TEN-IBC B3012

Radiological Examination Transfer on ATM Integrated Networks

RETAIN

Deliverable D6:

Analysis of the Trials User and CIG Point of View

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(P01) Université de Rennes 1 / CERIUM
(P02) OFFIS, Oldenburg
(P03) Hospital Vall d'Hebron, Barcelona
(P04) CCG, Coimbra
(P05) RLHK, Düsseldorf
(P06) AP/HP Lariboisière Hospital, Paris

THOMSON Broadcast Systems (P07)
Ouest Standard Telematique (P08)
SYSECA (P09)
PHILIPS Systemas Medicos (P10)
GE Medical Systems (Sponsor)

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1 INTRODUCTION

In the recent years a "paradigm change" in the industrial societies away from the orientation on means of production towards an orientation on information is increasingly visible. The permanent availability of relevant information becomes more and more a central factor for economic success. The technical counterpart of this discussion about an "information society" is the development of fibre optics based high-speed network technology since mid of the 1980s. These "information superhighways" will form the backbone for a quick and blanket-coverage distribution of information in the next decade. The European Union has initiated the TEN-IBC initiative ("Trans European Networks - Integrated Broadband Communications") in order to evaluate the technical, economical and legal framework for the establishment of such information superhighways in Europe. TEN-IBC is a series of currently nine research projects in different market sectors, for example journalism, applications in supercomputing, fashion design, CAD/CAM, multimedia marketing and health care applications.

1.1 RETAIN

The RETAIN project ("Radiological Examination Transfer on ATM Integrated Networks") as one of two health care related TEN-IBC projects deals with applications of high-speed wide area networks in telemedicine / teleradiology. Like all TEN-IBC projects, it is structured into phases. The first phase in 1994 performed an analysis of user requirements and available technology and defined a medical teleworking service based on the results of this analysis. The second project phase in 1995 performed trials with the proposed services in a very limited setting (three clinical sites), validating the feasibility of the approach. In the third project phase in 1996 intensified trials with a second system generation have been performed, involving clinical users (radiologists, neurologists and neuro-radiologists) from six hospitals in four European countries:

- Department of Radiology, CHRU Pontchaillou, Rennes (F)
- Department of Neuro-Radiology, Université de Paris VII, AP/HP Lariboisière (F)
- Department of Radiology, Städtische Kliniken Oldenburg (D)
- Department of Neurology, Rheinische Landes- und Hochschulklinik, Düsseldorf (D)
- Department of Radiology, Hospital Universitari Materno-Infantil Vall d'Hebron, Barcelona (E)
- Department of Medical Imaging, Hospitais da Universidade de Coimbra (P)

Figure 1-1 shows the locations of the participating hospitals as well as the network connections between them (black: ATM high-speed lines, grey: ISDN).

Figure 1-1: The RETAIN Conference Network

The “application scenario” of the RETAIN project is the consultation of remote specialists for difficult and emergency cases. The tele-conference system developed for this purpose allows the physicians

- to use visual telephony services
- to discuss and diagnose on digital medical images with computer support
- to include analogue image sources (films, ultrasound video or a patient camera) in the discussion.

1.2 Rationale for the RETAIN Application Scenario

Figure 1-2 illustrates a typical workflow of radiological diagnostic services and their embedding into clinical medical procedures. It should be noted that the figure is a simplification – in urgent cases procedures might be performed in a different order or totally left out. In the vast majority of cases, however, the procedure will be as depicted in the left column of the figure, top to bottom.

The clinician (i.e. neurosurgeon) is the physician who is responsible for the patient and, in turn, the treatment or referral to a different hospital. He requests a radiological study (i.e. MRI brain scan) which is created and evaluated by the radiology department. In regular cases he will just receive the images and a written report from the radiology department. In difficult cases, however, a case conference involving the clinician, radiologist and more physicians who have performed different studies (e.g. a pathological tissue analysis) is performed where the case is discussed and the further procedure is planned.

In difficult cases either the radiologist reading the images or the case conference may decide to request a second opinion from a remote specialist. In a conventional procedure one or two films are sent (e.g. with express service or taxi) to a specialist, who reads them and gives his advice. This may, depending on the situation, take a few hours or a week. Using telecommunications technology in this case saves the transport costs and time and allows both sites instant access to the available information in full quality. Images on film cannot be copied without loss of information so that only digital transmission can be considered as lossless.

Should the case conference decide that the patient cannot be treated adequately, the patient is usually sent (e.g. with helicopter in emergency cases) to a more specialised hospital, typically a university hospital. The specialist at the remote centre decides if he can treat the patient more appropriately than the local hospital. If not, he usually sends the patient back. The use of telemedical consultation allows to present the case in advance to the remote expert centre, avoiding expensive and unnecessary transports as well as duplicate studies which today happen frequently when not all information from the referring hospital is sent together with the patient. On the whole, the two dashed boxes in Figure 1-2 show the areas where the introduction of telemedical consultation is expected to have most effects on the processes involved.

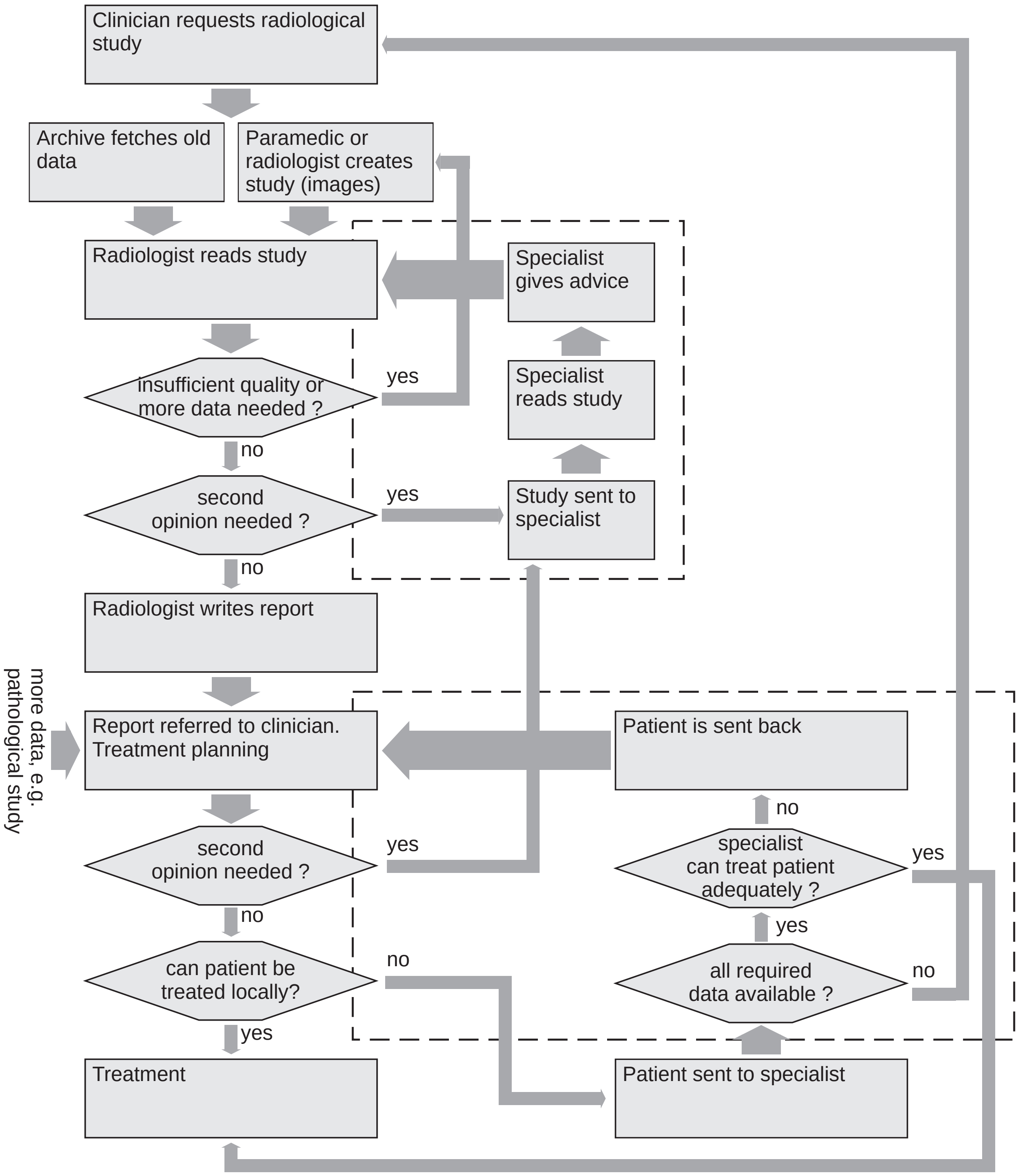


Figure 1-2: Typical Radiological Workflow

1.3 Expected Medical Benefits from Telemedical Consultation

The existing literature on telemedicine claims certain *medical* benefits of telemedical consultations. Although most benefits mentioned here will have economic effects at least on a macro-economic level, it would hardly be possible to quantify them unless a broad introduction and use of telemedicine services over years takes place, allowing for statistical evaluation. In addition to these medical benefits, many *financial* benefits are often claimed as well. These will be addressed in the financial analysis in section 7.2. Areas of telemedicine beyond the “scenario” of RETAIN are deliberately disregarded, for instance the whole sector of primary care support systems (e.g. public information databases or tele-monitoring systems).

1.3.1 Improvement of Patient Care

- Improved health care delivery for "deprived" areas (e.g. rural areas) by the possibility to request remote expert advice.
- State of the art therapy planning by access to up-to-date information. This is of prime importance in medical areas where the knowledge changes rather quickly (e.g. Oncology).
- Quicker treatment in emergency situations by an acceleration of diagnostic procedures (e.g. less time to wait for confirmation of a diagnosis).
- Reduction of physical and psychological burdens on the patient (e.g. treatment close to the patient's home; less radiation by avoidance of unnecessary examinations).

1.3.2 Improvement of Diagnostic and Therapy Procedures

- Decisions on diagnosis, therapy and patient referral can be accelerated and safeguarded by access to remote expert advice.
- Advance coordination of patient referral allows to avoid unnecessary transports and to optimise resource allocation.
- Decreased patient stay times by "just in time" diagnosis.
- Better utilisation of resources (e.g. expensive, seldomly used equipment) by the possibility to "outsource" or centralise such examinations by means of telemedicine.
- Improved patient compliance by integrating the patient into expert consultations.

1.3.3 Improvement of Emergency Services

- Accelerated access to specialist advice and patient information decreases mortality rate in emergency cases.

1.3.4 Improvement of Skills, Competencies and Know-how

- Frequent telemedical consultations improve physicians' know-how by the diffusion of expert knowledge ("continued medical education", CME), resulting in more accurate diagnoses.
- More accurate care management and care administration as a result of efficiency gains in skills and competencies.
- Telemedicine facilitates the creation of teaching case databases and the acquisition of "interesting" (difficult) cases by research centres (e.g. university hospitals).
- Telemedical consultation equipment can easily be used to arrange regional training sessions (e.g. over multipoint video conference facilities).
- Changes in clinician "information seeking" behaviour (e.g. improving "evidence-based" clinician practices).

Finally, there is also a human aspect for the physician using the technology: Telemedicine improves the possibilities for communication in the medical community. Physicians can more easily share experiences, knowledge and techniques in a gratifying way.

2 TECHNICAL ANALYSIS OF THE RETAIN TRIALS

During the second RETAIN project phase in 1995, a technical evaluation has been performed as well, so the question arises which additional results this document can describe in comparison to [Ret2-9]. However, there are some significant differences between the project phases resulting in this new evaluation:

- The RETAIN 2 trial phase was quite limited in time and number of participants, so that statistical results from the trials were of limited value as well. Given the by far larger number of trials performed during this project phase, we are able to back some results from [Ret2-9] with more credible data and, in general, put more emphasis on statistical results (e.g. section 3.1).

- A new system generation was developed under consideration of the physicians' assessments from [Ret2-9] and resulted in improved system performance and functionality (e.g. multi-point conferencing)
- The use of advanced network services (ATM multicast and asymmetric VPs) resulted in a new view on available network products and services.

Differences between this document and [Ret2-9] as well as common ground are discussed in more detail in each section where appropriate.

2.1 Technical Data of the Project

The technical data of the RETAIN conference system and the local networking infrastructure at the participating hospitals are discussed in more detail in [Ret3-2], [Ret3-3] and [Ret3-4]. However, the overview given below should be sufficient to understand the discussion on technical aspects in this chapter.

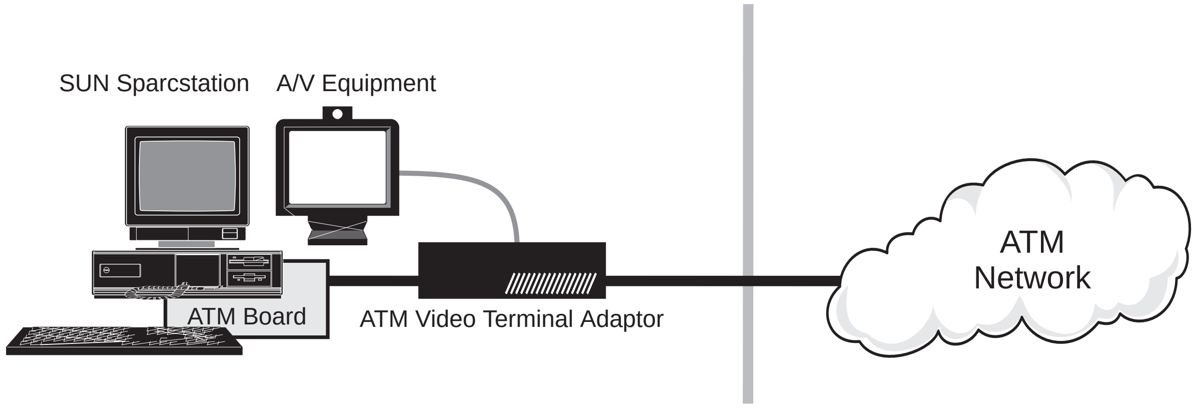


Figure 2-1: RETAIN Conference System

Figure 2-1 shows the concept of the RETAIN conference system. It consists mainly of two components: A workstation which is used to transmit, review and discuss digital medical images and an ATM video terminal adaptor (video codec) which transmits real-time audio and video in high quality over an ATM network. The video terminal adaptor serves as a simple ATM switch: bandwidth available on the wide area network (e.g. on the reserved ATM virtual path) is available to a “secondary device” which is connected to the terminal adaptor via a standard ATM interface (155 MBit/s multimode fibre, SDH/STM-1). On the wide area network, the terminal adaptor is connected directly to the network termination without any switch inbetween. The terminal adaptor can be equipped with 34 MBit/s electrical (G.703) and 155 MBit/s optical (multimode and monomode) interfaces.

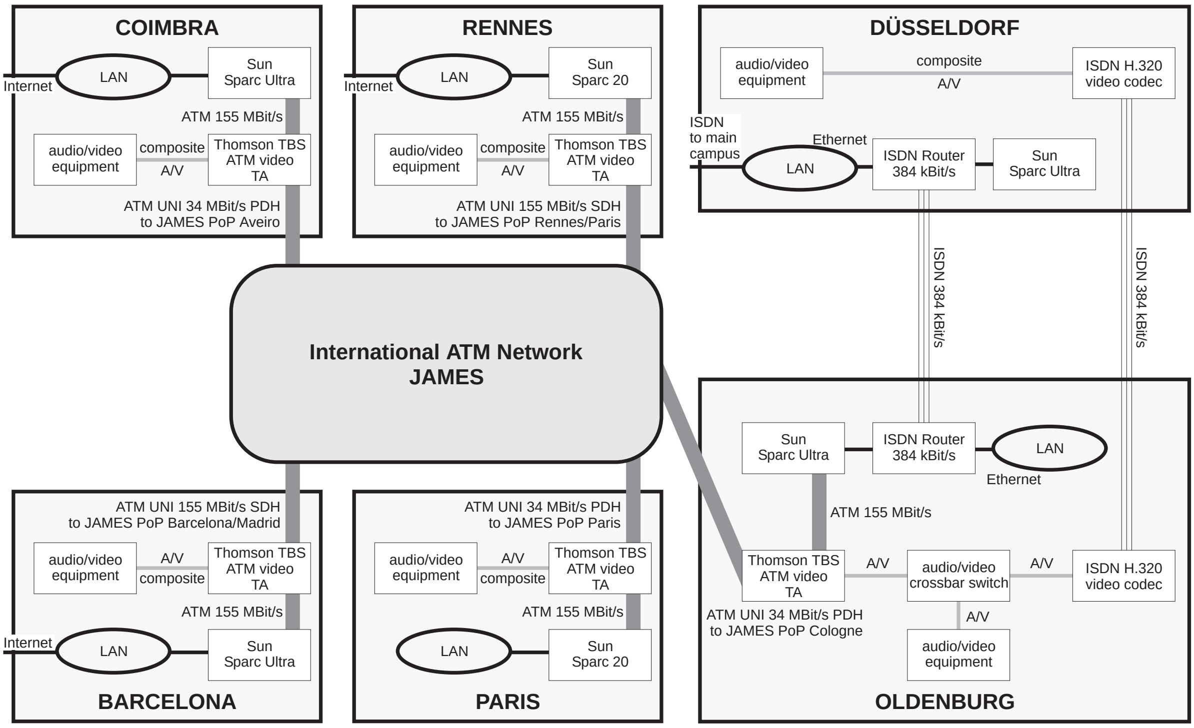


Figure 2-2: Structure of the RETAIN Conference Network

Figure 2-2 shows the equipment and network connections used in the different sites of the RETAIN conference network. Most sites used the system exactly as described in Figure 2-1. In addition, the RETAIN workstation was connected to the local hospital network (LAN or PACS network) where available. In this way, digital medical images could be uploaded to the RETAIN workstation using the DICOM Storage Service which is supported by most commercial medical image archives and workstations. Two hospitals (Düsseldorf and Coimbra) used film scanners to digitise images available on film only. The scans were converted into DICOM ("secondary capture images") and then uploaded to the RETAIN workstation. ATM network connections were switched over the JAMES network ("Joint ATM Experiment on European Services"), an experimental European ATM network connecting 18 European public network operators.

The RETAIN sites Düsseldorf and Oldenburg were in a special position. Düsseldorf was not connected to the JAMES ATM network and used a standard ISDN video codec (PictureTel 4000 system) and an ISDN router (6 multiplexed ISDN B-channels with an aggregated bandwidth of 384 kBit/s) to connect to Oldenburg. For connections between Düsseldorf and a site connected to the ATM network, Oldenburg served as a "dial-in point" for Düsseldorf, routing the data traffic from ISDN to ATM and converting the audio/video signals. For this purpose the ATM and ISDN video codecs were connected on the analogue interfaces (composite video, line audio). A digital time base corrector restored the proper video signal timing required by the ATM video codec.

Application	Name	Description
1	Visual telephony	ATM based visual telephony and image transmission
2	Multipoint visual telephony	ATM based multipoint visual telephony and image transmission
3	CSCW application	Transmission and cooperative (CSCW) review of digital medical images
4	Narrowband access point	Access to the visual telephony and CSCW application from ISDN.
5	Multimedia messaging	Creation, offline transmission and review of medical multimedia documents containing medical images, voice, text and graphical annotation.

Figure 2-3: RETAIN Applications

In technical terms, the RETAIN conference system can be described as five applications with separate technical data (e.g. bandwidth requirements). Figure 2-3 defines these applications.

2.1.1 Visual telephony

The ATM video terminal adaptor uses the ETSI compression algorithm ETS 300-174 [ETSI 92], an algorithm for the digital transmission of TV signals at 34 MBit/s. The terminal adaptor supports video bandwidths ranging from 6 to 34 MBit/s. The ETSI algorithm is similar to MPEG II, providing an equivalent image quality at a slightly increased bandwidth and a better real-time behaviour (no bi-directional motion estimation). The final product of the terminal adaptor (which is a prototype only) is expected to support both ETSI and MPEG II. Audio is transmitted as uncompressed PCM audio at 44,100 or 48,000 samples/second (CD/DAT audio quality). The video quality at 6 MBit/s ETSI is very similar to consumer TV quality (e.g. cable TV or satellite TV).
On the ATM interface, the codec uses ATM Adaption Layer 1 (AAL1) which adds a certain overhead to the audio/video data, resulting in a required bandwidth of about 8.5 MBit/s (at the video rate of 6 MBit/s, which was used throughout the project).
The latency of the audio-video transmission is less than 0.5 seconds (including the ATM wide area network latency), providing a high-quality video conference facility. Audio and video signal latencies are synchronised. The codec behaves quite well on unstable ATM connections – a certain cell loss causes the image to become a bit noisy, with increasing cell loss causing a decrease in image quality. After a breakdown and re-establishment of the connection, the codecs synchronise again within about two seconds.

2.1.2 Multipoint visual telephony

Two “advanced” features of the ATM network protocol make it especially suitable for multi-point connections:

- **Unidirectional VPs:** ATM is a connection oriented protocol and connections are always established in “virtual paths” (VPs) which are switched through all ATM exchanges (switches) on the way between the terminal equipment on both sides. For each VP, separate “quality of service” parameters (e.g. bandwidth and cell loss ratio) can be defined. VPs are always uni-directional so that it is possible to establish unsymmetrical connections.
- **Multicast VPs:** ATM also supports multicast VPs which have one sender, but more than one recipient. The network itself is responsible for duplicating ATM cells where appropriate.

In RETAIN, these two features were used for “multipoint visual telephony” trials, in which all participants multi-casted either their audio signal or both audio and video to all other participants. In addition, a bi-directional TCP/IP connection to a “master site” was established for the CSCW application (see section 2.1.3). The RETAIN software automatically re-configured the video codec to "listen" on a different VP each time the "session floor" was passed to a different participant [Syse 96]. On the JAMES network, the ATM multicast service was provided by the France Télécom JAMES node in Paris–Bagnolet.

In technical terms this application is very similar to simple ATM visual telephony, except that the bandwidth requirements are significantly higher. For instance, with four participants every partner would receive 3 x 8.5 MBit/s = 25.5 MBit/s only for the audio/video signal. Although technically viable as lab experiments have shown, none of the multipoint trials performed in RETAIN was successful, as section 2.3.3 explains.

2.1.3 CSCW application

Core of the RETAIN conference system is the software for cooperative review and discussion on digital medical images. This application, developed in the project under consideration of the ratings the physicians gave to the performance of the first system generation in [Ret2-9], runs on Sun workstations. It allows to import medical images from different network sources using the DICOM [NEMA 94] standard for image transmission. Images can be collected into "digital patient folders" containing images of different modalities and textual descriptions. Such patient folders can then be fully or partly transmitted to a conference partner. As soon as the data has arrived, the images can be reviewed cooperatively. Whenever one user performs an operation (e.g. selecting an image, pointing or drawing on the image), the results of the operation are displayed synchronously on both sides.

Most commercial "computer supported cooperative work" (CSCW) applications implement this behaviour by a "screen sharing" approach. In this approach only one copy of the application is running on a "master system", and all output of the program (draw commands sent to the graphical user interface) is distributed to all conference partners. All actions performed by the users (keys pressed, mouse actions) are queued into the single "event queue" of this application. This approach is unusable for medical applications because of the "window level and width" operation, which is used quite frequently. Medical images usually contain more than 256 shades of grey, typically 12–16 bits/pixel (4096 to 65536 shades of grey). This is more than the human eye is able to perceive at once, but nevertheless contains significant information. All software for review of medical images allows to select a certain range of the available shades of grey to be displayed with the full grey range supported by the display. This allows to enhance contrast for certain types of tissue, e.g. bone or soft tissue. This operation requires a re-computation (linear transformation) of the displayed bitmapped image from the original data set for each change of the parameters. Using a screen sharing approach, every change of the window level or width would result in the re-transmission of 0.25 to 1 MByte image data. Even with a broadband network this is very inefficient: It usually takes a while until a physician is satisfied with the window settings and most of them prefer to change the window level and width interactively step-by-step. Therefore, this function must be very fast, and this can only be achieved locally. Commercial workstations often even provide special hard- or software support to speed up this central function for image review.

Therefore, the RETAIN software takes a different approach. A copy of the application is running at every conference participant. Images are transmitted in advance of the discussion in full definition (e.g. 16 bits/pixel) using DICOM. The applications synchronise explicitly over a protocol based on ToolTalk (a part of the "common desktop environment" (CDE) offered by many manufacturers of Unix systems). ToolTalk uses RPC over TCP/IP.

2.1.4 Narrowband access point

As described above, Oldenburg served as an "ISDN access point" for the hospital in Düsseldorf during consultations between Düsseldorf and a partner on the ATM network. The ISDN video codec (PictureTel 4000 system) used 6 ISDN B-channels in parallel, supporting both the standard ITU-T H.320 protocol for visual telephony over ISDN [ITU 93] and the proprietary SG4 protocol. The ISDN router used 6 more ISDN B-channels with TCP/IP over X.25 and offered a throughput of 38 kByte/s at the TCP layer. The typical transmission time for CT/MR was 14 seconds/image.

In the beginning of the project it was also discussed if a combined use of ISDN and SMDS services would be appropriate for a “narrow band access point”. SMDS (“switched multi-megabit data service”) is a connectionless datagram service offering bandwidths from 64 kBit/s to 34 MBit/s and is commercially available in many countries. Figure 2-4 displays the concept for a combined ISDN/SMDS dial-in point.

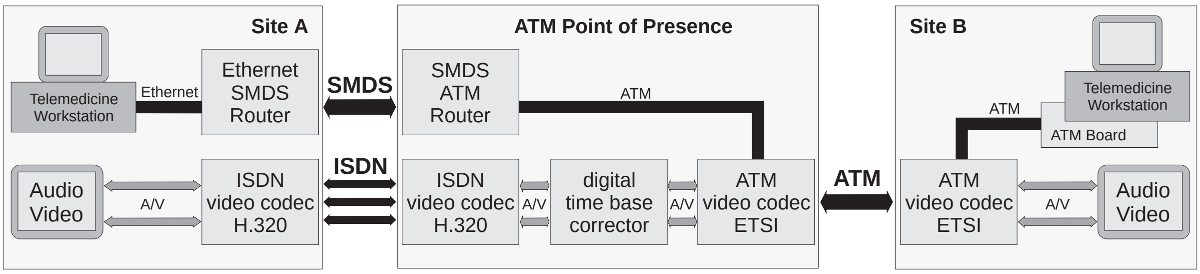


Figure 2-4: ISDN/SMDS access point

Since SMDS is a connectionless service, it is not suitable for real-time transmission so that audio/video would still be transmitted over ISDN. However, it is a quick and relatively inexpensive way of transmitting large volume of data (e.g. medical images). The idea was finally abandoned because it was too expensive and too complex for only few months of trial time, but combining different transmission technologies still seems to be a promising approach for narrowband access to ATM networks.

2.1.5 Multimedia messaging

The Multimedia messaging application allows to create presentations from patient folders in the RETAIN software. It is possible to record speech in parallel to operations on the images (selecting – pointing – drawing) and to transmit and play back such an animated presentation at a different site. This allows physicians to handle cases “offline” or to prepare for an online consultation by reviewing the presentation recorded by the sender of the request.
Unfortunately the integration of the multimedia messaging application into the main software system was not finished during the trial phase so that no clinical cases were handled with this application. Therefore, the discussion in section 4.3 is not based on practical experience of the users.

2.2 Technical Problems

At first sight it does not seem to be a good idea to begin a project evaluation with a detailed description of the problems occurred during the trial period. However, many of these problems relate to unsolved technical or organisational questions related to IBC hardware and networks, or “traps” other implementors of telemedicine systems might as well run into. Therefore, in this section we try to describe problems which might occur to others as well and to draw lessons from them.
Between August, 1996 and January, 1997, 33 point-to-point sessions and 6 multipoint sessions were performed (including technical tests as well as clinical sessions). 15 of the point-to-point sessions and 5 multipoint sessions failed for various reasons explained in sections 2.2 and 2.3 of this document. During the successful clinical trials, some 80 patient cases have been discussed (the case consultation forms described in section 3.2 have been filled-in for 58 cases, but several cases have been discussed more than once and for some cases forms have not been filled in).

2.2.1 ATM Cell Loss in the Wide Area Network

Several of the RETAIN trials failed because of cell loss problems in the ATM wide area network. Typical symptom for this problem was a slightly “snowy” video image (at least on one side) and a drastically reduced throughput on the TCP/IP level. The problem was not caused by an overcommitment of the ATM “virtual path” - even switching off the video image and thus reducing the emitted bandwidth from 10 MBit/s to 2 MBit/s did not solve the problem on the TCP/IP level. Up to now it is not clear if the problem was caused by ATM traffic control mechanisms (e.g. burst length) or an incorrect behaviour of one ore more ATM switches in the net. The most important experience, however, was that a slight cell loss, causing a video image just to become a bit noisy, reduced the TCP/IP throughput to zero.

