Geneva, showed an error-free transmission of the ATM cells between IRT – Geneva – IRT across all the networks and network layers involved, under normal operating conditions of the satellite link.

The ECI codecs attached to the Fore ATM switches worked perfectly. No visible or audible effects were noticed on the decoded video and audio signals. The recording of the decoder output signal on the D5 studio VTR was perfect, and no problems were encountered with the synchronization of the recorder to the decoded SDI signal.

A test was carried out where the power on the Frankfurt up-link was reduced in order to increase the bit error rate in the demodulated 34 Mbit/s signal received in Geneva. By decreasing the power, step by step, the occurrence of visible or audible errors in the decoded signal was monitored. At levels down to 2.4 dB above the failure point of the demodulator, no visible or audible effects were detected in the picture or sound respectively. Below this level, the ECI decoder stopped decoding the video and audio. This behaviour of the codec was chosen intentionally by counting the errored ATM cells and stopping the decoding process at a certain error level. If such a behaviour had not been wanted, this feature of the decoding at high bit error rates could have been switched off.

## **4. IRT demonstration at Systems 98**

At the Systems 98 national computer exhibition in Munich, the IRT demonstrated – in the context of “systems networking” – various broadcast applications on a real WAN (622 Mbit/s) installed between the IRT and the exhibition area, including local networks within the IRT and at the exhibition area. The network configuration, together with the demonstrated applications, is shown in *Fig. 5*.

### **4.1. Broadcast applications**

The demonstration was based on the live transmission of studio-quality video/audio signals, the distribution of an MPEG-coded TV programme as well as the distribution of a radio programme via ATM. In addition, a high-speed file transfer (the content of three CDs, i.e. 2.8 GB) took place within about three minutes over the WAN and through the IRT network back to the exhibition area. Also demonstrated was the exchange of audio programme material between two servers (using the Digas software) via the same ATM connections to the IRT and back to the exhibition.



