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Application and evaluation of high speed data transfer for decision support in remote health care.

ARMSTRONG, I.

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Application and Evaluation of High Speed Data Transfer for Decision Support in Remote Health Care.

Thesis presented for the degree of Doctorate of Philosophy within the Robert Gordon University

In January 2001

By

Iain Armstrong B.Sc. (Hon.)

The Robert Gordon University in collaboration with RGIT Montrose Limited (formerly RGIT Limited) and the Accident and Emergency Department of Aberdeen Royal Infirmary; the studies were partially funded by the European Commission under the Health Telematics Components of the 3rd and 4th Research Framework Programmes.

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ABSTRACT.

This thesis describes the use of telemedicine and medical decision support facilities to improve remote health care in three different scenarios viz. remote communities, merchant marine vessels and offshore installations. In each scenario, telemedical technology and new operational procedures were devised and applied, taking into account the health care requirements of the remote population and the medical education of the remote practitioners.

In the community scenario, videoconferencing, teleradiology and telepresence were used to improve clinical information transfer between the remote general practitioner and Accident and Emergency consultants. The telemedical link was used to treat 120 patients and saved the transfer of 70 of these patients to the large urban hospital during the clinical trial period. Measures of satisfaction of the functionality and quality of the videoconferencing and teleradiology were determined and evaluations made.

The merchant marine and offshore scenarios used the existing telecommunications infrastructure to provide an improved telemedical service. Clinical data collection protocols, procedures and medical assessment questionnaires were used to increase the relevant clinical information transfer. Digital and video cameras were implemented to increase the information that could be sent to the specialist practitioner in an emergency. In the merchant marine environment, a specific software application, appropriate to the medical service was implemented, connecting the medical attendant on board with the shore based medical decision support facilities and services. The offshore medic received medical decision support from the shore-based doctor. This service has been

improved through the addition of telemedicine technologies and clinical data collection and transfer procedures. Remote practitioners, patients and specialist medical care providers were found to be satisfied with improvements in remote health care service provision in either of these scenarios.

Telemedical technology and its application were found not to be the inhibiting factors in the application and use of telemedicine and medical decision support in remote health care. In each scenario, cultural, managerial and organisation issues played a significant role in the success or failure of telemedicine. The medico-legal issues were found to be over-rated as barriers to dissemination of telemedicine in supporting remote health care. Medical decision support was shown to be key component in the provision of remote health care together with:

- Suitably trained personnel at both sites.
- Efficient communications.
- New procedures developed for telemedicine implementation.
- Specialist availability.
- Clinical information transfer.
- Knowledge of the medical indent.
- Continuing research and analysis to improve the system/service provision.

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GLOSSARY.

Accident and Emergency (A&E)	Accident and Emergency Departments in the UK are usually associated with larger hospitals and receive all patients requiring immediate care from minor injury to major trauma. In the UK, Accident and Emergency is a medical speciality.
ARHT	Aberdeen Royal Hospitals Trust. (Now Aberdeen University Hospital Trust).
ATM	Asynchronous Transfer Mode.
Attachment	The attachments are data files. Attachments can be images, data, reports, video or sound clips.
Attachment Wizard	An attachment wizard is capable of creating and displaying an attachment.
B-ISDN	Broadband Integrated Services Digital Network.
BRI	Basic Rate Interface.
CamNet	A proprietary telepresence system developed by BT Laboratories.
CCITT	Consultative Committee on International Telegraph and Telephony.
CME	Continuing Medical Education.
CT	Computerised Tomography.
ECG	Electrocardiogram.
EEG	Electroencephalogram.
ESA	European Space Agency.
FO/First Officer	First Officer on board a merchant vessel, frequently given responsibility as medical attendant on board. Responsible for the health of all crew members.
FDDI	Fibre Distributed Data Interface.

Fundholding	The practice of making medical departments or GP practices responsible for their own financial management and budget requirements.
G7 Nations	United States, Japan, Germany, France, United Kingdom, Australia, Canada. Now G8 with the inclusion of Russia
GCS	Ground Central Station. The routing centre for MERMAID calls for medical assistance.
General Practitioner (GP)	In the United Kingdom, the term General Practitioner describes the physician who provides primary care to the community. Although a non-specialist, a GP undergoes a period of training involving rotation through a number of specialist disciplines including obstetrics, geriatrics, psychiatry and orthopaedics, etc. The GP's surgery is usually the first point of contact for the patient for anything other than a medical emergency. Patients are referred as necessary to specialist physicians in large urban hospitals.
GHT	Grampian Healthcare Trust.
GMDSS	Global Maritime Distress and Safety System.
GP Based Hospital	A small hospital serving small urban or rural communities. This type of hospital may have varying levels of medical services and therefore employs health care professionals such as radiographers and nursing staff. A level of immediate care may be provided by casualty facilities.
GPS	Global Positioning System.
GSM	Group Special Mobile. A European digital mobile telephone standard.
GUI	Graphical User Interface.
H324	ITU Video Standard for low-bitrate communication. H324 ensures the provision on low bitrate terminal system capability.
Health and Safety Executive (HSE) Offshore Division	Government body that regulates health and safety activities on board offshore oil and gas installations. Perform very similar activities to the MCA.

HSD	High Speed Data.
HTML	Hypertext Mark up Language.
HTTP	Hypertext Transport Protocol.
IEEE	Institute of Electrical and Electronics Engineers.
INMARSAT	International Maritime Satellite Organisation.
IP	Internet Protocol.
ISDN	Integrated Services Digital Network. (ISDN-2 is the simplest and least expensive option that offers 2 x 64 Kbits/s channels known as the 'B' channels).
ISO	International Standards Organisation.
ITU	International Telecommunications Union.
JPEG	International Standard for still colour image compression. JPEG refers to the "Joint Photographic Experts Group", the working group set up to define the standard by the ISO and CCITT (Pennebaker, 1993).
Kbits/s	Kilo bits per second. A measure of the speed of transmitting data. (Compressed video requires a minimum of 64 Kbits/s and better quality is obtained with some multiple of 64 Kbits/s).
LAN	Local Area Network.
LES	Land Earth Station. Unit capable of transmitting and receiving satellite communications e.g. INMARSAT.
LUH	Large Urban Hospital. A city hospital providing the entire specialist medical services and departments for the surrounding communities, and remote regions, on one site.
MAN	Metropolitan Area Network.

Maritime and Coastguard Agency (MCA)	Division of the United Kingdom Department of Transport, formerly titled the Marine Safety Agency (MSA), responsible for regulating the merchant marine industry, as well as all other marine activities. They do not have jurisdiction over the Offshore Oil and Gas Installations, which are regulated by the UK Health and Safety Executive (HSE) Offshore Division.
MAQ	Medical Assessment Questionnaire.
MCC or MCCs	Medical Care Centre or Centres. Providers of medical decision support for the MERMAID Sea Vessels.
Medivac	Medical evacuation from an offshore oil installation, either by dedicated or scheduled helicopter flight.
MERMAID	Medical Emergency Aid through Telematics. An EC funded Telematics Applications project for medical decision support in the merchant marine industry.
Modem	Modulator/Demodulator.
MPEG	Standard for the coding, decoding, compression and transmission of digital video and audio. MPEG refers to the "Moving Picture Experts Group", the working group set up to define the standard by the ISO (Mitchell, 1997).
PC	Personal Computer.
PRI	Primary Rate Interface.
PSTN	Public Switched Telephone Network (the analogue telephone network).
RCH	Remote Community Hospital. A Small GP based hospital serving small or rural communities. This type of hospital may have varying levels of medical services and therefore employs health care professionals such as radiographers and nursing staff. However the medical staff are non-specialist GPs. A level of immediate care may be provided by casualty facilities.

RS 232	An alternative name for the V24 interface that is by far the most popular interface for low speed data transfer (typically up to 19200 bits/s). This is commonly seen as the "serial port" on the rear of most personal computers.
SAVIOUR	Study of the Application of Video Image Transfer, Orthopaedics up to Rehabilitation.
SCDC	Simple Cases Drug Consultant.
SDK	Software Developers Kit.
SME	Small and Medium-sized Enterprise.
SV or SVs	Sea Vessel or Vessels. Vessels with the MERMAID application on board, capable of connecting to a medical care centre through the ground central station.
TCP/IP	Transmission Control Protocol/Internet Protocol.
Teleconferencing	A voice and/or videocommunication between two or more participants.
Teleconsultation	A consultation that is performed when the patient is remote from the specialist consultant, using telemedicine techniques.
Teleconsultant	The higher level medical practitioner, capable of providing medical decision support to the remote practitioner in the "field".
Teleconsulting	Consulting from a distance using telecommunication and/or telematic means.
Telematics	The use of telecommunications and informatics (information technology) in combination (Arnbak, 1991).
Telemedicine	The use of telecommunication and/or telematic services in medicine. In the literature it is often used in a more restrictive sense referring to direct patient care oriented clinical activities (e.g. Brauer, 1992).
Telemetry	The means of monitoring and studying physiological functions from the remote site (Kagetsu, 1992).

Telepresence	Virtual presence of a distant person at a site giving the person perception of the site.
Teleradiology	The point to point electronic transmission of diagnostic images (Jeutter, 1990).
Token Bus	LAN system connection stations together with a common bus topology. Network access is by passing a control around the logical ring similar to the Token Ring.
Token Ring	LAN system connecting stations together in a ring formation.
UKOOA	United Kingdom Offshore Operators Association.
URL	Uniform Resource Locator.
VC7000	A proprietary videophone for use on ISDN-2 or X21 data interface.
WAN	Wide Area Network.
WWW	World Wide Web.
X21	Standard defining the physical signalling and connection to some data networks. (This includes the portable ground station used in this project).
X25	ITU standard for interfacing to packet-switched public data networks.

1.0 INTRODUCTION.

The cost of health care services is spiralling in the Western economies. Health care services currently drain between 8 and 25 per cent of the gross national products (Darkins, 1997). The health care costs of any commercial process such as in factories, on offshore oil installations and on board sea going vessels are correspondingly high. Health care service costs in remote areas continue to rise due to the transportation costs of either the medical practitioner or the patient.

The European Community (EC) was presented with the benefits of embracing the application of information technology in European society in general by Commissioner Bangemann (1994). Information and telecommunication technologies were advancing so quickly that pro-activity in the field of telematics was necessary to ensure participation in this "New Industrial Revolution". The "Information Society" action plan proposed the ending of monopolies, and the creation of partnerships and industries working together to create this information society. European citizens would benefit from a higher quality of life and a wider choice of services and entertainment. Ten applications were chosen to launch the information society: teleworking, distance learning, a network for universities and research centres, telematic services for Small and Medium-sized Enterprises (SMEs), road traffic management, air traffic control, electronic tendering, trans-European public administration network, city information highways and healthcare networks.

Market forces were to have a key role to play in the creation of the information society. The liberalisation of telecommunications, particularly infrastructure, across Europe was recommended (Carpentier, 1994). This liberalisation has continued over the latter half of the 1990's and is very evident at present. The Bangemann group recommended the interconnection of networks across Europe, appropriate regulation and standardisation and reduction tariffs. Issues relating to IPR, privacy, data security, media ownership and a competition policy were proposed as part of the process to bring about the Information Society. The improvements in network capabilities and bandwidths available provided an ideal platform to continue improvement in the provision of health care services, particularly in the field of remote health care.

The population distribution in Europe is such that a significant number of its inhabitants are geographically isolated from the large urban centres. Since specialist medical services are almost invariably located in such centres, inequality in access to services is the result. As medical services become ever more sophisticated, this inequality is increasingly unacceptable. This goes against another goal of the EC, that of "equal access to healthcare and health for all". Gott (1995) suggested that these goals were not yet being promoted within Europe. Telemedicine and decision support in remote health care are the potential solution if applied appropriately and cost effectively.

The remoteness of medical services is not only apparent in home or community environment, but also increasingly in the working environment. Work forces are increasingly becoming more and more isolated from high quality medical care when working in such environments as the offshore oil industry, the Polar Regions, remote oil and mineral exploration sites.

The problem is indeed global. The majority of the world's population does not have access to high quality healthcare services. However it is only the developed and industrialised nations which have enjoyed this high quality health care to date, and still see the primary objective as providing it for their own citizens working and visiting these underdeveloped areas.

1.1 Telemedicine.

Remote health care is the provision of medical services at a remote location, either a remote community or worksite. A remote location could be anything from a spacecraft, to an island community, an offshore installation or some other remote worksite. It could equally be a decompression chamber, where doctors or medical providers are not able to directly treat the patient (Norman, 1985). These are instances where medical care is provided from a distance. Telemedicine is a means or tool that can be used to provide the health care at these remote sites. Telemedicine is the delivery of healthcare and the transfer of health care information across distances; it is any medical activity performed over distances (Craig, 1999). Telemedicine is a means to provide medical decision support from a higher authority or knowledge and experience to the person providing care on site.

Since the advent of telecommunications, the practice of telemedicine has provided medical support for people living and working in remote regions. Regions where the population is small and thinly dispersed cannot support or justify the expense of providing dedicated medical practitioners (Brauer, 1992). Basic clinical information was capable of transmission over the analogue telephone network. The constantly increasing bandwidth available for everyday communication enables more and better quality clinical information to be transmitted to a medical specialist.

Telemedicine can be defined as the use of electronic signals to transfer medical information from one site to another (Telemedicine Information Exchange, 2000) or "medicine conducted when the patient is distant from the doctor" (Siderfin, 1995a).

Telemedicine combines the use of information technology and telecommunications to allow medical information transfer between the patient and the doctor. The doctor is provided with sufficient clinical information to make sound decisions on remote patient management. Most telemedicine applications use an intermediary at the remote location to provide the clinical information for the doctor. The doctor is capable of providing advice on patient management. The complexity of the telemedicine technology may be dependent on the medical qualifications of the intermediary (i.e. whether the remote person is a first-aider or an offshore medic). The technology used to perform telemedicine can range from a simple telephone, to satellites, to state of the art videoconferencing equipment. Although the definition is broad, telemedicine is increasingly being used as shorthand for remote electronic clinical consultation.

The recent advances in telecommunications and information technology have fuelled the improvements in telemedicine provision. Ideally applications should not be driven by technology but by need. Telemedicine is not just technology, neither is it a medical speciality, but a process to aid the provision of medical care. The costs of technology required for telemedicine have fallen drastically during the 1990's, and continue to fall (Yellowlees, 1997a).

Telemedicine applications range from radiology to psychiatry. Prison inmates have taken part in psychiatric consultations with specialists using videoconferencing. By using telemedicine, the prison system can save thousands of dollars when compared to the cost of transporting prisoners to medical facilities. Surgery has even been conducted using telemedicine technology. A doctor in an urban hospital has observed and advised a physician performing surgery in a rural operating room (Telemedicine Information

Exchange, 2000). This was done in the southern United States when an amputation was necessary but time would not allow for the patient to be transported to the larger facility. The surgeon in the urban hospital watched the surgery via video, and guided the rural physician through the successful amputation.

Jardine (1999) identifies a number of benefits and potential benefits of the application of telemedicine: equitable access to care in remote settings, home care for the elderly, reduced professional isolation, reduced referrals, access to centres of excellence, reduced clinician travel, unnecessary patient transfers, earlier treatment and diagnosis, facilities for education and CPD, improved use of resources, avoidance of admissions and speeds up discharge, and integration of community-based health and other services. Other potential benefits include, filtering and prioritisation (triage), records co-ordination and better targeted treatments (Clough, 1998). To take advantage of these potential benefits, the way healthcare is delivered will need to undergo very substantial changes.

The provision of medical care at remote work sites can be uneconomic. Doctors are expensive commodities and are not cost effective in the majority of instances. The medical practitioner on site may seek medical decision support from a specialist.