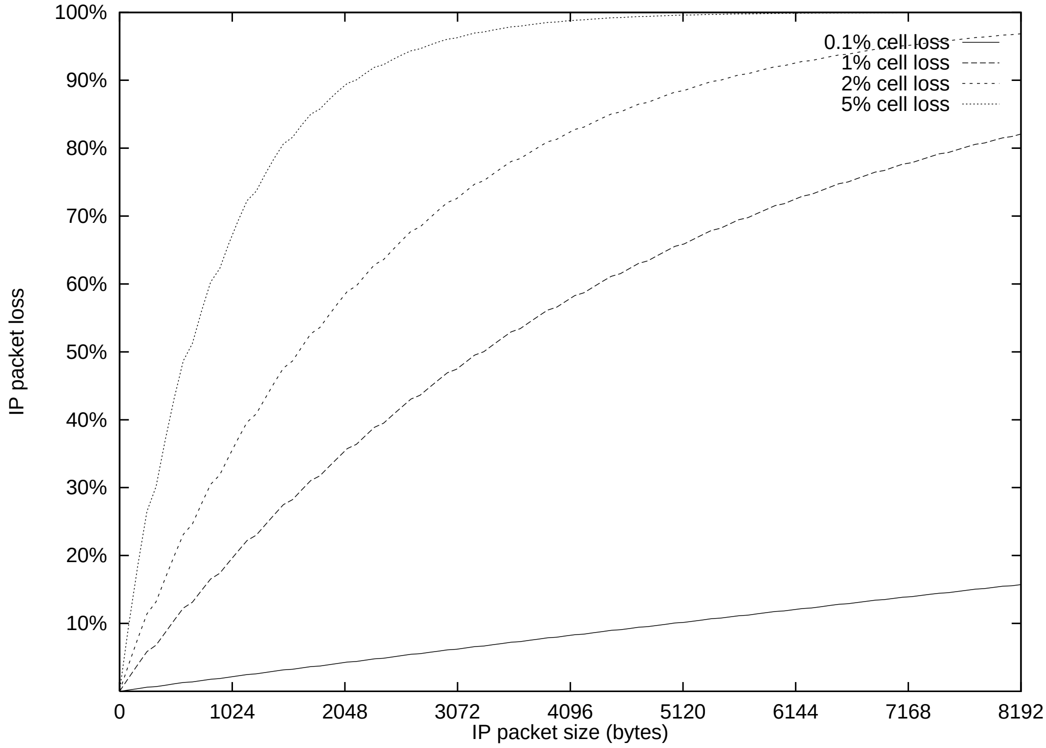


Figure 2-5: Probability of IP packet loss depending on packet size and ATM cell loss

Figure 2-5 displays the reason for this behaviour. TCP/IP transmits information in “transport units” (packets) of variable size. For every physical connection, a “maximum transfer unit size” (MTU size) can be negotiated. High throughput requires large MTUs (e.g. the default MTU for the ATM boards used in RETAIN is 9 KByte), resulting in IP packets that are transmitted over the ATM network as a large number of ATM cells. If one of the ATM cells belonging to an IP packet is dropped by the network, the IP packet is completely dropped on the receiving side (CRC error). Figure 2-5 displays the probability that an IP packet is invalid depending on IP packet size and probability of cell loss on the ATM layer.

With large IP packets (8 kByte), even an ATM cell loss probability of only 1% will result in a loss of more than 80% of the IP packets. With a smaller packet size (the smallest MTU size supported by the ATM boards used in RETAIN is 1500 bytes), 1% ATM cell loss still causes about 20% of the IP packets to be dropped.

The data throughput on the TCP layer is additionally decreased by the TCP congestion control mechanisms. In order to avoid a “flooding” of the network with data, TCP transmits data in blocks which size is limited by the so-called “congestion window”. When a block is lost during transmission (e.g. because of ATM cell loss) TCP uses the “multiplicative decrease congestion strategy” to slow down transmission, assuming that the network is congested. [Come 91, p. 193] describes the algorithm:

> *…because TCP reduces the congestion window by half for every loss, it decreases the window exponentially if loss continues. In other words, if congestion is likely, TCP reduces the volume of traffic exponentially and the rate of retransmission exponentially. If loss continues, TCP eventually limits transmission to a single datagram and continues to double timeout values before retransmitting. The idea is to provide a quick and significant traffic reduction to allow gateways enough time to clear the datagrams already in their queues.*

Although this algorithm works well in Internet environments, in this case the slow-down of transmission speed does not relieve the cell loss problem so that TCP ends up transmitting single datagrams with huge timeout values. The throughput drops effectively to 0.
This behaviour shows that current implementations of TCP/IP over ATM behave quite poor in wide area network environments where the ATM "quality of control" parameters (e.g. cell loss) cannot be totally controlled.

2.2.2 Unsupported VPI allocation schemes on current ATM hardware

ATM is a connection oriented protocol. Each physical connection between two ATM devices (e.g. switches) can transport data for multiple virtual connections with different real-time and bandwidth characteristics in parallel. Virtual connections are identified in ATM by the notion of "virtual path identifier" (VPI) and "virtual channel identifier" (VCI) numbers. The VPI, which is encoded into every ATM cell, identifies a virtual connection between two directly connected ATM devices, which means that the VPI number can change with every "hop" in the network. The VCI identifies a sub-channel within the VPI and remains unchanged end-to-end. In case of a RETAIN consultation, a single virtual path with 25,000 cells/s was allocated on the ATM network. This VP contained three virtual channels per direction of transmission (video, audio, TCP/IP). The two VPI numbers on both ends of the connection, however, were assigned by the network operators for every single connection.
In RETAIN, the workstation is more or less directly connected to the wide area network. The ATM video terminal adaptor embeds cells from the workstation into its own cell stream, but it changes neither VPI nor VCI of cells directed from or to the "secondary device" (workstation). The problem is that most ATM boards available on the market today are designed for in-house use only and support only a single VPI number, namely VPI 0. However, VPI 0 is always reserved in wide area networks for network operator tasks. The Zeitnet board, which was finally used in RETAIN, was the only ATM board we could find on the market which supported at least the VPIs 0–3. In this way, WAN operation was possible, but still difficult sometimes because everytime a network operator assigned a VPI > 3, re-negotiations were necessary.
An additional difficulty arises through the fact that for every connection the VPI number had to be configured into the ATM board driver. This operation required system administrator's privileges (and skills – network configuration of Unix systems is a complex task!) and usually a reboot of the machine. This is acceptable for a research project where technicians are always available, but absolutely unreasonable for use by physicians in every-day clinical use.

2.2.3 A multitude of audio and video encodings needing to be converted

A hurdle that should not be underestimated when audio/video devices are to be connected (e.g. for the ISDN dial-in facility installed in Oldenburg) is the multitude of audio and video signals that have to be converted.
While the audio conversion is still easily comprehensible (stereo–mono, symmetrical–asymmetrical, different impedance), video conversion can be complex. In our case, the ISDN video codec used composite video for input and output. The ATM video codec expected either YCbCr with separate composite sync or a digital uncompressed 4:2:2 PAL signal with 270 MBit/s (SMPTE 125). Especially the signal timing had to be very precise. On the decoder side, the ATM video codec produced RGB with composite sync and a (somewhat unusual) signal level of 1 V_{pp}. A large set of converters including a digital time base corrector (TBC) was necessary to make the two codecs "co-operate".

2.2.4 Network protocol stack problems in WAN environments

The RETAIN software used the ToolTalk protocol, which is part of the "common desktop environment" (CDE) offered by many manufacturers of Unix systems, to synchronise the applications during a consultation. Although all sites used Sun hardware with Solaris operating system (versions 2.3 to 2.5.1), connection establishment was sometimes only in one direction possible (usually from the newer OS release to the older OS release).
Additionally, ToolTalk created large problems when used over ISDN. ToolTalk is based on the RPC protocol ("remote procedure call") which in turn uses the XDR library ("external data representation")

and operates over TCP or UDP (connection-oriented or connectionless). The ISDN router used X.25 encapsulation of IP packets over ISDN. For reasons we were unable to determine (probably a bug in ToolTalk/RPC or an incorrect timeout value assigned by the system), the use of ToolTalk over ISDN caused a permanent re-transmission of RPC messages (with every new ToolTalk message all messages sent before were repeated), flooding the network after a few seconds with RPC traffic and inhibiting any reasonable use of the software – reaction to a mouse-click could take several minutes. Finally, a daemon was developed which was started on both sides of the connection, listened to the local ToolTalk “traffic” and transmitted data intended for the other system explicitly over a Socket based protocol. In this way ToolTalk operated only locally, and all connection establishment and re-transmission problems ceased.
An interesting question also occurred during installation of the ISDN routers. Although both France Télécom and Deutsche Telekom claim to offer a fully ETSI compatible ISDN (DSS1 protocol), the routers needed to be configured differently to operate correctly: The “Signalling TEI” number had to be set to 127 for France, but to 0 for Germany. Unfortunately, it takes an ISDN protocol analyser and telecommunications specialists to find out about such details.

2.2.5 Miscellaneous technical problems

Like any research project working with prototype hardware and software, we experienced some problems with hardware defects and the resulting – significant – repair times. Probably more surprising was the poor performance of some commercial devices: The Ascend inverse multiplexer used by the ISDN video-codec to connect to 6 B-channels often had to be resetted after a successful connection because it refused to dial again otherwise.
The software clearly was in prototype stage as well (in terms of installation procedures, documentation and stability), causing some trouble: In Düsseldorf no ATM video terminal adapter was present, so the RETAIN software tried to “re–program” the uninterruptible power supply attached to the workstation, obviously with “strange” results.
In summary, however, the system performed quite good for a research prototype, as the user ratings in chapter 4 underpin.

2.3 Organisational Problems

2.3.1 Credibility problems in user community due to late JAMES project start

According to the original timetable of the project, trials should have been performed between February and June, 1996. However, the late start of the JAMES project, on which RETAIN had to rely for the ATM network connections, resulted in a delayed trial period between September and December, 1996. Although not a problem technically, this delay decreased the credibility of the project at its user community. Physicians who had prepared case presentations for consultations could of course not wait for months for remote advice so that these preparations were effectively lost.

2.3.2 Unreliable JAMES connection establishment policies

On today's ATM wide area networks, the connection establishment procedure is *“connection by fax”*, as somebody pointed out. All projects requesting connections over the JAMES network had to prepare a “technical framework document” (TFD) which described all involved sites and pre-planned the connections over months in advance. Changes in the connections had to be requested a few days in advance.
Although reliability of the connection setup has improved compared to the “European ATM Pilot” (the predecessor of JAMES which was used for the RETAIN-2 trials in 1995), the manual connection setup was still somewhat unreliable:

- Some connections failed because wrong VPI numbers were assigned or insufficient bandwidth was allocated in some switch along the “virtual path”. It was always difficult to find out where on the virtual path the problem was located, because each network operator was only responsible for their national part of the international JAMES network.

- Although the RETAIN TFD document had been prepared with close co-operation of a network operator, other network operators still had problems in interpreting the TFD when complex connection settings (multicast VPs, uni-directional VPs etc.) were requested.
- All regular connections were pre-planned in the TFD, but still the network operators employed different policies on connection establishment: For instance, Deutsche Telekom policies required that all connections were requested by the “Lead PNO” (the network operator assigned to support the project, in our case France Télécom), and then confirmed by the customer. However, France Télécom policies required that uni-directional connections had to be requested by the originator (e.g. the German site), not by the “Lead PNO”. Some of our trials failed because of this sort of disorganisation.

2.3.3 Failed multipoint experiments

As described in section 2.1.2, some “multipoint visual telephony” trials were performed in RETAIN, in which all participants multi-casted either their audio signal or both audio and video to all other participants. In addition, a bi-directional TCP/IP connection to a “master site” was established for the CSCW application. This means that every participant received three audio/video signals (uni-directional VPs multicasted by the France Télécom JAMES node in Paris–Bagnolet), sent its own video signal to Paris Bagnolet (also uni-directional) and additionally established a bidirectional VP to the “master site”, giving a total of 5 VPs for each partner except the “master site”, which operated on 7 VPs in parallel. In *none* of the multipoint experiments, all VPs were set-up correctly by the network operators – every time some VPs were switched in the wrong direction, allocated with insufficient bandwidth or missing at all (see section 2.3.2 on JAMES connection establishment procedures).

It also turned out that the ATM hardware used in the workstation had difficulties with handling multiple VPIs in parallel. Although supported by the driver, as soon as VPIs to multiple partners in parallel were established, the TCP/IP over ATM connection failed.

To sum up, it seems that multipoint conferencing on ATM, although technically possible, is still one step beyond possibilities of current ATM services.

2.3.4 Network related problems difficult to debug

During the trials it turned out that most network related problems could not be reproduced in a local loop, e.g. by connecting two ATM video terminal adapters or two Sun ATM boards directly “back to back”. This meant that analysis of these problems could only be performed during the trial times (twice a week), when a JAMES connection was established. This significantly increased the time required to provide and test solutions and decrease the time available for medical trials. Future ATM projects should consider this when designing their timetables.

3 USER BEHAVIOUR ANALYSIS

3.1 Trace File Analysis

The RETAIN software automatically created “trace files” containing information about all major actions performed by the users (e.g. displaying images, pointing or drawing etc.). The figures in this section have been derived from the trace files produced at all sites over the trial period September to December, 1996.

3.1.1 Duration of Case Consultations

Figure 3-1 displays the duration of the individual case consultation over the project's trial period. Consultations of less than two minutes (which are likely to be tests or inadvertent selection of the wrong case) as well as consultations of more than one hour, which were caused a few times by technical problems, have not been included in the evaluation. Consultations took between three and 45 minutes, with a rather even distribution over time.

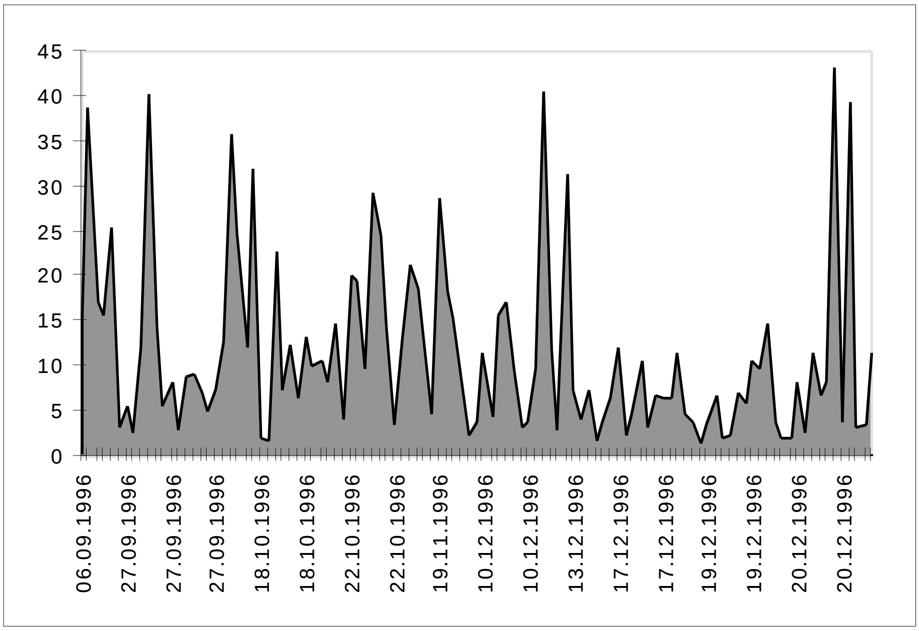


Figure 3-1: Duration of Case Consultations during the Trial Period

Figure 3-2 displays the percentage of consultations shorter than the time indicated on the *X* axis. As can be seen on this figure, 55% of the consultations were shorter than 10 minutes and about 85% shorter than 20 minutes. The average duration was 11.4 minutes (median: 8.2 minutes), with a standard deviation of 9.78.

This confirms the figures measured during the 1995 trial period [Ret2-9], where we claimed an average duration of 10.6 minutes with a standard deviation of 6 minutes. Therefore, we may assume that a tele-medical case consultation typically takes 5–15 minutes with an average of 10–11 minutes. This figure (in slightly modified form, see section 3.2 for an explanation) will serve as a basis for the estimation of labour and communications costs in the financial analysis (chapter 7).

Compared to classical “eye to eye” consultation, both duration and proceeding of remote consultations (see section 3.1.3) are quite similar, as the physicians participating in the trials confirmed: Classical consultation can be separated into four steps which also typically take around 10 minutes:

- clinical explanation of the case
- quick analysis of all available images
- selection and commenting of the best images allowing diagnosis
- conclusion, e.g. a list of possible diagnoses or a proposed treatment.

This proceeding is very similar to the user behaviour observed during the RETAIN trials, see section 3.1.3: User Behaviour.

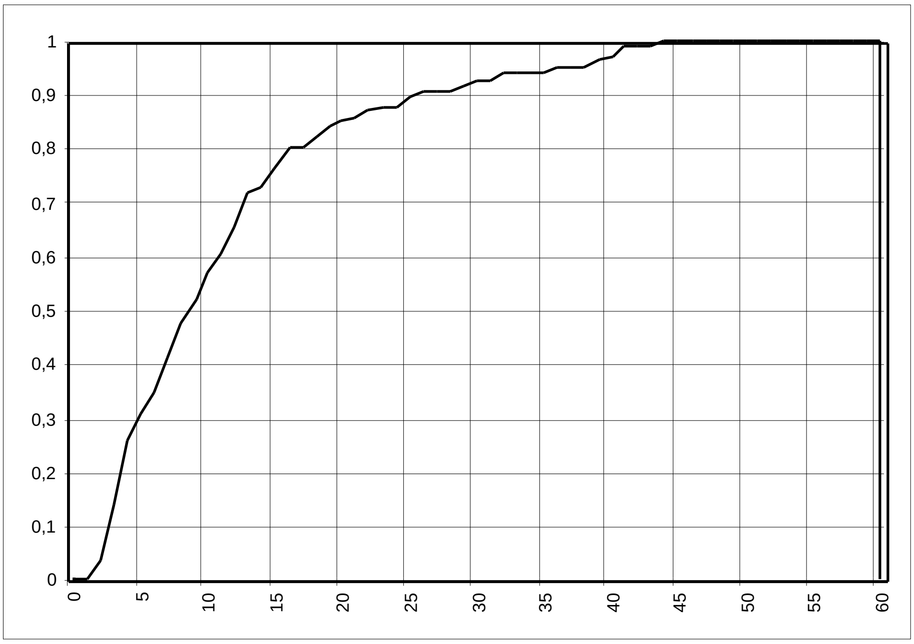


Figure 3-2: Duration of Case Consultations

3.1.2 Number of Images and Series per Patient Case

Figure 3-3 displays the number of images that have been reviewed (not transmitted) per case consultation. Perhaps surprisingly, in about one third of the cases the physicians needed only 5 or less images and in only 18% more than 25 images were required to review the case. The average number of images reviewed was 16.8 (median: 10), with a standard deviation of 19.8.

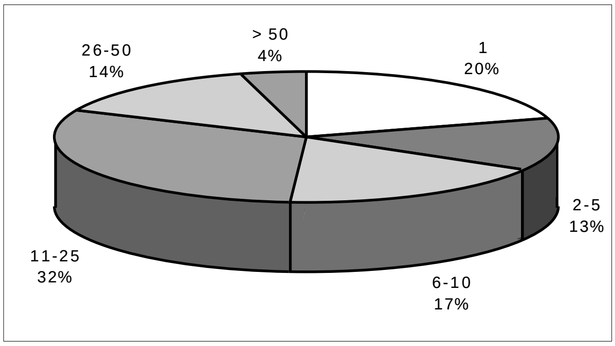


Figure 3-3: Number of reviewed Images per Case

The images discussed for a single case sometimes belonged to different series, e.g. different modalities or imaging parameters (with and without contrast medium etc.). Figure 3-5 and Figure 3-4 further detail the data from Figure 3-3 by displaying the number of series per case and the number of images per series reviewed.

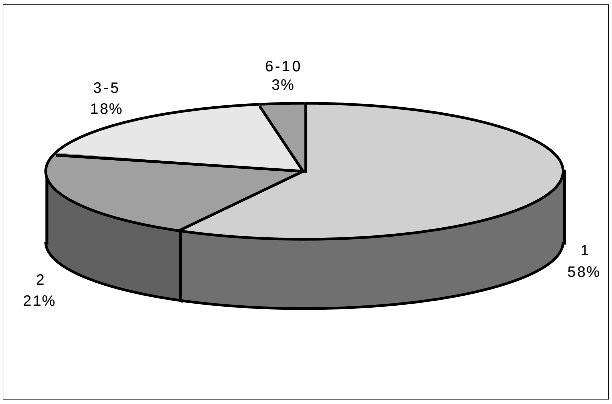


Figure 3-4: Number of reviewed Series per Case

In 42% of the cases, more than one series was required (average: 1.9 with a standard deviation of 1.5). Consequently the number of images reviewed per series was significantly smaller, with an average of 8.5 images per series (median: 5) and a standard deviation of 13.4.

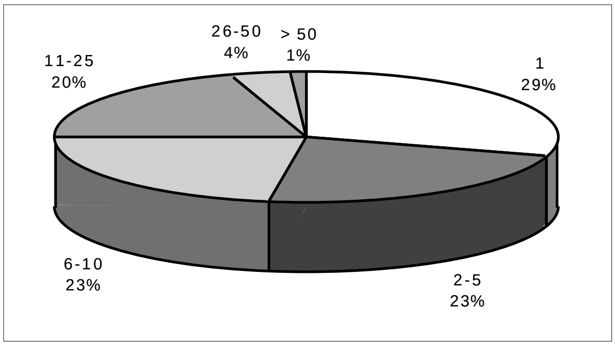


Figure 3-5: Number of reviewed Images per Series

An analysis performed by the European Workshop for Open Systems [EWOS 93] described typical sizes of digital medical image data and the resulting bandwidth requirements (for transmission of a series within two seconds), as displayed in Figure 3-6.

Modality	Images per Study (mean-max)	Resolution (width x height x bit-depth)	Bandwidth MBit/s mean	Bandwidth MBit/s max	Bandwidth MBit/s lossless	Bandwidth MBit/s lossy
Film/CR	2 - 4	2K x 2K x 12	64	128	32	9.6
CT	50 - 120	512 x 512 x 16	100	240	80	24
NM Static	6 - 20	128 x 128 x 16	0.75	2.5	0.8	0.25
NM Dynamic	50 - 180	64 x 64 x 16	1.56	5.6	1.9	0.56
NM MUGA	25 - 30	64 x 64 x 16	0.8	1.0	0.3	0.1
NM SPECT	50 - 180	128 x 128 x 16	6.25	22.5	7.5	2.25
NM PET	62 - 93	128 x 128 x 16	7.8	11.6	3.9	1.16
MRI	80 - 200	512 x 512 x 16	160	400	133	40
MRI Selected	5 - 10	512 x 512 x 16	10	20	7.3	2
US Radiology	20 - 75	512 x 512 x 8	20	75	25	7.5
US Cardiology	35 - 140	512 x 512 x 8	35	140	46.7	14
US Card. Stress	240 - 600	512 x 512 x 8	240	600	200	60
US Selected	5 - 10	512 x 512 x 8	5	10	3.3	1
Dig. Angiography	4	512 x 512 x 8	4	60	-	-
Dig. Fluoroscopy	2	512 x 512 x 8	2	12.3	-	-
Dig. Photography	1 - 5	256 x 256 x 8	1	5	1.7	0.5

Figure 3-6: Bandwidth Demands of Medical Image Transfer according to EWOS

If we compare this data to Figure 3-5, it becomes clear that the number of images required for a case consultation is by orders of magnitude smaller than the typical series size. We may conclude that a careful pre-selection of images before transmission would significantly decrease bandwidth requirements in comparison to Figure 3-6. However, the selection would be performed by the clinician seeking advice, not by the expert. This means that the physician preparing the consultation would either need to have sufficient expertise to select exactly the images the expert might want to see, or have the possibility to quickly transmit additional images during the conference. Quick image transmission during a conference would again require high bandwidth because a specialist would not be willing to wait a long time for additional images. In addition, the usage figures in section 3.1.3 indicate that the course in which images from a series are selected during a conference can be difficult to predict. Therefore, conclusions from the values in Figure 3-3 should not be overemphasised.

The structure of the RETAIN trace files does not allow to precisely compute the volume of data transmitted per case (the medical images have been erased after the conferences for data protection reasons), but we can give a reasonable estimation: If we assume a volume of 2 MByte per image for small series of up to 5 images (1024x1024 pixels, 16 bits/pixel, a typical size for DSA) and 512 kByte/image for larger series (512x512, 12 bits/pixel with word-alignment, a typical size for digital CT and MRI images), the average volume required per case during the RETAIN trials was 9.3 MBytes and the largest volume (132 CT images, see Figure 3-12) per case was 66 MBytes.

Figure 3-7 shows the transmission times for these average and maximum volumes, depending on the sustained bandwidth on application level (e.g. IP and ATM protocol overhead not included). It should be noted that both X and Y axis are displayed in logarithmic scale.

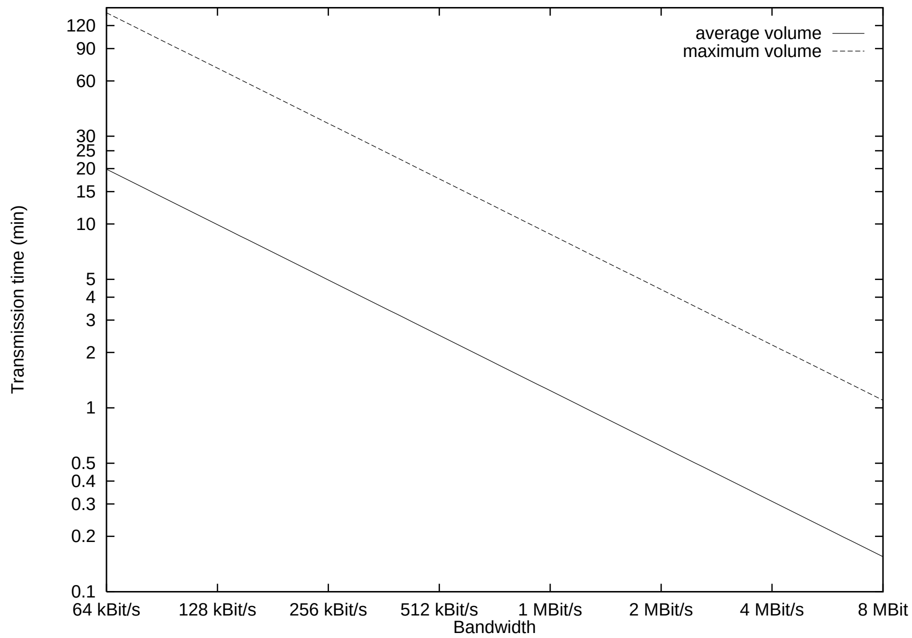


Figure 3-7: Transmission times at different bandwidths

At a sustained bandwidth of 2 MBit/s, average transmission time would be 37 seconds and the maximum transmission time 4:24 minutes, which seems to be sufficient for most applications. The physicians used this transmission time to present the clinical symptoms or para-clinical results of the case to the conference partner. In contrast, at 128 kBit/s (e.g. 2 ISDN B-channels without consideration of the protocol overhead) the average transmission would take 9:55 minutes and the maximum was 70:24 minutes. This will hardly be acceptable for an “online” transmission, but might be acceptable when there is sufficient time for a data transmission in advance to the conference. In addition, compression could be used to further decrease transmission times on narrowband connections (see [Ret3-7] for a discussion on image compression).

3.1.3 User Behaviour

The trace files created by the RETAIN application for all trials allow to visualise how physicians reviewed, switched and manipulated images belonging to a patient case in course of the consultation.

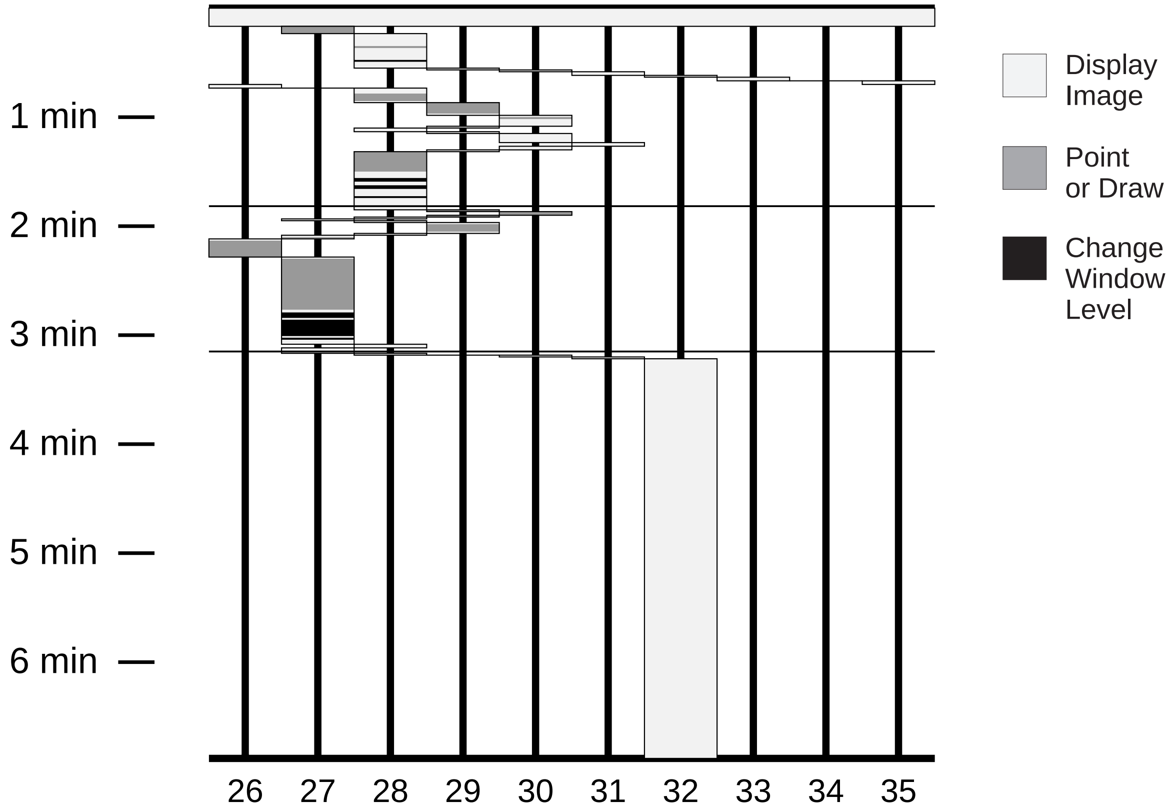


Figure 3-8: Case Consultation Example 1

Figure 3-8 displays in graphical form a case consultation which was performed from radiologists in Oldenburg to a Neurologist in Düsseldorf on December 20th, 1996. In the beginning of the conference a selection of images from a CT study (slices 26 to 35 of a larger series) were transmitted from Oldenburg to Düsseldorf. The consultation, which took a total time of 7 minutes, began with a review of the “series overview” which displays all images of one series as “thumbnails” in a single window. Figure 3-9 displays such an overview window.