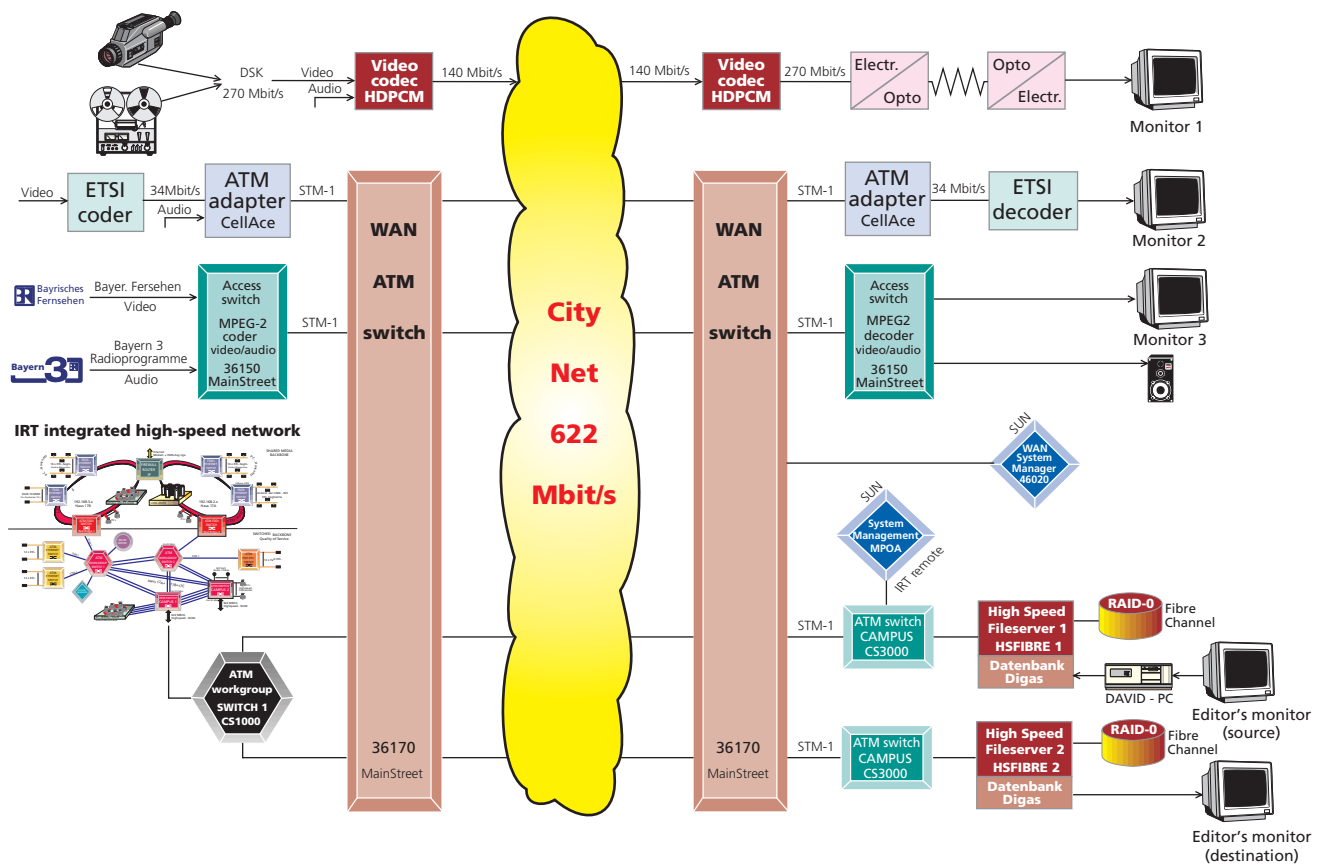


Figure 5 IRT network configuration demonstrated at Systems 98.

The common management of this WAN, and other networks such as an Intranet and the Citynet structures, was demonstrated – in co-operation with the partner company Huber & Feneberg (involved in the planning, implementing, managing and maintenance of local-area and wide-area networks and network components) – using advanced management systems for the installation and administration of connections across all the networks involved. The broadcast applications shown were:

- ⇒ real-time transmission from the IRT, to the exhibition area, of digital video signals (source: 270 Mbit/s DSC) after bit-rate reduction to 140 Mbit/s (SDH access rate) with a Hybrid Differential PCM (HDPCM) codec designed by the IRT;
- ⇒ real-time distribution from the IRT, to the exhibition area, of the BR TV programme via 34 Mbit/s on ATM;
- ⇒ distribution from the IRT, to the exhibition area, of the BR television programme via DVB on ATM at 14 Mbit/s;
- ⇒ distribution from the IRT, to the exhibition area, of a BR radio programme via ATM;
- ⇒ high-speed data transfer from the exhibition area via the WAN and IRT LAN back to the exhibition area and onto the second server, via ATM using the ATMedia ATP protocol with direct access to the signalled ATM network connection (UNI 3.1);
- ⇒ automatic update of a database with audio programme material via ATM (DigaReplicator from David) and the same connection mentioned above;
- ⇒ remote management of a Multi Protocol over ATM (MPOA) domain via the WAN;



- ⇒ transmission of 270 Mbit/s DSC signals via fibre-optic adapters designed by the IRT.

### **4.2. Network infrastructure**

The following network components were used in order to set up the WAN together with connections to the LANs.

- ⇒ Seimens SDH add/drop multiplexers (ADMs) with crossconnect function for the 622 Mbit/s SDH layer and two separate fibre connections on different routes through Munich in order to enable emergency protection of the backbone connection. Also, various optical STM-1 interfaces and a 140 Mbit/s PDH access interface installed in the ADM.
- ⇒ Newbridge WAN ATM switches (MainStreet Xpress 36170) for mapping all the ATM-based broadcast applications onto the SDH backbone.
- ⇒ Newbridge access ATM switches (MainStreet Xpress 36150) equipped with an MPEG-2 4:2:2 codec for the bi-directional exchange of video/audio signals with contribution quality. This access switch could be managed via the common WAN ATM manager from Newbridge.
- ⇒ A 140 Mbit/s HDPCM codec (IRT) for the direct mapping of studio TV signals onto SDH.
- ⇒ A 34 Mbit/s ETSI-compliant codec (RE).
- ⇒ ATM 34 Mbit/s adapters (Cellware);
- ⇒ Two Windows NT file servers with FC disc arrays.
- ⇒ A Sun-based ATM LAN management system (Newbridge).
- ⇒ A Sun-based ATM WAN management system (Newbridge).

### **4.3. Message to the visitors**

As far as the use of new network techniques for broadcasting applications are concerned, the important message to visitors at Systems 98 can be summarized as follows.