Telemedicine will have significant impact on the delivery care in such areas as community and home care, primary care, accident and emergency services, quality assurance, overcoming distance and isolation, empowerment of patients, training and the reconfiguration of general health care provision.

To succeed in the contemporary health care environment, telemedicine needs to be a commercial as well as a clinical success. Telemedicine has the potential to provide reduced healthcare costs, high quality medical care in the community and reduced loading on urban hospitals and therefore waiting lists. However, as the Lancet pointed out in 1995, the overriding drawback of telemedicine was the lack of formal cost-effectiveness: the economic benefits of telemedicine had yet, and still require, proving (The Lancet, 1995). Hakansson (1999) also implies that there has been insufficient implementation of cost-effectiveness studies in telemedicine. The same author proceeds to state that the greater the number of users of a telemedicine systems, i.e. the more patients are seen by telemedicine, the more financially viable the system will be. However, some studies have shown that there is a point when the increased numbers of teleconsultations will make a specialist on location more economically viable (Bergmo, 1997).

The reduced costs from the implementation of telemedicine are likely to be attributed to: reduction in travel of patients and/or staff, changes in staff skill mix, reduction in clinical risk, more appropriate patient treatment and referral, reduction in capital costs, more rapid treatment and referral, and secondary to primary care shift of services (Darkins, 1997).

On the implementation of telemedicine services, there has been a tendency to focus on the technology. The success of telemedicine applications is in the patient contact and not the network traffic (Darkins, 1997). The commercial success of telemedicine is that it makes clinical interactions of higher quality and cheaper than they might have been otherwise. However, there are inherent difficulties involved in the introduction of any new technologies or change in working practice. So telemedicine and remote medical decision support pose particular difficulties because their introduction is likely to have a direct impact on the way the clinicians do their work (Clough, 1998). Working practices may change so that patients are provided with more information, GPs have a greater choice in referral routes, specialists review clinical decisions, conformity with protocols, care may be undertaken by the less skilled and less autonomy for clinicians. Some specialist medical practitioners may see a threatening future where they reside in offices reporting on images and results. Most barriers to telemedicine arise out of attitude and belief of those involved (Jardine, 1999).

A potential problem on the implementation of telemedicine could centre on the loss of personal contact between clinician and patient. There has been little evidence of this however (Clough, 1998). This may be due to fact that, to date, the most successful telemedical applications have been those that have required minimal patient contact in conventional medicine e.g. radiology, pathology and dermatology. These are the primary telemedical applications in the United States (Yellowlees, 1997a).

There are a number of barriers that remain to be overcome in the eyes of some evaluators, such as reimbursement, medico-legal and regulatory issues (Goldberg, 1996). Research is needed to establish the cost-effectiveness of telemedicine for various medical applications. Danneskiold-Samsoe (1998) stated that in the Nordic countries, Hospitals believed that telemedicine led to equal access to specialist services and better education of primary health care physicians. The views, however, were not based on technological assessment or economic evaluation.

Remote medical practitioners are the gatekeepers or advocates for their patients in respect to secondary and tertiary care. In this situation, the need to facilitate communication and information exchange between remote practitioners and medical decision support providers, e.g. GPs and A&E Consultants, is enormous. Patients increasingly demand more information from their GPs and telemedicine has a role to play in this situation too (Wallace, 1997). Telemedicine is likely to increase patient compliance for treatments. The old culture of "doctor knows best" is no longer tenable. Patients want to know more and if there is doubt will consult somebody who does know. Although the Internet is a convenient source of general knowledge, specific knowledge requires an expert. Telemedicine offers the prospect of the on-line expert (Darkins, 1997).

Jardine (1999) suggests the following elements need to be addressed in the implementation and management of a telemedicine service:

- Planning: as part of a strategic or operational plan.
- Assessment: evaluation of costs, barriers, risks, clinical outcomes and benefits.
- Implementation: change management and project management.
- Staffing Issues: education, training, role changes, consultation and skills assessment.
- Patient Involvement: education, consultation and involvement.
- Post Implementation: user feedback, evaluation, support and maintenance.

These elements are known to any management consultant, and are those, which have to be considered in change management. However some are frequently overlooked in the implementation of telemedicine technologies.

Telemedicine systems will be implemented because there is no alternative or because telemedicine is better (Wootton, 1996). In emergency situations in remote environments, there may be no alternative but to use a telemedicine system. These are situations such as Antarctic bases, merchant marine vessels, spacecraft, aircraft and possibly even battlefields. Alternatively, telemedicine could be the method of providing a better service, such as to remote communities. Finally, there may be situations where telemedicine services are required by international law, such as will be in the case of merchant marine vessels.

There is a growing realisation that telemedicine development will only occur and sustain itself within a structured development or under a national telemedicine strategy. A recent investigation into telemedicine in Australia (Mitchell, 1998) concluded that development was fragmented and relied heavily on two major applications, teleradiology and telepsychiatry. A lack of public awareness together with no national strategy is blamed and requires action to be taken to ensure the development of telemedicine services for this sparsely populated continent. Fellow Australian, Yellowlees (1997b) provides a number of pointers to avoid in the development of a telemedicine system, including; "grand installations of technology", no training requirement, base application on geographical need rather than user, and over evaluation. Yellowlees (1997b) suggests that evaluation is required up to a point, but once in service provision, over-evaluation <u>restricts</u> rather than develops.

Despite these barriers and the lack of national strategy, funding and the development of telemedicine activities continues. Allen (1999) however suggests that the adoption of telemedicine is slowing due to entrenchment among older medical practitioners, lack of predictable reimbursement and lack of compelling cost analyses.

In Europe, the European Community (EC) has funded a number of telemedicine initiatives through health telematics research. The EC funding of healthcare telematics stems from EC policy to strengthen industrial competitiveness, and technology development is driven by application needs, not the technology itself (EC, 1993). In 1993, 26% of the EC Research and Technology Development budget was spent on developing and improving health care services (97.8 MECU).

The European Communities recognised that modern methods of health care are expensive and that there were conflicts between patient expectation and actual service provision. Almost all health care functions could benefit from the technologies of information and communications. The initiative was taken to stimulate and apply information and communication technologies to health care with the objective to "make a significant advance in the performance of health care systems, a major increase of the productivity of medical and biotechnological research and development, and a significant reduction in the growth of health expenditures" (EC, 1993).

The objectives of the EC research of the application of telematics to health care were:

- To improve the quality, accessibility and flexibility of care.
- To increase the effectiveness of patient care bringing about reductions in cost.
- To contribute to establish minimum standards and common functional specifications.
- To contribute to agreed codes of practice, protection of privacy and reliability.

- To stimulate co-operation in the analysis of requirements and opportunities and to contribute to the common adoption of a regulatory framework.
- Adoption of common technical specifications.
- Activities developed dependant on user needs (EC, 1993).

Two of the studies considered within this thesis were funded by the European Commission under the Health Telematics Components of the 3rd and 4th Research Framework Programmes.

1.2 High Speed Data Transfer.

The emergence of high-speed digital communication networks in recent years has made telemedicine applications much more economically possible. Increasing use and available bandwidth, capable of transmitting large amounts of clinical data, images and information from remote sites, providing the specialist with a complete clinical picture. Analogue communications mediums have provided a sound basis for simple clinical information transfer. The higher bandwidths available with digital communication, combined with decreasing transmission and hardware costs have overcome one of the main barriers to telemedicine application. Cost and speed are decreasing and increasing respectively making high bandwidth use acceptable. However, the use of higher bandwidths may not provide the best telemedical service for the remote area. Studies that have utilised existing telecommunications mediums to provide telemedical services, are capable of sustaining provision and demonstrating cost effectiveness.

The three medical scenarios, which are studied, use, the Integrated Services Digital Network (ISDN), the International Maritime Satellite system (INMARSAT) and the Internet to permit clinical information transfer.

1.3 Telemedicine Evaluation.

There may be many technical and organisational problems that have yet to be solved if the full potential benefits of "telemedicine" technologies are to be realised. De Maeseneer (1995) lists a number of factors which some may feel hinder the acceptance or diffusion of telemedicine as a means of providing effective health care. De Maeseneer cites lack of evidence of cost-effectiveness as one of the primary factors.

The application of new medical technologies has been implicated in the rising costs of healthcare (Rosen, 1998). Rosen (1998) suggests that a solution to this may be to control technology diffusion while research is conducted to assess clinical and cost effectiveness. Unfortunately there is pressure exerted to diffuse the technology by the media, public demand and even the enthusiasm of the medical profession. However, to ensure continued and effective use of any new technology, evaluation is essential. There is a requirement for evaluation of telemedicine research to ensure medical service provision based on evidence of its efficacy.

The evaluation of a telemedical system should analyse three issues: quality of patient care, legal issues and cost (Huston, 1996). Issues of quality of patient care refer to the reliability and replicability of telemedical diagnoses, patient response to treatment, identification of telemedicine risks and identification of types of consultations that can be carried out via telemedicine. The main legal issue that must be ensured through telemedicine is confidentiality. The final issue is cost, and the comparison of costs of traditional medical techniques with those of telemedicine (Huston, 1996).

Policy makers have to propose clear objectives about what they expect to achieve by telemedicine implementation. Mooney (1994) suggested that there are two recognisable attributes when applying healthcare for remote areas, efficiency and equity. Efficiency relates to the economic or cost effectiveness of the system, whereas equity refers to the notion of equal access to health care. The healthcare provider must realise that the two may not exist in the same service provision, especially in the case of remote health care. To provide equity of access to remote communities or worksites, and therefore a choice, may not be cost effective or an efficient use of resources.

The foundation of any telemedical consultation however is the requirement for the transmission of clinical information that is good enough for a diagnosis to be reached by the clinician. While many pilot programs involving new communications technologies have been set up, these tend to concentrate on the functional aspects of the equipment. There appears to be the assumption that the process of medicine will remain unchanged regardless of the means used to gather the necessary information (Kagetsu, 1992).

Frameworks for the evaluation of telemedicine have been proposed in terms of economics or cost-effectiveness (Sisk, 1998) and clinical effectiveness (Grigsby, 1995). Sisk (1998) states that the costs of providing telemedicine should be compared with the costs of the alternative methodology. Unfortunately telemedicine technology is ultimately, and rightly so, used in a number of applications and by a number of medical departments to provide services. The apportionment of costs can therefore be challenging. Even if the telemedicine equipment is utilised by only one service (that is to say it is under-utilised) then the cost effectiveness evaluation is still not clear. Factors such as the method of reimbursement, licensing and of course the quality of care are not addressed. A cost effectiveness evaluation done in this manner may not be necessary if the telemedicine service has been implemented to provide equity of health care (Mooney, 1994).

Grigsby (1995) proposes a framework to study the efficacy of telemedicine as a diagnostic medium. The majority of new technologies have been compared to the service that they are replacing. For example, teleradiology images are still commonly compared with the interpretation from the original analogue image (Kagetsu, 1987). Effective analysis may be achieved by narrowing the scope of the evaluation; choosing the most prevalent cases for study, or those difficult to diagnose, determination of appropriate levels of diagnostic accuracy and minimal levels of sensitivity and specificity (Grigsby, 1995).

Clough (1998) suggests that most believe that telemedicine has proved itself both technically and clinically, and that the key issues now concern the manner in which these services are managed to maximise benefits.

1.4 Thesis Overview.

This thesis examines the application of high-speed data transfer or telemedicine for three remote health care scenarios: community, maritime and offshore application, and evaluates the provision. Telemedicine and medical decision support should reduce costs/provide savings and increase quality benefits. The three differing scenarios have a common requirement for medical decision support and remote health services, primarily for emergency cases, either illness or injury. The scenarios required medical service provision to be improved. The application of telemedicine in community care has been undertaken to improve healthcare services to the local community, telemedicine will help provide better healthcare. Telemedicine application in the merchant marine environment is being undertaken to improve on present communication media, and also as a legal requirement. Finally, medical decision support has been provided within the offshore industry for a number of years, and telemedicine is being investigated as a potential means of adding value to remote health provision. Telemedical technology has been applied in those scenarios that are appropriate to the qualifications of the remote practitioner, the person physically attending the patient.

These three scenarios were chosen as suitable studies to examine the application of telemedical technologies for medical decision support in remote worksites. The organisation from which these studies were conducted provides medical support to remote work areas such as the Antarctic and offshore installations. These telemedicine research studies were undertaken in to investigate methods to improve medical service provision by the organisation.

Primarily the community medicine scenario was used as a test bed for equipment, procedures and transmission mediums. The community medicine scenario provided a suitable requirement for medical decision support using telemedicine technologies, without an excessive distance between the remote and specialist centres. Both ends of the link could be visited, technical and procedural problems solved, evaluation monitored and clinical staff opinion sought.

The latter two scenarios viz. merchant marine vessels and offshore oil and gas platforms are locations where the medical service organisation can commercially provide services. In these scenarios there is an absolute requirement for high quality medical care to be provided to a screened population. These scenarios are not as restricted by cost, however cost benefit must be shown. Technology and experience gained from the application of telemedicine in the community environment were applied in these two scenarios, with the aim of improving the service provided by the organisation. At present, in all three scenarios there is not a legal requirement to provide a telemedicine service. However an innovative approach was investigated for each scenario.

Table 1.1 delineates the different scenarios showing how the three archetypal applications chosen for study are representative of the generic telemedicine challenge.

Scenario	Remoteness/ Evacuation	Constraints on Resources	Communications Infrastructure	Qualifications of Remote Practitioner	Types on Injuries Treated
Community Medicine	Routine Evacuation	Constrained by NHS Funding	High Quality Infrastructure Exists e.g. ISDN	High – Nurses and GP	Wide Range of A&E Injuries
Merchant Marine	Evacuation Very Difficult	Constrained by Market Forces	Restricted Bandwidth e.g. INMARSAT and Marine Radio	Low – First Aider	Advanced First Aid Only
Offshore Installation	Evacuation Possible but Sometimes Hazardous	Constrained by Production Costs	Bandwidth is Restricted but Improving e.g. Satellite and Internet	Medium – Nurses and Paramedics	Minor A&E Injuries (Minor Injuries Clinic)

Table 1.1: Scenarios Representing Generic Telemedicine Challenge.

The move presently in the medical field is towards evidence-based medicine. This means that for every change in medical care, there must be scientific evidence demonstrating the benefits from the action. The action has to be best for patient care and medical treatment. If the action is for cost reduction reasons, then there must be evidence that the action does not reduce the quality of patient care. Therefore there have to be scientific trials of telemedical applications proving that health care provision is improved.

Patients and health care workers are coming into contact with telemedical services for the first time, and must have the confidence that medical services provided in this manner are as effective as traditional means. Telemedicine and medical decision support are being applied in these scenarios to:

- Provide equal access to healthcare in these remote locations.
- Resolve difficulties recruiting doctors due to professional isolation and poor continuing medical educational opportunities (CME).
- Provide a cost-effective service using a less medically qualified person at a remote worksite reduced costs.
- Provide high quality medical care, no matter where.
- Improve on present system providing healthcare services.
- Reduce costs by saving patient transfers and reducing transport costs.

The three applications which have been undertaken as part of this study show that telemedicine applications can be undertaken which meet the user requirements, are fit for purpose, are likely to be successful and lead to full service provision. The evaluation of telemedicine applications is paramount to prove the efficacy of the telemedical intervention.

Much of the technology that has been implemented within telemedicine applications has not been designed with remote health care as the primary function. Telemedicine applications are often technology driven. The technology is created and a purpose sought retrospectively. These studies have attempted to use new but simple technology to improve healthcare provision.