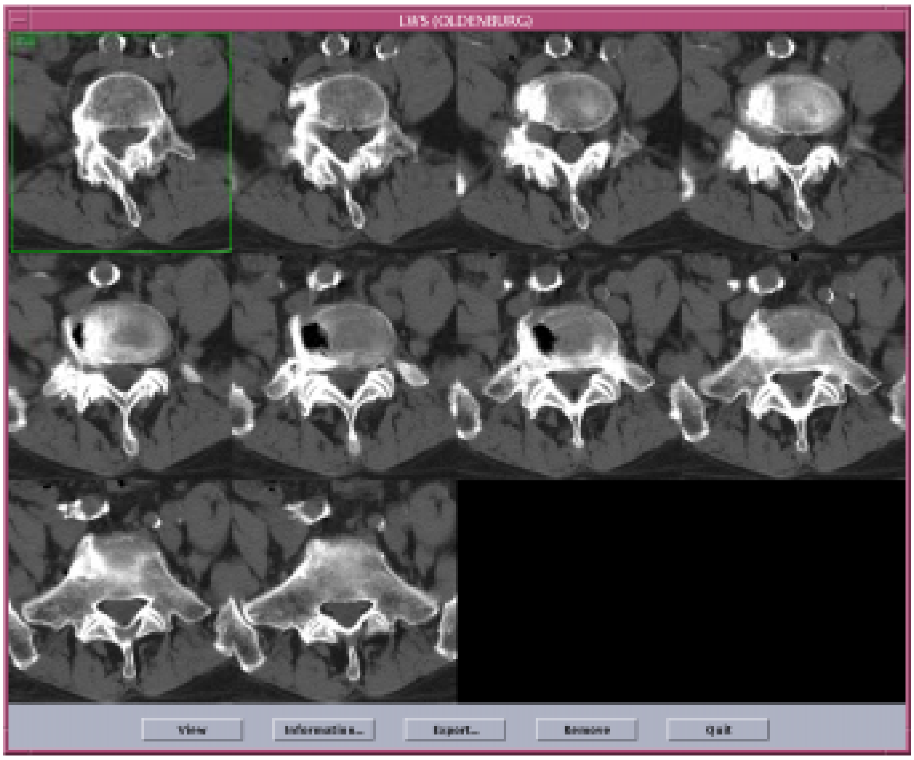


Figure 3-9: Overview Window

The physicians then started to review the individual images in full resolution. The boxes in Figure 3-8 show how the physicians switched between the images over time. Light grey areas in the boxes indicate a simple review of the images, dark grey areas indicate that the "cooperative mouse pointer" was used to draw into the image or point to the screen. Black areas indicate that the grey scale range of the image ("window level and width") were adjusted. Black horizontal lines finally indicate that a grey scale range which was selected for a single image was "propagated" to all images of the series. Figure 3-10 displays a sample CT display window with its GUI controls.

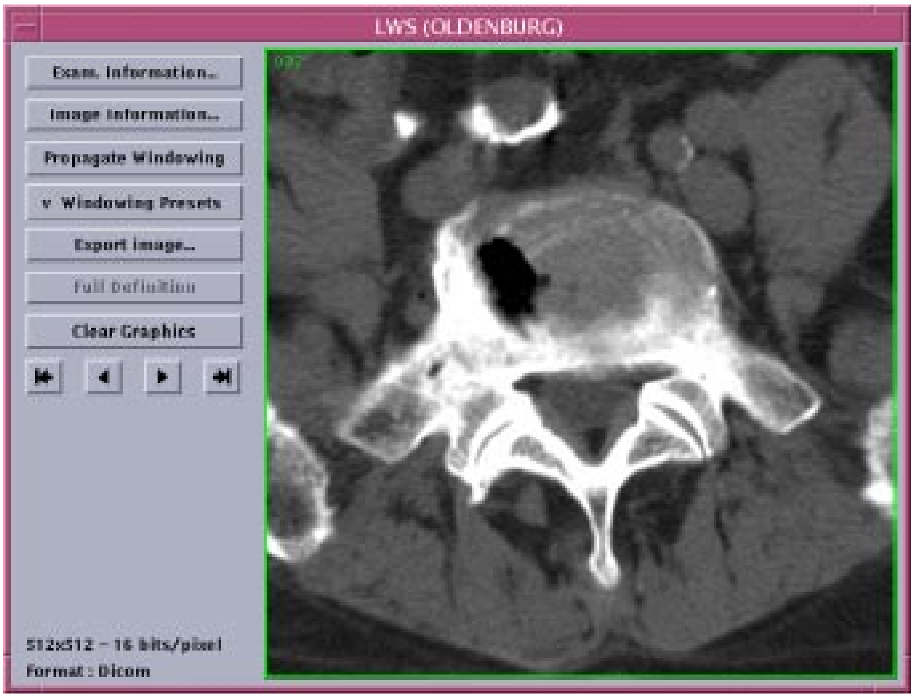


Figure 3-10: Image Window and GUI Controls

A tool developed for the evaluation of the RETAIN trace files created some 100 usage graphs for case consultations during the RETAIN trial period. Two representative cases have been selected for presentation here.

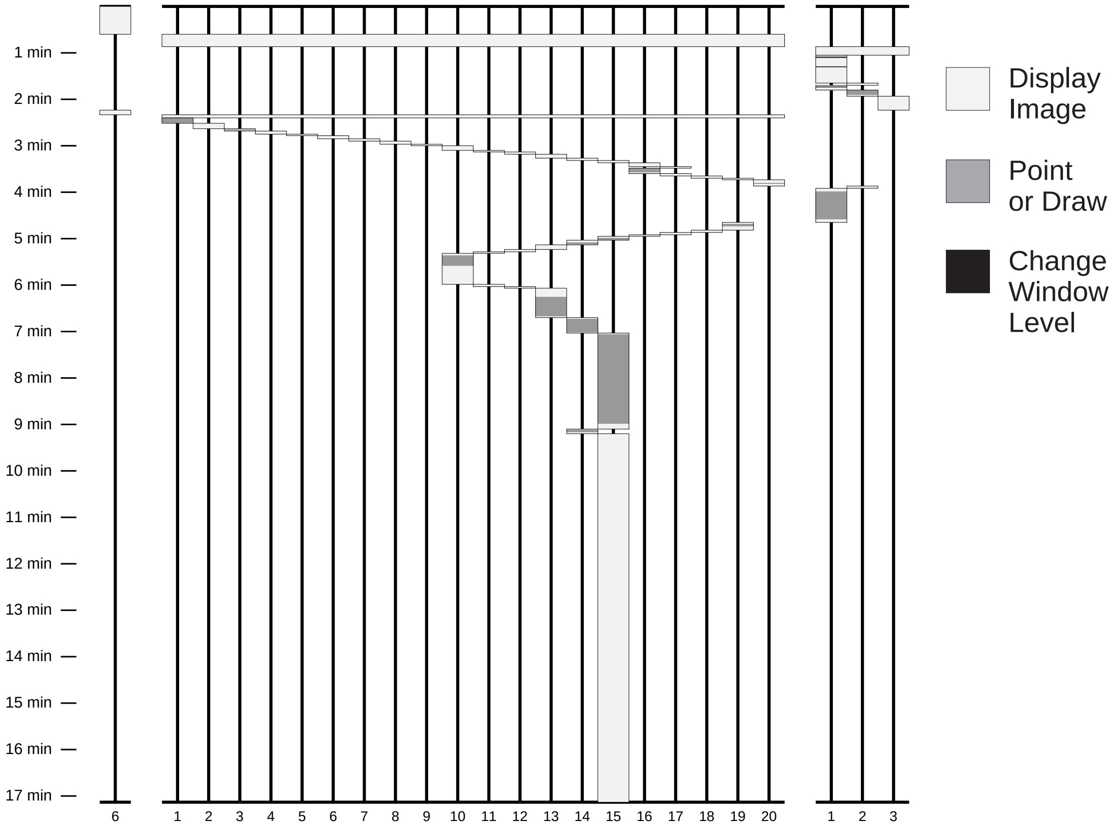


Figure 3-11: Case Consultation Example 2

Figure 3-11 has been selected as a very typical example showing a usage of the system which can be observed in many consultations. This figure depicts a case consultation performed between Rennes and Paris on September 20th, 1996. The consultation, in which three series of images were available for the patient in question, can be separated into three phases:

In the first phase (first 1.5 minutes of the consultation) the physicians tried to get an overview on the available data by reviewing all three series overview windows.

In the second period (up to minute 9) the images were reviewed and discussed in more detail, after a while focusing on the images displaying the findings best (in this case around slice 15 of the scan, which is depicted in Figure 3-11).

In the remaining time (47% of the total duration) the physicians discussed on the consequences (e.g. therapy options) of their common diagnosis. The image display was obviously of less importance at this time, and switching as well as pointing on the image stopped.

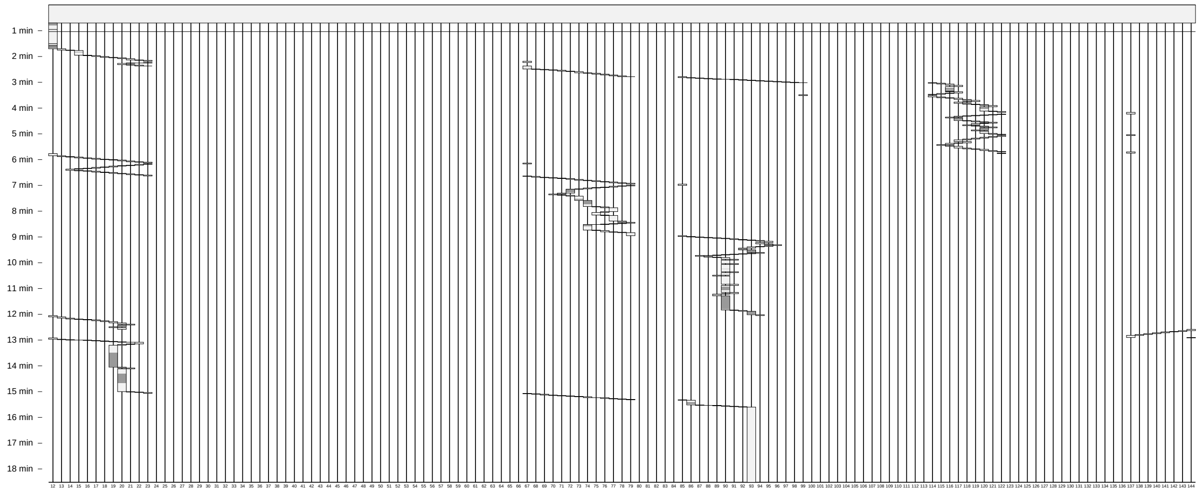


Figure 3-12: Case Consultation Example 3

Figure 3-12, which again displays a conference between Rennes and Paris, about one month later on October 29th, 1996, serves as an example for untypical courses of discussion. In this case only one large series of 132 images was available. Again, the figure shows the characteristical three phases (overview – diagnosis – discussion), but in this case the image review took 15 of the 18 minutes and 42% of the images (56 in total) were reviewed with no particular order or restriction to a region. This shows that it can be very difficult to predict which images of a series are relevant for a consultation – in this case a pre-selection (e.g. for ISDN transmission) would have been likely to be insufficient.

The usage graphs show that it is possible to automatically create a detailed "profile" of a case consultation. In addition to the financial analysis in chapter 7 where a fixed per-case consultation fee is assumed, the idea of charging costs for consultations based on an automatically created usage profile might be worth further consideration. Such a "pay per click" charging scheme would clearly have disadvantages (it would be counter-productive if physicians could increase their revenues by just "playing around" with the system), but it might as well serve as a basis for a fair reimbursement of costs under consideration of the real expenditures of a consultation.

3.2 Analysis of Patient Forms

In addition to the automatic data collection by the RETAIN software (trace files, see section 3.1) the physicians were asked to fill in certain forms for each patient case which was discussed "over the network". Section 9.1 shows these forms. The first form, filled in before the conference, shortly describes the case, available information (e.g. modalities) and expectations from the remote consultation. These forms were sometimes transmitted to the remote hospital in advance to the conference via fax. The second and third form were filled in during (or shortly after) the conference by the presenting site and the remote site, respectively. They describe the results of the consultation and the physicians' opinion on the case as well as problems occurred during the conference and "comments or suggestions".

3.2.1 Classification of Patient Cases

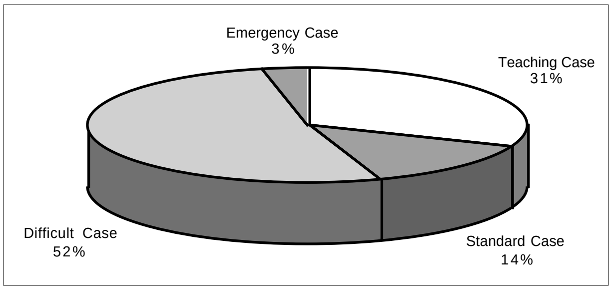


Figure 3-13: Classification of Patient Cases

Figure 3-13 shows how the physicians classified the cases discussed over the network. About one third of the cases were "teaching cases", e.g. interesting or rare cases treated in the past which were presented and discussed, but not related to the actual treatment of the patient. In two thirds of the cases the patient currently was in treatment and the physicians used the opportunity to request remote advice which might otherwise have been requested by conventional means (e.g. mail). Difficult cases are the typical "candidates" for a second opinion whereas standard cases where diagnosis and treatment are well-known would probably not be discussed over a conference network in a non-experimental setting. Even a few emergency cases were discussed – this was only possible when a difficult emergency case happened to be under examination during one of the pre-planned RETAIN conference dates because all connections had to be requested some days in advance (see section 2.3.2). The large share of real cases from daily routine indicates that the physicians really considered the RETAIN conference system as an important tool (at least potentially, given the experimental stage of the system).

3.2.2 Modalities Used and Image Quality

One of the most important aspects of telemedicine is the quality in which images can be acquired, transmitted and viewed. In contrast to the second project phase [Ret2-9], where medical images were transmitted over the "video channel" as well as in digital form, in this project phase all medical images were digitised or acquired digitally and transmitted in loss-less, uncompressed digital form.

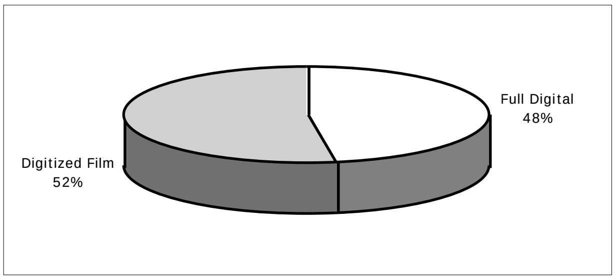


Figure 3-14: Digital Data vs. Digitised Film

Figure 3-14 shows the distribution of digitally acquired versus digitised images. This reflects the current state of introduction of digital imaging technology in the hospitals involved in the project. Although 98% of the images used for the consultations (see Figure 3-15) were created by digital imaging techniques (CT, MRI, DSA and 3D reconstruction), only about 50% of these images could be transmitted (uploaded) to the RETAIN workstation in digital form. Reasons for the inability to upload images digitally are:

- the modality does not support digital image export over a network
- the modality supports only legacy protocols
- no network connection to the RETAIN workstation is available
- images are created by a different institution and delivered on film only
- images are not archived digitally so that studies older than a few days are available on film only

However, the image quality was assessed by the physicians as "good" or "excellent" for the vast majority of images including the film scans. A few studies were rated as "acceptable" or even "unusable" because of inadequate scanning. The physicians stated that the difficulty with using a film scanner was rather that digitisation of images from film in good quality is a very time consuming procedure.

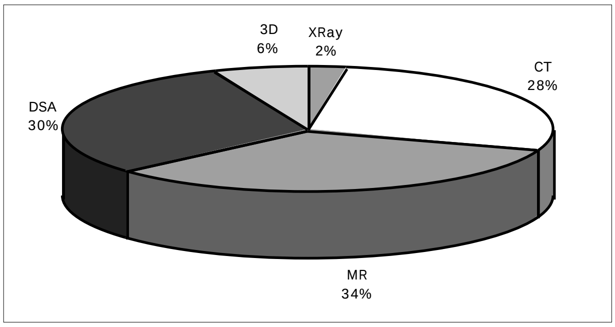
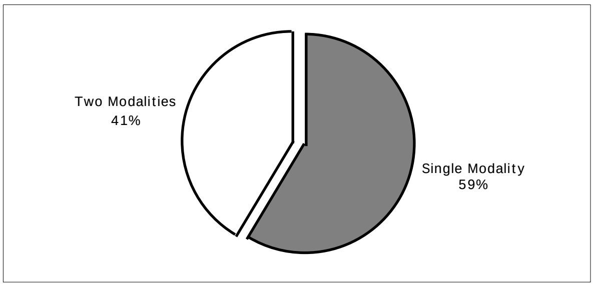


Figure 3-15: Use of Medical Image Modalities

Figure 3-15 shows the distribution in which the different medical image modalities have been used. It is remarkable that conventional X-rays have hardly been used during the trials although X-ray is the most often used radiological imaging technique. Two reasons explain this observation:

- Although X-ray is the oldest and most inexpensive radiological modality, the spatial and contrast resolution of X-ray images is very high, requiring high resolution displays and a careful (time consuming) scanning. Therefore, the physicians may simply have avoided to use X-ray.
- Most consultations concerned difficult cases in which CT or MRI are usually available in addition to the initial X-ray examination so that it is possible to do without X-ray.

The rare use of X-ray is very interesting because unlike all other modalities used in the project, the high spatial resolution of X-ray images (see Figure 3-6) cannot be displayed in full definition with standard workstation equipment. If it is possible to do without X-ray in most cases, hardware requirements (and, in turn, hardware costs) for telemedicine systems could be decreased significantly.



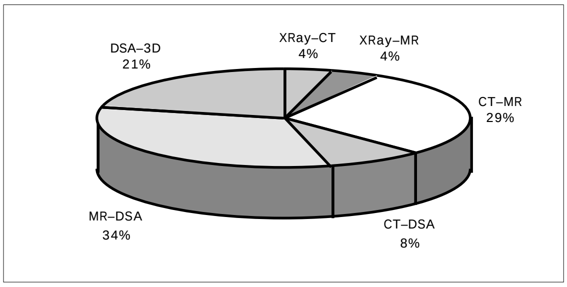


Figure 3-16: Number of modalities per case and combinations of modalities

Figure 3-16 shows that about 60% of the cases were discussed with images from only one modality available. In cases where more than one modality was used, the most usual combinations were MR-DSA (34%), CT-MR (29%) and DSA-3D Reconstruction (21%). The large percentage of cases where more than one modality was used for the consultation indicates that it is not sufficient for a hospital to have access to images from only one modality for tele-medical conferences (e.g. CT only). Since few hospitals will have full digital access (e.g. DICOM PACS) to all modalities which might be of interest for a tele-consultation, appropriate means for digitising films will be necessary in most hospitals.

3.2.3 Medical Expectations and Results

Figure 3-17 shows the expectations the physicians named before the consultations. Three types of consultations can be identified:

- *Clarification of diagnosis:* In these cases the diagnosis was not clear and the physicians requested expert advice (e.g. a remote diagnosis). This is the “classical” form of consultation.
- *Discussion on treatment options:* In these cases the diagnosis was clear, but the possibilities for treatment (“operation or radiotherapy?”) were discussed.
- *Presentation of rare case:* This was the typical “expectation” for a teaching case.

The fourth group, “other”, relates to rather unusual expectations like “presentation of new examination technique” or “prognosis needed”.

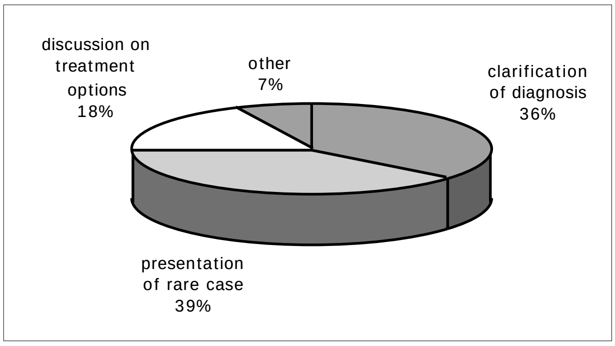


Figure 3-17: Expectations of case consultations

Figure 3-18 shows how the physicians assessed the success of the case consultations in medical terms. In this figure only trials without significant technical problems are considered: the physicians were able to transmit and discuss images. Nevertheless 21% of the trials were considered as unsuccessful, because the expected results could not be achieved:

- The consulted site was unable to give advice on the case.
- An expert of a certain sub-speciality was required, but not available during the conference.

The rating “no medical interest” relates to a few cases where the conference network worked technically, but no medical case worth discussion was available at the pre-planned conference date.

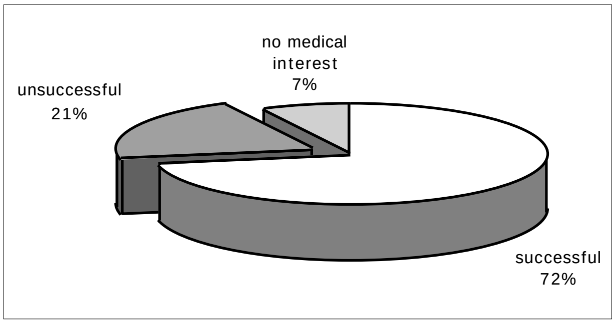


Figure 3-18: Medically successful and unsuccessful consultations

3.2.4 Problems with the RETAIN application

In addition to the technical problems described in section 2.2, the physicians named some problems with the RETAIN software:

- Sometimes the application had to be restarted, e.g. because there was no more free memory in the system.
- The adjustment of the grey scale window (level and width) with the middle mouse button was impractical when level and/or width had to be changed from a very large to a small value or vice versa.
- In some sites Sparc 20 systems were used which reacted rather sluggish when high resolution DSA images (1024x1024 pixels) were displayed.
- Some users found it confusing that the active image window could be covered by the image database overview window.
- When only a part of a series was transmitted to the conference partner, it was not visible in the overview window which images were available on both sides and which not.

3.3 Analysis of Video Recordings

In addition to the trace files which were automatically created by the RETAIN software during all consultations, some trials were also recorded on video tape. Figure 3-19 shows two snapshots taken from these video tapes, displaying a case conference between radiologists in Rennes (left side) and a neuro-radiologist in Paris on December 20th, 1996.

Figure 3-19: Video recording of RETAIN conference Rennes-Paris, December 20th, 1996

The review of the video recordings mostly confirmed the conclusions drawn from the trace files in section 3.1 – it was surprisingly easy to follow the video recordings in parallel to reading the automatically created usage behaviour graphs (e.g. Figure 3-11) which proved to give a good impression of the course of the consultations. However, some aspects which are not reflected by the traces should be pointed out:

- During the course of the trials, occasional delays caused by technical reasons were not reflected in the trace files: Instable ATM connections breaking down for some seconds, occasional re-adjustment of the audio setup, for instance re-positioning of the microphone in order to remove annoying audio feedback, and some delays between case discussions caused by a change of the session participants. In the traces, these delays simply increase the duration of the case discussions. This means that the real average duration of a case consultation is slightly shorter than the figure indicated in section 3.1.1 (11.4 minutes). An average of 10 minutes seems to be a good estimation. This is also confirmed by the “patient forms” (section 3.2) where the physicians estimated most of their case discussions to have take “around 10 minutes”.
- Usage of the software and the overall system was quite “fluent”. Usage problems (e.g. difficulties in finding the right function) could not be observed. This indicates that, once the connection was established and the software was running, the software could be handled intuitively and that it was adequate for the purposes of medical case consultations (see chapter 4 for an in-depth discussion on adequacy). However, it should be noted that starting the system (e.g. connection setup, configuration of the trial) was not always trivial and that technical support was available to the physicians during all trials. Therefore, technical problems during the course of the trials (e.g. restart of the system, reset of the video codec) could be performed quickly and easily. This would have been different if no technical support had been available. This underpins that the system was adequate for its purpose at a prototype, but clearly not as a “shrink-wrapped” commercial product or service.
- The tight mesh of human communication (video conference) and image review during the diagnosis phase of the consultations (see section 3.1.3) was remarkable. The physicians eyes' focus changed between the two monitors every few seconds in this phase. This raises the question if a one screen solution would be preferable for the users. Experiments with a video overlay board allowing to display the video conference image on the workstation screen have been carried out during RETAIN 2 in 1995, but were abandoned because on-screen display was insufficient for group-to-group conferencing and transmission of medical video (e.g. live transmission of ultrasound ex-

aminations or endoscopy). However, a combination of a two-monitor solution with the option to display the video conference image on-screen alternatively should be considered for future systems.

4 RESULTS – PHYSICIANS POINT OF VIEW

One of the main questions of the RETAIN project evaluation is whether the telemedicine system developed in the project is able to fulfil its users' requirements. This question of “adequacy” of the system for the purposes it was used for has been examined in all TEN-IBC projects in the context of the “TEN IBC consolidation” activity. In order to find a common ground for the comparison of project results, each project analysed its developments in terms of *services*, *objectives* and *success criteria*. A service is defined as an application or set of applications which together offer an added value to a user (e.g. could be offered as a separate product). The RETAIN conference system can be described as a set of three services:

- *Teleradiological broadband conference and consultation service (online):* This is the main service of the RETAIN project. It can be described as a system allowing to combine visual telephony with a computer supported co-operative review of digital medical images. The system allows users to upload digital medical images from an image archive (PACS) or medical workstation to the RETAIN workstation, to transmit these images to one or more conference partners and to request a “second opinion” from an expert over the “conference network” which is based on ATM. In addition, multi-point conferences can be performed in order to present interesting cases or new techniques to a larger audience (“tele-teaching”).
- *Narrowband access service:* ATM networks are rarely available today, and not all hospitals interested in teleradiological conference services will have access to ATM in the close future. Since hospitals will hardly be able or willing to purchase multiple “telemedicine workstations” (e.g. one for ATM, one for ISDN), and since there is no interoperability between narrowband and ATM services today, a “dial-in point” for ISDN users into an ATM based telemedicine network would be an important added value, allowing for a smooth migration to broadband technology.
- *Medical multi-media message and presentation service:* In addition to online transmission and discussion of patient cases it seems useful to create a “case presentation” consisting of images, sound (speech) and graphical overlay (e.g. arrows on the images) which can then be transmitted over the network and reviewed locally offline (e.g. as a preparation of an online conference). This is especially important for narrowband users which can in this way significantly decrease wait times (transmission delay).

The five RETAIN applications described in section 2.1, which are defined in technical terms (e.g. different network requirements), can directly be assigned to the services described here, as shown in Figure 4-1.

Services / Applications	Broadband conference service	Narrowband access service	Message service
Visual telephony	♦		
Multipoint visual telephony	♦		
CSCW application	♦		
Narrowband access point		♦	
Multimedia messaging			♦

Figure 4-1: Assignment of applications to services

In order to evaluate the users' assessment of these services, a questionnaire has been designed and filled in by 15 physicians from all sites involved in the project. Section 9.2 shows this “Service Adequacy Questionnaire” which is the basis for the discussion in this chapter.