In the long term we should avoid specially-designed and aligned transmission networks for broadcast applications, as these may be too expensive. Instead, we should rely on standard telecommunications technologies including SDH and ATM. One difficulty here is that the various bit-rates used in the broadcasting environment are not covered by the access rates into SDH hierarchies. However, ATM offers the necessary flexibility for the transport of our signals economically and is necessary and important for future broadcast networks.

Future broadcast networks should provide optimal functionality for the real-time transport of broadcast signals and for increasingly-used file transfers with possibly very high transfer rates. These file transfers must not interfere with real-time applications. Therefore one important demonstration at the exhibition was the coexistence of real-time and file transfers on the same network links.

SDH and ATM networks are standardized world-wide and the equipment is offered by a range of different manufacturers. These standardized technique will be available and used for a long time to come. Hence, short-term changes to network techniques, in order to follow changing applications with short life cycles, should not be necessary.



And last but not least, the standardized MPOA technique provides tools for the optimized operation of complex and seamless integrated LANs and WANs for broadcasting applications.

### **4.4. Experience gained**

This demonstration proved that the network shown in *Fig. 5* could be installed in a very short time (plug-and-play). Operation of the network, assisted by advanced network management tools, allowed the flexibility to cope with all the broadcasting applications demonstrated. The video and audio transmissions were error-free for the full duration of the exhibition. Even after a (not intended) failure of the total power supply to the installation, the complete network together with all the applications recovered after about four minutes without any problems and without any operator intervention.

## **5. Network developments in Europe**

From the inputs provided by EBU member organizations and from discussions within the EBU NDC project groups N/Services and N/Telecom, it is evident that the digitalization of broadcasters' networks is under way in many EBU member countries.

Parts of these networks, or even full contribution and distribution networks (including primary distribution to transmitters), are already fully digital using SDH connections: the main applications running on these networks are 140 Mbit/s PAL or SDI for contribution, as well as 140 Mbit/s and 34 Mbit/s PAL for distribution. MPEG-2 Transport Streams are distributed either directly via DVB channels (e.g. for satellite distribution to cable head-ends and for DTH services), or by using ATM over terrestrial networks based on SDH or using the Asynchronous Serial Interface standard on dark fibre connections. These dark fibre connections are used for feeding terrestrial DVB-T transmitters including single-frequency networks.

ATM will be used in the future to an increasing extent, due to the possibilities offered by it for the flexible use of network capacity with a variety of network-access bit-rates which are not covered by SDH. Furthermore, real-time streaming as well as file transfers are possible over ATM. Tests have been carried out in order to prove that all the functional and quality requirements of broadcasters can be fulfilled with ATM – for both real-time and non-real-time applications.

Today, television distribution/contribution services are being offered, using ATM wide-area network techniques in the core network. Furthermore, there is agreement that ATM will be the chosen technique for integrated broadband services provided over wide-area networks. ATM networks are being set up on a national basis in many countries, with growing capacity and coverage. However the international gateways between these national ATM networks seem not to be adequately developed at the moment.

## **6. Interworking issues**

The interworking of equipment and applications is an issue to be considered at several layers in the full network/application scenario. As far as the SDH layer (as a basic network transport mechanism for carrying ATM signals) is concerned, there is no interworking problem because there is world-wide standardization in this area. Interworking problems may be encountered



if management systems from different manufacturers are used for controlling the connections in the SDH network.

In the past, the interworking of ATM equipment from different manufacturers was known to be difficult because proprietary solutions were on the market for the signalling and management of ATM connections between switches in an ATM network. More recently, standardization in the telecommunications world (via the ATM Forum as well as in the ITU) has brought about some progress here. The signalling, for example to set up ATM connections, is now a standardized procedure which can work across the boundaries between local-area and wide-area ATM networks, if the standardized procedures are enabled and the proprietary protocols are disabled in the switches involved.

Standards such as AAL-1 and AAL-5 are available for the mapping of application signals into an ATM cell stream. If all elements of these standards are implemented and used in the respective ATM adapters, and no proprietary functions are added to the AAL-5, then interworking is assured.

As far as codecs for video and audio connections are concerned, there is the world-wide MPEG-2 standard. If coding and decoding equipment that is compliant with the MPEG Transport Stream is used, there should be no interworking problem at all. Again, the management functions implemented for the operation of the codecs from different manufacturers may not be compatible but, as the decoder normally follows the settings in the encoder, basic interworking should be ensured. Tests at the IRT have shown that interoperability between MPEG coders and decoders from different manufacturers can be achieved, even if connected via ATM adapters and ATM networks.