There are a number of medical specialities that are better suited for telemedical delivery. These are presently the most common telemedicine applications: teleradiology, telepathology and teledermatology. These applications do not provide integrated health care to the whole of a community or work site. To prove the value of telemedicine, an integrated telemedicine service, which incorporates a number of specialities must be demonstrated. The cost benefits of such a system will only be demonstrated once it fulfils its potential and sustains a effective telemedical service. This thesis will examine the three scenarios to which emergency and minor trauma telemedical care is provided. The systems provide an integrated care to remote populations based on user needs and use off the shelf hardware.

Chapter 2 of this thesis will review the literature on telemedicine and telemedical applications, as well as discussing the high-speed data communications systems available for application. Issues that affect the application of telemedicine are discussed, and elements to consider in the implementation of systems are presented.

Chapter 3 presents the three scenarios, describing the rationale for the implementation and the background to each scenario and location.

Chapter 4 discusses the application of videoconferencing, teleradiology and telepresence in the context of a rural community hospital for emergency trauma cases.

Chapter 5 discusses the provision of a software-based application providing medical decision support for the merchant marine industry, for accident and illness on board sea vessels.

Chapter 6 presents how a simple and effective telemedicine service can be provided for the personnel on board an offshore oil installation.

2.0 TELEMEDICINE AND COMMUNICATIONS LITERATURE.

This section describes how health care has been provided to many of the remote worksites and communities world-wide. Telemedicine has been applied to improve the means and quality of health care in these areas, and specific applications are described. The emergence and reducing costs of digital telecommunications has encouraged the application of telemedical technology and improved the cost effectiveness of these applications. The various telecommunications mediums are described and the advantages of the three utilised in this study explained. Because telemedicine is not merely the application of technology, but requires a change in the way health care is provided, these changes are discussed. Telemedicine is a method of providing healthcare services to a remote site, but is not a medical speciality in its own right. The medical specialities that have benefited from the application of telemedicine are described.

Telemedicine is a process that can be used in the provision of medical decision support for remote areas, communities and worksites. As stated, the very nature of these remote environments means that standard medical provision is not affordable or easy to provide. There is a shortage of medical personnel willing to work at remote areas due to professional isolation and lack of continuing medical education. Telemedicine has the potential to provide medical support and education.

Reduced to its simplest form, telemedicine refers to the provision of health care services via telecommunications, the transmission of medical information between interconnected, geographically separate health care facilities (Anogianakis, 1996a). It is a system of health care delivery in which physicians can examine and discuss treatment with distant practitioners and patients, and therefore advise on patient management, through technology which can range from a simple telephone, satellites, state of the art video conferencing equipment to advanced information systems.

It has been stated that, "Telemedicine is an exciting new technique for healthcare delivery and one of which is potentially very important. Its proponents believe that telemedicine could do for healthcare what the personal computer has done for the office" (Wootton, 1999a).

Telemedicine is used as a generic to describe medical treatments that are carried out at a distance. Unfortunately there are relatively few published studies confirming telemedicine as an overall cost effective technique, and as a result it remains a largely experimental technique. Few healthcare providers are likely to implement new techniques without such evidence. There are a number of highly publicised sustained telemedicine services, e.g. teleradiology between the Middle East and Massachusetts (Richardson, 1996) and a telemedicine link for the UK armed forces in Bosnia (Vassallo, 1998). Unfortunately the majority of telemedicine activities in Europe are still deemed to be at the research stage and not operated commercially. The European Commission is aware of the failure to take the next step. All health telematics research projects are now required to submit exploitation plans at the proposal stage, and projects are focussed more on application (Healy, 1998).

As the number of applications has grown, confusion over the exact nature or definition of telemedicine has also grown (Bashshur, 1995). The introduction of other specialities and terms such as **medical informatics**, **telecare**, **telehealth** and **telematics** have fuelled this confusion:

Medical informatics is often used in conjunction with modern applications of telemedicine. Medical informatics refers to a wide range of information technologies (such as specialised computing systems, computer workstations, database designs, software) used in medical practices, telemedicine can refer to the uses of telecommunications to distribute such services.

Telecare is defined as the provision of nursing and community support to a patient at a distance (Wootton, 1999b).

Telehealth may seem to expand the previous definitions of telemedicine to include; patients using the Internet for counselling, education and information, health information networks, and sensor technology to remotely monitor and manage patients (Holt, 1999).

Telematics is the combined use of telecommunications and informatics. This is a three-layer approach, combining local input devices, connected and communicating with remote applications (De Moor, 1994).

Fundamental to the application of telemedicine and telecare is the transmission of clinical information, and the provision of expert medical opinion. Telemedicine is used in the delivery of healthcare, and also fundamental in the diagnosis and the resultant care provision.

Telemedicine is mostly identified with the provision of health services based on application of telecommunications, for example remote consultations and remote diagnoses within various medical specialities. Medical distance learning and remote instruction are now included in the concept of telemedicine.

In practical terms telemedicine has three main dimensions: telecommunications, medical informatics and healthcare provision.

Europe and America are the prime telemedicine research activity areas. In 1999 it was reported that the Americas undertook 48% of telemedicine research, Asia 6%, Australiasia 3%, and Europe 43%. The majority of this research work concerns diagnosis and clinical management at a distance. Europe and the USA have completely different healthcare management systems, and as a result some of the research is not easily transferable. Primary telemedicine research in Europe is spread all over the continent, however the UK, with 44% of the activity is the prime mover in the field; Austria has 8% of the activity, Belgium 2%, Finland 5%, France 3%, Germany 5%, Italy 10%, Norway 14%, Spain 5%, Sweden 2%, and Switzerland 2% (Wootton, 1999a).

A survey of medical professionals using telemedicine to provide medical services was undertaken by the Science Advisory Board in 1998 (Kelly, 1999). The reasons provided for the implementation of telemedicine were: to deliver quality care to rural and under-served areas, the increasing demand for access to medical information, to enhance continuing medical education, the need to reduce costs and increase efficiency, and to improve the continuity of health care. Concerns over the use of telemedicine related to the cost of equipment, inter-operability problems, image quality, patient confidentiality, the lack of established protocols and evidence of cost/benefit evidence. It was agreed that rural, primary and home healthcare represented the three most promising applications for telemedicine.

In Sweden, a review of telemedical applications identified the following reasons for the introduction of telemedicine: greater opportunity for consultation and access to specialists, moving healthcare closer to the patients, more efficient use of unevenly distributed expertise, less travel for staff, shorter care processes, safer emergency care, lower costs by co-operation and improved organisation, and co-ordinated specialist expertise in planning care and treatment (Sjogren, 1999).

Wootton (1999b) describes a method of classifying telemedical activity using the content or form of information against the interaction that takes place.

		Interaction	
		Pre-recorded	Real Time
Information Form	Video		*Telepsychiatry*
	Still Images	*Teleradiology*	

Figure 2.1 : Classification of Telemedicine Activities.

This means that real-time or live interaction is likely to take place in medical specialities such as telepsychiatry or trauma care. These are specialities that normally require the remote consultant to have live interaction with the patient. A psychiatrist relies as much on visual cues during an interview as the verbal interaction. Likewise, an Accident and Emergency (A&E) specialist uses a physical examination, in combination with an interview to extract clinical information. Therefore during a remote or telemedical consultation, live video interaction is imperative for these and similar specialities.

Other specialities such as radiology, which commonly involve the examination of still images, facilitate the store and forward type of telemedical interaction. Radiographs are pre-recorded, digitised and forwarded to the radiologist for examination. The radiologist does not interact directly with the patient.

The medical specialities that do not require hands-on interaction with the patient, allow a simpler application of telemedicine to provide the service. By far the most commonly applied type of telemedicine service is that of teleradiology (Sjogren, 1999). Even in normal radiology service provision, the radiologist may not even see the patient. Therefore the fact that the patient is hundreds of miles away is irrelevant. The other most popular telemedicine activities that fall into the same category are telepathology and teledermatology. Normally dermatology would require the viewing of the patient. However for telemedicine application, it is very easy to capture dermatological images, and forward them to the distant dermatologist for opinion. Dermatology can be adapted to this store-and-forward interaction that appears the more successful telemedical method. However, there are some medical specialities or instances where live two-way interaction is necessary if not essential. The technicalities of this interaction must be dealt with and accounted for. Video interaction is still expensive. Medical specialities that require minimal patient contact by the specialist, such as radiology and pathology, are still felt to have the highest potential for telemedical application (Sjogren, 1999).

Telemedicine may have initially looked like another set of high-technology equipment looking for an application. But telemedicine is an advanced system of health care delivery that (through advanced communications technologies) connects primary care physicians, specialists, and patients in ways previously unimaginable. During a teleconsultation a physician could possibly: interact with a patient, retrieve information from the patient's electronic file, take video photographs of an affected body area, send transmissions, and store notes and images for later reference. With this powerful communication medium, physicians have more resources and greater flexibility. At the same time, medical office and hospital staff have to find different ways of scheduling patients, to store patient information and to submit information electronically while filling new and changing roles. Managers must address trouble-free operation of transmission networks, standards of quality care, training of personnel, reimbursement, regulatory puzzles, and other issues. Finally, insurance companies and other third party payers must look for new ways to validate and process claims. Telemedicine is not simply about technology and new equipment. It is a process, "whose successful exploitation requires organisational changes in the structure of the relevant health service" (Wootton, 1999b).

Telemedicine requires a shift of mind and an ability to see new and more productive interrelationships among medical professionals, patients, insurers, policy makers, businesses, and the community at large. Telemedicine challenges the leaders of hospitals, clinics, nursing homes, mental health facilities, and medical schools to rethink the ways they provide a complex array of health services, functioning less as isolated entities and more as a whole. This challenge may be one of the main barriers to the introduction of telemedical services. The way in which healthcare services are managed requires to be changed.

For a teleconsultation to proceed and aid effective medical care, a number of interactive factors must be present in the communication media. The communication means must offer seamless connectivity and inter-operability with other systems, compression without loss of information and assured quality of service at a cost effective price (Kopsacheilis, 1997). An emerging attribute required for telemedical application is the ability to function over a number a different bandwidths. This scaleable functionality can ensure wider connectivity to more potential users, utilising whatever means are available at the remote sites.

A view taken by Mackinnon (1997) is that the level of equipment specialism is reducing as the realisation that simple technology and communications are as effective and more economic. The current basis for telemedicine is the provision of simple, cost effective methods of communicating and disseminating information for better medical practice, rather than the highly publicised and adventurous applications of robotic surgery and virtual reality. An example of the effective application of simple technology is the provision of health services to remote islands of Croatia using a modem and Internet system over the Public Switched Telephone Network (PSTN) (Ostojic, 2000). This system paid for itself within 46 teleconsultations, achieved high savings in transport costs and lost labour days, and was widely accepted by patients.

2.1 Remote Health Care.

Health care has been provided to remote communities and worksites for many years. Remote general practitioners in Scottish islands cater for the health care needs of the local community. Presented with a medical problem, which they cannot deal with, the GP sends the patient to the specialist hospital for treatment. Health care provision on oil installations takes on the same system. The offshore medic provides the primary point of contact for the medically screened workforce. Injury or illness outwith the medic's capability requires evacuation of the worker.

Remote health or medicine incorporates a number of factors that make up an effective medical service provision. Norman (1988a) suggests that basic medical training, medical supplies, effective medical communications and the availability of appropriate trained doctors and specialists to provide advice are necessary. These factors combined with pre-employment medical examinations for remote work sites can reduce the medical risks. Remote communities must still attempt to attract a rural GP to provide primary care services.

One of the most remote areas of the world is the Antarctic. A number of countries operate research stations on the Antarctic continent. The British Antarctic Survey uses the basic principles listed above in the provision of primary health care to its bases. The situation is much more severe in this remote location, where the bases can be effectively cut off during the winter months, with evacuation impossible. Specifically trained doctors (Haston, 1996) form part of the over wintering team. They boast a well-equipped sickbay and effective communications system (to the UK) for advice.

Structured clinical data collection has been one of the best methods in improving medical communication with the Antarctic bases using the bandwidths and equipment available (Siderfin, 1995a). This technique has been effectively adapted for remote field parties using VHF radio communication (Siderfin, 1995b).

The Polar Medicine Branch of the Australian Antarctic Division has experienced similar barriers in the provision of remote health care to their distant bases. Telemedicine has been applied for a number of years for many specialities: teleradiology, microscopy, ECG interpretation, gross pathology and dermatology. Videoconferencing is possible. However, a low cost simple system is maintained as it is reliable and easy to use (Allen, 1996a).

Another example of extreme remote health care is that provided to expeditions, which by their very nature, distance themselves from professional health services. A survey of expeditions showed that the combination of pre-screening, training, medical communications, medical supplies and appropriate medical support had been adopted successfully in the majority of cases (Johnson, 1984).

2.2 History of Telemedicine.

Telemedicine was practised long before modern telecommunications systems were developed. Plague victims in the middle ages were treated across a river to minimise risks to the physician (Wootton, 1999b). Postal diagnosis, advice and directions for treatment were not unheard of.

Telemedicine really developed with the introduction of electronic communication. Since the advent of telecommunications, remote health care, medical decision support and telemedicine have been used to provide medical support for remote regions. Initially analogue communications techniques were employed in telemedicine provision, but these have gradually been replaced by digital methods. A classic case of telemedical support using the telegraph system was highlighted in the obituary of John Joseph Holland (Holland, 1997) one of the founders of Australia's flying doctors. A postal worker communicated with Holland regarding the treatment of a man who had fallen from his horse. The telegraphs instructed the postal worker in performing a perineal and supra-pubic cystostomy. These treatments were successful.

Radio medical support has been provided to seafarers since at least the 1920's. The Sahlgrenska Hospital in Sweden has been giving medical advice to ill or injured sailors in the Swedish merchant fleet since 1922 (Sjogren, 1999). The Italian radio medical centre (CIRM) has successfully provided radio medical assistance to seafarers worldwide since the 1950s (Amenta, 1999; Parrish 1997).

In the United States, the National Aeronautics and Space Administration (NASA) has played an important part in the development of telemedicine (Bashshur, 1977). NASA began experimenting with telemedicine in the 1960's when sending astronauts into space. During space missions, physiological data was sent back to earth for monitoring. NASA provided much of the technology for the early telemedicine demonstrations projects in the USA.

The Telemedicine Information Exchange [http://tie.telemed.org] in the US highlights six telemedicine projects from 1955 to present day, which demonstrate the application of telemedicine technology in improving remote health care:

1. The Nebraska Psychiatric Institute using a two-way link of closed circuit television for consultations and education with the state hospital.
2. The provision of emergency and occupational health care to a remote airport from Massachusetts General Hospital, transmitting images etc. by microwave.
3. The improvement in village health care in Alaska by audio and video communication with a state hospital. The network used the first Applied Technology Satellite launched by NASA.
4. NASA providing medical support for Papago Indians as well as astronauts during the STARPAHC project. X-rays and ECG were transmitted for evaluation using a two-way microwave and audio transmission system.
5. NASA undertaking an evaluation of video requirements for remote medical diagnosis in collaboration with SCI. The frame rates and bandwidths of various systems were compared.
6. The Telemedicine Centre of the Memorial University of Newfoundland using teleconferencing for many of is medical decision support services. The Centre

provides consultation, education and medical data transmission over interactive audio networks.

The Telemedicine Information Exchange presently lists two hundred and fifty two active telemedicine projects internationally. These projects are both research and service based.

In the United Kingdom, the National Health Service has a well-developed information management and technology strategy. The strategy has been reinforced through a number of recent governmental "White Papers", such as the NHS Executive Information for Health – "An Information Strategy for the Modern NHS 1998-2005", which has set out the future of regional healthcare services within Scotland, England, Wales and Northern Ireland. However these are general policies that only touch upon or mention telemedicine as a means of healthcare delivery. They do not establish forward a telemedicine strategy. Therefore telemedicine may appear to be still relatively uncoordinated at a National level, and may be a future target for the Department of Health and Healthcare Trusts. Healthcare authorities and trusts are both able to make decisions on the use and application of telemedicine within their organisations, and are funding local projects and telemedicine applications.