4.1 Teleradiological broadband conference and consultation service (online)

At first glance, the objective of teleradiological consultation is to support physicians in their work, especially in difficult and urgent cases. Since medical ethics require that every new medical service which is introduced *must not* decrease the quality of health care delivery for the patient, telemedicine will also have to show that it can improve treatment quality for the patient. Finally the ever increasing cost pressure in health care requires that new, expensive technology like ATM based telemedicine proves its potential to decrease costs of health care delivery. Therefore, objectives and success criteria of the teleradiological broadband conference and consultation service can be described as follows:

- *Facilitate the cooperative discussion and diagnosis on digital medical images between remote physicians:* In order to attain this objective, three criteria must be fulfilled: At first, in order to use the RETAIN conference service, images must be available in digital form. This means that images are either “native” digital data or they are digitised using a film scanner or a frame grabber. Digitisation of film is a time-consuming procedure and significantly decreases image quality. Therefore, availability of a digital image network in the hospitals at least in the close future is a key factor for acceptance of the conference service. Secondly, there must be a real need for remote medical consultation, otherwise the service will not be used by the physicians. Finally, the performance and functionality of the system must be accepted by the users.
- *Increase treatment quality by improving access to specialist expertise:* An increased quality of health care delivery resulting from specialist expertise must be reflected by changes (improvements) in diagnoses and treatment plans due to remote advice. On the long term the average patient mortality rate should decrease and the cure rate should increase. In addition, frequent mutual consultations should result in an improved training of the participating physicians (“diffusion of expert knowledge”).
- *Decrease costs incurred by unnecessary patient transports and physician travel:* Success criterion for this objective is a measurable decrease in expenses for unnecessary patient transports (e.g. patients returned by the remote hospital) and physicians accompanying patients during transport or travelling in order to request expert advice by classical “eye to eye” consultation.

These issues are covered by 25 questions in section 2 of the “Service Adequacy Questionnaire”.

4.1.1 Improvement of cooperation between remote physicians

Availability of the necessary infrastructure is the first success criterion for an improvement of cooperation between physicians by means of telemedicine. Currently two of the six RETAIN sites already use a digital image network (PACS) and three more sites have digital medical modalities available. Five of the six sites stated that the infrastructure required to take advantage of a teleradiological broadband conference service was *partially available* in their hospital today, one site assessed their infrastructure as adequate.

Four of five sites with partial availability of the necessary infrastructure estimated that adequate infrastructure will be available within 1–3 years, one site estimated 7–10 years.

A broad introduction of telemedical services will not only require a few hospitals to have an adequate infrastructure, but many. The question was put to the physicians in which time they expected 50% of the hospitals in their country to provide an appropriate infrastructure. The answers (which concern four different countries) show a significant variation, and for no single country a common position is visible. Figure 4-2 shows the answers, ranging from “4-6 years” up to “more than 10 years”.

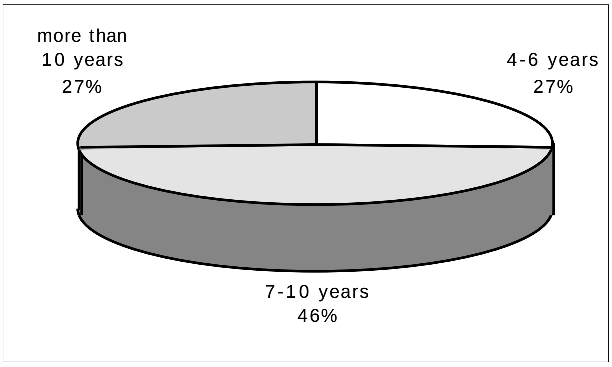
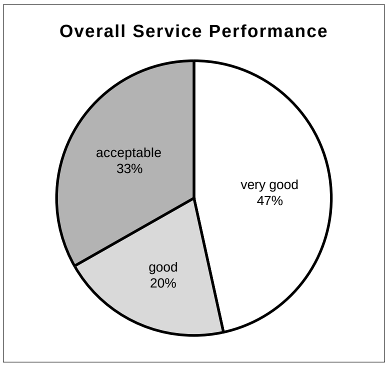


Figure 4-2: Appropriate Infrastructure in 50% of the Hospitals will be available in…

Although all physicians clearly expressed a *need for remote medical consultation*, the current level is rather low. The physicians estimated that they currently request remote advice (classical consultation e.g. by sending films) in 0–10 cases per month for one radiology or neurology department. The number of incoming advice requests is generally higher, ranging from 0–30 requests per month and department (average: 12.7). Most hospitals participating in RETAIN can be described as competence centres for their region or country, which explains why more incoming than outgoing advice request were stated. All physicians expect these figures to increase a bit or to increase much in the next five years (median: "increase much").

Another success criterion for a teleradiological broadband conference service is a good *performance of the system.* Only if users are satisfied with the system, it will be used on the long term. The RETAIN conference service was clearly in prototype stage and significant improvements in terms of stability, reliability and installation/maintenance procedures would be necessary for non-experimental usage. Nevertheless, the ratings for the overall performance of the system are quite impressive with two thirds of the users assessing the system as "good" or "very good", as displayed in Figure 4-3.



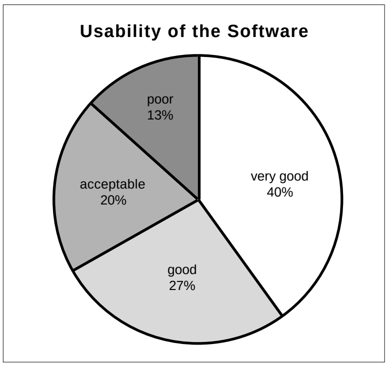


Figure 4-3: Ratings of the RETAIN Telemedicine System and the RETAIN Software

The usability of the software received a worse rating than the overall system. Partly this is due to the difficult start-up and maintenance procedures which reflect the experimental status of the software, but user comments also indicate that introduction to the system (training) could have been better:

- "One of the two users must be familiar with the software."
- "Overlapping windows are difficult to manage."

Figure 4-4 shows the user ratings for the video, audio and digital image quality. The rather poor ratings for audio quality are surprising – audio transmission used 44,100 16-bit samples per second which corresponds to compact disc audio quality. However, problems related to audio feedback were not uncommon during the trials and we also experienced problems with inoperational (damaged) audio subsystems in the audio/video codec. This confirms the evaluation of the second project phase in [Ret2-10] where we stated concerning audio subsystems with room microphone and loudspeakers:

Since this kind of installation is very susceptive for audio feedback problems (perceived as echo due to the long signal latency), the use of echo cancelling equipment is recommendable if this functionality is not offered by the video codec itself. Especially for international tele-radiology conferences where physicians use a foreign language and understanding the partner is more difficult anyway the influence of the audio system quality must not be underestimated.

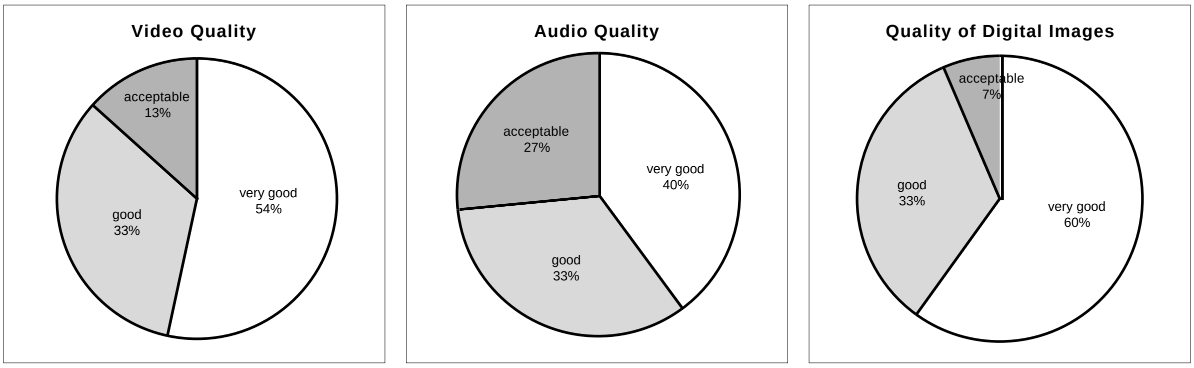


Figure 4-4: Ratings of Video, Audio and Image Quality

Finally, the user ratings for the quality of digital medical images are suprisingly good considering the fact that more than 50% of the images were scanned films (see section 3.2). It shows that scanning films carefully, although very time consuming (see section 3.2.2), has finally paid off in the resulting image quality. Summing up, the system performance was *"better than good for an experimental service"*, as one physician noted.

4.1.2 Increase of treatment quality

The potential of a teleradiological conference service is made plain by the fact that in at least 17 cases the case discussion during the RETAIN trials resulted in a changed diagnosis which either affected the patient treatment or (in teaching cases) would have affected it if the patient had still been in treatment.

There is no common ground on the question in which percentage of cases a change in diagnosis or treatment could be expected from teleradiological consultation if used on a regular basis. Figure 4-5 shows the estimations which range from 5 to 50%. [Pisa 95] reports that an experimental teleradiology consultation service in Italy, which carried out about 1000 sessions from 1987-89, resulted in a modification of the diagnosis in 31% of the cases, which shows that the estimations are not too bad.

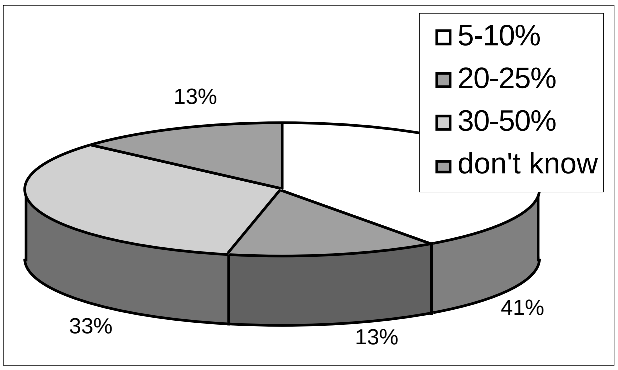


Figure 4-5: Expected Number of Cases with Changes in Diagnosis or Treatment

Independent from this figure, 14 of the 15 physicians who filled in the questionnaire expect an improvement or an important improvement in health care delivery for the patients from the introduction of telemedical services (median: "improvement").

Another aspect of increased treatment quality is the training effect often claimed for telemedicine (see section 1.3.4). We asked the physicians whether they had learned something new related to their medical skills (not technical skills) during the RETAIN trials and whether they expected that the other physicians had profited from their presentations as well. Figure 4-6 displays the replies which show that almost all physicians (93%) learned at least "a bit" during the trials. Most of them (80%) also believe that their conference partners profited from their presentations as well, although expectations are more modest than real experiences.

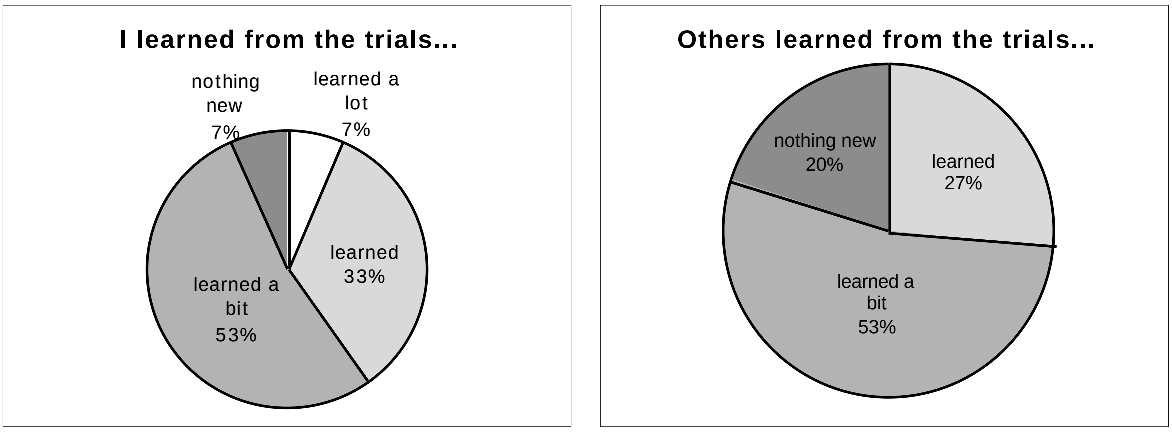


Figure 4-6: Medical Experience gained by the RETAIN Trials

These positive experiences are reflected in the assessments of the value of the teleradiological conference system as a means of diffusing and distributing expert knowledge. As Figure 4-7 shows, 87% of the physicians assessed the system as useful or very useful (median: "very useful").

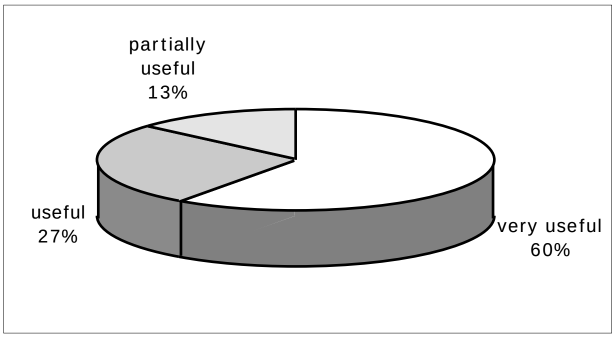


Figure 4-7: Value of the System for Distribution of Expert Knowledge

An important question is under which circumstances a teleradiological conference system might result in a *decrease* instead of increase in treatment quality for the patient. About 50% of the physicians never expected such a decrease because teleradiology system would always be complementary to the options available to physicians today. Some concerns on possible mis-uses of the system were stated, however, which can be summarised as follows:

- Overestimation of the "expert's" advice or a lack of clinical information given to the expert
- Inappropriate reaction to technical problems (waiting too long if the connection is "down" or using inadequately scanned films for diagnosis)

Many physicians pointed out the importance of complying to established standards of continuing medical education and professional skills in order to avoid such misuse.

4.1.3 Decrease of costs for patient transports and physician travel

It was beyond the limited scope of the RETAIN project to *prove* that the teleradiological conference service can decrease the number of unnecessary patient referrals (especially transports) and the physicians' travel times. This would require long-term statistical evaluation of a telemedicine system in operation. However, even the physicians expectations on how this service might influence transport and travel costs vary significantly, as Figure 4-8 shows. While there is no common position on the question how the total number of patient referrals to different hospitals may change (ratings from "increase a bit" to "decrease much", median value: "no change"), most physicians expect a decrease in the number of *unnecessary* patient referrals (median value: “decrease a bit”). Some physicians noted that the number of unnecessary patient referrals should not be overestimated: “The majority of patients is referred for good reasons”. Most physicians also expect a decrease in travel times for physicians (median value: “decrease a bit”), although estimations are “weaker” than for the reduction of patient referrals

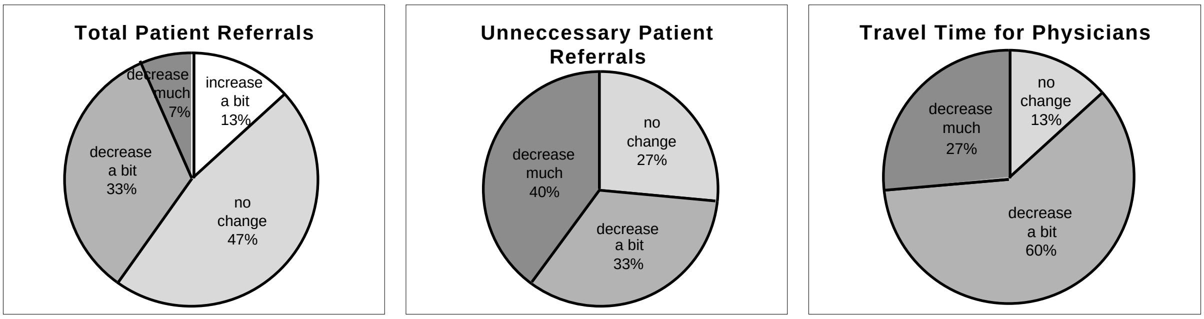


Figure 4-8: Expected Effects on Patient Referrals and Travel Time

In addition to cost savings from a reduction of patient referrals and physician travel, most physicians also expect other rationalisation savings. The following rationalisation potentials have been identified:

- avoidance of unnecessary double examinations
- cost savings in film, conventional mail/express service, telephone
- shorter hospitalisation time for patients (due to faster diagnoses)
- better utilisation of resources (e.g. expensive equipment)
- increased use of (inexpensive) interventional radiology instead of surgical treatment

The question where the use of telemedical services may save costs must be completed by the question in which situations the use of such services may lead to a cost increase. Some potential cost drivers have been identified by the physicians:

- in the start phase of a telemedical service, everything will be done twice (conventionally and digitally) for safety reasons
- increased labour costs for the physicians preparing the request and the consulted experts
- many advice request might be a waste of time
- physicians might be tempted to perform additional (unnecessary) examinations before consulting an expert in order to be prepared as good as possible.
- teleradiological consultation might lead to inappropriate activism (doing “something”, e.g. interventional radiology, where no appropriate treatment is possible anymore).

4.2 Narrowband access service

The narrowband access service should of course allow ISDN users to establish a connection to users of the ATM based conference service. Furthermore an acceptable video conference and a sufficient quality of medical images must be provided.

- *Allow users without ATM access to participate on the teleradiological broadband conference and consultation service:* This is mostly a technical question which has been solved, as section 2.1.4 shows. Although the solution used in RETAIN is far from being optimum, it can be implemented with “shrink-wrapped” standard hardware. On the long term, an ISDN dial-in facility for a widely used ATM based conference service would be a typical service provider business like the ISDN multi-point video conference switches offered as a commercial service today.
- *Retain medically acceptable image and sound quality despite bandwidth limitations:* An ISDN user must use his system with a significant lower bandwidth compared to ATM. Even with the “high-end” system used in RETAIN (12 ISDN B-channels used in parallel, 6 basic rate interfaces) the

available total bandwidth is only 4.1% of the bandwidth reserved for a connection over the JAMES network (25,000 ATM cells/s). Therefore, increased transmission times and a decrease in video and sound quality are inevitable. However, the system performance must still be acceptable for medical case discussion where a misunderstanding caused by the limitations of the technology may have disastrous consequences for the patient.

These issues are covered by 9 questions in section 3 of the "Service Adequacy Questionnaire".

4.2.1 Medically acceptable image and sound quality

The narrowband access service became operational rather late in the RETAIN trial phase. In this section, only the answers of the physicians who have actively worked with this service before answering the questionnaire have been considered.

The overall performance of the "RETAIN service" using ISDN dial-in was assessed as "acceptable" or "good", a rating slightly worse than the rating of the ATM based service (see Figure 4-3). The usability of the software was identical to the rating for the ATM based system. ISDN video quality was rated as "acceptable". The video quality offered by the 6 B-channel video codec was clearly sufficient for person-to-person video-conferencing (classical advice requests) and the double encoding and decoding of the audio and video signals did not significantly decrease image quality. ISDN audio quality was rated as "good" – the G.711 audio transmission was equivalent to an ISDN telephone connection. Obviously "CD audio quality" is not necessary for medical advice requests.

Transmission speed for digital medical images was rated "acceptable" to "poor". The transmission of 9.3 MByte of image data (the average per-case volume, see section 3.1.2) took four to five minutes (perceived TCP throughput: 38 kByte/s, see section 2.1.4). However, it was not possible to transmit large series of images during a consultation. The physicians noted: *"ISDN speed is acceptable when prefetching (transmission of image data in advance to the conference) is used"*.

No medical images have been transmitted over the ISDN "video channel" so that image quality was not affected by ISDN limitations. However, during the second RETAIN phase experiments with video transmission of medical images have been performed [Ret2-9], the results of which are also discussed in [Ret3-7].

4.3 Medical multi-media message and presentation service

A service for the off-line presentation of medical cases must allow its users to easily create such case presentations, to transmit them to an expert centre "with request for advice" and to perform an on-line conference based on the off-line presentation transmitted in advance.

- *Facilitate the off-line presentation of a patient case consisting of medical images, text, voice and related information:* In order to be successful, the service must offer the functional power required by its users: It must be possible to display medical images, change the contrast resolution ("window level and width"), emphasise regions of the image or point to certain details. It must also be possible to add plain text or spoken explanations to the "multi-media case presentation".
- *Support a variety of networks including Internet transmission:* Especially today where ATM connections must be pre-planned and requested days in advance, it makes sense to use a different technology for the offline transmission of case presentations, e.g. Internet e-mail. Besides technical aspects (the system must support TCP/IP) the use of a shared, open network like the Internet also raises questions on data protection aspects for which a satisfying solution must be found.
- *Support online consultation by allowing to transmit patient cases in advance to the conference:* Users will not be willing to prepare medical case presentations twice for offline presentation and online discussion. This means that an important success criterion is a seamless integration of the multi-media message service and the teleradiological conference system. It must be possible to use the data (e.g. images) from a case presentation which was received offline for an online consultation.

These issues are covered by 9 questions in section 4 of the "Service Adequacy Questionnaire".

4.3.1 Off-line presentation of a multi-media patient case

As pointed out in section 2.1.5, integration of the multimedia messaging application was not finished during the RETAIN trial phase so that physicians were not able to practically use this tool. Therefore, the adequacy of the functional power cannot be assessed.

4.3.2 Support for different networks including Internet

Conceptionally the Multimedia message tool is based on TCP/IP as a transport protocol. In addition to point-to-point connections (e.g. ATM, ISDN) this allows to use shared wide area networks like the Internet for transmission of medical data. We asked the physicians about the data protection techniques they would request for the use of this service over point-to-point connections compared to Internet transmission.

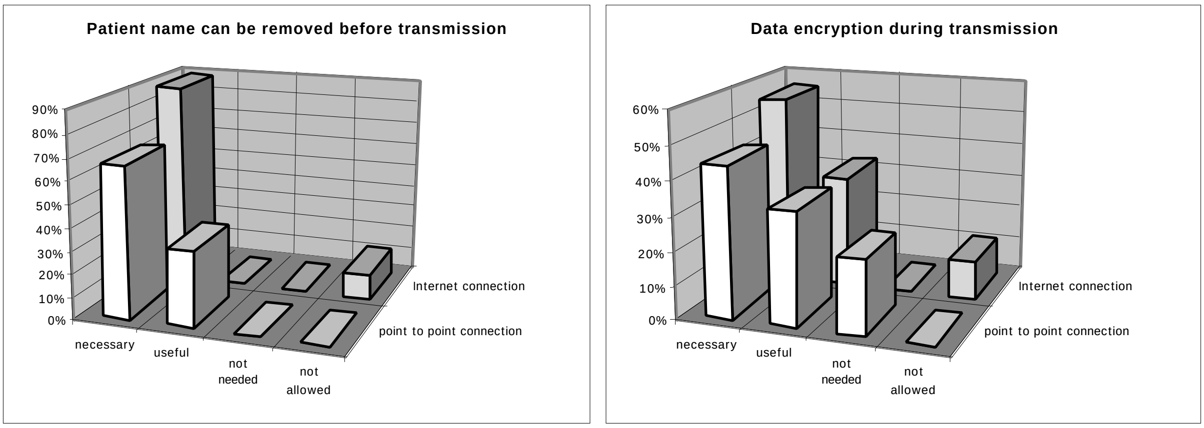


Figure 4-9: Data Security Requirements (1)

Figure 4-9 shows the importance ratings the physicians assigned to removal of patient name and demographics before data transmission and data encryption during transmission. Most physicians consider the possibility to make case presentations anonymous before transmission as absolutely necessary. Especially transmission over Internet (which is rejected by some physicians at all, reflected by the rating “not allowed”) requires anonymous data. Data encryption during transmission was also considered necessary or useful by most physicians. This is important because some European countries (e.g. France) restrict the use of encryption technology very much. Some physicians argue that encryption is not needed because anonymous data can hardly be abused.

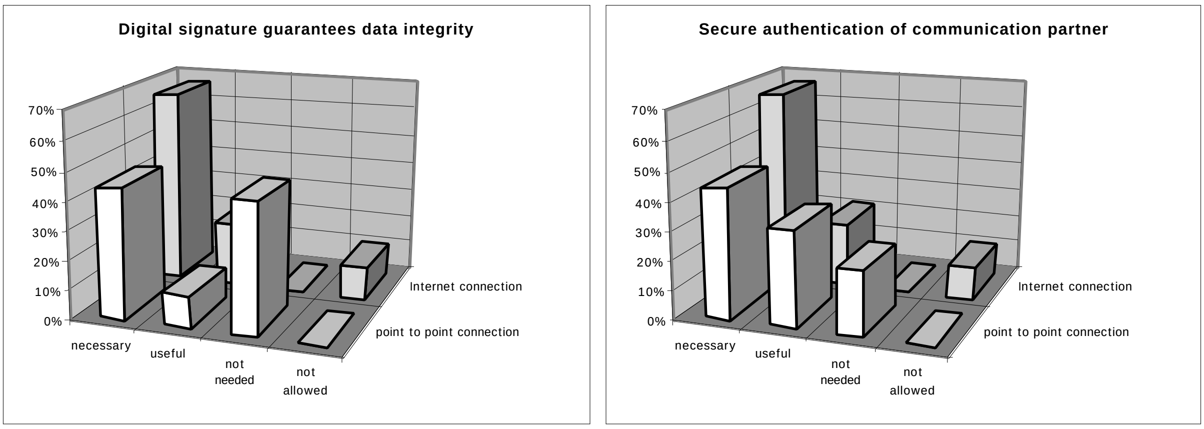


Figure 4-10: Data Security Requirements (2)

Figure 4-10 shows the requirements on digital signatures and secure authentication. Opinions vary on the question if point to point connections require additional digital signatures to avoid manipulation of data during transmission. However, most physicians would like data integrity to be guaranteed for Internet transmission. The same result applies to the question of a secure authentication of the communication partner (e.g. by means of chipcards). Physicians who believe that digital signature and secure authentication of the communication partner are not needed in point to point connections trust in the security provided by the user connection setup ("dialling").

4.3.3 Transmission of patient cases in advance to online conferences

A multimedia message service could be seen as an enhancement of online telemedical conferencing services or as an alternative service *replacing* online conferencing. We asked the physicians how they would assess the value of such a service as an enhancement or as a replacement for an online conference service. Figure 4-11 shows the results. Most physicians considered a means for "offline" consultation as a useful or very useful enhancement of online conferencing because it facilitates preparation to the online consultation and allows physicians to schedule their time more freely. The availability of multimedia messaging without online conferencing (e.g. only completed by telephone) was still rated as useful by two thirds of the physicians, but the ratings are clearly worse. However, especially in narrowband environments where transmission times are significantly larger than in broadband environments, multimedia messaging might still be a very good alternative to conventional consultation via mail and telephone.

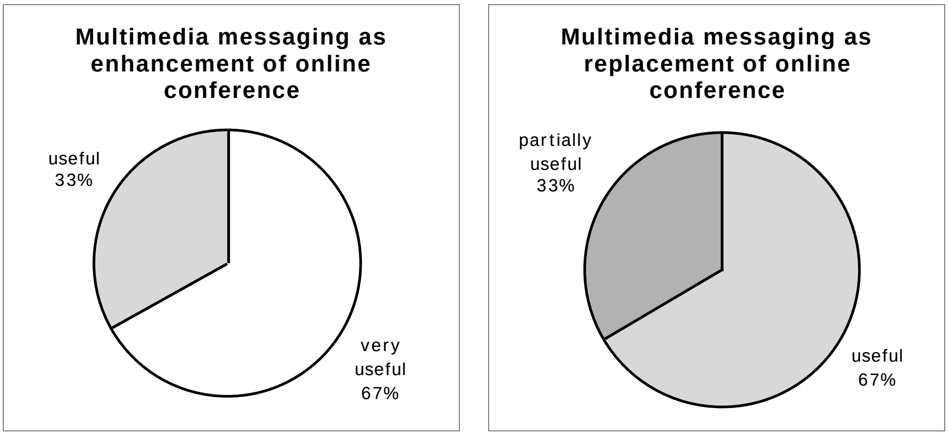


Figure 4-11: Multimedia Mail as Enhancement or Replacement of Online Conferencing

5 RESULTS – CIG POINT OF VIEW

The RETAIN consortium reflects the "common interest group" for applications in telemedicine: Hospitals (Vall d'Hebron Barcelona, RLHK Düsseldorf and Lariboisière Paris) are represented in the consortium as well as researchers in medical information systems and communications technology (CERIUM Rennes, OFFIS Oldenburg, CCG Coimbra). The participation of communications systems industry (THOMSON Broadcast Systems, OST/AQL and SYSECA) and manufacturers of medical imaging devices and workstations (PHILIPS Systemas Medicos and GE Medical Systems) completes the picture.
The following statements from the project partners describe their expectations and results from the RETAIN project as well as the possible influence these experiences may have on further activities.

5.1 CERIUM, Rennes (F)

Statement from Didier Lemoine, researcher at CERIUM, Rennes.

The CERIUM has always focused its activities in the intersection between the clinical world, the medical imaging research area and the industrial world. The RETAIN project, initiated by the CERIUM was naturally of great interest because the needs to facilitate the communication between physicians were clearly identified in the medical community, ATM, a new promising broadband telecommunication technology was emerging while new N-ISDN teleradiology commercial services had already shown some limits. The global objectives of the RETAIN project globally match those of CERIUM; if the previous phase of this project has already shown the interest of possible teleradiology services based upon B-ISDN technologies, the advent of such a new market requires far more specifications in terms of medical needs and in terms of services network operators may propose. Financial aspects must not be neglected and simulations must be confronted to trials. RETAIN has helped CERIUM to increase its expertise by yielding some pieces of response to these issues, even partial. This expertise may contribute to develop some collaboration with companies involved in medical imaging or in telecommunications sectors. Moreover, the Rennes hospital site (as well as other RETAIN sites) may be considered as a good candidate to participate to new R&D projects, at the National as well as the European level.

5.2 CHRU Pontchaillou, Rennes (F)

Statement from Dr Jean-François Héautot, Radiologist at CHRU Pontchaillou, Rennes.