## 7. Conclusions

Summarizing the results from all the tests carried out by the IRT, we can state that the ATM technique as available today is adequate to fulfil practically all the functional requirements of a wide range of broadcasting applications. Economies can be achieved by choosing the trans-

### Abbreviations

<b>AAL</b>	ATM adaptation layer	<b>MPEG-TS</b>	MPEG transport stream
<b>ATM</b>	Asynchronous transfer mode	<b>NIC</b>	Network interface card
<b>DSC</b>	Digital serial components	<b>NMS</b>	Network management system
<b>DTH</b>	Direct-to-home	<b>PCR</b>	Programme clock reference
<b>DVB</b>	Digital Video broadcasting	<b>PDH</b>	Plesiochronous digital hierarchy
<b>ENG</b>	Electronic news gathering	<b>SDH</b>	Synchronous digital hierarchy
<b>ETSI</b>	European Telecommunications Standards Institute	<b>SDI</b>	Serial digital interface
<b>FC</b>	Fibre Channel	<b>SDTI</b>	Serial data transport interface
<b>FDDI</b>	Fibre-distributed digital interface	<b>STM</b>	Synchronous transport module
<b>GPS</b>	Global positioning system	<b>SVC</b>	Switched virtual connection
<b>LAN</b>	Local-area network	<b>WAN</b>	Wide-area network
<b>MPEG</b>	Moving Pictures Experts Group	<b>WDM</b>	Wavelength division multiplex

mission bit-rate over each connection, according to the application and the desired Quality of Service.

Dedicated management systems enable the easy administration and maintenance of ATM networks, from either central or distributed operational facilities.

Numerous tests carried out by the IRT on the signal quality during real-time transmission prove that even very high demanding studio contribution applications can be established and operated via ATM networks – provided that the network adapters (whether external or included in the codecs or interfaces for the video and audio signals) are designed to meet all quality requirements. If we have experienced problems (in just a few experiments only), this was due to exceeding certain limits, such as the phase drift in video signals or the PCR jitter of MPEG Transport Streams: careful analysis of the problem and subsequent discussions with the equipment provider have led to speedy improvements in the equipment involved.

As the interoperability of ATM switches and adapters is an essential requirement of complex network configurations which connect broadcasting stations nation-wide or perhaps internationally, testing should be continued to ensure that easy interoperability can be achieved across all makes and versions of the equipment in use, both now and in the future. First trials have shown that interoperability can be achieved with an increasing number of equipment from different vendors if the proprietary control protocols are switched off and standardized procedures are enabled.

ATM is a good choice for providing future enhancements to digital broadcasting networks, for the following reasons:

- ⇒ raising the speed of interface cards (at the moment up to 2.4 Gbit/s);
- ⇒ the falling costs of the equipment;
- ⇒ a complete set of management tools is available;
- ⇒ the advantages of seamless interconnection of LANs and WANs in combination with switched virtual connections (dial-up facilities).

The increasing use of WDM-based optical networks will increase the flexibility of ATM-based networks even further, if very high bit-rates are needed (i) for aggregate real-time transmission of several high-quality video signals in distributed production scenarios and/or (ii) for very high transmission speeds for file transfers between production environments.



**Herbert Hofmann** obtained a Dipl. Ing. in communications engineering at the Technical University in Munich. He then joined the Institut für Rundfunktechnik (IRT) in 1969 where he worked in the field of holography and optical communication. He was involved in bit-rate reduction techniques, in the introduction of a teletext service in Germany and in the digital processing and transmission of TV and HDTV signals. In 1986, he became head of the "Picture Processing and Transmission" section and, later, head of the "TV Systems and Psycho-optic" section of the IRT.

Mr Hofmann is a member of several national and international working groups and has led various working groups in European projects concerned with digital television. Since May 1996, he has been head of the new IRT department "Digital Networks" whose work is dedicated to the evaluation of different network techniques (SDH, ATM, VLANs, FC etc.) for carrying audio and TV applications over both campus networks and wide-area networks.

Herbert Hofmann is currently Chairman of the EBU/INDC project groups N/Services and N/MT.