A study funded by the Department of Health to review telemedicine in the UK (Clough, 1998) identified 24 Projects in 8 clinical areas. Unfortunately, the study also showed that very few projects were able to prove cost effectiveness and had done cost effectiveness studies. A further review (Jardine, 1999) stated that telemedicine did have a great potential for revenue generation, but activity was on research and being done by commercial organisations rather than the NHS. There was a clear need identified for co-ordination of telemedicine at a national level. This further study identified the wide range of medical specialities in which telemedical applications are being undertaken in the UK: radiology, dermatology, cardiology, endoscopy, ophthalmology, education, psychiatry, trauma care, primary care, pathology, home monitoring and nursing. These applications have used varying degrees of technology, from the plain old telephone system to satellite ultrasound video.

The Department of Health has further funded the UK National Database of Telemedicine [www.dis.port.uk/ndtm] that lists all telemedicine applications and research projects in the UK. In 1998, a total of 61 projects were listed: 45 in England, 7 in Scotland, 4 in Wales and 5 in Ireland, covering the same applications which were listed above. The Database also listed 18 commercial applications being undertaken within the UK, but outwith the NHS.

2.3 High Speed Data Communication.

The emergence of high-speed digital communication networks in recent years has made telemedicine applications much more economically possible. Analogue communications mediums have provided a sound basis for simple clinical information transfer. The higher bandwidths available with digital communication, combined with decreasing transmission and hardware costs have overcome one of the main barriers to telemedicine application.

The three medical scenarios, which are studied, use the Integrated Services Digital Network (ISDN), the Maritime Satellite system (INMARSAT) and the Internet to permit clinical information transfer. These three systems plus the other potential clinical information carriers are described and discussed.

2.3.1 Telecommunications.

Communication networks may be classified as public or private. Private networks are generally owned and operated by a single organisation and are often referred to as local area networks (LANs). Private networks are extensively used to connect computers/computer equipment within a building or group of buildings. Current LANs typically provide data communications at up to about 16 Mbps within an area of 1 km^2 or less. Typical applications of a LAN include connecting computers within an office or department, connecting computers within a university campus or a hospital and connecting computer equipment within a factory.

Public networks are operated by a service provider for use by a number of service users. These networks are generally necessary for interconnection between sites and are therefore called wide area networks (WANs).

Networks designed for interconnection over a large site or possibly within a city are sometimes referred to as metropolitan area networks (MANs), and may be public and/or private. It is common practice for a single organisation to lease lines from a public service provider for the purpose of interconnecting private LANs on separate sites. These extended networks are then referred to as virtual private networks.

Heterogeneous local and wide-area networks are commonly interconnected to form inter-networks. This interconnection may be performed on an ad-hoc basis by a private organisation or it may be co-ordinated by a set of recommendations or standards. Additional high-level protocols hide the details of underlying sub-networks from the network user permitting computers to communicate without regard to their physical network connections.

One obvious large inter-network is the Internet (Comer, 1988) that is of global proportions and interconnects most scientific, large commercial, educational establishments and home users. The Internet grew out of the ARPANET, which originated in the US (Defence Advanced Research Project Agency). The Internet uses a suite of high level protocols referred to as TCP/IP (Transmission Control Protocol/Internet Protocol) to allow open communication between computer systems on separate sub-networks. The TCP/IP protocol suite has advanced since its inception and is now capable of supporting real-time traffic such as video and audio. This is an active research area and new protocols to support video conferencing are under constant development.

Communication networks may also be classified according to their mode of operation as either circuit-switched networks or packet-switched networks. Circuit-switched networks require bandwidth to be allocated along all links making up the path through the network between two communicating nodes. These networks may therefore be viewed as being equivalent to a single continuous communication link through the network between the two communicating stations. Packet-switched networks require transmitted data to be grouped into blocks referred to as packets. These packets are then individually submitted to the communication network. The network routes each packet from the source to the destination node. Packet-switched networks only allocate bandwidth to a connection on demand; that is when there are data packets in transit through the network.

Circuit-switched networks are characterised by a constant relatively low transit delay but a relatively high connection set-up time. Packet-switched networks are characterised by a variable transit delay (which depends on network loading) and a relatively low connection set-up time. Traditionally, circuit-switched networks have been used for real-time traffic such as telephony where the end-to-end delay is important and packet switched networks have been used for computer data traffic which usually exhibits a "bursty" requirement for bandwidth.

There is demand for integrated service networks that support both real-time and computer data forcing a compromise between traditional circuit-switching and packet-switching networks. The trend in networking is towards packet-switched networks that provide special facilities in order to minimise the end-to-end delay for real time traffic and to provide guaranteed bandwidth. The International Telecommunications Union - Telecommunications Standards Sector (ITU-TSS) (formerly CCITT, Consultative Committee on International Telegraph and Telephony) has standardised a mode of operation, which will be, used in high speed integrated service networks and this is referred to as the Asynchronous Transfer Mode (ATM). This mode of operation requires special packet-switching nodes (referred to as fast packet-switches) and supports the statistical multiplexing of separate variable bit rate traffic streams onto common links within the network. Small packets referred to as cells are transmitted through the network. Cells are switched through the network following predefined paths (or virtual circuits) between the switches.

Telecommunications Enabling Telemedicine.

A telemedicine application is a multi-media application requiring the communication of real-time traffic in addition to conventional data traffic. Communications that support integrated services are ideally required.

ISDN is the first widely available public network to provide support for integrated services. It has evolved from the public telephone network and is therefore a circuit switched network and well suited to the transfer of constant-bit-rate real-time traffic. ISDN is based on International Standards and is therefore the obvious current choice to support wide area telemedicine applications.

Existing LANs provide much higher bandwidths than used in ISDN systems and these could be used to support telemedicine applications that are distributed around large sites such as hospitals. These sites could be interconnected over the wide area using dial-up ISDN connections.

Leased lines could be used as an alternative to ISDN if the dial-up capability of ISDN was not required and all communication were between a small number of fixed sites. This would only be advantageous if the lines were to be highly utilised.

Emerging LANs are designed particularly to support real-time traffic such as video and audio in addition to computer data and are likely to provide enhanced service for telemedicine applications.

Future public networks will be based on the ATM. The much higher bandwidths available will provide the potential for significantly higher quality services. It is likely to be a number of years before ATM is widely available.

2.3.2 Integrated Services Digital Network (ISDN).

ISDN has evolved from the existing telephone network (which has been digital between branch exchanges for a number of years) by extending digital connectivity to the end user (CCITT, 1989a,b&c). An ISDN connection provides the user with a direct digital connection without the need for a modem. Since ISDN is a circuit switched network, it is particularly suitable for transmitting real-time data such as digitised speech and video but less suitable for "bursty" computer data traffic. ISDN can also be used as a means to connect LANs on geographically separate sites.

A number of different ISDN user interfaces are available. The basic subscriber interface (Basic Rate Interface or BRI) provides the user with two 64 kbps B channels, to be used for data transmission, and a 16 kbps D channel normally used for signalling (setting up and managing calls) and packet mode services. This interface has been successfully applied in the provision of community health care and decision support to GPs (Armstrong, 1997). A higher bit rate interface (Primary Rate Interface or PRI) is available which provides thirty 64 kbps B channels (in Europe) and one 64 kbps D signalling channel. Foetal ultrasound services to the Isle of Wight have been provided successfully from Hammersmith using ISDN 30 (Fisk, 1995). An intermediary interface is available, offering six B channels and transmits data using the 384 kbps bandwidth. ISDN 6 has been applied in the provision of medical education for Saudi Arabian pathology students (Brebner, 1999).

2.3.3 Satellite Communication.

Communications satellites provide a means of transmitting data between geographically remote locations, for example between continents. House, a pioneer of telemedical services in Canada stated, "satellite services are needed to provide medical communication links to more isolated areas in which terrestrial systems are unavailable, impractical or impossible" (House, 1985). A communications satellite provides a communications capacity which public telecommunications companies may lease to provide, for example, transatlantic data communications. Private companies may also lease sections of this capacity to provide data communications between remote sites as part of a Virtual Private Network.

A geo-synchronous satellite refers to the orbit relative to the earth, which at a distance of about 36000 Km, places the satellite at a relatively fixed point above the earth's surface. This position allows an earth station to point continuously to the Geo-synchronous Earth-Orbit (GEO) satellite without the need to reposition the antenna reflector on the ground. Deployment of three satellites in equatorial orbit can cover the Earth's entire surface, except for the two Polar Regions.

GEO satellites are a proven technology. They are relatively low in cost and have long life spans, typically 12 years or longer. On the negative side, they have transmission delays of 250 milliseconds, and there are limits on frequency re-use associated with satellites in GEO. An important feature for communications is mobility, and although it is technically possible to have hand-held units or cellular-like units with GEO satellites, this service is not yet commercially available.

INMARSAT (International Maritime Satellite Organisation), COMSAT (Communications Satellite Corporation), and INTELSAT (International Telecommunications Satellite) are the dominant GEO satellite communications service providers. Their markets have historically been providing emergency communication services to seagoing vessels worldwide, providing communication links to cruise ships, and broadcasting video transmissions. They provide seamless global coverage, with primary connectivity through the public switched telephone network and with mobile terminals. One of the first applications of satellites has been to use them as radio link repeaters to connect distant points on the earth. These kinds of satellites are primarily used for setting up intercontinental trunks, that is, for connecting a small number of distant high traffic terminals. These satellites can also operate with a large number of fixed stations, each of them generating low traffic.

Very small aperture terminals (VSATs) are small, inexpensive satellite dishes with supporting electronic hardware and software that provide voice, facsimile, and data transmission capabilities. Conceptually similar to earth dishes, VSATs receive and transmit signals to and from geo-synchronous satellites. These measure on average 1.8 meters in diameter, and the systems are usually implemented as part of a network. VSATs provide a private communications network, which can be leased from a service provider or owned and operated by the user. They typically handle up to 64 kbps of digital transmission. VSATs are used for two-way applications such as telephony, videoconferencing, interactive distance learning, local-area network interconnection, real-time inventory management, and point-of-sale data gathering.

Direct Broadcast satellite (DBS) is primarily a residential service that provides one-way, multi-channel video and digital audio service via a small satellite dish (approximately 45 cm). Subscribers receive up to 150 channels.

<u>INMARSAT.</u>

The first communication systems for mobile users via satellite have been provided for seagoing vessels by INMARSAT, founded in 1979 with commercial services available from 1982. INMARSAT operates a global communications network of 10 satellites (upgraded when required, now in INMARSAT-3 satellites), which provide communications facilities anywhere in the world, except the extreme Polar Regions. The organisation has 79 member countries, but is used by more that 160 countries. Each member country appoints a Signatory, typically, but not always the main telecommunications operator in the country, who invests in INMARSAT and provides INMARSAT services to the end users. In addition to the satellites, the INMARSAT system comprises Land Earth Stations (LESs) which are operated by signatories and which provide the links between the satellites and the terrestrial telecom networks.

The INMARSAT space segment consists of the satellite and support facilities operated by INMARSAT. These are based currently on 4 operational regions (Atlantic Ocean Region-West (AOR-W), Atlantic Ocean Region-Fast (AOR-E), Indian Ocean Region (IOR), Pacific Ocean Region (POR)), each with its own operational satellite, with back-up satellites in the event of failure. The satellites are placed in a "geo-stationary orbit," 35,700 km. over the major ocean regions, and provide global coverage with the exception of the Polar Regions above 76° North and below 76° South. The coverage area for a satellite is defined as the area on the earth's surface (sea or land), within which line-of-sight communication can be made with the satellite. If an INMARSAT terminal is located anywhere within a particular satellites coverage area, and the terminal's antenna is directed towards that satellite, it is possible to communicate via that satellite with any Coast Earth Station (CES) that is also pointed at that particular satellite (Wright, 1996). Coast Earth Stations exist worldwide, operating in different Ocean Regions, generally based in INMARSAT signatory countries. The Sea Earth Station (SES) operator can choose the most suitable CES for the communication service required, as long as the CES is within the same Ocean Region as the SES. Each CES acts as the communications gateway between the INMARSAT network and the international telecommunications network.

Mobile stations, called Mobile Earth Stations (MESs) are allocated band L (1.5 - 1.6 GHz), while fixed stations (LESs) are allocated band C (4 - 6) GHz. INMARSAT terminals can be used everywhere, subject to local regulations. Calling from a fixed network to an INMARSAT terminal, the subscriber in most cases dials the desired INMARSAT terminal ID preceded by a special 3-digit "ocean region" code, equivalent to a country code. Calling from the MES, the user dials the desired LES or MES number preceded by a 3-digit code for the selected LES. Users pay only for the time they are actively using the network. There are more than 20 manufacturers of MESs, and more than 55000 MESs used by customers.

There are four MES types. INMARSAT-A supports high-quality telephone, fax, data, telex and high-speed data (up to 64 kbps)(Rijndorp, 1993). INMARSAT-B, is the digital successor to INMARSAT-A, offering lower airtime charges and all the functionality of INMARSAT-A, plus some additional features. INMARSAT-M is in response to demand for a smaller, lighter and cheaper mobile satellite telephone, which typically comes packaged in a briefcase. Easily portable, with battery operation and lower overall cost of operation, the system is particularly useful for emergency and disaster relief communications and for mobile medical teams. INMARSAT-C is useful in situations where sending and receiving short written messages is preferable to voice communications. This system provides two-way messaging and data communications on a store-and-forward basis, as well as one-way position and data reporting.

Small digital terminals can be either mounted on a vehicle or carried in a briefcase (weighing about 4 Kg). When combined with a small PC, INMARSAT-C can provide a means of reaching hospitals or authorities with an accurate assessment of the situation and requirements. The message can be delivered via a phone or data line. At the mobile/portable end, received instructions can be displayed, stored in memory or printed. This system can be used in telemedicine applications, such as in the assessment of epidemic risk after floods or earthquakes.

Apart from INMARSAT A,B,M, and C there is also a fifth type of INMARSAT. The INMARSAT-E system makes use of the existing INMARSAT infrastructure to provide a cost-effective means of distress alerting. An INMARSAT-E EPIRB (Emergency Position Indicating Radio Beacon) is defined as an L-Band geo-stationary satellite EPIRB approved by INMARSAT for the Global Maritime Distress and Safety System (GMDSS) for the ship-to-shore distress alerting function over INMARSAT.

<u>The INMARSAT-A Satellite Communications System.</u>

INMARSAT-A is the most commonly used means of satellite communication for the merchant marine worldwide. It is estimated that there are more than 25000 marine subscribers to the INMARSAT-A system. The provision of telemedical services to ships must take into account the fact that the INMARSAT-A system provides access to a wide range of communication services from practically anywhere on the globe, to any other location, for example a rescue or emergency medical centre (Anogianakis, 1996a).

The communication services users can have at their disposal depend mainly on the type and installation of the terminal. However the following services can be considered representative of the INMARSAT-A system: distress communications, automatic dial-up telephone calls, automatic dial-up telex calls and automatic dial-up facsimile calls. Optional extras can include: medium speed data (2.4 - 9.6kbps), high-speed data (56 or 64kbps), person-to-person calls, maritime assistance and medical assistance.

Satellite Communications Telemedical Applications.

An early application of a satellite system to provide medical care used the Canadian hybrid satellite Anik B. The system provided teleconferencing, slowscan TV and ECG and X-ray transmission supporting offshore medics (House, 1985). The system was only in operation 50% of the trial period due to the motion of the offshore installation, but did save patient transfers.

The INMARSAT satellite system was used successfully to provide emergency medical support to the developing country of Senegal in Africa from Canada in 1990 (Muhedkar, 1990). The provision was successful however very expensive considering the "free" provision of satellite time by INMARSAT for humanitarian reasons.