- *Expectations:* Retain 3 was expected to give us a confirmation of what Retain 2 had foreseen [Heau 96:]
  - the feasibility of a European teleradiology network linking specialised medical centres.
  - the utility of meetings on a regular basis between medical teams through a video conferencing network.
  - .he usability of the software on a larger scale.
  - the value of the system as a means of knowledge diffusion.
- *Results:* The network is still experimental. The bad communication between European network operators is still a source of problems in spite of their claiming that they are on the fast lane of the "information highway".

  Good relationships are easy to establish between teams. ATM is a tremendous tool to get people speaking to each other. It is exactly as if the partner was in the same room. We have been most of the time in relation with Paris or Barcelona. Real ties have been established. It is absolutely obvious that really objective consequences in terms of patient care would have resulted of the sessions if we had been in a more natural context, with our usual correspondents. Even though, the sessions have proven to be efficacious.

  The ten-day digital storage in Rennes is the major improvement in Rennes. The preparation of session is not a burden any more. It is just a matter of a mouse click now. In my opinion, this is the most important result. The service will be 100% used only in a full digital environment.

  The value of the service as a knowledge diffusion is obvious. Something must be found to use it as an accredited means of continued education.

  In another field, it is important to find a way to better protect the anonymity of the patients. Changing names can be confusing for the user, but the provider does not care. It will make demonstrations and dissemination easier, too.

  The radiology community seems more mature than two years ago. The popularity of Internet is probably one of the reasons. We do not see any more amused smiles when we speak about the interest of videoconference. Yet, the refusal of the Retain 2 related papers at the RSNA is surprising. Hopefully we will be luckier this year.
- *Exploitation:* A paper will be submitted to the RSNA and French Society of Radiology meetings, as well as a written paper to Radiology.

  The results of the evaluation (deliverables) will be used to support a suel to the French project Immediat (ATM used on a regional basis in Brittany for neurosurgery emergencies). The development of a regional broadband service is foreseen. Health and education seems to be the most natural applications of the service.

  An advisory board of telemedicine is being set up by the French ministry of health. The head of Rennes neurosurgery department is a member of it. Rennes and Paris are the only places in France where ATM has been tested for teleradiology. Thus, the guidelines will be disseminated "at the top".

5.3 OFFIS, Oldenburg (D)

Statement from Prof. Peter Jensch, member of the Board of Directors, OFFIS, Oldenburg

- *Expectations:* All sites of the clinical partners had prior experiences with local PACS (Picture Archiving and Communicating Systems) and two partners also had video-conference experiences. The physicians participating in RETAIN expected to get in touch with remote sites. Our *technical* interest was to examine whether it would be possible
  - t1) to use full digital communication, i.e. to connect the departmental LAN set-ups with ATM wide area links, especially to connect a CT during specific times to ATM equipment in such a way;
    that digital images are available for conference purposes without telemedicine interfering with the normal departmental routine;
    that all technical interfaces starting at medical devices (CT, PACS etc.) and ending at the ATM line connectors fit together and are manageable by the technical staff
  - t2) to integrate video-conference equipment with digital imaging
  - t3) to get an assessment of the technical complexity of the combination of digital and video conference means: What is necessary (in staff quantity and quality, investment) to support, maintain or to manage the technical equipment
  - t4) what technical alternatives have to be available in the case of malfunctions of the telecommunications system.

  In addition to their technical content, all these aspects also concern *usability.* RETAIN promised to offer high quality consultation with remote experts. We were interested to examine questions related to system usability:
  - u1) What is the value of a second opinion from the view of a medical school and a regional hospital?
  - u2) What is the impact of such technology on the clinical routine?
  - u3) What is the influence regarding the profile and the workflow of a radiology department?
  - u4) How can conventional (film based) radiology be integrated in remote consultations?

- *Results:* Regarding the expectations the experiments resulted in the following "learned lessons":
  - t1) It was hard to integrate all technical system components. Main problems arose in the use of the interfaces of different system components. In hospitals it is still common that even the simplest connectors do not fit together. Furthermore cable routing in the building is problematical. In both cases special agreements between the hospital management, hospital technical maintenance staff, the (mostly manufacturer based) technical equipment maintenance staff and Deutsche Telekom were necessary. These agreements turned out to be very time consuming (in negotiation) and legally complex in the sense that especially modifications in the maintenance schedule and tasks (for the clinical routines) needed written agreements. We clearly see a need for a standardised (in-house) policies in hospitals on how to cope with computers and telecommunications networks. This could be supplied by special staff (at large hospitals) or by specialised service centres (for small hospitals)
  - t2) Video-conferencing via ATM was technically complex because the system components were laboratory samples. Also the integration of ATM equipment into the existing video-conference set-ups was not trivial in the sense that switching between different video sources (cameras for microscope, x-ray, patient) and video monitors was only possible in a way acceptable to the users after very intensive training of physicians and technical staff. The audio adjustments proved to be very delicate and also accounted as a source for most system malfunctions. For future systems, we see a need for a standardised (computer controllable) video-switch board and a practical free speech system.
  - t3) The integration of digital conferencing and video-conferencing was only possible in the presence of technical people acquainted and trained with the set-ups who were able to overlook all data paths from image sources via the communications means down to the "image

sink". Needed: Further training of physicians (background in telecommunications and information management)

t4) Malfunctions of different set-ups were not uncommon. Alternatives for most technical parts of the system were carefully planned and available mostly via ISDN links. The handling of malfunctions was only possible for qualified persons. Future systems will require improved technical stability and better training of the hospital's technical staff.

Results concerning usability aspects are:

u1) During the experiments it turned out that the value of a second opinion is very important. Medical schools get in touch with daily cases and regional hospitals get a feeling which expert is appropriate for a special (complex) case. More important than the a second opinion is the instantaneous assistance by another physicians in acute situations or during off-duty periods.

u2) The adjustment of the different time schedules is problematic. There is a trade-off between the number of cases and the availability of communicating partners (experts).

u3) A profile shift will happen. Available (hidden) expertise in a department will become obvious to others and will be demanded from others (with all positive and negative side effects). Profile changes will affect the whole workflow of the department, down to the nurses and orderlies. Adequate training of the departmental staff is still a problem.

u4) It turned out during the trials that the use of conventional x-rays is an unsolved issue because high quality film scanners are quire expensive, and not available in most hospitals. In contrast, several hospitals of the RETAIN consortium have already decided to invest in computed radiography (digital radiographs) in the future and internal planning is already directed to this aim.

In addition to these results, there were also some "lessons learned" we had not expected in advance to the project:

- *Pros:* The physicians got a feeling on bandwidths and learned to discuss bandwidth as an economical issue, i.e. not all cases need a high bandwidth. Of interest is a guarantee of a specific bandwidth/performance. Physicians are willing to "map" clinical scenarios to a variety of bandwidths.
- *Cons:* The (current) pre-planing of connections by the telecoms with an uncertain guarantee of link qualities is inappropriate for medical applications. Reliability and availability are questionable today, but must be improved for clinical use.

  Currently, economical issues do not fit in the - legally enforced - management of budgets. The main reason for a negative assessment is the situation that the advantages of telecommunications are related to other departments than radiology, but these are not forced to pay for the expenses. This will change in the future.

- *Exploitation:* RETAIN gave a more precise view of telecommunications possibilities to the physicians and the administration of the hospitals than existed before. Clinicians and Managers are willing to define clinical activities for various bandwidths, including ISDN (128 kBit/s – 2 MBit/s), SMDS and ATM.

  As a clear result of RETAIN, regional areas of interests are currently being formed. In the Weser-Ems region in the north-west of Germany, special interest groups with medical leaders are being set-up for Radiology, Cardiology and Neuro-radiology in order to implement new application areas such as

  - collaboration of radiologists (in order to optimise personal resources, e.g. on-call services during night hours and week-ends)
  - regional competence centres (focused on specialists, spatially distributed)
  - new types of data exchange (electronic transmission of medical multimedia data)

  Despite the - currently - unsolved question of cost reimbursement, collaboration between radiologists for selected services was started and is already in experimental use via ISDN. The chosen services are open for broadband communication. Furthermore there is a common understanding of different types of services for future use in communication, especially to bridge inpatient and outpatient care. The rationale behind this is an augmentation of the day-clinic concept.

5.4 Hospital Universitari Materno-Infantil Vall d'Hebron, Barcelona (E)

Statement from Dr Joaquim Piqueras, radiologist and PACS manager at Hospital Materno-Infantil Vall d'Hebron, Barcelona.

- *Expectations:* We expected to learn from real and direct experience on teleworking applied to radiology, with the following main emphasis:
  - Feasibility of the whole concept of "Teleworking in radiology"
  - Technical challenges: Connection to local modalities and the public network.
  - User workplace: Installation planning, organisation of the workspace, additional tools and sources of information needed by experts.
  - User Interaction: User interface, transmission procedures (real-time transmission, mailbox transmission), Value of synchronisation tools.
  - Modifications

  Furthermore we expected to learn on ATM implementation in Radiology:
  - ATM potential for multimedia communications
  - ATM potential for PACS and information systems backbone
- *Results:*
  - ATM Teleradiology is technologically feasible: many examinations have been transmitted and discussed. The RETAIN workstation provides a good replacement for lightboxes allowing productive teleworking. Technical problems encountered should be considered temporary.
  - Teleradiology among users from different medical cultures is feasible and videoconference is a great help. Many other medical users may use a RETAIN or RETAIN-like workstation for cooperative work.
  - Teleradiology is not a completely new product service but a way to deliver reporting and consulting expertise. The cost of the reporting -expertise- is only an small part of the examination cost. It should compete with proved traditional methods.
  - Teleradiology provides its benefits to clinical end-users: The requesting physician and/or patient, and much less to involved radiologists. Following the financial health organisation in Spain, Teleradiology should be paid by framework contracts between institutions, departments, or by the patient. ATM costs should be paid by the patient or shared among different groups of users.
  - Different service products may require different network services and costs. n-ISDN has a role for many applications where ATM is not available or when cost or low volume of data should be considered.
- *Exploitation:* We cannot consider commercial exploitation of the system in our institution on the short term. The current Spanish medical reimbursement policies does not have a budget for additional consultation expenses to run a commercial teleradiology service on public or private institutions. ISDN is just introduced in Spain.

  On the mid-term, ATM networks will be used to connect satellite institutions, always depending on the same final budget, both by public health system networks and by private insurance companies networks. In a managed care environment, costs for teleconsultation will be a part of integral population care.

5.5 CCG, Coimbra (P)

Statement from Carlos Martins, researcher at CCG Coimbra.

- *Expectations:* RETAIN 3 as initially planned was supposed to provide a wide range of trials in order to be able to evaluate the technical aspects and the end-user reactions on the offered service. My expectation was that it would be possible to use the first trials to correct and improve any technical problems so that during a second phase it would have been possible to evaluate the regular

use of the service by physicians.
The used bandwidth and high quality of videophony would have been the big advantage in relation to other systems (e.g. based on ISDN) since they should provide means and tools for the fast exchange of data and experience.

- *Results:* The major issue is the not-readiness of cross-country ATM network in Europe. It was quite clear that there must be a big effort (political and technical) by the telecommunication providers in order to make this service "usable" in a commercial way.
  The few trials that succeeded have shown that the users consider them as good professional tools and react very positive to the whole set-up.
  It is possible to conclude that once the ATM service works there will be a real possibility for the regular use of teleworking systems in this area.
- *Exploitation:* The CCG has a high interest in the teleworking technology applied to the medical area. The RETAIN project has given us experience and knowledge that will be applied in future projects in this area.
  The CCG participates in other ongoing projects that involve teleconferencing tools and some ideas and results of RETAIN might be used for solving similar questions in these projects. Besides this we are also committed to participate in new projects that address the medical telematics area and think that for this purpose the experiences gained in RETAIN will be very useful.

5.6 Rheinische Landes- und Hochschulklinik Düsseldorf (D)

Statement from Dr F.-J. Schuier, head of the department of Neurology.

- *Expectations:* We expected a reasonably fast and easy to use software for teleconsultation to solve difficult cases by the support of specialists (i.p. with questions of e.g. difficult seizure cases). Also a high speed of image transfer and pointer sharing was expected. No expectations with regard to technical aspects since we had no idea on the underlying technology and its problems.
- *Results:* The RETAIN software was very easy to use and to comprehend after short introduction; the excellent technical support by the OFFIS and CERIUM groups was astonishing (I mean what I wrote). I was surprised by the fast fixes of problems with ftp-changes "on the fly" provided by OFFIS and I was equally surprised about the performance of the ISDN-ATM hybrid CERIUM had provided for the last session. I was equally but negatively impressed by the technical problems of the lines! As much as the performance of RETAIN even with the ISDN (6 lines) bottleneck was convincing, as much were problems with time wasting due to line-problems unconvincing.
- *Exploitation:* I would like to use the RETAIN software with ISDN lines. If ATM would become reliably available, the pricing would be decisive for its' use in clinical medicine. Only if the price is slightly above ISDN I would consider it acceptable for clinical directors and administrators. In a project paying the line costs I would like to use and invest time, since being connected to expert centres with such a tool would greatly enhance the capacities of my department.

5.7 Université de Paris VII, AP/HP Lariboisière (F)

Statement from Dr Jean-Pierre Guichard, Neuro-radiologist at Lariboisière.

- *Expectations:* We expected a simple application, with tele-cursor and the ability of zooming, drawing and windowing. It is interesting to communicate with different teams, to acquire some new experience. To "open a window" on a different point of view. One more important thing for us is to participate in a European project.
- *Results:* The software is easy to use. Technical support of the CERIUM, OFFIS in Germany and CCG in Portugal was helpful. The start-up of the session is difficult with the management of the different European network providers. Europe is building! An interesting finding is that we can have more profitable exchange with a distant practitioner who sometimes does not speak the same language than with a practitioner in our own hospital. We have seen a lot of interesting cases and we hope we have shown some interesting cases, too. During these 5 to 6 months the session was a weekly expected habit and now "something is missing".

- *Exploitation:* We have another, different experience of telemedicine for Paris and its suburbs. This is the ISDN network for the neurosurgery urgency. This system is less sophisticated and less attractive than the RETAIN project. If ATM is cheaper it could be very pleasant to use.

5.8 Ouest Standard Telematique / Alliance Qualite Logiciel (F)

Statement from Danièle Cloâtre, engineer at AQL.

- *Expectations:* Three main points motivated OST/AQL to collaborate in the RETAIN-3 project:
  - to improve our knowledge and technical expertise on new technologies in the frame of a wide area project like RETAIN using an ATM network,
  - to derive practical recommendations for the use and design of ATM equipment,
  - to get a better knowledge of European ATM network services evolution and to be aware of what kind of application may use it.
- *Results:*
  1. ATM Integration:
     One of the main jobs for OST/AQL in this project was to contribute to the integration of teleradiology software over an ATM network. RETAIN gave us the opportunity to study the market of AAL5 boards which is growing significantly compared to last year (second RETAIN phase).
     It turns out that AAL5 board manufacturers are still more concerned with integrating ATM service to a LAN area context rather than to a WAN one. Most of them provide interoperability between ATM and existing networks such as Ethernet, as well as standard protocols like TCP/IP. Moreover, most of the boards drivers include different ATM standardisations (Classical IP, LAN Emulation, UNI 3.1) for different platforms (Unix or Windows, SBUS, PCI or EISA bus).
     As long as the teleradiology software was already using TCP/IP protocol, we had no problem in finding an AAL5 board that includes an Classical IP protocol module. But only two AAL5 boards matching the other RETAIN constraints and actual European WAN ATM network service (use of multiple VPs with a VP number different from 0) were found. We used the same model on all the sites (Zeitnet). On the other hand, we did not have to adapt the software to RETAIN needs like we did last year,.
     Finally, RETAIN tests have shown that using a LAN application on a WAN network is not straightforward: complex protocol stacks or inadapted MTU sizes may affect performance of data exchange and could result in bandwidth saturation and ATM cell loss. If time and budget were available, complementary actions could have been useful for better failure investigations:
     - conduct local ATM tests for multiple connections (with a local ATM switch available),
     - purchase AAL5 API software (this API software was not available at the time of the RETAIN project but announced: WinSock 2 API conforming to ATM Forum specifications) with the board to act more specifically at the AAL5 level (dynamic VP/VC bandwidth or MTU size changes, accurate statistics, ...),
     - purchase ATM tools like an analyser to measure accurately ATM cells loss and actual bandwidth used.
  2. European ATM Network
     - *ATM service provided:* As long as OST/AQL was responsible for all contacts with the Public Network Operators, this brought a good vision of ATM service provided by the European operators and how this service has been developing for the last year (second RETAIN part). Concerning the ATM network service, it was still a VP service kind with all the inconvenience of static allocations and the risks of potential errors at the PNOs or final user level. On each RETAIN site we tried to decrease this probability of allocation error by using an automatic configuration of the audio/video terminal adaptor VP/VC numbers for all point to point or point to multipoint connections. Moreover, we always tried to use the same VP number for the TCP/IP data flow between two sites when setting up the AAL5 board. Nevertheless, several sessions failed due to static VP allocations at the PNOs or RETAIN sites

level. ATM signalling could certainly improve connections process with expected quality of service.

– *PNO involvement and coordination:* We also noticed a better involvement of the PNOs and their wishes to consider the ATM WAN service as a pre-commercial one. All along the project, they improved their ATM service by offering a better technical support. RETAIN offered us the opportunity to test ATM connections between six countries (Germany, Spain, Portugal, Great Britain, Belgium and France). This third phase of RETAIN always proved that multipoint connections worked.
  However, some coordination problems still exist between the different PNOs (European procedures are not always efficient or respected, Bandwidth or VP number allocations required are not always respected). Moreover, different ATM costs always exist from one country to another. This seems to show that the PNOs does not attach the same importance to this new generation of broadband network (especially in Germany).

- *Exploitation:* OST/AQL are extremely concerned with the ATM technology evolution as one of our main activity is Networking (at a software or hardware level). Moreover, we closely work with telecommunications research centres (CCETT in Rennes, CNET in Lannion) which initiated ATM technology. RETAIN, where medical users were deeply involved, is a good way to get real feedback about real user requirements and to orient our personal developments suitable to these needs. RETAIN results also enforced our ATM expertise that will help us to contribute to future national or international projects related to other WAN multimedia applications.

5.9 Syseca (F)

Statement from Alain A. B. Bloyet, SYSECA Rennes.

For SYSECA Rennes, the RETAIN project framework has been a preliminary contact with an application in the medical field. From this point of view, our participation in the project has been very fruitful. Through the realisation of the terminal adaptor control panel we have increased our knowledge in ATM. We have used again this preliminary experience in telemedicine in order to lead to success a project in this field that has been qualified *“information highway experiment”* by the Ministry of Industry.

5.10 GE Medical Systems Europe (F)

Statement from Dessislava Ganeva, Bruno Klipfel and Laurent de Chevron Villette, GE Medical Systems Europe

- *Results:* The RETAIN project covers very large aspects of teleradiology going from technical points of the ATM network, passing through clinician's behaviour using the teleradiology application and the legal issues that such applications could involve. RETAIN helped us clarifying the following topics:
  – The possibility to use the ATM technology for teleradiology
  – The tree channels - data, video, audio - are clearly separated and every one of them could be added or removed depending on user's need
  – There are two types of applications that need different types of networks. The synchronous applications, or the “live” teleradiology, need network supporting mechanisms for synchronisation. And the asynchronous applications, like the “multimedia mail” ARRA, that could use any network.
  – The teleradiology opens legal, organisational and cost questions: how a specialist is reached to participate to a session of teleradiology, how is he paid, who takes the responsibility for the diagnosis etc.
- *Exploitation:* The project clearly showed the technical feasibility of the teleradiology applications over high speed networks. Various applications can be considered, synchronous vs. asynchronous, video channel available or not, leading to development of highly *configurable* products matching specific user needs and environments.

However, there are still aspects of the teleradiology that need to be evaluated prior to considering any product development. We are interested in the final evaluation ***of clinical needs and the costs*** of the solution. It is why we are looking forward the final evaluation of the RETAIN project.

6 REGULATORYENVIRONMENT FOR TELEMEDICINE IN EUROPE

Any application of telemedical services in Europe is subject to national health care legislation, both in terms the of the legal and financial framework of health care delivery. It is beyond the scope of this analysis to describe the regulatory environment in which telemedicine has to be performed for all European countries. Therefore, Germany, France and Portugal as countries in which RETAIN trials were carried out, have been selected as examples on how different – and complex – such environments can be.

6.1 The Health Care System in Germany

In Germany the district and metropolitan governments must guarantee health care delivery for the population. The compulsory of health insurance depends on the level of income. If income is below a certain threshold people have to be insured with the public health insurance companies, otherwise one can opt for a private insurance company, but he needs no insurance. The public health insurance scheme covers the insured person and his/her close relatives. The health insurance fees depend on the level of income. Private health insurance companies insure individuals and provide tailor-made insurance policies containing a required minimum coverage. Insurance contributions are paid half each by the employer and the employee. Employees' contributions are automatically drawn from their income. A new care insurance was introduced in 1994, in order to create sufficient funds to guarantee the nursing of long-term ill people.

In comparison with other countries the inpatient care of German citizens in hospitals is of a high standard. But since 1980 the costs of health care services increase continuously. Especially the costs of the inpatient services increase faster than of the outpatient services. The most important reasons for the increasing costs are the demographic development, the progress of technology and the payment system for health care services.

The demographic development means that the number of older people grows more than the rest of the population. The growing degeneracy causes more expenditure of nursing care, longer duration of stay in hospital and therefore more costs for one patient. Because of a lack of outpatient care and home care older people get more frequent inpatient care in hospital. But this is not the main reason for the expenditure.

The costs for new and better technology increased. The total amount of technical medical equipment for the whole country in a year is 3 to 4 thousand millions German Marks. If the costs of “middle” and “little” technical equipment are added to the total, it can also not be the reason for the expenditure, because the total costs for hospitals was 96 thousand million of German marks.

The main reason why costs of health care services increase continuously is the payment system of health care services. In the past there was no transparency between services and costs. The hospitals had no reason to work economically.[Pfa 95]

In 1993 the GSG (Gesundheitsstrukturgesetz - health care structure law) was a start to solve the problem. It serves as a basis to turn hospitals into economic enterprises. The law is introduced step by step because the health care system is a very sensible system and obviously, it would be likely to cause a crisis if the health care system collapsed. In the following sections the health care system before 1993, the transitional phase and the present of the health care system in Germany is explained. The following sections only take the role of public health insurances into account.

6.1.1 The Health Care System before 1993

Before the 1. January 1993 the costs of health care services in hospitals were normally paid by the health care insurances (e.g. per quarter). Health care insurances did not have to pay if it could be proven that the hospital did not work economically. But this was nearly impossible to prove, because there was no transparency between real performed services and charged services.

Hospitals did not have to care about the stability of the insurance fees. They acted according to the principle of covering their costs. So, more costs had to be covered by the policy holders in form of higher insurance fees. On the basis of the payment system for charging services the hospital had no incentive to work more economically than they had to do.
Until 1993 the hospitals had a dual financing system charging. Investment costs and other costs (e.g. personnel costs) were separately charged. Investments and support funds have to be made available by the federal state government and the communal corporation of the region. The granted funds for acquisition, development and lease costs of hospital buildings have to be raised from the federal state and the communal corporation of the region as well. The fund level depends on the total population. The investment program is prepared by the minister of social affairs and then decided by the cabinet. Some hospitals are supported by charitable institutions and churches. The acquisition, use or joint use of medical technical equipment was coordinated between the local administrative body, the persons concerned and the “Kassenärztlichen Vereinigung” of the country (regional general practitioners organisation). If new equipment was not planned for a hospital they might appeal for charity help. Costs of medical services are paid by the insurance contribution.[KGH 86]
Personnel costs of nurses et al. are paid on the basis of the statutory salary scale.

6.1.2 The Transitional Phase

Between 1993 and 1995 a fixed budget depending on the budget of 1992 was introduced for hospitals. The stability of insurance fee was guaranteed by the law. In this phase the cost controlling in hospitals is pushed into the background. The organisation of the hospital was adapted on a fixed financial plan. They have to balance revenues which are below or beyond their fixed budget.[Pro 96]
Now the health care system puts emphasis on saving costs by coordination of inpatient and outpatient services. And for this reason it was facilitated by the GSG to perform outpatient operation and pre- and post- hospitalisation treatment. The hospitals have to save the costs by reducing inpatient nursing care.

6.1.3 The Present Situation

The planned health care services of a hospital and their costs must be calculated in advance and be inspected by the internal controlling. In 1996 hospitals have a budget depending on the real performed services of the year before (1995) with a percentage increase which depends on the statutory salary scale.
In the year 1996 a new payment system was introduced. The payments for the services can be divided into different cases:

- “Fallpauschalen” (FP), which are flat rates for the charging of all services for certain cases or procedures
- “Sonderentgelte” (SE), which are special rates for the charging of a part of services (e.g. special operations), which have to combined with the “Fallpauschalen”
- “Abteilungspflegesätze” (department care fares), which are for the charging of the medical and nursing services (e.g. in the case of confinement to bed) of a department
- “Basispflegesatz” (base care fares), which are for the charging of other services than the medical and nursing services (e.g. hotel costs)
- “vor- und nachstationäre Behandlung” (pre- and post- hospitalisation treatment)
- “ambulante Operation” (outpatient operation)

FP and SE have fixed tariffs for every kind of service and are defined in the “BGBl” (Bundesgesetzblatt - Federal Law Gazette). There are relations between FP, SE, the International Statistical Classification of Diseases, Injuries, and Causes of Death (ICD) and the International Classification of Procedures of Medicine (ICPM). Figure 6-1 illustrates one example of the FP 2.02 for an operation of endocrine glants in a main department. It does not cover the medical treatment of a general practitioner, who also looks after a certain number of patients in a hospital.

FP-No.	Definition of FP		ICD-9	ICPM	tariffs for FP			upper limit of days to stay in hospital	tariffs for the part of basis services			stay in hospital (days)
					tariff for personnel	tariff for material	total	(Grenz-verweil-dauer)	tariff for personnel	tariff for material	total	(Verweil-dauer)
2.02	Stru-ma	subtotal thyroid gland re-section on both sides	240, 241, 242.0 to .3	5-062.3 to .5	3,190	1,290	**4,480**	16	470	480	950	7.82

Figure 6-1: FP 2.02 (Group 2: Operations of Endocrine Glands) [Die 96]

The FP-Number 2.02 has a relation to the ICD-9-Numbers 240, 241, 242.0 to .3. These ICD-9-Numbers are the classifications of “Struma”. They have a relation to the ICPM-Number 5-062.2. This ICPM-Number is the classification of the treatment of “Struma”. The FP 2.02 defines a total of 4.480 tariff points.

The different states of the Federal Republic of Germany can pay different values for one point. The value depends on the mean average of a model hospital that works economically. Today in Lower Saxony the value of one point is 1.06 German Marks. This means a hospital can charge 4748.80 German Marks for a subtotal thyroid gland resection on both sides. Personnel and medicine costs are included. The value of one point can increase or decrease depending on a change of the basic conditions.

The FP is used for the charging of a complete treatment of a case. It defines services in accordance with the ICD and the ICPM. A precondition is that the upper limit of days to stay in hospital are not exceeded.

This upper limit of days to stay in hospital was defined to reduce costs. In the past patients are kept in hospitals as long as it was justifiable. The daily nursing fee of a patient in an intensive care unit is the same as the daily nursing fee of a patient who is just before the discharge. This phenomenon causes avoidable costs of thousand millions. For this reason patients which have to stay longer in bed than the upper limit of days are charged by the department care fares and the base care fares.[Pfa 95]

Normally only FEs have to be paid. But if additional services, which are not covered in the FP, have to be done, a further SE can be charged. SE's can be operations, methods of treatment or diagnostic methods. Figure 6-2 shows the SE 2.03 which can be an additional operation to the FP 2.02.

SE-No.	Definition of SE	ICD-9	ICPM	tariffs for SE		
				tariff for personnel	tariff for materia l	total
2.03	removing of a malignant growth of the thyroid gland surgically, ...		5-061.1, .2; 5-062.6; ...	1,560	630	**2,220**

Figure 6-2: SE 2.03 (group 2: operations of endocrine glands) [Die 96]

Additional charges of SEs are possible if:

- the operation is an operation of another area (The definition of other area is ambiguous) during the same or another operation
- it is a relapsed operation
- the diagnostic or therapeutical services can not be charged by a FP

- the patient is a haemophiliac.

If a patient needs more than one service at a time, the main service and additional services have to be defined. In many cases there is more than one possible combination of FP and SE. It is also possible that a patient is treated by different physicians of different hospitals. One FP can only be paid once. Then the hospitals have to agree about the charge. If the services can be paid by FP and an additional SE, the hospitals have to agree which one uses the FP and which one the SE. This is very difficult to decide because in many cases there is more than one combination who can charge the FP and who the SE.[Krö 96]

The revenues which are below or beyond the fixed budget (of SE/FP and of department and base care fares; not of pre- and post- hospitalisation treatment and outpatient operation) have to be balanced. In the year 1996 the revenue below and beyond the fixed budget of FPs and SEs must be paid back by 50 per cent. The revenues below and beyond the fixed budget of department and base care fares have to be balanced by 75 per cent. If the budget is still beyond the fixed budget after this procedure, it has to be balanced again.