The US Army has successfully used satellite links between remote field hospitals and medical facilities in Europe and the US. The link between the Somalian capital of Mogadishu and the Walter Reed Medical Centre in Washington DC, provided earlier diagnosis and treatment during Operation Restore Hope. This telemedical link significantly reduced the evacuation rate of soldiers (Schneider, 1996). The US Army subsequently invested heavily in satellite links and telemedical services for Bosnia.

British Airways is collaborating on development of a briefcase-sized monitoring kit to be carried on long-haul flights. Heart rates, blood pressure, oxygen levels in the blood, temperature and other data will be collected and transmitted via satellite to surgeons on the ground. Cabin staff will then be helped to make a diagnosis or give treatment (Bagshaw, 1996).

2.3.4 Internet.

The World Wide Web (WWW) and the Internet have revolutionised communications within the last ten years. As already stated, this inter-network grew out of the US Defence Advanced Research Project Agency network and is now of global proportions and interconnects most scientific, large commercial, educational establishments and home users. The Internet is making possible a wide range of activities, including accessing information, messaging, electronic mail (E-mail), and business transactions. One of the keys to the success of the Internet has been the improvement in electronic publishing. In particular, the World Wide Web (WWW) links documents by providing hypertext links from server to server, and has become a centrepiece of Internet activity because its documents can obtain text, graphics, video, audio and animation. A wide variety of new tools are emerging that help locate information on-line. These tools will help standardise the way electronic documents are stored and represented (Anogianakis, 1996a).

The World Wide Web (better known as the Web) was created out of the basis of work carried out by the Counsel European pour la Recherché Nucleaire (CERN) in Switzerland. It uses hypertext pointers to allow access to a miscellany of data, anywhere in the world. The user clicks on a word, phrase, or image, and the data requested are retrieved. The WWW is a subset of Internet servers that support the Hyper Text Transport Protocol (HTTP) and contain documents prepared with the Hyper Text Mark up Language (HTML). Every Web page has a unique Internet location, called a Uniform Resource Locator (URL). Because they are linked together via hypertext pointers and share a common appearance, Web sites appear to be joined into a seamless entity, whereas, in fact, they can be scattered all over the world and are operated by thousands of individuals and organisations. Web browsers are software packages that run locally on the user's machine and display Web pages according to the commands contained in the HTML codes.

The Internet is transforming the healthcare industry both in the dissemination of information and the execution of transactions. Internet technologies are well poised to do this for a number of reasons (IBM, 1999):

- The low start up cost of simple Internet based e-business solutions.
- The flexibility of browser-based solutions is well suited to the healthcare environment, the frequently changing relationships between physician, hospitals, financiers and patients.
- The growing ubiquity of the Internet allows for the widespread adoption of network-based applications.
- The complex and inefficient supply chain-linking financiers, providers, pharmaceuticals and their suppliers begs for standards and affordable sets of e-business solutions.

The Internet represents many opportunities. Two of its features in particular appear vital for healthcare in the future; the emergence of open networks with standardised communication and transaction protocols, and the existence of communities in cyberspace. Patient online community activism has already had an impact on the care of patients with cancer, aids and depression (Holt, 1999). Internet access is as cheap as the basic phone service. Patients are using the Internet to access information much more than any doctors are recommending them to do so. Patient education is a major part of health care provision. The Internet is clearly a great resource for education and information, if properly presented. The successful use of the Internet depends on those providing the information successfully understanding what motivates their sick populations, and proving that the impact of that education both works to lower utilisation of acute services and ultimately creates better health outcomes (Holt, 1999). On the other hand, the Internet has a number of disadvantages. Most users have low bandwidth connections (PSTN) that make the transmission of high-resolution images and high quality videoconferencing impractical or impossible. The Internet is not a controlled or managed network that allows one to ensure the timely transmission and receipt of medical information. And finally, in the area of security, the Internet opens up the system for hostile intrusion, even with protection in place (Goldberg, 1996).

Healthcare portals are becoming increasing common, allowing patient access to more in-depth healthcare information and knowledge. Portals, as the name suggests, are doors or gateways onto the Internet. Healthcare portals are therefore web sites which host an enormous amount of information directed at the public, but which also provide a number of valuable services for the medical profession (Windows on Healthcare, 1999). Many enquiries to the healthcare portals come from patients who do not get enough information in the real world. The Internet offers an abundance of fact sheets, self-help groups, testimonies and information on drugs, many of which fill the gap in the patient's knowledge (Kiley, 1998a). The portals can direct patients to where appropriate information can be found. However, the scientific validity of the information provided to patients by many of these medical web sites is in doubt. The patient cannot be sure of the accuracy of the content. Medical specific search filters (such as OMNI, http://www.omni.ac.uk, or Health on the Net, http://www.hon.ch) may ensure that the patient is receiving information with medical substance (Kiley, 1998b).

Portals such as WebMD, does not only offer services to the public but to the medical professions as well [http://my.webmd.com]. The WebMD service allows doctors to develop their own web sites and provides email access. Doctors are able to promote themselves on the Internet, to a much wider audience. Databases of medical information, such as the French Sentiweb, a database of communicable disease surveillance (Boussard, 1996), can be accessed and utilised by doctors in monitoring illness trends within their communities. An addition to the web browser, Netscape Navigator, facilitates teleradiology applications. The Medweb plug-in allows Netscape to transmit compressed images (Telemedicine and Virtual Reality, 1997).

The potential future of the Internet as a venue for telehealth, and in particular active remote patient management, is quite different from its current use. This does not mean that the current health care uses of the Internet - research, information retrieval, marketing, simple transactions and chat and bulletin boards - are becoming less used. What it does mean is that "both the community aspect and the information/education aspect of the current Internet are going to be harnessed for the ends of encouraging patient and clinicians in the process of care management" (Holt, 1999).

Some healthcare organisations support the use of Internet software and protocols, and provide medical services of a more tightly controlled Intranet to ensure the security of transactions, legacy and guarantee levels of service (Swartz, 1996). These privately managed and maintained Intranets provide a high-speed network in a secure environment with a guaranteed level of service (Edwards, 1997). Internet tools, together with an intranet have reduced specialist and nurse time in the examination of leg ulcers in community care (Dearnley, 1997). Images are taken prior to specialist clinics and sent to specialist for review. In addition, intranets have the potential to provide huge savings in the reduction of paper messages within a healthcare system. Internet and Intranet security can be maintained by a number of options; authentication, encryption and firewalls (Jayaram, 1997).

The Internet may not be all good news for healthcare providers. A well-informed patient may have access to data concerning best treatment. However the treatment may not be affordable to healthcare providers with limited funding. An imbalance between patient expectations and achievable healthcare service provision could become a reality (Coiera, 1996).

The Internet has already been used to provide medical support, second opinion and preventative healthcare to under served areas in Russia (Mannaerts, 1997). Information has been transmitted via email in a protocol to ensure data was complete. Data included attachments such as images and x-rays. The system was felt to be cheap, fast, afforded privacy and did not interfere with the specialist's timetable. As email attachments, any medical data can be transmitted to another specialist centre for second opinion.

There are a number of web based videoconferencing systems have become available: First Class, CUSeeMe and Real Video. Desktop videoconferencing cameras such as the Connectix and QuickCam models are relatively cheap and easily available. These provide connection with low refresh rates over basic bandwidth, PSTN etc. A major problem with videoconferencing over the web is bandwidth (Fitzpatrick, 1997). Using some networks, bandwidth can be variable and connectivity disruptive. Some manufacturers have overcome the problem of varying bandwidth, using software that adjusts sampling rates accordingly. Audio quality remains constant and video refresh rates drop (Progressive Networks, 2000).

2.4 Telemedicine.

Since the advent of telecommunications, the practice of telemedicine has provided medical support to people living and working in remote regions. Regions where the population is small and thinly dispersed cannot support or justify the expense of providing medical practitioners and even if it were feasible to do so, professional isolation and a lower standard of living prevents recruitment of doctors to such regions (Brauer, 1992).

Given the advances made in telecommunication systems there is an increasing expectation that all citizens, whether urban or rural, should have equal access to health services. Telemedicine may offer a solution to the problems of healthcare delivery, namely: equity of access to healthcare, cost containment and uniform quality (Bashshur, 1995).

Telemedical services, appear to fall into two main categories. Firstly, there is the utilisation of existing telecommunication links to transmit basic clinical information in the form of patient history and to obtain expert management advice. This type of service is widespread and includes telephone consultations between clinicians for a second opinion. It also includes true telemedical services, e.g. offshore oil and gas installations in the North Sea where primary care is provided by a skilled paramedic who seeks higher-level advice from shore based clinicians through telephone consultation when required (Armstrong, 1996a). There are many examples of this type of service worldwide, and in this sense, very few medical practitioners or paramedics are truly isolated and virtually all who are in remote areas practice telemedicine.

Secondly, another dimension is added by ambitious telemedicine 'experiments', often using state-of-the-art technology, possibly set up with a political motive to demonstrate that 'voters' in less economically favoured areas have equal access to health care. However, they do point the way to the future, e.g. the Medical College of Georgia, Department of Telemedicine, has conducted an ambitious, fully-integrated experiment designed to bring equal access to health care to the citizens of Carolina (Sanders, 1993). Some hospitals and health care providers in the United States have been accused of purchasing a "telemedical pig in a poke" (Grigsby, 1995). Telemedicine systems that were not fit for purpose or not required were implemented, and subsequently failed. Healthcare administrators, advised by a technical consultant, made decisions on equipment selection. There was no participation from the intended user (Franken, 1995). The technological dilemma that exists in the implementation of telemedicine, is whether to choose the latest technology regardless of how well it fits specific needs (Bashshur, 1997). Without enthusiastic user involvement, such a telemedical application will fail.

Seven early systems operating in the USA were reviewed by Bashshur and Lovett (Bashshur, 1977) who concluded that in spite of their overall success that "the fate of telemedicine may rest not on its proven worth to uniquely identified disadvantaged population groups but on its proven applicability to a broad spectrum of the population.".

Between these two extremes, the greatest advances in telemedicine have been made in specific applications e.g. teleradiology. It has been suggested that this may be the result of digitised diagnostic images e.g. computerised tomography (CT) scans illustrating how easy digitised images are to handle in terms of acquisition, transmission, storage and retrieval (Hansell, 1990). Although it is widely accepted that conventional film is not matched by any other medium in terms of spatial resolution, archiving and dynamic range, there would be enormous advantages in having a fully digitised radiology department.

A considerable number of pilot programs have been conducted in teleradiology. In addition, it is now common for digitised images to be transmitted around networks in large hospitals. It is this type of application, which is likely to speed up the evolution of more integrated telemedical systems as clinicians recognise the potential for maximising the clinical information that is available to them.
This was illustrated in a study carried out for ESA in which it was found that in teleconsultations involving telephone and facsimile only, the quality of clinical information was considerably improved when a structured history-taking procedure was adhered to. Results suggested that without this structure and in the absence of the visual prompt of the patient's presence, medical practitioners made errors in history-taking, which resulted in a number of dangerously incorrect diagnoses (Haston, 1993).

Until true high quality video image transfer is possible at acceptable prices, it is likely that medical practice will have to be modified even when video conferencing is used for consultation. Although there is a dramatic increase in the volume of information received by the clinician when he/she can see the patient, even the highest fidelity video images currently available do not provide complete information. A 1974 study commissioned by NASA (NASA, 1974) demonstrated that with TV resolution of 200 lines/picture height and 10 frames/second which was considerably less than the optimum available quality, clinicians were still able to diagnose more effectively than with voice only communication. It should be noted however, that in this study, structured patient evaluation forms were used.

Brauer suggested in 1992 (Brauer, 1992) that, considering the advances made in telecommunications, the literature on telemedicine was relatively poor. The same author explained that this was also true for medical informatics and suggested this was because healthcare specialists and informatics specialists had not been working together; each is focused on his/her own speciality. During the 1990's this situation changed. The introduction of two specialist telemedicine journals viz. "The Journal of Telemedicine and Telecare (UK)" and "The Telemedicine Journal (USA)", together with international telemedicine conferences, has increased the telemedicine literature and awareness substantially.

In Sweden telemedicine intervention has had a number of effects on application. Telemedicine had medical effects; providing better quality care/better and safer diagnosis, faster examination/diagnosis/treatment/care, and increased exchange of knowledge. Telemedicine had effects on the organisation; improved co-operation and co-ordination within the hospital, more efficient methods of work developed and less patient and staff travel. Telemedicine appeared to have economic effects as well; lower travel costs, lower care costs due to shorter care processes, time savings, lower staff costs due to less out-of-hours work, but increased costs due to investment in equipment and communication costs. The application of telemedicine had the following effects on the patients: less travel and fewer visits, increased safety, and faster case management.

Finally the telemedical applications were felt to offer better opportunities for education and professional development of clinical staff (Sjogren, 1999).

Grigsby (1995) suggests that a number of factors should be considered when implementing telemedicine and posed the following questions: What medical services are currently provided? What the nature of the population to be served, e.g. hazardous environment or occupation? What is the demand for specific services, e.g. shortages? What is the attitude of providers? Are all the physicians enthusiastic?

The attitude of physicians can be largely responsible for the success or failure of a telemedicine program (Grigsby, 1995). In Sweden, 83% of telemedical applications are said to have been initiated by medical professionals (Sjogren, 1999). As a result, 75% of Swedish hospitals are using telemedicine to provide regular medical services. Ignorance and resistance from health care professionals, administrators and health care policy makers has been cited as one of the barriers to the wider acceptance telemedicine in the community (Hakansson, 1999). Finley (1996) suggests that before undertaking the implementation of a telemedicine services, the institutions must be sure that the physicians involved are enthusiastic.

Telemedicine technology has been applied in the provision of remote medical decision support for involved peace-keeping activities in Bosnia. The United Kingdom approach has been to use simple and proven technologies to provide medical decision support for the field hospitals. The use of a high-resolution digital camera, laptop computer, satellite telephone and a landline has aided the provision of specialist opinions in radiology, dermatology, plastic surgery, orthopaedics, urology, ophthalmology and pathology (Vassallo, 1998). This cheap and (presumably) cost effective system has provided excellent results, using the transmission of high-resolution digital images as email attachments, the cornerstone of simple service provision. Conversely, the US has applied state of the art technology, operating over the INMARSAT B network at 128 kbps between field hospitals and the equivalent of ISDN 6 for communication with Washington. The system incorporates video conferencing, teleradiology, high-resolution still imagery, ultrasonography, teledentistry and Internet access. The high technology driven system has produced positive results, saving evacuations and providing higher quality of care in this inhospitable region. However no comment is made on the cost effectiveness of the system (Calcagni, 1996). Navein (1997) conducted an audit of the system and suggested that experience of use (saving 9 evacuations) appeared to make the system cost effective, but without financial evidence. Calcagni (1996) does comment on the fact that human interaction with the system was important, training was necessary and that the operation of the system did require changes to procedures. Low user acceptability and lack of technical support hindered the 24-hour telemedicine service provision. An integrated system, which included backup, training and maintenance of both ends of the link, may have ensured the success of the link (Navein, 1997).

In view of the dramatic developments in technology, combined with rapidly reducing costs, technology is not a barrier to the implementation of telemedicine. Yellowlees (1997a) suggests that the barriers are procedural, or in the manner in which the telemedical service is provided. Five ingredients are required for the successful telemedical system: clinical leadership, appropriate training in the use of the technology, acceptance by users and patients, strong institutional support, and an appropriate location (Yellowlees, 1997a). A strong case can be made that telemedicine systems should not be viewed simply as the augmentation of existing medical practices with telecommunications and computer technology, but rather as transformations of existing arrangements that exploit technological and organisational capabilities to develop new systems of care. This does not imply that limited applications such as teleradiology and telepathology are of little use, but rather that these specific applications alone are not complete telemedicine systems (Bashshur, 1995).