For example: The fixed budget of the FP/SE is 20 and of department and base care fares is 80. The total is 100. The actual receipt of the FP/SE is 15 and of department and base care fares is 85 (total = 100). 50 per cent of the additional FP/SE have to be balanced. In this case it is 2.5 for FP/SE. 75 per cent of the additional department and base care fares have to be paid back. In this case it is -3,75 for the department and base care fares. After the balance procedure the hospital gets a budget of 98.75 (15 + 2.5 + 85 - 3.75 = 98.75). This means a loss of 1.25 for the hospital.[AÄE 96] This is a very simplified example. The real calculation is more complex.

6.1.4 The Future of the Health Care System

In the next years the German health care system will be modified. From 1997 hospitals should be more self-governing. Hospitals and health care insurances must negotiate a fixed budget per year. Hospitals have also to balance revenues below or beyond the budget in the future. From 1999 the costs for maintaining hospital buildings have to be covered by the health care insurance companies. This will be done by an increase of the department and base care fares (1.1 per cent) or by a flat rate (20 German Marks per year) which has to be paid by the policy holder. Technical medical equipment has also be paid by the policy holder. In the future there will be a single financing system (“monistisches Finanzierungssystem”). Then health care insurance companies control the whole budgets for hospitals. The responsibility for hospital planning and the support funds for the hospitals are handed over by the Federal state government and the communal corporation of the region to the health care insurances. The Federal association of the health care insurances are involved in the planning of hospitals. At state level the association of hospitals and the association of health care insurances agree for an upper limit of all fixed budgets for the hospitals. The total can be changed if:

- there is a change of medical services or of the number of special medical cases,
- additional capacities for medical services are created on the basis of the investment program of the state,
- it is invested in rationalisation.

The development of personnel costs by upgrading, changing the basis of calculation of the pensions, or changing the social insurance are not taken into consideration. The value of points for the FP and the SE is negotiated at the state level and is limited by the upper limit of all fixed budgets for the hospitals.

In spite of the stabilisation of the health care insurance fees in 1997 they increase 1.3 per cent in the old states of Germany and 2.3 per cent in the new states of Germany. From 1998 the change of health care insurance fees will be estimated by the Federal associations.

If the hospitals have revenues below or beyond the fixed budget, they have to balance it according to following calculation[Moh 96]:

“Abteilungspflegesätze” and “Basispflegesätze”:

- revenues beyond the budget <= 5% must be paid back by 85%

- revenues beyond the budget >= 5% must be paid back by 90%
- revenues below the budget must be balanced by 50%

FP / SE:

- revenues beyond the budget have to be paid back by 75%
- revenues below the budget are balanced by 50%

The acquisition, use or joint use of medical technical equipment will be no longer coordinated between local administrative bodies, the persons concerned, and the “Kassenärztlichen Vereinigung” of the country (regional general practitioners organisation). Probably hospitals and the Federal association of health care insurances will co-ordinate but this is not quite sure.
In the future the outpatient care will be of a great importance because it is expected to reduce costs. The coordination between inpatient and outpatient is very important, because some operations or treatments can also be done outpatient. Therefore, the role of general practitioners (GPs) will be more meaningful and a trend for more specialised GPs exists.
The achievement-orientated payment system aims at economical services and economy. This can be archived if the profitability of services is increased by more specialisation. This means more specialised hospitals and general practitioners.
The introduction of the new payment system with FP and SE for the payment of services means to reduce the internal costs of the service if a hospital wants to make profit. This could create a loss of quality of services. Therefore, in the future a quality control of health care services will be introduced.

6.1.5 Telemedicine and the Health Care System in Germany

Obtaining a second opinion is accepted by the law but today it is not possible to charge telemedicine services. The new health care system in Germany establishes the basis of telemedicine since more and more hospitals and GPs will be specialised. Patients have to be examined at different places and laboratory findings are made at other locations. Experts for special cases are at different places. All these examples mean an exchange of patient information in form of images or text.
The health care insurances are very interested in information-management to have a basis on controlling the quality and economy of services. They want to improve the quality and the economy of services by communication, cooperation and coordination.[Pfa 96]
If it can be proved that telemedicine is useful for patient care and reduces the costs of treatment in general then it could be possible that the health care insurance companies accept telemedicine. In this case the flat rates would have to be extended to account for remote diagnosis (telemedicine).
Telemedicine could also be seen as rationalisation:

- Physicians have not to travel so often.
- Patient folders have not to be send by conventional mail anymore.

If a hospital invests in rationalisation a part of costs would be financed by the health care insurances. In this case the budget of the hospital would increase in the following year. Then the hospital could pay the costs for the acquisition of technical equipment for telemedicine and installation.
If hospitals close departments which are not profitable they cannot guarantee best care of the patients. In some cases patients have to be transported to other hospitals for further examinations which might not be necessary and could be prevented by telemedicine. It would be a better service for the patients if the physicians consult other hospitals or GPs to fill the lack of services. The quality of the hospitals would increase. This is very important because the health care insurances and the patients themselves will attach more importance to the quality of services in hospitals. If it can be additionally proved, that the hospitals can reduce their costs for health care services by obtaining a second opinion or remote diagnosis, then the hospitals could consider to introduce telemedicine.
The charging of telemedicine services has to be controlled by the hospitals. Today many hospitals have to split up FPs and SEs internally, if a patient has to be treated in different hospitals. They could also split up their FPs and SEs if a diagnosis of a patient is made at a remote side. The federal association of hospitals could define a fixed tariff for remote diagnosis which can be charged.

The conclusion is that the expert would get additional revenues for the remote diagnosis and the physician who consults the expert guarantees for a good quality of health care services in her/his hospital. The acquisition of technical equipment for telemedicine and installation costs can be paid by the revenue of the hospital. To increase the quality of a hospital it would be a good investment. Another possibility is a support from charity help to make telemedicine possible.

6.1.6 Data Protection, Data Security, Liability, Patient confidentiality and Privacy in Telemedicine

In Germany the basis for data protection in medicine is the federal law of data protection. The medical confidentiality derives from §203 StGB (“Strafgesetzbuch”) (the violation of private law). Patient data is any data or information, whether oral or recorded in any form or medium, that identifies or can readily be associated with the identity of a patient. Without the permission of a patient a physician is not allowed to talk about the patient case. Patient information should only be used correctly. Patients have to be asked if the information may be used in an other context (e.g. research). Health care insurances are allowed to get data which are used for preparing an overview of patients and physicians.
The law distinguishes two kinds of telemedicine scenarios[Jac 96]:

- “Telekonsilium”: A physician wants to make a diagnosis of a patient and confers with one or more physicians, or experts. Obtaining a second opinion is accepted by the law and data transmission is allowed if necessary. The risks of data transmission have to be avoided as far as possible.
- Teleconsultation: The patient is not been helped by a doctor of medicine. The case is orally explained and/or is summarised by the transmission of images or readings. The situation differs from “Telekonsilium”, because there is another basis for the making of results and the medical confidentiality of the “teleassitant” person or other persons is not necessary. The results of teleconsultations are not very precise, because the teleassistant person is usually not with a knowledge of the subject.

Data protection can be achieved by the identification and authentication of senders and receivers. Identification can usually be done by a user name and a password. It prevents unauthorised attempts to get access. The use of encryption is an additional protection. Local data can be encrypted with a symmetric encryption algorithm and shared data can be encrypted with a public key encryption system, e.g. pretty good privacy (PGP). Digital signatures and checksum methods can be used to protect integrity and authentication against unauthorised change of data. Further necessary precaution could be to store data transactions in order to have necessary evidence in case litigation should arise. Electronic records and especially those which are not erasable, e.g. optical disks, may be accepted as evidence in the Courts.[Eng 96]
The liability in medicine is very clear. The physician who is responsible for every kind of decision is usually the senior consultant. The liability in telemedicine has to be controlled by concluding a contract between the parties involved in telemedicine services setting out the liabilities incurred by each party. The practitioner who is asking for advice is responsibility for transmitted information.[Las 96]

6.2 The Health Care System in France

The State is very centralised. Most decisions were made in Paris until 1982 when a lot of power was transferred to the Departments (a smaller area than the Region; Rennes is in the Department of Ille-et-Vilaine, Region of Brittany; Paris is a Department in itself, in the Region Ile-de-France). Healthcare is a special sector, because the basic level of administration is the Region.
The Social Security is the main healthcare organisation. Private organisations (often non profit mutual insurance companies) can take in charge the reimbursement to the patient of the “third part”(part of the costs not reimbursed by the Social Security).
In principle, everyone (employees, employers, and independent workers) pays for the Social Security a percentage of his / her income. A “Medical Aid” exists for those who cannot contribute to the Social Security (e.g. homeless people). This was inadequate for many years, because the costs increased endlessly, and the Social Security is threatened to become bankrupt.

A big reform is undertaken by the prime minister Alain Juppé to obtain a balance of the Social Security budget.
From now the total of the healthcare decreases and is voted by the French parliament. The government fixes, how much of the total amount goes to public hospitals, to private hospitals, to ambulatory medicine (“in-town physicians”), and to social-medical sector. The government fixes also the expenses of the private sector (hospitals and ambulatory) because the patients are reimbursed by the Social Security like the patients of the public hospitals.
Everything is managed by the ministry of health, through its deconcentrated services. For the hospitals (public and private), the main change is the creation of Regional Agencies, whose directors will be “Health Super-Préfets” with the power to restructure the hospitals in view of health costs containment. The Regional Agencies will now gather the administrative and financial aspects of the government tutelage on the hospitals.
The payment for the health insurance companies is calculated by the Social Security and the “Medical Aid”. 70% of medical services are paid by the Social Security. The rest is paid by the patient or his/her mutual insurance company. 100% of medical services are paid by the Social Security if the patient has expensive or long diseases or if the patient is very poor. The payment for health care companies can inflate. It can only be replaced by an analytic accountancy based on the medical activity. Patients which have no Social Security card pay the hospitals directly. If the hospital gets money directly from patients, it is deducted of the following years allocation (“group 2” takings).
Public hospitals must deliver care to everybody. They have a global budget fixed by the Agencies that they cannot overspend. They have their own budget for maintaining and building hospital buildings. The Social Security pays monthly the endowment allocated by the Agency in advance. Apart from the global budget there may be a decrease or an increase of the budget equivalent to the reimbursement of borrowing interests (exemption to the rule of self-supporting). The technical medical equipment is funded usually by the hospital budget but sometimes by charity subscription. Necessary additional capacities can be funded in a hospital by additional endowment, grants and borrowings. There is an area health planning on a regional basis (deconcentrated services of the government). It regulates the equipment acquisitions (CT, MR, hemodialysis, etc.) and of the organisation (beds) in hospitals. It also decides where special technical equipment is located.
In France there are more general than specialised hospitals because of their public service mission to match all the needs of the population. They must be able to care for all patients. Private hospitals can more easily specialise in dedicated fields, and thus are able to be more efficient.
Private Hospitals may be profit or non profit. The same rules as for public hospitals apply regarding area planning (number of beds, equipment) for them.
In France hospitals have an annual global budget fixed by the “Préfets”. The global budget inflates more and more because it depends on the budget several years before. The fixed budget is independent of the real performed services, but an analytic accountancy taking into account the real services is set up (Information Systems Medication Program, in French: PMSI). The idea is to pay for the real medical services assessed at medical information data and not at administrative data (number of beds, of employees). The PMSI bases on Diagnostic Related Groups which relate the expenses on the kind of patients you have treated. It is weighted by the difficulty (elderly, polytrauma, etc.) and not only by their number (qualitative assessment instead of quantitative). In fact the fixed budget bases on the activities of the year 1985, first year of the global budget, plus an annual increase, which itself decreases from one year to another. Before the global budget, the hospitals were paid back by the Social Security, according to the number of days the patient had spent and the diagnostic and therapeutic procedures which had been performed, but without any control of the adequacy of expenses. The global budget is fixed, but the activity assessment must stick to the reality, to be ready for the moment when budgets will be allocated according to the real activity. Revenues which are below or beyond the fixed budget have to be balanced if one considers the Social Security point of view. The only benefits hospitals can make come from subsidiary (“group 3” takings) profits. This is what other hospitals pay, if e.g. their laundry is made in this hospital, or the computerised processing of the salary bulletins of their employees. This would be a possible way of funding a teleradiology service. The hospital can reinvest revenues only if it is a subsidiary “group 3” profit. It must be taken into account that if a hospital receives a donation, it must redeem it, as if it had to renew it after a certain (fixed) time, which

means that in fact it creates a new source of expenses. For instance if it is given a 1 MF house by an old lady's testament, it will have to redeem it during 40 by saving 50 KF per year. If it receives 5 MF in money and buys a CT scanner, it will have to redeem it during seven years by saving 0.71 MF per year, in order to be able to purchase a new one after this period.

The development of personnel costs is taken into account by the hospital global budget, but the salaries are regulated by the "Statute of the Public Office" or by professional agreements in the private sector. In the future the government could help the hospitals to fulfil salary increasing agreements made at a national level with employees unions, but today this is not usual and the hospital has to take this in charge.

There is an upper limit for the total of all budgets of the hospitals. The Parliament votes a global budget which is distributed by the government.

Certain medical and health-related services are fixed by rates. There are fixed rates for daily fees for the stay with an additional rating of the diagnostic and therapeutic procedures (General Nomenclature of Professional Acts, NGAP), but this is theoretical. In the public hospitals it is only used to charge mutual insurance companies or self paying patients which are very rare. In private hospitals the global budget weighted by an analytic accountancy is set up at a national and regional level. Before they were paid by the patients (themselves reimbursed by the Social Security). But this had an inflationary effect and was unfair to public hospitals constrained in their global funding. The "Préfet" (government chief administrator in the region) fixes the daily fees, and the Social Security and the Government fix the NGAP by consensus with the Social Security and the physicians professional organisations. They can increase or decrease the budget depending on the balance of the Social Security.

Quality control of care becomes the mission of a specialised government agency which existed before: ANDEM (National Agency for the Development of Medical Evaluation). From now it will be called National Agency for Accreditation and Health Evaluation (ANAES) and will have to process a certification of hospitals for expensive activities. This will obviously be used by the hospitals Regional Agencies for restructuring the hospitals.

In France there is no cost-controlling mechanism, but the National Agency for the "Development of Medical Evaluation" is in charge of setting up and popularising guidelines.

The health care system put emphasis on saving costs by coordiantion of inpatient and outpatient services, but today the health care system is more hospital-centralised. Health care networks increasing the role of GPs are planned to develop outpatient based care. Some already exist for AIDS and Drug abuse (They could be used by the government as pilot experiences of capitation system which is turned down a priori by the professional associations).

In France the GPs are primary care physicians and all work in private practice. The patient is free (for the moment…) to prefer the direct access to specialists or to hospitals. There are lightly more specialists than generalists in France. The GPs have fixed tariffs for services (NGAP). They can receive travelling expenses for visiting a patient at home, but not for asking an advice. The patient pays directly the GP for a service and is afterwards reimbursed by the Social Security. The tariffs are fixed by convention with the Social Security, validated by the government.

The information exchange between physicians and GPs is very important. It is even regulated by the Law. But in fact information exchange is very bad between hospitals and "in-town" physicians.

Today there are no rules for funding or charging telemedicine in France. If a hospital was able to assess the additional costs caused by a TR (Teleradiology) service (i.e.: more on-duty physicians), it could agree with other hospitals on a fee which would give it "group 3", subsidiary takings, but no fixed fee exists at the moment in the NGAP. (A good example is the osteodensitometry which is not reimbursed by the Social Security: the hospital has evaluated the cost at 450 FF per patient, and the patient is charged accordingly). The Ministry of Health (in general), and radiologists and directors (in Rennes in particular) are working on it. Physicians in private practice could also do it, as far as the Social Security has not to pay for it.

It could be profitable for hospitals and they could get more patients thanks, if they provide TR services.

6.3 The Health Care System in Portugal

In Portugal the law guarantees the health care delivery for all citizens. The government is responsible to ensure that every citizen receives an adequate medical care. There are different schemes based on healthcare systems and insurance companies. 85 % of the Portuguese population pay taxes for their health care. 15 % of the Portuguese population pay the health care services to the hospitals directly. The public health care system is managed by the “Serviço Nacional de Saude” (SNS - National Health Service), which is divided into five autonomous regional administrations. SNS reports directly to the Ministry of Health. Access to the public system is open to all citizens at minimal cost as guaranteed by the Constitution. Private health care has a long tradition in Portugal. It has been delivered by religious orders for centuries. In more recent times, a number of hospitals and clinics have been opened to provide improved care to the public and to private medical insurance programs under contract.[Por 97]. Some of the private hospitals belong to insurance companies. Others belong to private companies. The rest are public hospitals.

The government decides where new hospitals have to be planned and is responsible to cover the costs for maintaining and building of a hospital. For the private hospitals the insurance companies and the private companies are responsible.

In Portugal there are no investment or support funds from the state government. The technical medical equipment (e.g. MRI) is funded by the government (most of it) or by foundations and private companies. The government decides where special technical medical equipment is located. It depends on a study of the regional needs.

The Portuguese hospitals are more general than specialised. Specialised hospitals are only located in the urban centres like Lisboa, Porto, and Coimbra.

There is an upper limit for all hospitals in the country. Each hospital gets a budget which has a limit and depends on the real performed services of the year before. The development of personnel costs is taken into account by the government. In special cases a change of the budget can be performed. These changes need a superior authorisation (probably from the administration director). Revenues of the hospitals which are beyond their budget have to be balanced with the budget of the next year. In Portugal there are no cost-controlling techniques of health care services.

After a study which concerns the national and regional needs, the health care system puts emphasis on saving costs by coordination of inpatient and outpatient services. It is preferred to treat patients outpatient because outpatient care of a patient reduces costs.

Each health care service has its own fee. The government fixes these rates. They can be decreased and increased according to an annual plan.

You have to pay a fixed charge towards the cost of most kinds of medical treatment, and for each consultation (whether in a health centre or in hospital) and each

additional diagnostic investigation. All costs exceeding the fixed charges are for the account of the health service.

A considerable number of people are exempt from payment of the fixed charges. There are the following categories[Por 97]:

- pregnant women and nursing mothers,
- children up to the age of 12,
- pensioners receiving a pension of not more than the national minimum wage and their dependants,
- unemployed persons registered with employment offices and their dependent spouses and children,
- employees receiving a monthly income of not more than the national minimum wage and their dependent spouses and children,
- most persons who are disabled or have an incurable or long-term disease.
- persons receiving a lifetime monthly allowance.

The payment for the health care insurances can decrease and increase. This depends on the actions performed at all hospitals. The hospitals can reinvest revenues based on a several years' investment plan. The hospital administration board makes this plan and the Ministry of Health approves it. Addi-

tional capacities like more equipment and more beds can be funded by the government and the support of foundations and companies.
The GP is the first person in the chain who examines the patient. There are more specialised GPs in Portugal. They can charge the health care services with tariffs based on base salary plus an overtime or an additional emergency service and can receive reimbursements for travel expenses. All these tariffs are calculated by government rules.
The information exchange between physicians of the hospital and the GPs is very important because the GPs refer the patient to the physicians of the hospital and the physicians of the hospital refer the patient back to the GP. But today hospitals and GPs have not the possibility to charge telemedicine services.
Funds for:

- technical medical equipment,
- technical equipment for telemedicine,
- installation costs for telemedicine equipment,
- line rental for telecommunications,
- and usage cost for telecommunications

could be raised by the healthcare and education Ministry and scientific research. Hospitals can also reinvest the revenue, if that is one of priorities of the annual plan.
Today an expert can charge a remote diagnosis, but there exists no tariff. More centres are needed to use this set-up so that it becomes a routine procedure, removing it from the experimental "status". Telemedicine should become first a routine tool at hospitals (not an experimental thing as now) and therefore it is necessary to implement it at more health care centres.

7 FINANCIAL ANALYSIS

7.1 Introduction

Currently the health care systems of most European countries face a similar challenge: An increasingly ageing population, stagnancy of the gross national product and the ever-increasing costs of modern "high-tech medicine" services put an intense economic pressure on the health care systems.
In this situation, a new technology promising to improve health care will not only have to improve the quality or delivery of care in order to be successful (like the introduction of computed tomography in the 1970s which improved quality of care at the expense of increased treatment costs), but will also have to prove its potential to rationalise and cut down costs in the hospitals.
A multitude of telemedicine pilot projects has been and is being carried out in Europe, however, as [Telmed1] points out, mostly in non-commercial settings, e.g. within European R&D programmes. Although virtually all telemedicine pilots claim benefits in health care delivery and most of them also point out possible cost and resource savings by the use of telemedical services, few quantitative information about costs and benefits of telemedicine is available.
This analysis is not intended to address the costs and benefits of telemedicine in general, but limits itself to the "scenario" used in the RETAIN trials: Consultation of remote experts on medical cases by means of visual telephony combined with computer-based transmission of digital medical images and related information. This scenario, often referred to as "teleradiology", is one of the major application scenarios for telemedicine discussed in literature.

7.2 Expected Financial Benefits from Telemedical Consultation

Besides the medical benefits described in section 1.3, which show at best indirect financial effects, there are also direct financial benefits to be expected from telemedical consultations. Benefits usually claimed in literature on telemedicine are:

7.2.1 Reduction of transport and travel costs

- Avoidance of unnecessary patient transports (emergency cases and patient referral)
- Avoidance of image transport via taxi or express service (today for urgent advice requests images (films) are often copied and the higher quality originals then sent to the specialist).
- Reduction of travel costs for physicians accompanying the patient during examinations performed in a different hospital or discussing diagnoses/therapy planning with specialists at remote locations on-site.
- Reduction of travel costs for physicians participating in CME (continued medical education) events.

7.2.2 Reduction of personnel costs

- Reduction of physicians' travel times
- Diffusion of tasks carried out by higher paid personnel to lower paid personnel such as nurses and paramedics.

7.2.3 Rationalisation savings

- Reduction of patients' stay time in hospitals through more efficient medical and administrative practices (“just-in-time diagnosis”)
- Avoidance of unnecessary double examinations after patient referral
- Better capacity utilisation of expensive equipment by the possibility to offer examination services to remote hospitals or to outsource such examinations to remote centres.
- Reduction of film costs for copying conventional images which are sent to remote specialists as advice requests.

Unfortunately it is not possible to quantify most of these figures in the limited framework of a research project, because most of them could only be evaluated in a long-term statistical analysis (e.g. statistics on the development of the number of patient transports over time, average number of radiological examinations per patient, utilisation of high-tech equipment etc.) which would require professional use of a telemedical consultation system over years.

7.3 Expected Costs of Telemedical Consultation

Whereas it is difficult to quantify the financial benefits to be expected from telemedicine, it is rather easy to define the costs, depending on the technology used.

7.3.1 Investment costs

- Telemedicine equipment: workstation, video codec
- Peripherals: digitiser, cameras, time base corrector, VCR, laser camera, ...
- Network access installation

7.3.2 Regular costs

- Regular (e.g. monthly) fees for the telecommunications network
- Maintenance and replacement costs

7.3.3 Usage dependent costs

- Connection fees for the telecommunications network
- Personnel costs and overheads
- Consultation fees (if applicable)

7.4 The TEN-IBC Business Models

In TEN-IBC, the "Consolidation Project" has the task of collecting and consolidating all TEN-IBC research projects' self-assessments in terms of adequacy for purpose and economic viability of the products and services developed. The common model on which the "business case analysis" for the economic consolidation of all TEN-IBC projects is based describes the use of telecommunications networks in terms of "service providers" and "users":

- A Service Provider offers a "value added service" over a telecommunications network. For example, a brokerage service could allow its users to sell or acquire products or resources (computing time on supercomputers, reproduction rights for copyrighted work etc.) over the network. In addition to cost reimbursement, the service provider would expect a certain revenue.
- A User uses a service offered by a service provider over the network (e.g. selling or purchasing products over the network brokerage service). This implies that the user also expects advantages from the usage of the service.

This model might be a simplification, especially in the very complex health care sector, but it allows to do some cost–benefit estimations for the application of telemedical services. In "our" case, we define:

- A service provider is a knowledge centre which offers medical advice over a telemedicine facility. Usually this will be a university hospital to which difficult cases can be referred. Therefore, the advice request will often relate to the necessity of patient referral to the university hospital.
- A user is a hospital or general practitioner requesting advice regarding diagnosis, treatment or referral from a knowledge centre.

In terms of the services described in the "adequacy, for purpose, of products and services" analysis (see chapter 4) this is only one of three services, namely the "Teleradiological broadband conference service". The other two services will not be considered here:

- A "Narrowband access service" is no peculiarity of the health care sector – connecting people who use different access technology into one teleconference is a typical network service provider business (like the commercially available video-conference multipoint switches).
- In RETAIN, the "Medical multi-media message and presentation service" is a supplement to the main service – it allows to transmit case presentations offline in advance (which is especially useful for narrowband connections) and, therefore, allows for a more flexible information management. No separate business case analysis for this service is performed here, although it could be considered worthwhile for applications in narrowband environments.

In applying the models, some explicit simplifications are necessary. We assume that cost savings resulting from a "successful" consultation benefit only the user, not the provider (in reality this may depend on the question whether a patient would be referred to the specialised hospital when no remote consultation is possible and whether this would produce costs or revenues for the specialised hospital). Furthermore we assume that the expenses of the service provider plus some revenue are paid by the user. We consider the health care sector as a free market (which is clearly not true in most European countries).

Therefore, the results of the model cannot be applied to any real health care sector without change. Legal restrictions will affect the model (for instance any cash flow between hospitals may be impossible) and some financial benefits may not apply because of the structure of the health care sector. For instance, in countries where the hospitals are paid per patient and day, a hospital will not be interested in decreasing the average patient stay time although this would be a saving on a macro-economic scale.

In addition, it should be recognised that health care can in general not be reduced to a cost/benefit analysis. In reality there might be more motivation to use telemedical services than a cost/benefit analysis might indicate. Some people argue for instance that the diffusion of expert knowledge (continuous medical education, CME) is part of the task of university hospitals, and that their costs should be covered by the additional CME funds allocated to such institutions and not by the "users".

In addition, the possibility to acquire more "interesting" cases for research work might also be a motivation for such institutes to "invest" in telemedicine.

7.4.1 ATM Tariff Models

A key question for the estimation of usage costs for a telemedicine system are costs for the telecommunications network. Today, ATM wide area network services are hardly available on a commercial basis, and where available, tariffs are often prohibitive. Since it is very difficult to predict future tariffs for broadband services, all TEN-IBC research projects agreed to develop their financial analyses on a set of five fictitious ATM tariffs, which are shown in Figure 7-1. Although the tariff models are fictitious, they are related to commercial or pre-commercial tariffs existing today. Tariff model "B" follows the most inexpensive ATM tariffs existing on the European market today (e.g. in Finland) whereas model "D" follows the rather expensive tariffs in countries where the telecommunications market is still regulated (e.g. France and Germany). Tariff models "A" and "E" go beyond the limits of current tariffs, and model "C" is a compromise between "B" and "D". This broad range of tariff models allows to estimate how costs for "broadband telemedicine" may develop depending on the development of tariffs.

Tariff	Monthly rental for each bandwidth (Ecu)					Usage charge (Ecu)	
	2 Mbit/s	4 Mbit/s	10 Mbit/s	34 Mbit/s	155 Mbit/s	per hour/ Mbit/s	per Mbyte
A	500	700	1,000	1,700	2,000	10	1
B	550	800	1,500	2,700	3,000	15	1
C	900	1,300	2,500	4,000	5,000	43	3
D	1,500	2,200	4,000	6,000	8,000	86	10
E	2,800	4,500	8,000	11,000	15,000	200	20

Figure 7-1: ATM Tariff Models for the Financial Analysis

All five tariffs are structured in a similar way. Monthly rental costs depend on the type of network interface, which limits the maximum available bandwidth. In addition to the usual 2 Mbit/s (PDH E1), 34 Mbit/s (PDH E3) and 155 Mbit/s (SDH STM-1) interfaces, two additional bandwidths (4 and 10 Mbit/s) are offered because many TEN-IBC projects expressed bandwidth requirements in this range. In addition to the monthly rental, each connection costs a "usage charge" which can either be charged depending on reserved bandwidth and time (charge per hour and MBit/s) which would be typical for connection-oriented services, or by volume transmitted (per MByte) which would be typical for connection-less data traffic (e.g. SMDS or Frame Relay networks). The type of charging may be chosen by the user.

The RETAIN conference system required a bandwidth of 10.5 Mbit/s (25,000 ATM cells/s) with constant bit rate for a point-to-point connection. Video transmission used the ETSI compression scheme (see section 2.1.1) but it is expected that future commercial products will used MPEG-2 instead, which will slightly decrease bandwidth requirements (e.g. from 6 to 4 Mbit/s for the video stream). Therefore a 10 Mbit/s ATM service seems to be appropriate for a future ATM based "RETAIN-like" telemedicine service. Since visual telephony produces a significant data volume during connections, it seems appropriate to select a connection-oriented charging scheme per hour and MBit/s.

The question arises whether these tariff models are realistic and if it makes sense to perform cost estimations with such a high bandwidth (compared to existing ISDN based telemedicine applications which mostly use 2–6 ISDN B-channels). Some people argue that today's ATM tariffs (e.g. model "D") are intended to *prevent* customers from using a service the network operators would be unable to provide in acceptable quality. Comparison with tariffs for other commercially available network services back this opinion:

- *ISDN:* Current ISDN tariffs in Germany are about 300 Ecu per hour for one MBit/s (e.g. 16 B-channels from Hamburg to Munich at business hours). Of course an ISDN based system would not use 10 Mbit/s. For a “high-end” system, 6 to 12 B-channels seem appropriate (12 B-channels were used in RETAIN for ISDN connections), resulting in connection costs of 113-230 Ecu/hour. This compares well to a 10 Mbit/s broadband connection at tariff model “B” (150 Ecu/hour), but not to tariff model “D” (860 Ecu/hour).