With the exception of the telemedicine program at Memorial University, none of the programmes started prior to 1986 have survived (Peredina, 1995). Early evaluations of these projects suggested effective use of equipment. However, programs simply disappeared when external funding was withdrawn. Peredina (1995) suggests that the single most important factor in their demise was the inability to justify projects on a cost-benefit basis. Telemedicine programmes have re-emerged in the US, and are now better managed and based on need rather than location. However, the mistake of using the "best" and most expensive equipment has not been learnt. The implementation of telemedicine may be as much a political and economic issue as it is about health care provision (Peredina, 1995).

With the exception of image-orientated specialities, such as teleradiology and telepathology, few clinical studies have documented the accuracy, reliability or clinical utility of most applications of telemedicine as a primary diagnostic or therapeutic modality (Peredina, 1995).

Telemedicine has educational potential during routine teleconsultations. General practitioners and specialists can review cases through video-conferencing or any other telemedical medium. There are substantial educational gains for both parties without the requirement for either to move from their normal working environment (Harrison, 1996).

Telemedicine is an integrated and complete system of healthcare delivery and education that is positioned to exploit the available technological, organisational and systemic capabilities (Bashshur, 1995).

Telemedicine has the potential to restructure the system of providing patient care, continuing medical education, and patient health education, but can only do so if implemented in full fidelity (Bashshur, 1995).

Optimally, telemedicine systems consist of efficient mixes of manpower, technology, organisation and clinical applications. Their goal is to expand the distributive efficiency and enhance the productive capacity of health care (Bashshur, 1997).

The evaluation dilemma is the balance between political objectives and the scientifically valid results. Bashshur (1997) suggests that evaluations of some projects are completed during pilot phases where the product has not yet reached maturity or steady service provision. Cost-effectiveness in an immature product may be difficult to prove.

Sanders (1995) campaigns for the use of open architecture and inter-operability in the design and creation of telemedicine technology. Technology that allows easy integration, maintenance and communication with other manufacturers equipment will allow greater diffusion of telemedicine. The use of off-the-shelf equipment, complying with international standards, capable of functioning on a range of bandwidth may be a simple and effective answer to health care provider's problems. However, whatever is applied, it must meet the user needs.

2.4.1 User and System Requirements.

The provision of remote medical decision support, or telemedicine is only practicable if the general requirements of a telemedical consultation are met. A telemedical consultation will only be possible and worthwhile if there is: a source of expertise, a communication channel and appropriate terminal equipment available. The terminal equipment should be safe, support the intended functionality, be easy to learn to use, adhere to standards, and be cost justified. Although ease of learning and use are important considerations when evaluating telemedicine equipment, inevitably some user training will be necessary. The training requirement should identify personnel requiring training, the level that enables the clinical users to operate the terminal equipment effectively and efficiently, whether post-training support is necessary and who should provide such support. Wherever possible, formal person-to-person training should be supplemented by simple point-of-use instructions, explanatory documentation, and on-line help where appropriate. As Goldberg (1996) states, the successful implementation of broader telemedicine systems will be highly dependent on a clear understanding of the user requirements.

When a telemedical consultation takes place, there are a number of interaction modalities that may be encountered. A key consideration governing such interaction is the relationship between respondents at the remote and specialist sites. Whilst it will always be the case that the respondent at the specialist centre will be a medical practitioner having expertise in an appropriate domain, the respondent at the remote site may be :

1) A non-specialist medical practitioner.
2) A healthcare practitioner who is not medically qualified, for example a radiographer.
3) A patient interacting directly with the specialist site respondent.

Clearly an important concern of both remote and specialist centre users will be the usability of the various telemedical technologies involved in any link. At the specialist site, users may be required to: manipulate images, operate videoconferencing equipment and operate a PC application controlling image transmission. At the remote site, users may be required to: operate image capture, scanning and manipulation equipment, operate videoconferencing equipment, operate auxiliary equipment such as telepresence headsets and ECG recorders, and the integration of such data into transmissions, and finally, but most importantly, operate image/signal transfer equipment.

At the start of any application, none of the clinical users involved may have experience of any of these telemedical, IT or innovative communication technologies, so the training requirement, ease of learning and ease of use of the various equipment/user interfaces will be of significant importance.

Telemedical consultations undertaken by a centre with an already heavy service provision commitment will require organisation changes to be made to ensure efficiency on regular and new telemedical services. Both have significant resource management implications.

Clinicians are not the sole users of any telemedicine service. Patients are affected by this mode of medical service provision. Even as early as 1978, Bashshur (1978) noted the reluctance of the public to give up the more traditional face-to-face contact with a physician. This reluctance must be overcome if any telemedicine is going to prove itself economically. However Bashshur noted in the same article that there was a willingness within the rural population to embark on the new technology if it did not mean a total abandonment of traditional arrangements.

2.4.2 Remote Consultation.

The definition of "consult" is "to seek information or advice". A patient may consult a doctor for advice and a doctor may consult another professional for advice on a patient. If telecommunications are used for consultation then there is a considerable difference between these two examples. When a patient seeks advice from a doctor, the meeting is generally face-to-face and even if the doctor has no need to conduct a formal examination, he is helped in his assessment by seeing the patient. In this situation, voice only teleconsultation will be of less value than voice and video. Nevertheless, this type of consultation has been practised since the advent of the telephone and is still the only means of seeking medical advice in many parts of the world. Short wave radio, VHF radio, microwave and cable and satellite telecommunications have been used in teleconsultation exercises with variable quality and reliability (House, 1977) The medical scope of teleconferencing by telephone has been increased by adding ECG, EEG, slow-scan television and other informatics services. The slow-scan television, although used for transferring visual information, only transmits still images. The first interactive video link for medical use was established in 1964 (Bashshur, 1977). There are many studies that indicate that the use of television as well as the telephone for remote consultation, facilitates clinical decision-making and reduces referral rates (Moore, 1975; Muller, 1977). Cost, image quality and convenience of use have always been the limiting factors in the use of video teleconsultation. With the increasing availability of HSD communications over the ISDN network, these limitations are likely to disappear.

Medical consultations have been proven beneficial when the remote practitioner is a nurse or has a non-clinical background. Cost savings estimated at £42,000 per annum have been possible with the telemedical support of a nurse-led minor centre (Darkins, 1996a). Approximately 40% of telemedical consultations resulted in the patient handling the treatment on site. A telemedical support for an elderly community where a nurse acted as an intermediary between patient and doctor, has been successful in reducing GP and patient travel (MacDuff, 2000).

Sickness during air travel can have expensive consequences. A study of medical emergencies among commercial air travellers in Seattle, showed that only 25% of medical emergencies with passengers occurred in flight. Medical emergencies were relatively rare, occurring only one per 753 in-bound flights. Of these medical emergencies, only 7(≈1%) resulted in diverted flights (Cummins, 1989). The EC funded HERMES project (Bagshaw, 1996) is investigating the use of telemedical communication to improve in flight medical provision.

The barriers to decision support and telemedicine for remote health care as seen by the medical profession include licensure issues (in the US and similar health structures), availability and cost of technology, use of computerised medical records (confidentiality), reimbursement and malpractice issues. Despite these barriers, telemedicine funding, applications and service continue to grow. Other barriers may exist which stem from the medical profession itself. Without enthusiastic champions of telemedicine at the remote and specialist centres, telemedicine services will not be sustained. There may also be resistance from some of the medical profession, who might believe that the art of medicine is destroyed with the removal of the laying on of healing hands. Bashshur (1977) believed there may be apprehension from medical practitioners, and that the loss of the laying of healing hands would jeopardise the quality of care.

2.4.3 Legal Issues and Liability.

Many clinicians view the lack of clarity regarding clinical liability in a telemedicine consultation as an important barrier to its application (Clough, 1998). Opinions differ as to whether this is a simple problem that requires the currently accepted principles to be applied or whether it is a matter of greater complexity (Stanberry, 1998a).

The foundation of a teleconsulting doctor's duty to a patient is the same as that which any conventional doctor owes to a patient, i.e. the nature of the doctor-patient relationship. The teleconsultant may incur liability at any time after accepting responsibility for the telepatient (Stanberry, 1998b).

The US medical licensing system has exacerbated the problem. Physicians are only permitted to practice in the state in which they are licensed. Interstate telemedical consultations are therefore inhibited unless the physician providing the service is registered in both states (Physician Insurers Association of America, 1996). Laws, such as the Telemedicine Demonstration Act 1996 and bills permitting the development of a proposed registration program for out-of-state physicians wishing to practice telemedicine in California, have been necessary to ensure the diffusion of telemedicine (Schanz, 1996).

In first case mentioned previously, where a remote non-specialist medical practitioner is seeking medical decision support from a specialist using a telemedical link, the situation is essentially the same as that of any medical practitioner seeking a second opinion from a specialist. This is a scenario that has been common in all medical specialities for many centuries, excepting only that in telemedical communication it involves more sophisticated means than for example a letter. The clinical responsibilities of the practitioners involved are as they would be in any "second opinion" style of consultation.

Concern on the part of medical practitioners regarding clinical responsibility is more likely to occur in the other two scenarios. Situations may arise in which specialist medical practitioners may feel that the relative adequacy of history taking and examination in remote vs. proximate contexts must be taken into account should issues of clinical responsibilities arise.

The Australian health care system faces the same problems as those posed in the US, relating medical defence and liability (Yellowlees, 1997a). The acceptance of the image quality during telemedical consultations may vary dependant on the type of consultation and other clinical information transmitted (X-rays images may require high quality or high transmission bandwidths).

In Canada, the simplest solution, and probably the most acceptable, has been applied. Physicians who make a diagnosis or give advice over a telemedicine system are held liable in the same manner as in a face-to-face consultation (Elford, 1998). Insurers have agreed to cover the physicians for malpractice that occurs when using telemedicine.

Liability for the inaccurate transmission of clinical data or the failure of any computing or telematic system appears still to fall at the feet of the clinician (Smith, 1995). Harm caused by failures of computing equipment are few (e.g. Failure of London Ambulance computing system), however clinicians may require or should recognise the need for safety critical certification. In telemedicine, if the system fails, the remote clinician should be able to resort to the service currently being provided, which should remain accessible in case of emergency. However, in time this may not be sufficient, as consumer's demand and have come to expect the highest quality of care in their community.

Telemedicine is not thought to raise any new issues of principle in comparison with the use of telephone, fax and mail for consulting (Wootton, 1996). It does not alter either the duty of care owed to patients by healthcare staff or their interpersonal relationships (Brahams, 1995).

The legal issues in telemedicine have been hard to identify and successfully solve. One method of uncovering them may be to let telemedicine activity proceed and deal with litigation as it arises. This would not be a very sensible option, and a more prudent approach may be examine the differences between conventional medicine procedures and telemedicine, and legislate to avoid any problems (Stanberry, 1998c). Most proponents of telemedicine argue that there are few differences and that current legislation is very much applicable. The same rule should apply to the transmission of data, no matter what the medium, from written letter to interactive videoconferencing.

Stanberry (1998c) suggests that there is no change in the doctor's professional duties. Both medical practitioners (remote and specialist) are liable for patient treatment. Both are liable to do no more and no less than they are qualified. Both are responsible for patient treatment, and if the remote practitioner does not agree with prescribed treatment then it must be voiced.

2.4.4 Confidentiality and Security.

Teleconsulting doctors are under a legal obligation, just as they would be in any other aspect of their professional practice, not to disclose confidential information, which they acquire in the course of treating a patient through a telemedical link (Stanberry, 1997). The doctor has a duty not to disclose any such information that comes from other sources such as medical records or other medical personnel.

In the UK, patient information is subject to the confidentiality laws of the EC and the UK. This means that clinical information should not be disclosed unless in agreement with the patient. Ultimately the responsibility for its safety lies with the clinicians, and compliance with the standards has been used as a legal defence (Molteno, 1996). Clinicians' problems are compounded when this information is required to be transmitted to another medical practitioner. In Scotland the confidentiality of personal health information is imposed through a code of practice (Scottish Home and Health Department, 1995). This is a general code of practice and can equally and easily be applied to telemedicine services.

Teleconsultation technology can rely upon the use of the storage media other than the traditional physical substrates such as paper and film. Concerns regarding confidentiality arise from two properties of computer disc storage. Firstly, disc contents may be accessible from remote sites using networks. And secondly, in contrast to physical medium storage, computer disc contents can very easily be copied. As Makris (1997) states, "the use of data processing and telecommunications in health care must be accompanied by appropriate security measures to ensure data confidentiality and integrity, protecting patients as well as professionals accounts". These security mechanisms, such as cryptography, should be transparent to the end user, easily implemented but effective. Cryptography imbues five basic concepts: authentication, access control, confidentiality, data integrity and non-repudiation.

Concerns regarding confidentiality may also arise in respect of data transmission, prior to storage. Goldberg (1996) views the transmission of information as an extension of the medical record, and has the same requirements in terms of confidentiality and security. Disclosure of any of this information makes the physician liable.

Medical practitioners may have concerns regarding privacy during teleconsultation. Doctors "discussing" a case using letter or telephone have a high level of privacy. Using videoconferencing technology in the patient's presence may compromise such privacy. It might be argued that this is all to the good. The patient should have access to all communication pertinent to their medical health.

2.4.5 Medical Records.

It is important that teleconsultation is integrated into the pre-existing medical record keeping system without needless duplication at two or more healthcare sites. Patient consent may currently be required if teleconsultations are recorded and information transmitted during a teleconsultation, such as dermatology or radiology images, are included in the patient record (Stanberry, 1997).

Interpreted in its widest sense, a given patient's medical record comprises all of the data pertinent to that patient's clinical care throughout life. Viewed in this manner, current medical records are heterogeneous, distributed, redundant and incomplete; heterogeneous in that multiple storage media are employed; distributed in that information is stored at more than one geographical location; redundant in that some items of information are duplicated; incomplete in that clinical information may be collected and used but not stored in the medical record. Examples of information, which is exploited but not stored, include monitored data, X-ray images, and telephone discussions.

The advent of telemedicine and medical informatics has led to an enormous increase in the volume of data that can be captured, and to new possibilities for data storage and distribution. It is likely that issues related to the integrity of the medical records will be of increasing concern to medical practitioners.

The gathering and transmission of patient information must adhere to the UK regulations in place as a result of the EC Directive on Data Protection of 1995. Patients expect that all information about them be treated as confidential. Patient information can only be passed on if required for treatment and care, public health reasons, research, co-ordination of health care activities, or for health care administration and teaching (Department of Health, 1996). Information must not be communicated for commercial gain. On the whole, patient information is passed on only with patient consent. However, as is the case with telemedicine, medical practitioners will pass on and receive patient data that is pertinent to the remote treatment of the patient. The communication and storage of patient data during and following a telemedical consultation, means that telemedicine systems are subject to the strict security measures adopted for data protection.

There has been recent emphasis on the standardisation of patient medical records. The movement of populations for work and leisure has highlighted the need for a common electronic medical record, capable of communication across Europe or the world. It has been estimated that 10% of painful medical tests are unnecessarily duplicated because the medical record is not available or not understood (Rossing, 1994).

The designation of liability by contractual means, between the hospitals and remote users of a telemedical network, would be the clearest and most straightforward way of achieving uniformity and predictability in terms of distribution of responsibility for data protection and security (Stanberry, 1998d).

Inconsistencies between medical data collection and storage systems in remote and specialist centres can cause problems in recording and utilising clinical data. The transfer of the medical records has been a barrier to telemedicine in some instances because of the potential breach in confidentiality seen by some protagonists (Physician Insurers Association of America, 1996).

2.4.6 Reimbursement.

The barrier of reimbursement, which was held to be inhibiting the progress of telemedicine in the US, has been lifted in some States. California and Oklahoma have passed legislation allowing reimbursement for telemedicine services. However one year after their introduction, there was no recorded application for reimbursement (Lapolla, 1997). It has been suggested that the commonly advertised barriers to telemedicine application, of reimbursement, confidentiality, liability etc, are but "straw men" for the real barriers. The introduction of a telemedical application will undoubtedly result in or require organisational change. The way in which the medical consultation is conducted will change. Without strategic planning for this change and the institution of protocols to facilitate telemedicine use, telemedicine will not be accepted. Together with the lack of information and education regarding telemedicine, this may be one of the main barriers at present. The costs of technology and communication charges are no longer an issue. Reimbursement for teleradiology, telecardiology and telepathology services has been undertaken within the USA. However these are exactly the applications where no patient contact occurs in conventional medical care provision. In the majority of other medical specialities in the US, guidelines state that the patient must be present with the physician (Goldberg, 1996; Franken, 1995). This could be the major inhibiting factor in the US.

The discontent with the lack of reimbursement for telemedicine services in the US, may be accentuated if a policy is implemented which narrows the definition of telemedicine (Peredina, 1998). A policy that suggests that only telemedicine services which use interactive videoconferencing for healthcare provision, are reimbursable, will inhibit simple, but effect still images consultations. The benefits of still image dermatology transmissions have been proven using PSTN. However a policy that requires video for reimbursement favours the higher cost, but not necessarily the most effective solution. Peredina (1998) favours a technology-neutral reimbursement policy in the United States.

The Australian Federal government has not yet recognised the use of telemedicine in the consultation payments scheme, and has therefore excluded private practitioners from practising telemedicine (Yellowlees, 1997a). Unfortunately these private practitioners are the main providers of healthcare services in rural Australia.

Canadian physicians are presently reimbursed for tele–EEG and teleradiology services, however telepsychiatry services will soon be negotiated through a fee for service system (Elford, 1998).

Peredina (1995) questions whether telemedicine should be expected to pay for itself. The most obvious savings associated with telemedicine (lower travel expenses and less time off work for patients) are not included in the cost accounting in healthcare.

Hakansson (1999) believes that the question of reimbursement must be solved if telemedicine expands beyond its present use. In Norway, all telemedicine services have been successfully reimbursed according to a fixed price list (Uldal, 1997).

Reimbursement has again been reported in the UK as a barrier to telemedicine progress (Clough, 1998). However there has been little evidence to say why this is the case, apart from some healthcare providers demanding a national reimbursement protocol such as in Norway.

Expansion and investment in telemedicine systems continues at a high pace despite the uncertainty of reimbursement policies (Hassol, 1997).

2.5 Telemedical Applications.

Telemedicine has a number of proven applications in Primary Care viz. teleconferenced medical consultations, linking doctors and patients to specialised care centres, transmission of clinical records, on-line access to patient information systems (telehealth), medical monitoring in high risk homecare settings (telecare) and networking for educational purposes (Wallace, 1997). Table 2.1 summarises some of the main telemedical services.

Medical field	Telemedical services	Aspects of telecommunication
Radiology	Remote diagnosis X-ray Remote diagnosis ET pictures Remote diagnosis ultrasound pictures Radiological remote consultations	Digitised still pictures Data communications Interactive video/audio comm.
Pathology	Remote diagnosis still picture Clinical pathological conference	Remote control of microscope Interactive video/audio comm. Still pictures digitised from microscope Data communications
Dermatology	Remote diagnosis of patient	Interactive video/audio comm. Still pictures

Otorhino-laryngology	Remote diagnosis of patient	Interactive video/audio comm. Video pictures from endoscope
Microbiology	Remote diagnosis of bacterial growth	Digitised still pictures
Psychiatry	Psychotherapy Psychiatric support	Interactive video/audio comm.
Gastroenterology Cardiology	Expert consultations Remote diagnosis of patient	Digitised still pictures Interactive video/audio comm. Interactive audio comm. Video pictures from echo Doppler

Table 2.1 – Telemedical Services.

2.5.1 Videoconferencing.

Videoconferencing does not appear to have fulfilled its potential in personal communication, although it has found its niche in business and healthcare. Videoconferencing allows face-to-face communication at a distance, and can be one-to-one communication (most common for remote consultations), one-to-many communication (for medical education) and many-to-many communication (Cunningham, 1996). Two main types of videoconferencing systems are available: PC based or desktop videoconferencing and stand-alone videoconferencing systems. The stand-alone videoconferencing systems can be units the size of a PC or studio based. Video conferencing in general requires ISDN 2 or greater bandwidth in order to achieve sufficient quality pictures and images for healthcare (Darkins, 1996b). Medical videoconferencing has been proved successful using the equivalent of one ISDN channel (64 Kbits/s) over INMARSAT A (Armstrong, 1996a) when used in combination with other clinical information transmission. The newer PC based systems allow white-boarding and application sharing (Couchman, 1994).

Videoconferencing systems allow the patient to interact with a remotely located physician, and when appropriate the medical provider may participate in presenting the patient to the consultant (Goldberg, 1996).

Telemedicine systems are most broadly conceived to consist of interactive videoconferencing technology that is supplemented by a range of peripheral devices such as an electronic stethoscope or endoscopes (Goldberg, 1996).

The use of videoconferencing technology has been applied to remote expert consultation in radiology. Radiological, CT and MRI images have been recorded by a video camera and transmitted over a public broadband network. A noticeable loss of diagnostic accuracy on transmitted high-spatial-resolution films was reported. However liver CT and MRI images captured by the video camera were deemed satisfactory (Krause, 1996). Any device with a video output e.g. ophthalmoscopes and any sort of endoscope can be fed into the CODEC of the videoconferencing unit and information transmitted for remote consultation (Goldberg, 1996).

The advantages of video-conferencing between two professionals, doctor-to-doctor or paramedic-to-doctor, are less clear, but the few evaluations reported indicate that users prefer visual contact to voice only. The relatively cheap cost and ease of access achieved by using dial-up services through the public switched network are certain to increase the use of videoconferencing between professionals. Goldberg (1996) believes that videoconferencing is an enabling technology for remote consultations because physicians can establish rapport and professional relationships with patients and other physicians irrespective of location.

The quality of the audio is equally as important as the images during a videoconference (Goldberg, 1996; MacDuff, 2000).

2.5.2 Teleradiology.

Teleradiology is the practice of radiology from a distance and involves the transmission and interpretation of x-ray images between two locations. Conventional film images are acquired by video camera or scanner, digitised, and stored on computer. Images are managed and possibly enhanced prior to transmission by the means available. Images may also be acquired directly by digital equipment (Markivee, 1989). Teleradiology systems are a unique combination of digital data networks and computer systems. Their function is the electronic transmission of radiographs or radiological images from one site to another. Teleradiology systems can use WANs to provide prompt interpretation of radiological images for patients in under-served areas and in medical facilities having no full time radiologists (Dywer, 1991). Radiologists from a specialist centre can be consulted easily and quickly whenever critical questions arise over a radiograph. Long-distance, real-time radiological monitoring of patients is possible, and second opinions can be obtained from specialists in difficult cases (Barnes, 1993). Teleradiology enables the specialist to make decisions immediately on the decision to transfer, the mode of transfer, whether the patient should be transferred at all, and what form of treatment might be commenced before the patient arrives at the specialist centre (Dohrmann, 1991).

The potential for teleradiology to bring expert radiological consultation to remote or under-served areas has been appreciated for longer than 20 years (Batnitzky, 1990). Commercial services date back as far as 1950, where picture facsimiles of x-rays were transmitted from a County Hospital into Philadelphia (Gershon-Cohen, 1950). Early teleradiology was limited by slow transmission rates of telephone based systems (analogue systems) and by the high costs of alternative telecommunication systems. The fastest personal computer modems available for use on normal phone lines could achieve data transmission rates of approximately 10,000 bits/sec, so transmission times per image ranged from 3 to 30 minutes. While tolerable, these times were impractical for routine use in situations that required the rapid transmission of more than a few images (Lear, 1989). The implementation of the ISDN with its fast transmission rates, has enabled teleradiology to become an economic and feasible diagnostic tool. Image compression has also played a large part in reducing transmission times and thus transmission costs. Early teleradiology implementations were based on analogue video cameras and closed-circuit television systems. The resolution proved unsatisfactory, and this technology was supplanted by digital electronics. Trials of digital teleradiology systems with low (512 x 512-pixel) to moderate (1024 x 1024-pixel) resolution yielded encouraging results (Goldberg, 1993).

Arguments against the use of digitised images have been raised in the past. The digitised images were at first considered to be of an inferior quality and unable to give sufficient detail for accurate diagnosis from examination. The early experimental work took place on small images with inferior compression. Compression techniques have since improved and the image quality is felt to be sufficient for accurate diagnosis from these digitised images. Kagetsu (1987) counted and classified errors which a group of radiologists made with film and transmitted digital radiographs (521 x 512-pixel). Clinically important discrepancies in reading were made in only 6% of the cases examined, with discrepancies resulting directly from the inadequacy of the digital display occurring in only 1.6% of all the cases. Other teleradiology field trials have produced similar results (Franken, 1989; Curtis, 1983; Gitlin, 1986). With this kind of base error rate, concerns about a slight loss of resolution may be misplaced. Transmitted digitised images are getting to a point where conventional film is not necessary (Franken, 1992) and indeed many radiology departments are in the process of installing state of the art digital systems, which include picture archiving. But in remote health care, the digitisation facilities at the remote site determine the quality of the diagnostic image. At the time of an emergency, the clinician's choice is not between perfect high-resolution images and imperfect ones. The choice is between imperfect digital ones and nothing. (Madonald, 1993).

Most of the research in teleradiology has focused on various aspects of diagnostic radiology (Mun, 1988; Huang, 1988; Hickey, 1990; Cawthorn, 1991; Page, 1981; Gitlin, 1986, Paakkala, 1991). Studies have shown favourable comparison between digitised and conventional film for chest images (Thaete, 1994) and renal calculi (Averch, 1997). Scott (1995) demonstrated unfavourable results in the interpretation of digitised radiology images by emergency medicine physicians. However no case history was provided for these physicians and they would not use teleradiology in isolation. The same author had evaluated an earlier teleradiology system and at that point concluded that the system was not acceptable for primary diagnostic interpretation of difficult fracture cases (Scott, 1993). One must be careful when evaluating a teleradiology system in isolation, as the system may not have been designed for that purpose. A system provided for emergency physicians will or should contain case history information or may be part of an integrated telemedicine system.

As far back as 1988, the US Military determined that the diagnostic quality of teleradiology technology was reliable and refined enough for routine clinical use (Masi, 1990).

As with pathology, diagnostic radiologists generally have little or no direct patient contact, and they deal primarily with the analysis of visual images. These two specialities are therefore perhaps the most easily adapted to a telecommunications medium. Many speciality areas can take advantage of teleradiology. Apart from chest radiology, which is the most important one, there are studies of this technology regarding urography (DiSantis, 1987), orthopaedics (fractures) (Scott, 1993), and mammography (Fajardo, 1990; Rubin 1990).

The question of legal liability of clinical consequences arising from missed radiological diagnoses using images less detailed than the original may have inhibited some radiologists from investigating systems in the past (Dohrmann, 1991). Teleradiology has matured quicker than other telemedical applications, primarily due to reimbursement schemes, clinical and cost effectiveness data (Jones, 1996).

The transmission of radiological images has been successfully demonstrated and aided effective remote health care using satellite communications (Carey, 1979; Cawthorn, 1991). The capture of radiological images using mid-range digital cameras has been shown possible and images sufficient for diagnostic purposes (Whitehouse, 1999). This methodology, using a digital camera to capture images off a light box, has been shown suitable for remote sites such as the Antarctic (Lenihan, 1996a).

A teleradiology service has been in effective operation between the University Hospital of Tromso and Troms Military Hospital, 160km distant, since 1992 (Viitanen, 1992). On average 6000 cases per year are dealt with using this teleradiology service. The service was implemented to save travel time, reduce reporting delay and to reduce reporting time in emergencies (Uldal, 1997). The teleradiology system has saved 5-6 radiologist hours per week. However another Norwegian study comparing standard radiology services with a teleradiology service for a remote community, showed no cost savings with the application of teleradiology. The comparison of costs did not consider the cost of travel, and travel saved, borne by the patient. But the service was justified on the grounds of equity of access and quality of care (Halvorsen, 1996).

In the majority of cases, teleradiology is not offered in isolation, but as part of a combined approach to remote health care provision (Jones, 1996). Carey (1985) assumed this to be the best solution during early evaluations of teleradiology systems. Teleradiology is an effective component in a remote health care technology system.

Cost conscious medical providers expand their teleradiology service along side other telemedical applications (Leighty, 1996). This combined approach ensures a complete clinical picture is communicated to the specialist providing the decision support.

Teleradiology is always one of the first telemedical applications to be used. A high proportion of telemedical consultations are radiology based. A survey Swedish applications in 1998 (Sjogren, 1999) showed that 21% of all applications were radiology based, with pathology second with 14%. Over 7000 teleradiology units have been sold within the United States (Goldberg, 1996).

Teleradiology has been proven using the Internet and standard Internet Service Providers. Radiological images together with still digital images and clinical data were successfully placed on a secure Website for viewing and consultation with an off site specialist (Johnson, 1998).

Teleradiology continue in use in three different guises: speciality consultation between radiologists, interactive ultrasound examinations, and the provision of emergency radiological services as part of an integrated system (Wright, 1995).

2.5.3 Telepresence.

Telepresence is the virtual presence of a distant person at a site, giving the person a sense of perception of the site. In a more general sense, telepresence is the use of audio-visual communications technology and remote sensing technology to enable people to experience and interact with environments that are physically distant, hostile, or inaccessible. The application of telepresence can electronically deliver expertise to a remote location. In health care, telepresence is the use of additional or auxiliary cameras to videoconferencing to enable the remote specialist to get a feeling of "presence" at the injury site (Matthews, 1993). The remote specialist has then a better opportunity to provide appropriate and timely medical decision support.

The electronic delivery of expertise is aimed at initiating or supporting some form of physical activity at the remote location. The physical activity can potentially be performed by machines or by humans. In the absence of fully autonomous robots, machines operated by a person at a distance can carry out tasks in remote or hostile environments. Some applications, such as telerobotic surgery and VR surgery have being explored (Green, 1991; Satava, 1992; Watts, 1993).

CamNet, developed at the BT Laboratories, is a experimental telepresence system that allows the remote operator to gain access to a expert and to obtain assistance in performing some form of practical task that is outside his or her area of immediate expertise (Matthews, 1993). The heart of the CamNet system is a headset worn by the operator who provides a platform for mounting a miniature video camera, a small visual display screen, and a two-way audio link. The technical attributes of the system are described in Section 4.8.3 and Appendix C. The CamNet telepresence system is suited to applications in medicine where there is a need to transport the "presence" of a doctor or specialist to assist in the diagnosis and treatment of an ailment. It is particularly useful when the need for a second opinion or expert advice is immediate. The specialist experiences the illusion of being on the remote operator's shoulder, seeing the problem as the operator sees it. The driving force behind the use of telepresence technology is the cost saving that can be achieved when compared with the traditional solution that requires the expert to travel to the location of the problem in order to assist in its solution. The CamNet headset has been successfully trialed in providing medical decision support to offshore installation medics (Armstrong, 1996a).