- *Broadband networks:* Before 1995, Deutsche Telekom operated a commercial broadband video-conference network called “Vermitteltes Breitbandnetzwerk” (VBN). This network used switched virtual connections which had to be requested from a network management centre – very much like the ATM services available today. The system was based on dedicated 140 MBit/s PDH E4 lines which transmitted audio, video (PAL composite uncompressed) and 2 Mbit/s of digital data in parallel. According to [Gass 94], connection costs were up to 300 Ecu/hour. It would not be fair to calculate the “per Mbit/s and hour” price of 2.2 Ecu since bandwidth could not be allocated dynamically. However, it does not seem reasonable as well to believe that a 10 Mbit/s ATM connection should cost 40% (tariff C), 186% (tariff D) or even 566% (tariff E) *more* than a dedicated 140 Mbit/s line!

These figures indicate that there is still a significant potential for price decreases in countries where rather expensive tariffs apply today. In our opinion, future ATM tariffs in a deregulated telecommunications market are much more likely to be in the range of tariff models “A” or “B” than “D” or “E”. And, as the comparison with ISDN above indicates, at these tariffs ATM (“B-ISDN”) might be an attractive alternative to narrowband ISDN.

Finally it should be noted that the tariff models in Figure 7-1 are very simple. Today's market for cellular phones with its multitude of tariffs indicates that future ATM tariffs might be much more flexible than indicated in this model:

- tariffs could support different “user types”, e.g. users with much network usage could select a higher monthly subscription rate but lower connection costs and vice versa. For a telemedicine system which will hardly be used 8 hours a day, it could be interesting to select a cheaper monthly subscription rate at higher connection costs.
- In addition to a connection-oriented or volume-oriented charging, network providers could charge a certain base price for the connection setup (dialling).
- The tariff model in Figure 7-1 can only be applied to “constant bit rate” (CBR) services. However, ATM will also support “variable bit rate” and “available bit rate” service (VBR, ABR) in the future. Charging schemes for VBR could for instance add additional costs “per burst Mbit/s” for bandwidth used beyond the guaranteed minimum bandwidth.
- In addition to variable bandwidth allocation, ATM allows to precisely define the characteristics of a connection in terms of “quality of service” (QoS) parameters. It is likely that tariffs will account for the quality of service delivered to the user.

7.4.2 The Service Provider Model

The “Service Provider Model” is a simple business case model for a service provider as defined in section 7.4 and not especially geared to health care. The model comprises a set of spreadsheets which allow to investigate how different ATM tariffs, usage intensities and service charges interact in financial terms. The key value for this analysis is the *necessary* charge per consultation, i.e. the amount of money a specialist has to charge for advice per case in order to cover his own expenses. Figure 7-2 shows a simplified version of the provider spreadsheet, filled in with sample data. The results described in section 7.5.1 relate to this and more sets of data. The following section describes the assumptions on which the data in Figure 7-2 is based.

- *General:* An interest rate of 10% on cash borrowings and 5% on cash deposits is just a reasonable estimation. A corporate tax rate of 30% may or may not be realistic for a particular country but can also serve as an average value.
- Service Charges: If expert consultation on a patient case is charged, it seems reasonable to expect a flat “per case” tariff which does not relate to the time needed for consultation or the amount of data transmitted. There will be no monthly “subscription charge” for the service provider (e.g. univer-

sity hospital) as well. The charge per unit (patient case) of 50 Ecu in Figure 7-2 is the lowest price under which the business is viable for the ATM tariff band "C" and the number of cases per year (5000) used in this set of data (see section 7.5.1 for an in-depth discussion).

- *Usage for Network Service Business:* Only in very rare cases a physician will consult a specialist from abroad. In majority of cases, consultation will be *regional*, in some cases national. Therefore, the potential number of users for a hospital offering teleradiological consultation services is limited by the number of regional hospitals in the same area. This depends on country and region, but a number of 10–20 regional hospitals for one "knowledge centre" seems reasonable. We do not expect that the service provider will have the full potential number of users from the first year. For this calculation, we start with a limited number of 5 users in the first year, expect 9 users in the second and 12 users from year 3 to year 10 of the model. The rationale for the "average usage per user and month" figures (here: 34 cases per month comprising 8 cases per week) is explained in section 7.4.3.
- *Network Service Based Revenue:* Since the only revenue for the service provider is the flat "per case" tariff charged to the users, revenues are constant from year 4, where the maximum number of users is reached.
- *Fixed Assets / Capital Expenditure:* Medical consultation on digital images is a useful service if (and only if) the required infrastructure – digital imaging modalities, digital archive and LAN) is available. We consider only the marginal costs for setting up a telemedicine system if the infrastructure already exists.
  The costs for a commercially available ATM video codec (visual telephone) can be expected to be on the same level as high-end ISDN video codecs – approx. 20,000 Ecu. A high performance workstation also costs about 20,000 Ecu. Together with peripherals (monitors, cameras, installation, network access) we assume a total investment of 50,000 Ecu, plus 10% of the purchase price per year for maintenance. Depreciation period: 5 years. We expect that the new investment in year 6 will be significantly lower (25,000 Ecu).
- *Annual ATM Expenses:* The RETAIN teleconference system requires a bandwidth of 10.5 Mbit/s (6 Mbit/s for video, 1.5 for audio, 2 for TCP/IP and 1 Mbit/s "buffer" to avoid cell loss on the constant bit rate link). With a different technology for audio/video transmission (MPEG-2 instead of ETS 300-174) audio and video would require approximately 6 MBit/s combined, so that a 10 Mbit/s ATM service seems to be appropriate for a future ATM based "RETAIN-like" telemedicine service. We assume that the connection is always set-up (and paid) by the user so that no usage charge has to be paid by the provider. In Figure 7-2, ATM tariff band "C" is used, but section 7.5.1 describes results for all tariff models.
- *Other Expenses:* In health care it is usual to define costs for a physician including his support team (administrative overheads, nurses and paramedics preparing and completing his work). For a specialist, we estimate 125 Ecu/hour (220,000 Ecu per year). According to the analysis from chapter 4, a typical consultation takes around 10 minutes per case. With the 5,000 cases per year estimated in Figure 7-2 and 220 working days per year at 8 hours/day, the specialist will use about 48% of his time for "remote advice". In practice this time would be shared among more than one specialist, but this is not relevant for the cost calculation. In the first three years of the model the number of users is still less than 12, but nevertheless the full 48% labour costs for the specialist are accounted because getting used to the system and to the changed work flow will eat up labour resources as well. Finally we also include costs of 2,760 Ecu/year for the use of premises (one "telemedicine room", 12 m^2 at 230 Ecu per m^2 and year) in the calculation.
- *Profit and Loss Statement:* These figures are computed from the "input" in the other sections. The most interesting figures from this section, the total expenses, revenues and the net profit after tax are shown in Figure 7-3. Whereas the expenses (labour, depreciation, network, taxes and interest) are rather constant, the revenues directly depend on the number of users. The net profit after tax becomes positive from year two in the data set shown in Figure 7-2.

- Operating Cashflow: Figure 7-4 shows the cash flow after interest and tax (unlike “net profit”, the cashflow includes full investment costs for the year accounted for, but no depreciation) and the cumulative cash balance over the modelled period of 10 years. Break even point for the cumulative cash flow is year 4.

General		
Currency used in the business plan		Ecu
What is the interest rate on cash borrowings		10%
What is the interest rate on cash deposits		5%
What is the applicable corporate tax rate		30%
Service Charges		
Unit for the usage-based service charge?		patient case

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
What is the connection charge	Ecu	0	0	0	0	0	0	0	0	0	0
What is the regular subscription charge	Ecu/month	0	0	0	0	0	0	0	0	0	0
what is the charge per unit for service usage	Ecu/case	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00

Usage for Network Service Business		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
What is the actual number of users expected		5	9	12	12	12	12	12	12	12	12
Average usage per user per month	Cases/month	34	34	34	34	34	34	34	34	34	34

Network Service Based Revenue		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Connection revenue	Ecu	0	0	0	0	0	0	0	0	0	0
Subscription revenue	Ecu	0	0	0	0	0	0	0	0	0	0
Usage revenue	Ecu	51,000	142,800	244,800	244,800	244,800	244,800	244,800	244,800	244,800	244,800
Total revenues	Ecu	51,000	142,800	244,800	244,800	244,800	244,800	244,800	244,800	244,800	244,800

Fixed Assets / Capital Expenditure		
Average lifetime of capital assets		5 years

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Planned annual expenditure on fixed assets	Ecu	50,000	5,000	5,000	5,000	5,000	25,000	2,500	2,500	2,500	2,500
Depreciation expense	Ecu	10,000	11,000	12,000	13,000	14,000	9,000	8,500	8,000	7,500	7,000

Annual ATM Expenses		
ATM tariff code		Tariff C
ATM charging method		per hour / mbit/s

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Bandwidth	mbit/s	10	10	10	10	10	10	10	10	10	10
Annual usage in hours	hours	0	0	0	0	0	0	0	0	0	0
Annual usage in mbytes	mbytes	0	0	0	0	0	0	0	0	0	0
ATM cost	Ecu	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000

Other Expenses		
Average annual salary per employee	Ecu	220,000

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Number of staff		0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Annual cost of premises	Ecu	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760
Total operating expenses	Ecu	148,360	149,360	150,360	151,360	152,360	147,360	146,860	146,360	145,860	145,360

Profit and Loss Statement		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Total revenues	Ecu	51,000	142,800	214,800	244,800	244,800	244,800	244,800	244,800	244,800	244,800
Total operating expenses	Ecu	148,360	149,360	150,360	151,360	152,360	147,360	146,860	146,360	145,860	145,360
Operating profit	Ecu	-97,360	-6,560	63,840	93,440	92,440	97,440	97,940	98,440	98,940	99,440
Interest expense	Ecu	6,868	6,896	3,354	-811	-4,469	-7,087	-10,716	-14,284	-17,790	-21,236
Profit before tax	Ecu	-104228	-13,456	60,486	94,251	96,909	104,527	108,656	112,724	116,730	120,676
Corporate tax	Ecu	0	0	18,146	28,275	29,073	31,358	32,597	33,817	35,019	36,203
Net profit after tax	Ecu	-104228	-13,456	42,340	65,975	67,836	73,169	76,059	78,906	81,711	84,473
Total expenses	Ecu	155,228	156,256	171,860	178,825	176,964	171,631	168,741	165,894	163,089	160,327

Operating Cashflow		
Operating cash balance (year 1)	Ecu	0

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Operating cashflow (before interest and tax)	Ecu	-137360	-560	70,840	101,440	101,440	81,440	103,940	103,940	103,940	103,940
Interest	Ecu	-6,868	-6,896	-3,354	811	4,469	7,087	10,716	14,284	17,790	21,236
Tax payment	Ecu	0	0	0	18,146	28,275	29,073	31,358	32,597	33,817	35,019
Cashflow after interest and tax	Ecu	-144228	-7,456	67,486	84,105	77,634	59,455	83,298	85,627	87,913	90,157
Cumulative cash balance after interest/tax	Ecu	-137360	-137920	-67,080	16,214	89,379	141,746	214,328	285,671	355,794	424,715
Operating profit margin	Ecu	-191%	-5%	30%	38%	38%	40%	40%	40%	40%	41%

Figure 7-2: Provider Model Spreadsheet

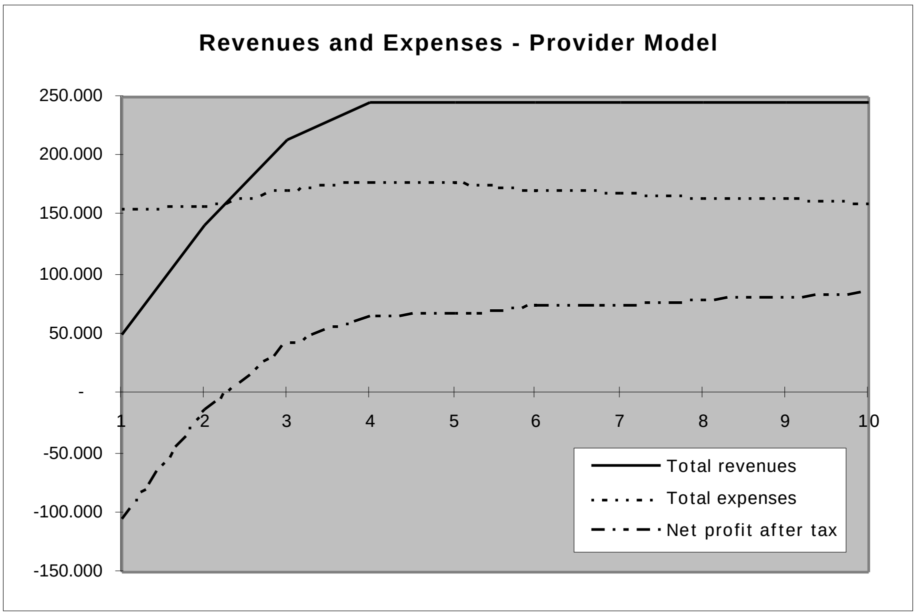


Figure 7-3: Revenues, Expenses and Profit after Tax for the Provider Model Spreadsheet

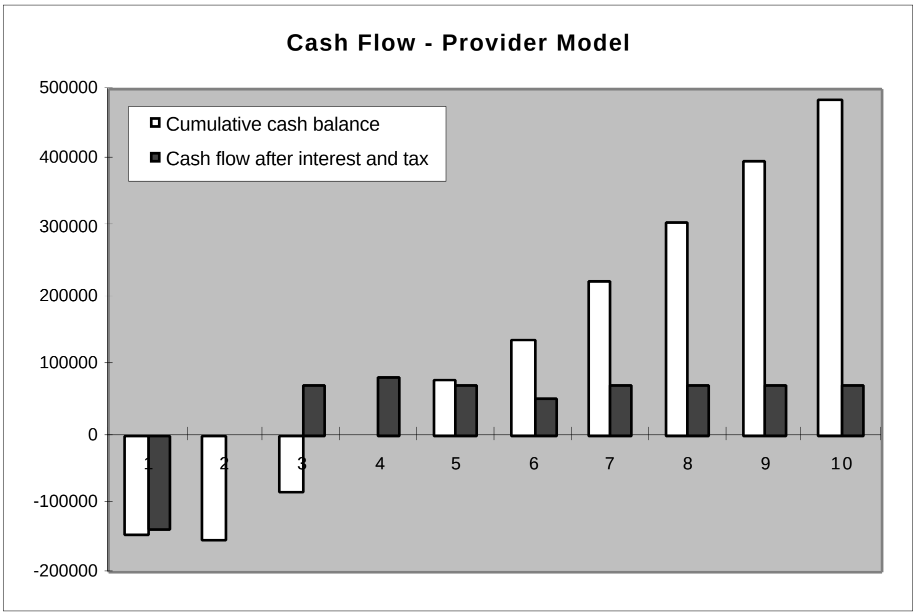


Figure 7-4: Cash Flow and Cumulative Cash Balance for the Provider Model Spreadsheet

7.4.3 The User Model

The "User Model" is a business case model for a network service user as defined in section 7.4. Like for the provider model, the key value for the analysis is the *necessary* charge per case, i.e. the amount of money the hospital *requesting* remote advice will need for a reimbursement of the costs of tele-medicine. Such a reimbursement can be

- revenues (directly charged to the patient or health insurance company)
- rationalisation savings (e.g. shorter patient stay time, no taxi/express service costs, less costs for unnecessary transports etc.)

A successful strategy for the introduction of telemedical consultation services would have to prove that the price charged to the patients plus the internal savings would be sufficient to cover the costs of such a service, plus a certain interest.
The following section describes the assumptions on which the data in Figure 7-5 is based. Since the user model is similar to the provider model in many aspects, only differences are explained where appropriate.

- *Revenue:* revenues depend directly from the "number of units sold" per year and the unit price which is at its lowest possible level for the network and service costs and usage intensity (number of cases per year) to make the model viable (see section 7.5.2 for a discussion on unit prices and viability). In [Ret2-10], we based the calculations for a medium-sized regional hospital on two different usage patterns:
  - a *"extensive usage pattern"* of two cases per week requiring remote expertise (which relates to the number of cases sent via taxi or express service today) and
  - a speculative *"intensive usage pattern"* of 15 cases per week. The rationale behind this figure is that the cost pressure in health care will cause increased concentration and specialisation and, therefore, increase the need for hospitals to cooperate and communicate. In addition we expect that an easy-to-use system which gives instant access to information and expert advice will significantly increase requests for expert consultation compared to today's "taxi transmitted" services.

  For the analysis in this chapter, four different "usage intensities" are considered: 2, 4, 8 and 16 cases per week (100, 200, 400 or 800 cases per year) which cover the range from a rather conservative system usage to a very intense usage. Figure 7-5 shows a data set with 400 cases per year.
- *Fixed Assets / Capital Expenditure:* We assume that user and service provider use an identical teleradiology system and, therefore, have the same investment costs and depreciation expenses.
- *Annual ATM Expenses:* As explained in section 7.4.2, the models assume that all connection costs are paid by the service user. With an average duration of 10 minutes per case, 400 cases per year result in 66.67 hours network usage. Figure 7-5 shows the resulting annual ATM costs for a 10 Mbit/s connection and ATM tariff "C".
- *TEN-IBC Service Expenses:* This figure is directly related to the "charge per unit" of the Service Provider model, multiplied by the number of cases per year. Service costs are calculated depending on the usage intensity: for two cases per week at the user model, the consultation costs for a provider serving 1,250 cases per year are assumed. In Figure 7-5, eight cases per week for the user and in turn 5,000 cases per year for the provider are used, resulting in a per-case fee of 50 Ecu (at ATM tariff "C" which also influences the provider's costs).
- *Other Expenses:* The calculation of personnel costs is similar to that of the Service Provider model, but we estimate "only" 100 Ecu/hour (180,000 Ecu per year) for the physician in the regional hospital. Two case requests per week at 10 minutes each require to 1% of the physician's time, 8 cases per week require 3.8% (1.3 hours per week, number of staff: 0.04). Costs for marketing, transport, insurance and administrative overheads are not considered separately, they are included in the base rate of 100 Ecu/hour for the physician.
- *Profit and Loss Statement:* Figure 7-6 shows revenues, expenses and net profit for the user model with the sample data used in Figure 7-5. Since revenues are constant in this model and expenses are only changed by the depreciation decreasing over time (reinvestment costs in year 6 are only 50% of the initial investment), the net profit is almost constant.
- *Operating Cashflow:* Figure 7-7 shows the cash flow (after interest and tax) and the cumulative cash flow for the data used in Figure 7-5. Although the net profit is positive from the first year for this model, cash flow is negative in the beginning because of the large investment in the first year. The cumulative cash balance becomes positive in year 4. A comparison between Figure 7-7 and Figure 7-4 shows that the user operates much closer to a pure "cost reimbursement" (rather low accumulated cash flow after 10 years) than the service provider. The reason for this difference is the assumption that the user has a constant revenue over the whole modelled period whereas the pro-

vider starts with few users. In order to reach a balanced accumulated cash flow after year 4, the provider has to operate with a higher profit margin than the user.

General

Currency used in the business plan	Ecu
What is the interest rate on cash borrowings	10%
What is the interest rate on cash deposits	5%
What is the applicable corporate tax rate	30%

Revenue

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Number of units sold		400	400	400	400	400	400	400	400	400	400
Average price of units	Ecu	257	257	257	257	257	257	257	257	257	257
Total revenues	Ecu	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800

Fixed Assets / Capital Expenditure

Average lifetime of capital assets	5 years

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Planned annual expenditure on fixed assets	Ecu	50,000	5,000	5,000	5,000	5,000	25,000	2,500	2,500	2,500	2,500
Annual depreciation expense	Ecu	10,000	11,000	12,000	13,000	14,000	9,000	8,500	8,000	7,500	7,000

Annual ATM Expenses

ATM tariff code	Tariff C
ATM charging method	per hour / mbit/s

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Bandwidth	mbit/s	10	10	10	10	10	10	10	10	10	10
Annual usage in hours	hours	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67
Annual usage in mbytes	mbytes	0	0	0	0	0	0	0	0	0	0
Total annual ATM costs	Ecu	58,667	58,667	58,667	58,667	58,667	58,667	58,667	58,667	58,667	58,667

TEN-IBC Service Expenses

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Connection expenses	Ecu	0	0	0	0	0	0	0	0	0	0
Subscription expenses	Ecu/month	0	0	0	0	0	0	0	0	0	0
Service usage expenses per unit	Ecu/case	50	50	50	50	50	50	50	50	50	50
Total annual TEN-IBC expenses	Ecu	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000

Other Expenses

Average annual salary per employee	Ecu	180,000

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Number of staff		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Annual cost of premises	Ecu	0	0	0	0	0	0	0	0	0	0
Annual cost of transport and travel	Ecu	0	0	0	0	0	0	0	0	0	0
Annual cost of marketing	Ecu	0	0	0	0	0	0	0	0	0	0
Annual cost of administration and support	Ecu	0	0	0	0	0	0	0	0	0	0
Annual cost of insurance	Ecu	0	0	0	0	0	0	0	0	0	0
Total operating expenses	Ecu	95,485	96,485	97,485	98,485	99,485	94,485	93,985	93,485	92,985	92,485

Profit and Loss Statement

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Total revenues	Ecu	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800	102,800
Total operating expenses	Ecu	95,485	96,485	97,485	98,485	99,485	94,485	93,985	93,485	92,985	92,485
Operating profit	Ecu	7,315	6,315	5,315	4,315	3,315	8,315	8,815	9,315	9,815	10,315
Interest expense	Ecu	-366	-682	-947	-1,163	-1,329	-1,745	-2,185	-2,651	-3,142	-3,658
Profit before tax	Ecu	7,681	6,997	6,262	5,478	4,644	10,060	11,000	11,966	12,957	13,973
Corporate tax	Ecu	2,304	2,099	1,879	1,643	1,393	3,018	3,300	3,590	3,887	4,192
Net profit after tax	Ecu	5,377	4,898	4,384	3,835	3,251	7,042	7,700	8,376	9,070	9,781

Operating Cashflow

		year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10
Operating cashflow (before interest and tax)	Ecu	-32,685	12,315	12,315	12,315	12,315	-7,685	14,815	14,815	14,815	14,815
Interest	Ecu	-366	-682	-947	-1,163	-1,329	-1,745	-2,185	-2,651	-3,142	-3,658
Tax payment	Ecu	0	2,304	2,099	1,879	1,643	1,393	3,018	3,300	3,590	3,887
Cumulative cash balance after interest/tax	Ecu	-32,319	-21,627	-10,463	1,136	13,137	5,803	19,786	33,952	48,319	62,905

Figure 7-5: User Model Spreadsheet

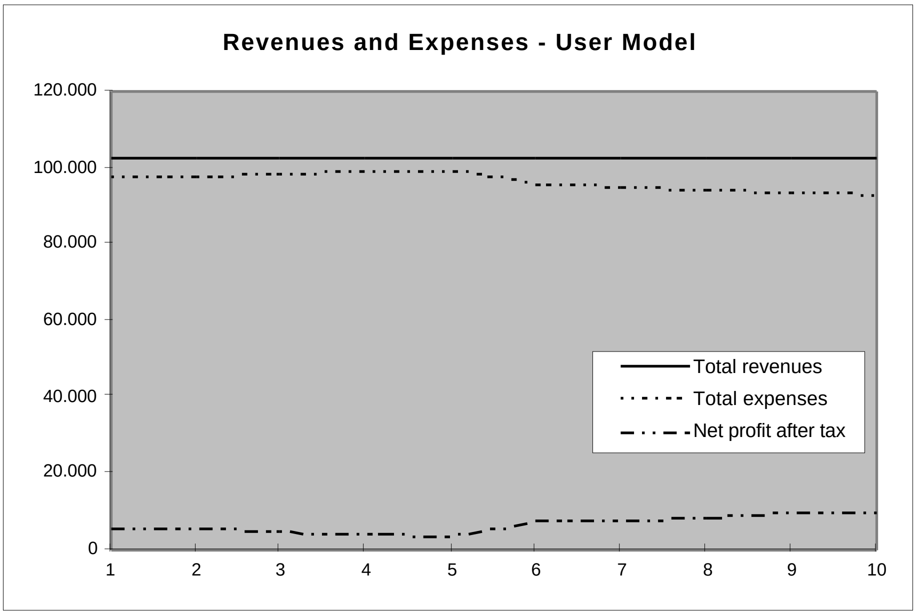


Figure 7-6: Revenues, Expenses and Profit after Tax for the User Model Spreadsheet

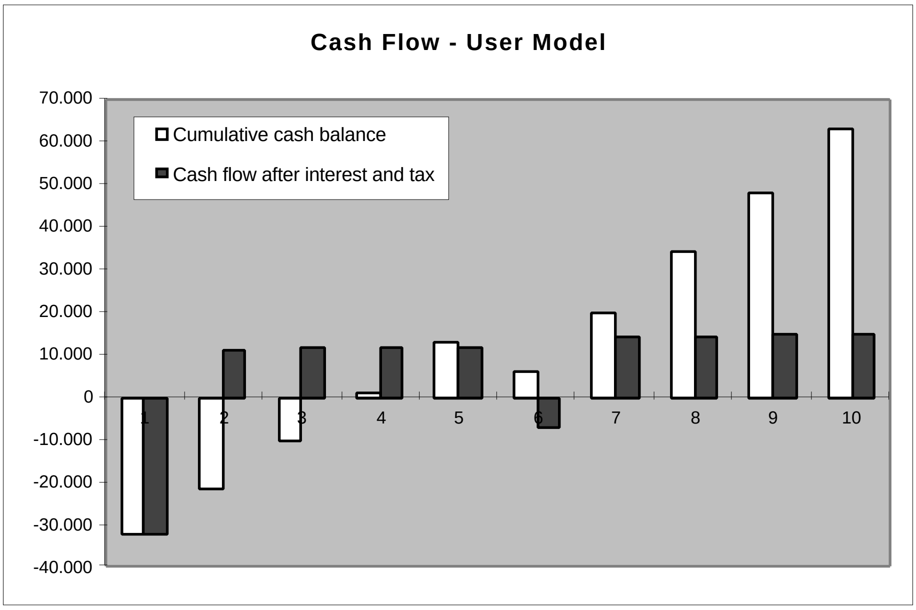


Figure 7-7: Cash Flow and Cumulative Cash Balance for the User Model Spreadsheet

7.5 Results

7.5.1 The Service Provider Model

We define as a “success criterion” for the service provider that the cumulative cash balance (after interest and tax) must be positive from the end of year 4 (a usual criterion for the viability for a business case model would be a positive cash balance from year 3, but the high investments in the first year justify this change).

Figure 7-8 shows the minimum price per case (in Ecu) the Service Provider has to charge in order to fulfil the success criterion, depending on the ATM tariff and the yearly system usage. A usage of 1250 cases per year relates to 12 users with two advice request per week each. This would result in an average daily system usage of one hour. 2500, 5000 and 10000 cases per year relate either to an increased number of users or an intensified usage of the system (4, 8 or 16 cases per week and user, resulting from intensified communication or from the use of the system by more than one department). Of course a usage of 8 hours/day is not realistic – it would hardly be possible to arrange a daily schedule for approx. 50 cases from up to 25 different users, possibly involving different departments as well. So this figure can serve as the theoretical "upper bound" of possible scenarios.

Cases/Year	**1250**	**2500**	**5000**	**10000**
Hours/Day	**1**	**2**	**4**	**8**
ATM Tariff A	74	54	44	39
ATM Tariff B	81	58	46	40
ATM Tariff C	96	65	50	42
ATM Tariff D	118	76	55	45
ATM Tariff E	178	106	70	52

Figure 7-8: Minimum Ecu price per case for the service provider

In [Ret2-9] the physicians stated that 25–50 Ecu per case could be a reasonable "price" for a telemedical expert consultation. If we limit the possible price of an expert consultation to 25–50 Ecu, the number of viable application scenarios reduces significantly. Figure 7-9 and Figure 7-10 show for a fixed price of 35 and 50 Ecu, respectively, in which year the cash flow (after interest and tax) becomes positive for the first time (left number) and in which year the cumulative cash balance becomes positive as well (right number). Commercially viable scenarios (according to the conditions defined above) are displayed in boldface. Numbers with asterisk (*) in Figure 7-10 indicate that the cash flow becomes positive in the displayed year, but drops to a negative value later again (after the re-investment in year 6).

Cases/Year	**1250**	**2500**	**5000**	**10000**
Hours/Day	**1**	**2**	**4**	**8**
ATM Tariff A	– / –	4 / –	3 / 8	3 / 6
ATM Tariff B	– / –	4 / –	3 / 10	3 / 6
ATM Tariff C	– / –	– / –	4 / –	3 / 7
ATM Tariff D	– / –	– / –	4 / –	3 / 9
ATM Tariff E	– / –	– / –	– / –	4 / –

Figure 7-9: First year of positive cash flow / cumulative cash balance at a fixed per-case price of 35 Ecu

Cases/Year	**1250**	**2500**	**5000**	**10000**
Hours/Day	**1**	**2**	**4**	**8**
ATM Tariff A	3* / –	3 / 5	**2 / 4**	**2 / 3**
ATM Tariff B	4* / –	3 / 6	**2 / 4**	**2 / 3**
ATM Tariff C	– / –	3 / 9	**3 / 4**	**2 / 3**
ATM Tariff D	– / –	4* / –	3 / 5	**2 / 4**
ATM Tariff E	– / –	– / –	4 / –	3 / 5

Figure 7-10: First year of positive cash flow / cumulative cash balance at a fixed per-case price of 50 Ecu

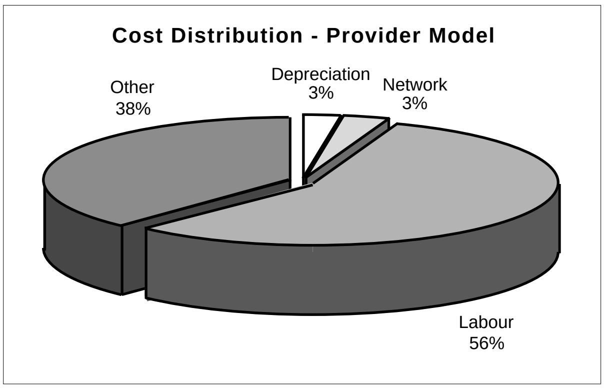
7.5.2 The User Model

The analysis performed here is similar to Figure 7-8. We define as success criterion for the user (as well as for the service provider) that the cumulative cash balance after interest and tax must be positive from the end of year 4. In addition to the "conservative" usage pattern of two cases per week we also examine scenarios with 4, 8 and 16 cases per week. Since an intensified use of telemedicine would also affect the Service Provider, the costs for the service provider are taken from Figure 7-8, with two cases per week at the user side corresponding to 1250 cases per year on the provider side etc. Figure 7-11 shows the minimum revenue (price charged to the patient plus average rationalisation savings) the user would have to yield in order to fulfil the success criterion.

Cases/Week	**2**	**4**	**8**	**16**
Cases/Year	**100**	**200**	**400**	**800**
ATM Tariff A	398	233	150	109
ATM Tariff B	473	276	176	126
ATM Tariff C	655	389	257	190
ATM Tariff D	929	562	378	287
ATM Tariff E	1,659	1,022	703	544

Figure 7-11: Minimum Ecu revenue per case for the user

Whereas the per-case costs for remote consultation seem reasonable for the ATM tariffs "A" and "B" and an intensified usage of the system of at least 8 cases per week (e.g. 109–176 Ecu), the cost increase for the other tariff bands and for less system usage seems surprisingly high, ending up in costs of 1,659 Ecu per case for tariff "E" and two cases per week, a number which will most likely be unrealistic in most application areas. Figure 7-12 shows how the costs for provider and user are distributed for the 109 Ecu/case shown in the uppermost rightmost field in Figure 7-11. This cost distribution assumes ATM tariff "A" and a very intense usage of the system (10,000 cases per year for the provider and 16 cases per week for the user). For the provider, costs are dominated by labour costs of the specialist and "other costs" (mostly profit, interest and tax). For the user, costs are rather evenly distributed. The costs for the service provider and the network costs each account for about one third of the total costs.



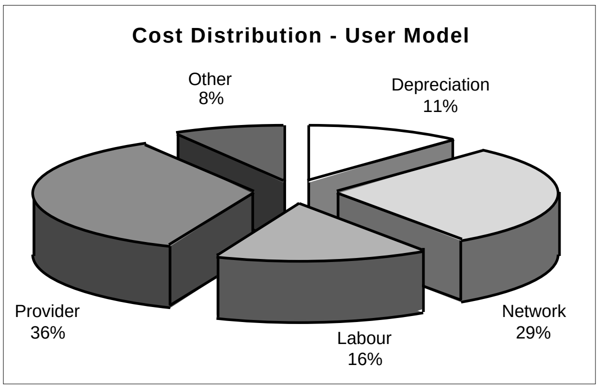


Figure 7-12: Cost Distribution for ATM Tariff "A" and an Intensive Usage Pattern

The picture totally changes when ATM tariff model "E" and the least intensive usage pattern (1,250 cases per year for the provider, two cases per week for the user) are used. Figure 7-13 shows the cost distribution for this case. Network costs now make up 44% of the total costs and labour is reduced to 12%, mostly because "other costs", dominated by profit, interest and taxes, is a rather constant overhead to labour, network and depreciation costs, accounting for about 40% of the total costs. Since all connection costs are paid by the user, the user model is much more perceptive to changed in network costs than the provider model. This is clearly visible in Figure 7-13 – in comparison to Figure 7-12, the network costs have increased from 29% to 78% of the total costs for the user. This indicates that network costs are the main cost driver for the total per-case costs of remote consultation according to the models described in this chapter.

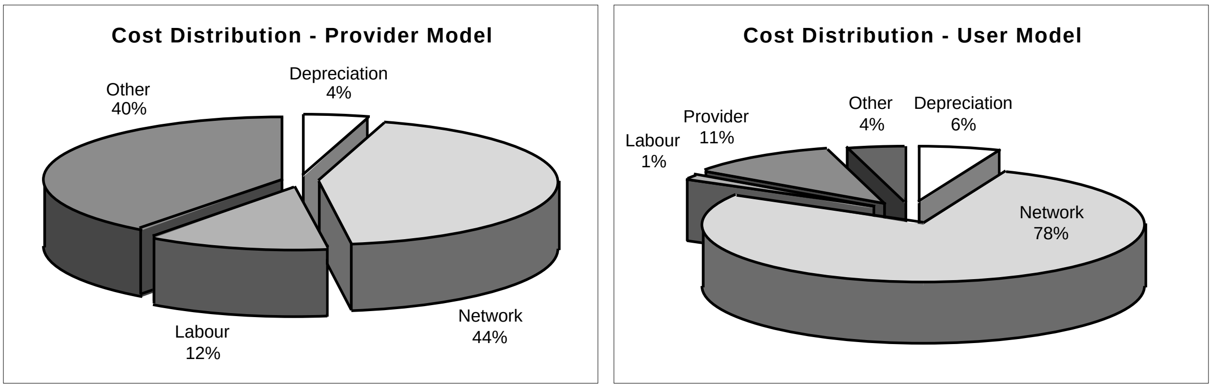


Figure 7-13: Cost Distribution for ATM Tariff “E” and a Conservative Usage Pattern

Figure 7-14 shows the percentage of network costs to the total per-case consultation costs, including network costs both of user and service provider. All 20 combinations of usage intensities and ATM tariff models are shown. As can be seen clearly, the share of network costs to the total costs is not influenced too much by the usage pattern (less usage of the teleconference system only increases the share of the monthly subscription rates charged to each case), but very much by the tariff model (i.e. costs per Mbit/s and hour).

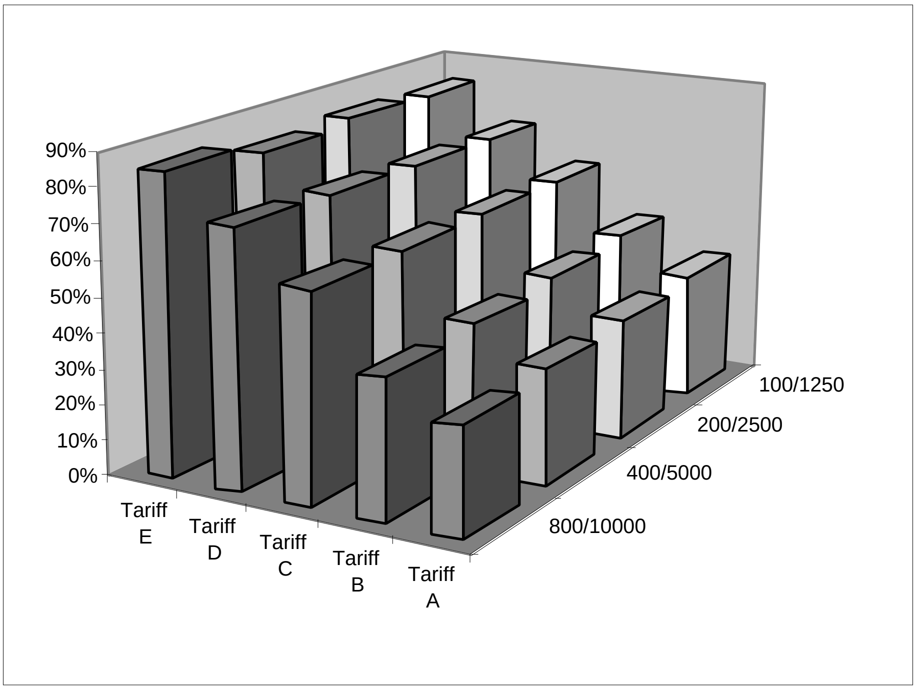


Figure 7-14: ATM Network Cost Percentages

It is beyond the scope of this analysis to answer the question whether the costs described above can be justified by the financial benefits an introduction of telemedical services will produce. This depends on the field of application (e.g. will expensive helicopter transports be saved, will the use of expensive high-tech equipment be minimised or utilisation improved).

However, a tendency in this analysis cannot be neglected: For the “expensive” ATM tariff models, network costs are a multiple (up to 3500%) of the labour costs for the physician requesting advice plus the highly paid specialist and his support team. In most cases it will hardly be possible to justify such network costs. For the “cheap” tariff models, the picture looks different. There is a regular distribution

between labour, network and system costs and, depending on the structure of the health care market and the internal hospital organisation, savings might justify a use of the system. The fact that from 1998 European telecommunication markets will be deregulated indicates that future tariffs for commercial broadband services might rather be related to tariff models "A" and "B" than to the more expensive tariffs.
In addition, a "business case analysis" for a particular hospital will have to consider the fact that "teleradiology" is only part of the "big picture" of telematics in health care. Other medical domains (e.g. dermatology, pathology, oncology or psychology) will have needs for similar communications systems. Other tasks related to medical imaging like centralised archiving of digital medical images at outsourced "trust centres" might use a technology similar to what has been used in RETAIN – or might even offer telemedical services as an added value on their networks. Therefore, the cost evaluation for a particular situation might be quite different from the "naked" analysis for broadband teleradiology presented here, because the main cost drivers – hardware, software and networks – might be shared among multiple departments or tasks.

7.6 Application of the Financial Analysis to the German Health Care Sector

In section 7.4 we claimed that the financial models cannot be applied to a real health care sector without changes. This section describes exemplary how the German health care regulations (see section 6.1) affect these models.
The financial benefits achievable with the use of telemedicine must be divided into benefits for hospitals and the health care insurance:

- Avoidance of unnecessary patient transports: Patient transports are paid by the health care insurance separately. Transport costs are not included in health care service fees which the hospital charge to the health care insurance (see section 6.1.3).
- Reduction of travel costs for physicians accompanying the patient during examinations performed in a different hospital or discussing diagnosis/therapy planning with specialists at remote locations on-site: Travel costs for physicians are charged separately to the health care insurances.
- Reduction of physicians' travel times: This is a benefit for the hospital, since physicians can perform a lot of other services during the former travel time. This can perform further rationalisation effects for the hospital since it is possible that the can save personnel staff.
- Reduction of patients' stay time in hospitals through more efficient medical and administrative practices ("just-in-time diagnosis"): Here we have to distinguish between two cases:
  1. The patient's stay time is reduced and his/her time for discharge is below the upper limit of days to stay in hospital (see section 6.1.3) for his/her case.
  2. The patient's stay time is reduced and his/her time for discharge is beyond the upper limit of days to stay in hospital for his/her case.
- In the first case it is a benefit for the hospital, because it charges the fixed rate for the service (a particular FP), but the time for the nursing care is shorter than fixed in the FP. The bed of the patient can be used for another patient. Any additional material costs which are included in the FP, can be saved. In this case the hospital makes a revenue. In the second case it is a benefit for the health care insurances, because they have not to pay additional department and base care fees, which are charged if the patient stays longer than the upper limit of days in hospital.
- Avoidance of unnecessary double examinations after patient referral: This is a benefit for the health care insurance, because double examination means double charging of examination costs.
- Better capacity utilisation of expensive equipment by the possibility to offer examination services to remote hospitals or to outsource such examinations to remote centres: This is a benefit for both. In the future the health care insurances (policy holders) have to pay for the expensive equipment (see section 6.1.4). If expensive equipment could be used by more than one hospital, the health care insurances save costs for same expensive equipment in other hospitals in the region. The benefit for the hospital is to offer additional services which can be charged. In this case the hospital gets additional revenue (see section 6.1.5)

- Reduction of film costs for copying conventional images which are sent to remote specialists as advice requests: This is a benefit for the hospital, because they can save material costs,

It is clear that there are many benefits in using telemedicine. But it is not quite simple to compare the saved costs and the additional costs for telemedicine (investment costs, telecommunications costs etc.) It is also not simple to decide who has the most benefits and has to finance telemedicine. Both the hospitals and the health care insurances profit from telemedicine and they should divide the costs for telemedicine implementation and the running costs among them. But in Germany it is not clear how they can share the costs.

If hospitals want to use telemedicine today, they have to pay the total costs, but the health care insurances would also profit. For this reason hospitals hesitate to use telemedicine and wait for a feedback of health care insurances.

Today the model described in section 7.4.2 and 7.4.3 cannot be applied to hospitals in Germany, because hospitals are on the one side enterprises, but on the other side they are supported by the government and depend on health care insurances. In the future it is planned that hospitals act more and more as enterprises. Then it could be possible to apply the user/provider-model.

8 CONCLUSION

The RETAIN project has shown that telemedicine, especially when applied to broadband technology, is a very complex field, influenced by technological, organisational, financial and legal questions. Although the potential benefits of this service – better health care delivery for the patient as well as cost savings for the health care provider – are clearly seen by the interest groups involved in this field, the barriers for “IBC Telemedicine” in Europe are still enormous:

- ATM WAN technology is not yet mature for telemedical use.
- Infrastructure in hospitals is developing, but it will take years before a “critical mass” is reached.
- Costs for broadband hardware and services are still prohibitive.
- National health care reimbursement policies often prevent the use of telemedicine.

In our opinion, the results of the experimental RETAIN conference service show that it is worthwhile to take the challenge of the remaining barriers: Even though the trial period was short, the system was a prototype and the connections had to be pre-planned yet were unstable, in several cases the diagnoses of patients currently in treatment in the hospitals participating in the project drew benefits from the project. This indicates how big the potential for an improvement of communication between physicians and in turn health care delivery for the patient would be for a professional, reliable and mature telemedical service.

9 ANNEX: FORMS AND QUESTIONNAIRES

9.1 Consultation Forms

RETAIN	Patient's name and ID:	Preparation Form (Presenter)	**A1**

Please use this form for the preparation of cases you will present.

Location:	Physician:	Date:

Patient ID:	Birth date:	Sex:

Available Image/Examination Data:	**Form of Digitisation:**
☐ X-Ray / Computed Radiography	☐ full digital ☐ digitised film ☐ video
☐ Computed Tomography (CT)	☐ full digital ☐ digitised film ☐ video
☐ Magnetic Resonance (MR)	☐ full digital ☐ digitised film ☐ video
☐ Ultrasound (still image)	☐ full digital ☐ digitised film ☐ video
☐ Ultrasound (cineloop)	☐ full digital ☐ digitised film ☐ video
☐ Digital Subtractive Angiography (DSA)	☐ full digital ☐ digitised film ☐ video
☐ other:	☐ full digital ☐ digitised film ☐ video
☐ other:	☐ full digital ☐ digitised film ☐ video
☐ other:	☐ full digital ☐ digitised film ☐ video
☐ other:	☐ full digital ☐ digitised film ☐ video

Case Classification and Description	
☐ emergency case ☐ difficult case, currently in treatment	☐ standard case, currently in treatment ☐ teaching case, not currently in treatment
Case description:	

What do you expect from the RETAIN consultation ?:

A1 951201

Figure 9-1: Form A1 – Preparation Form

RETAIN		Consultation Form (Presenter)	A2

Please use this form during/after the presentation of your case.

Conference date:	Case No. for today:	Case discussion recorded on video tape? ☐ No. ☐ Yes, on tape #:

Patient ID:	Local physician(s):	Location:
Duration of discussion:	Remote physician(s) participating:	Remote site(s):

How do you assess the image quality for the different modalities used in this case:

Results: What did you learn during the consultation ?:

Technology: Did you encounter problems? Please describe:

Comments or suggestions:
A2 951201

Figure 9-2: Form A2 – Consultation Form (Presenter)

RETAIN		Consultation Form (Receiver)	B

Please use this form for each case which is presented to you.

Conference date:	Case No. for today:	Case discussion recorded on video tape? ☐ No. ☐ Yes, on tape #:

Patient ID:	Presenting physician(s):	Presenting site:
Duration of discussion:	Local physician(s) participating:	Location:

How do you assess the image quality for the different modalities used in this case:

Your opinion on the case:	
☐ emergency case ☐ difficult case	☐ standard case ☐ teaching case
Case description / your opinion:	

Technology: Did you encounter problems? Please describe:

Comments or suggestions:
B 951201

Figure 9-3: Form B – Consultation Form (Receiver)

9.2 Adequacy Questionnaire

1 Demographic Information

1.1.1 Your Name:

1.1.2 Date: ______________________________

1.1.3 Location: ______________________________

1.1.4 Your field of expertise: ☐ Physician, ☐ Technician, ☐ Both

2 Teleradiological broadband conference service

The “core” service of RETAIN is computer supported video conferencing (the RETAIN software plus the video terminal) on ATM. We will call this a “teleradiological broadband conference and consultation service”.
In order to be successful for future non-experimental usage, such service would have to improve communication between physicians. On the long term, it would have to improve health care delivery and decrease treatment costs.

2.1 Will this service facilitate the cooperative discussion and diagnosis on digital medical images between remote physicians?

2.1.1 Does your hospital provide the infrastructure which is necessary to take advantage of this service (digital modalities, in-house network, PACS) **today**?
☐ Yes, ☐ No, ☐ Partially

2.1.2 In how many years do you expect this infrastructure to be available in **your** hospital?
☐ 1–3 years, ☐ 4–6 years, ☐ 7–10 years, ☐ more than 10 years

2.1.3 In how many years do you expect this infrastructure to be available in 50% of the hospitals in your country?
☐ 1–3 years, ☐ 4–6 years, ☐ 7–10 years, ☐ more than 10 years

2.1.4 How often does your department ask for remote advice or an external second opinion **today** (e.g. by sending films with taxi or express service)?
approx. _________ cases per month (our department has ___________ beds).

2.1.5 How often is your department asked for advice or a second opinion from “externals” **today**?
approx. _________ cases per month.

2.1.6 Do you expect such cooperation and consultation between physicians from different hospitals to increase or decrease in the future (e.g. next 5 years)?
☐ increase much, ☐ increase a bit, ☐ no change, ☐ decrease a bit, ☐ decrease much

2.1.7 How would you rate the overall “RETAIN” service as you have experienced?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

2.1.8 How would you rate the video quality (on the ATM network)?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

2.1.9 How would you rate the audio quality (on the ATM network)?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

2.1.10 How would you rate the quality of the digital images reviewed on the computer?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

2.1.11 How would you rate the usability of the software
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

2.1.12 Any comment on these ratings?

____

____

2.2 Will this service increase treatment quality by improving access to specialist expertise?

2.2.1 How many cases did you discuss so far during the trials you participated in?
approx. _________ cases

2.2.2 During the trials you participated in, did you experience a change of a diagnosis which affected the treatment of the patient (or would have affected it if the patient had still been in treatment)?
☐ No, ☐ Yes, in __________ cases

2.2.3 If you would use such a teleradiology service on a regular basis, in which percentage of the cases would you expect changes in diagnosis or treatment as a result of the second opinion?
approx. _________ %

2.2.4 How *much* would you expect this technology to *improve health care delivery* (quicker diagnosis, correct treatment, no unnecessary examinations or referrals etc.) for the patients affected?
☐ important improvement, ☐ improvement, ☐ little improvement, ☐ no change

2.2.5 How much have you learned (or gained in experience) in *medical* issues from the trials?
☐ learned a lot, ☐ learned, ☐ learned a bit, ☐ nothing new

2.2.6 How much do you believe have your conference partners learned in *medical* issues? ☐ learned a lot, ☐ learned, ☐ learned a bit, ☐ nothing new

2.2.7 How would you assess the value of this system as a means of diffusing and distributing expert knowledge?
☐ very useful, ☐ useful, ☐ partially useful, ☐ not useful

2.2.8 In which situation could you imagine that this technology leads to a **decrease** instead of an increase in treatment quality?

____

____

2.3 Will this service decrease costs incurred by unnecessary patient transports and physician travel?

2.3.1 Would you expect the availability of this technology to increase or decrease the total number of patient referrals from or to your hospital?
☐ increase much, ☐ increase a bit, ☐ no change, ☐ decrease a bit, ☐ decrease much

2.3.2 Would you expect the availability of this technology to increase or decrease the number of *unnecessary* patient referrals from or to your hospital?
☐ increase much, ☐ increase a bit, ☐ no change, ☐ decrease a bit, ☐ decrease much

2.3.3 Would you expect this technology to increase or decrease the time physicians have to travel to accompany patients during referral or examination at a different site?
☐ increase much, ☐ increase a bit, ☐ no change, ☐ decrease a bit, ☐ decrease much

2.3.4 What other cost savings would you expect from the availability of such a service?

____

____

2.3.5 In which situation could you imagine that this technology leads to a **cost increase** for the treatment (not including the telecommunication costs for the system itself)?

____

____

3 Narrowband access service

During the RETAIN trials, the RLHK Düsseldorf uses ISDN instead of ATM technology. For connections with Düsseldorf, Oldenburg serves as an "ATM–ISDN dial-in node". We can expect that even in some years not all hospitals in Europe will have access to ATM, so that an ISDN dial-in-service (or "narrowband access service") would be an important feature of an ATM teleradiology network.
Such a dial-in service would have to ensure connectivity between users on the ATM and ISDN networks (a mostly technical question) and at the same time retain an image and sound quality acceptable for medical purposes.

3.1 Will this service retain medically acceptable image and sound quality despite bandwidth limitations?

3.1.1 Have you participated in RETAIN trials involving Düsseldorf (and, therefore, ISDN)?
☐ No, ☐ Yes, approx.__________ Trials

If you have answered "No", the following questions 3.1.2 – 3.1.9 are not relevant for you.

3.1.2 How would you rate the overall "ISDN RETAIN" service as you have experienced?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

3.1.3 How would you rate the video quality?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

3.1.4 How would you rate the audio quality?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

3.1.5 How would you rate the transmission speed for digital images (e.g. CT studies)?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

3.1.6 How would you rate the usability of the software
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

3.1.7 Any comment on these ratings?

____

____

3.1.8 Have medical images been presented to you over the "video channel"?
☐ No.
☐ Yes. Modalities: ☐ CT ☐ MRI ☐ X-Ray ☐ DSA ☐ Other:__________________

3.1.9 If you have answered "Yes" in the last question, how would you rate the image quality of the different modalities?

CT:	☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor
MRI:	☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor
X-Ray:	☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor
DSA:	☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor
Other:	☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

4 Medical multi-media message and presentation service

The third "service" developed for RETAIN is the multimedia message facility developed by CCG. It allows to prepare "offline case presentations" which could enhance – or possibly replace – the online conferences.

4.1 Will this service facilitate the off-line presentation of a patient case consisting of medical images, text, voice and related information?

4.1.1 Have you created a case presentation with the multimedia message tool?
☐ No, ☐ Yes, approx.__________ Cases

4.1.2 Have you been presented a case with the multimedia message tool?
☐ No, ☐ Yes, approx.__________ Cases

If you have answered "No" to the last two questions, the following questions 4.1.3 – 4.1.5 are not relevant for you.

4.1.3 How would you rate the functionality ("functional power") of the software?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

4.1.4 How would you rate the usability ("ease of use") of the software?
☐ very good, ☐ good, ☐ acceptable, ☐ poor, ☐ very poor

4.1.5 Any comment on these ratings?

____

____

4.2 Will this service support a variety of networks including Internet transmission?

Besides the technical aspects, "support" for a certain technology also means that national regulations (security, safety, privacy etc.) must be taken into account.

4.2.1 If you used such a messaging tool only over *directly dialled lines* (like telephone lines), which level of security would you require?

Patient name and other demographic data can be removed before transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ not allowed

Data encryption during transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ not allowed

Digital signature guarantees that data cannot be changed during transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ forbidden in my country

Secure authentication of communication partner (e.g. Chipcard)
☐ necessary, ☐ useful , ☐ not needed, ☐ forbidden in my country

4.2.2 If you used such a messaging tool only over *a public network* (like Internet), which level of security would you require?

Patient name and other demographic data can be removed before transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ not allowed

Data encryption during transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ not allowed
Digital signature guarantees that data cannot be changed during transmission
☐ necessary, ☐ useful , ☐ not needed, ☐ forbidden in my country
Secure authentication of communication partner (e.g. Chipcard)
☐ necessary, ☐ useful , ☐ not needed, ☐ forbidden in my country

4.3 Will this service support online consultation by allowing to transmit patient cases in advance to the online conference?

4.3.1 How would you rate the value of the multimedia messaging tool as an *enhancement* of the "online" conference?
☐ very useful, ☐ useful, ☐ partially useful, ☐ not useful

4.3.2 How would you rate the value of the multimedia messaging tool as an *replacement* of the "online" conference (e.g. only offline messages and telephone conversation)?
☐ very useful, ☐ useful, ☐ partially useful, ☐ not useful

9.3 Financial Questionnaire

1. Does your law guarantee an adequate health care delivery for all citizens? If yes, who is responsible to ensure that every citizen receives an adequate medical care?
   (district and metropolitan governments, health care insurance, etc.?)
2. Who decides where hospital buildings are built?
   (district and metropolitan governments, health care insurance, etc.?)
3. Who is responsible to cover the costs for maintaining and building hospital buildings?
   (district and metropolitan governments, health care insurance, etc.?)
4. Are any investment and support funds from the state government or the communal corporation of the region (regional authorities) available?
5. How is technical medical equipment (e.g. MRI) funded?
   (federal state, the communal corporation of the region, charitable institutions or churches, etc.?)
6. Who decides where special technical medical equipment (e.g. MRI) is located?
   (local administrative body, the persons concerned, regional general practitioners organization?)
7. Do you have more specialized or general hospitals? Why? Explain.
8. Do you have quality control of care? If yes, how does it work? Explain.
9. Does your health care system put emphasis on saving costs by coordination of inpatient and outpatient services? If yes, how do you realise this coordination? Explain.
10. Explain how the health care services are paid.
    - Are all costs for the services performed in your hospital covered without a limitation by a hospital budget?
    - Does your hospital have a fixed budget (e.g. per year) which is independent of the real performed services?
    - Does your hospital have a fixed budget which depends on the real performed services of the year before?
    - Do you have cost-controlling techniques of health care services like health maintenance organizations (HMOs), point of service providers (POSs') or preferred provider organizations (PPOs) in America? If yes, how does it work? Explain.
    - Is there an upper limit for the total of all budgets of the hospitals in your country?
    - Do you have to balance revenues which are below or beyond your fixed budget? If yes, how does it work? Explain.

- Do you have fixed rates for certain medical and health-related services?
  (Services can be: examination, operation, treatment, nursing fee, etc.)
- If yes, who is fixing these rates? Can the rates be decreased or increased in the coming years? If yes, how?
- How can you take the development of personnel costs into account?
- Which sector of the hospital is most profitable?
  - Nursing fees
  - Inpatient operations
  - Outpatient operations
  - Inpatient examinations
  - Outpatient examinations
  - Pre-hospitalization treatment
  - Post-hospitalization treatment.

  Why is it most profitable?

11. How is the payment for the health insurance companies calculated?
    (What about older people, disabled and low income people?)
12. How can the payment for the health insurance companies decrease or increase?
13. How can a hospital reinvest revenues?
14. How can necessary additional capacities in a hospital be funded?
    (Additional capacities mean more beds, more equipment, more staff, etc. – everything that expand your hospital.)
15. Explain the role of general practitioners (GP) in your health care system.
16. Do you have more specialized or primary care GPs? Why? Explain.
17. How do general practitioners charge health care services?
    - Are there any fixed tariffs for services?
    - Do they receive reimbursements for travelling expenses?
    - How are the tariffs for services calculated?
18. Is the information exchange between physicians of a hospital and GPs important in your health care system? If yes, why?
19. Do hospitals or GPs have the possibility to charge telemedicine services today? If not, what has to be changed to allow charging of telemedicine services in the coming years?
20. How is it possible to raise funds for technical equipment for telemedicine today? If it is not possible, what has to be changed in the coming years?
21. Is it possible to raise funds for installation costs of technical equipment for telemedicine today? If not, what has to be changed in the coming years?
22. Is it possible to raise funds for line rental of telecommunications (e.g. monthly subscription costs) today? If not, what has to be changed in the coming years?
23. Is it possible to raise funds for usage costs (e.g. connection time) of telecommunications today? If not, what has to be changed in the coming years?
24. Can an expert charge a remote diagnosis today? If yes, does he charge the remote patient, hospital or health insurance? And if not, what has to be changed in the coming years?

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