2.5.4 Teledermatology.

Teledermatology is the capture and transmission of dermatological images to a specialist for examination and consultation. Teledermatology could be implemented using either video or static imaging or some combination of the two (Goldberg, 1996). Results of real time video images for dermatology have been positive when compared with in-person diagnoses. Photographic slides and video captured still images results have been mixed, with high accuracy, but low satisfaction of images quality (Krupinski, 1999). Dermatological diagnosis using high quality still digital photography has compared favourably with in person clinical diagnosis. Using store-and-forward techniques for transmission, high quality images have been produced and inexpensively communicated for specialist review (Krupinski, 1999).

The Welsh valleys have been successfully provided with a teledermatology service due to the lack on consultant dermatologists locally. Dermatology cases are diagnosed via a video link using a high resolution camera and ISDN (Davies, 1994). Dermatology teleconsultations are held via video-links with dermatologists located 40 miles away.

The UK Multicentre Teledermatology Project has undertaken a large number of realtime teledermatology consultations through four centres worldwide. A comparison of high definition cameras, connected as auxiliaries to the videoconferencing unit were undertaken. A comparison was also made by face-to-face consultations (Loane, 1997). A more expensive, higher quality (3-Chip) camera was found to provide a performance, with a higher proportion of correct diagnoses and fewer missed diagnoses than the slightly inferior counterpart. The study suggested that this type of consultation may be unsuitable for children and infants who may not remain static for high quality images to be captured (Loane, 1997). Diagnostic accuracy and clinical management regimes suggested via the realtime teledermatology link were compared with face-to-face consultation (Loane, 1998a). Sixty-seven per cent of diagnoses made over the video link agreed with face-to-face diagnoses. In 64% of cases, the same management plan was recommended in both consultations, and in 20% of cases dermatologists were unable to suggest a management plan using teleconsultation. The results suggested that a high proportion of dermatological conditions could be managed by realtime teledermatology. Patient satisfaction with the realtime teledermatology service was reported as very high (Loane, 1998b). Eighty-five per cent of patients were satisfied with the video link and believed that their time had been saved, and the majority were content to be part of a teleconsultation in the future.

The New Zealand component of the UK Multicentre teledermatology trial reports high acceptability and a reasonable degree of accuracy when using video conferencing for the diagnosis of dermatological diseases (Oakley, 1997). Seventy-five per cent of cases were correctly diagnosed by telemedicine in the first instance, the remainder requiring attendance at an out-patients clinic. Patient satisfaction with the service was reported to be high, and physician confidence in the system constantly increasing.

The concern about malignancy of skin lesions has been shown not to be significantly affected by the application of videoconferencing technology (Phillips, 1998). Teledermatology using interactive video images has not shown detrimental effects on diagnosis and treatment recommendations.

2.5.5 Telepsychiatry.

In the United Kingdom, psychiatric services have become community based, moving nearer to the patient. Staff resources are low, and psychiatrists are constantly moving between locations in order to view and treat patients (McLaren, 1996). Telepsychiatry, using videoconferencing techniques, allows the important face-to-face consultation to occur , without the need for travel. This is a method that is frequently used in a prison environment to ensure better security (Mekhjian, 1996).

Telepsychiatry has been successfully demonstrated from an early stage in the development of telemedicine. Menolascino (1970) and Dwyer (1973) showed successful treatment of psychiatric patients from a distance using videoconferencing. User and patient satisfaction was good, but often the patients were more comfortable with the technology than the physicians. Preston (1992) demonstrated that rural and isolated communities can benefit from the application of telepsychiatry.

Telepsychiatry is an interesting application because of the importance of simulating a face-to-face encounter (Goldberg, 1996). The use of a low cost videoconferencing systems has been proven acceptable for adult psychiatric consultations (McLaren, 1995). A number of patients refused psychiatric teleconsultations. This was put down to their illness rather than the quality of the link. As in other telemedical applications, telepsychiatry will require the practitioners to approach the service provision in a different manner to the standard consultation and modification of the clinic organisation (McLaren, 1996).

A telepsychiatry service in south Australia has been providing a sustainable service since 1994 (Hawker, 1998). In the period 1994-1998, over two thousand clinical sessions were performed using a videoconferencing link connected via ISDN 2. The system has the potential to move to ISDN 6 in the future. The service has overcome initial concerns by both patient and physicians that videoconferencing did not convey sufficient information and would replace visiting psychiatrists. The psychiatrists were still able to form meaningful relationships with patients and interact in a positive manner. Telepsychiatry augments and reduces the need for visiting psychiatrists but does not replace them.

A Canadian telepsychiatry service estimated that a minimum of 396 patient video-consultations were required per year, in order for the system to break even (Hakansson, 1999). However the same author reports the financial success of similar system in Australia, with a 40% reduction in transfer rates. The evaluation of the Canadian telepsychiatry service states that the use of videoconferencing for psychiatric consultations was a viable option for an integrated, community-based mental health service (Doze, 1999).

2.5.6 Remote Cardiology and Echocardiography.

The transmission of cardiac data provides the specialist with further information regarding a patient's condition. Transmission of ECG and vital signs is not a new telemedical application but is still aiding remote diagnosis and treatment when combined with other clinical data.

The transmission of cardiology data again dates back to manned space missions by NASA, where ECG data was transmitted back to earth for monitoring purposes. The transmission of cardiology data can be used to monitor emergency patients in transit from the site of accident to the most appropriate hospital for the injuries (Thorborg, 1990).

Cardiac auscultation, is a relatively old technique (Murphy, 1973) that permits a physician to examine systolic murmurs using an electronic stethoscope. This technique has also shown good results with paediatric patients (Mattioli, 1992).

Simple methods have been implemented to provide GPs with an aid to decision support when dealing with cardiac patients. A telecardiology diagnostic service provided to GPs used hand-held automatic standard 12-lead ECG transmitters that were capable of transmitting the data via PSTN (Shanit, 1996). Eighty-one per cent of patients whose information was transmitted were not admitted to hospital or were not required to attend out patient clinics. The 19% whose symptoms were identified as urgent cardiac problems received the best and most timely advice. The cardiac teleconsultation was assumed to be a reliable and cheap alternative to the outpatient clinics that were previously operated. Systems are now available that permit the transmission of ECG data and duplex speech simultaneously using a simple PSTN connection (McKee, 1996).

The Shahal pre-hospital 24-hour emergency cardiac service in Israel has over 40,000 subscribers. The service is manned by physicians and coronary care nurses who receive transmitted ECGs from patients who are experiencing problems. Patients carry a "Cardio Bleeper" for telephone transmission of a 12-lead ECG, which can then be compared with medical records. Treatment could be by authorised self-injection or the dispatch of a mobile intensive care unit (Shahal, 1997).

The Canadian Maritimes region has demonstrated cost effectiveness as well as improved quality of patient care in the provision of telediagnosis for paediatric echocardiography (Finley, 1996). The transport of new-borns with heart problems can be dangerous, and the provision of paediatric echocardiography using broadcast quality communication systems can save these transfers. Savings in transport costs alone account for three times the consultation costs. Chicago Memorial hospital operates a paediatric tele-echocardiography service using ISDN 6 (384 Kbits/s) (Berdusis, 1996). This real time service enables the cardiologist to pick the images to choose for enhancement and evaluation. Cost effectiveness has been shown only in certain cases.

Airlines commonly rely on chance of there being a doctor on board long distance flights. In practice the use of vitals signs transmission from aircraft has been proven. Using a radio link and a laptop PC, in-flight monitoring of a patient with cardiac problems on board an United Airlines, transatlantic flight has been made possible (Kincade, 1996).

Trained airline staff have been able to provide care for the stricken traveller until diversion to an appropriate medical care centre.

2.5.7 Tele-Otorhinolarynology (Tele-ENT).

Telediagnosis for ear, nose and throat problems can be carried out by otorhinolarynologists, who view the results of endoscopic examinations conducted at remote sites by general practitioners (Rinde, 1993). Pedersen (1995) reported high patient satisfaction with a tele-otorhinolarynological examination in northern Norway, and much preferred the service to the potential travel to the clinic for consultation. The local GP performed the endoscopic examination that was transmitted to the specialist in Tromso. This service was initially (1992) operated over a 2 Mbits/s network, donated by a project sponsor (Elford, 1997). This allowed high quality video resolution images to be transported back to the specialist in Tromso. Since the withdrawal of the subsidy for the 2Mb link, the project has operated the service using ISDN 2 with no significant difference in the quality of service provision. The costs of providing a teleconsultation service were compared with the alternatives, viz. patient travel and specialist travel (Bergmo, 1997). Analysis demonstrated that teleconsultation was only cost effect when patient consultation numbers exceeded 56 per annum. Below this, patient travel was the most cost effective option. Conversely, when patient numbers exceed 325 per annum, specialist travel to the remote community was the most cost effective option.

Stern (1998) compared interactive video and store and forward otorhinolarynology transmission with regard to remote diagnosis and images quality. No significant differences between local and remote otorhinolarynologists when interpreting examinations, indicating transmission having no effect. Specialists were more comfortable with the interactive video consultations, having more control over images to view and gather greater information. Further clinical data was required to be sent with the still images, and specialists felt that further training of the remote practitioner in image selection was required.

Tele-otolaryngology consultations between a specialist centre and rural primary care centres in Sweden demonstrated a decrease in referrals of 40%, using videoconferencing over ISDN 6 (Made, 1999). Patient satisfaction with the service was rated very high, and medical practitioners were satisfied with quality of videoconferencing for diagnosis.

2.5.8 Telepathology.

Much medical diagnosis depends on the interpretation of stained tissue preparations including blood films. Systems are now available to produce high quality video images of high magnification microscopic fields and these images can be digitised and captured for analysis, compression and archiving. As the images are digitised they can be transmitted from a remote site through the ISDN.

Telepathology is the process of transmitting digital pathology images over telephone lines (PSTN or ISDN) or LANs, WANs or MANs. The images may be transmitted in real time video or as still images (Dhiri, 1997). Telepathology is applied for five main reasons: to create a database of images, for an expert consultation, to combine data sources, to quantify morphological findings and to install remote control microscopes (Kayser, 1995). Like teleradiology, telepathology can be used for the primary interpretation of pathology images and second opinions on difficult cases (Goldberg, 1996). In telepathology, a pathologist is able to examine tissue specimens prepared by a distant on-site technician. Once the slide is prepared and placed on the microscope stage, the pathologist may be able to control the microscope telerobotically, viewing the specimen on a monitor (Schwarzmann, 1992). Telepathology has been widely accepted as a telemedical application due to the need it fulfilled. The increase in specification in disease classification has induced a specific need for data exchange and expert consultation (Kayser, 1992).

For remote expert consultation on still pathological images, ISDN may be the lowest bandwidth viable due to the amount on information required to be transmitted (Kayser, 1995). Failure to sample relevant portions of the specimen can prevent the consulting pathologist from arriving at an accurate diagnosis (Goldberg, 1996). The alternative approach is video microscopy. The consulting pathologist can scan the remote specimen and select fields to be viewed at higher magnification and/or captured in static form. Transmission of live images, especially those of frozen sections, for use on remote control microscope are useful for countries with poorly developed infrastructures or transportation problems from remote regions (Kayser, 1992).

The US Armed Forces Institute of Pathology offer an Internet based service, where digitised pathological images can be submitted for examination. Expert responses are provided within 24 hours. This Internet based service can be accessed from anywhere in the world, and is free for the US Military and associates. However any pathologist can submit a sample for a second opinion at $50 a sample (Kiley, 1998c).

Della Mea et al (1997) have undertaken trials sending pathological images by email for second opinion, remote image processing and quality assessment. Results have shown that good diagnostic agreement can be reached and no image degradation was noted. However the store and forward style of consultation, over Internet was not felt to be a fast enough medium for use in emergency cases.

Telepathology offers rapid turn around times, and can even be used for frozen sections when the surgeon is awaiting immediate feedback with the patient under anaesthesia on the operating table (Goldberg, 1996).

2.5.9 Telemedicine for Prisons.

As previously mentioned, the prison environment has proved an ideal application site for telemedicine. The prison may not be a geographically remote site. However transport and security costs in taking inmates to regional health providers are high. Public safety at these times is essential. Providing a telemedicine link directly into the prison ensures high quality medical care, which is speedily provided at no security risk. Mekhjian (1996) and Brecht (1996) report high satisfaction with such systems from both inmates and physicians. The majority of such systems are interactive video based. Costs are reduced by eliminating the need for additional security, vehicles, chase vehicles and travel time for physicians. Ninety-five per cent of consultations can save one or more trips to the local health care provider (Brecht, 1995). In Virginia, teleconsultation with inmates who were HIV^+, demonstrated net savings of $14,500 over a seven month period (McCue, 1997). HIV^+ patients were provided with required increase access to care and the system cost less to operate. The Ohio prison system demonstrated an £8.50 reduction per consultation (1998 costs) when telemedicine was used in preference to a consultation at the local health care provider (Brunicardi, 1998). Increased use of the system was possible and it was expected to reduce the costs of the telemedicine consultation further. Surveying prison inmates on their satisfaction with the patient-physician encounter via video link showed that only 9% were not satisfied with the consultation and would not be happy to be consulted in this manner again (Mekhjian, 1999).

2.5.10 Medical Education.

In many instances the same technology that has been applied to provide clinical services to a remote location has proven successful in providing a means of continuing medical education. The recruitment of medical practitioners at one point was felt to be hindered by the professional isolation experienced by the remote practitioner. Telemedicine is a method of communicating medical expertise for educational purposes to remote communities. In remote parts of Wales, the telemedicine technology that was originally provided for dermatology and radiology services, facilitates continuing education of both GPs and nurses (Freeman, 1995; Lewis, 1999). Remote practice nurses and doctors are able to take part in educational sessions and discussions using videoconferencing facilities, and lecture notes and other material are provided through a web site.

Simple teleconferencing has been successfully applied in remote areas of Canada since the mid 1980's (Lockyer, 1987). Doctors and other medical staff took part in weekly teleconferences with supplemented other educational formats such as video tapes. The teleconferencing was rated higher than videotapes or audio tapes due to its interactivity. Audio (medical education) teleconferencing is skill undertaken on a regular basis by Memorial University Hospital in Newfoundland.

A remote clinical consultation itself has the capability to educate the remote practitioner. For example considerable learning can occur for GPs through role modelling. The GP has the experience of practical demonstrations given by specialists, and practice in co-operation with the specialist (Akselsen, 1993). A remote practitioner is taught skills and gains medical knowledge during a clinical consultation with a specialist.

Telemedicine technology has in some instances been applied specifically for continuing medical education. Both undergraduate and postgraduate students have been provided with high quality medical lecturing, where it may not have previously been feasible, using videoconferencing and associated techniques. Post-mortem pathological lecturing has been provided to undergraduates in the Middle East (Brebner, 1999) and high quality dental education is provided using interactive telematics networks (Reynolds, 1999).

Interactive surgery teaching has been successfully undertaken between six universities using the SuperJanet network. The surgical presentation from one centre was relayed live to the five others, and students at all centres interacted and discussed issues with the presenter (Hobsley, 1997). The guidance or tele-mentoring by a remote surgeon of a less experienced surgeon through a procedure has been undertaken with positive results (Docimo, 1996). Specialist emergency support must however be on hand during such a procedure.

2.6 Integrated Systems.

As previously stated, it is not simply enough to apply telemedical technology to the medical applications to enable its practice at a distance. The requirement or need must be present. But the procedures used in the provision of a medical service will change with telemedical application.

A simple voice and video link is not sufficient for medical teleconsultation. Additional information is almost always required. The clinical user i.e. the doctor who is distanced from the patient, will require vital signs, radiography, the possibility of further examination and a close examination of certain parts of the body e.g. the eye. Details of past history may also need to be transmitted. Couchman (1994) describes the service provided by the Medical College of Georgia consisting of a central hub with a number of satellite sites. The physician at the hub can conduct a history and examination using two-way voice and video with zoom-focus facilities. Telemetry includes real time transmission of stethoscope sounds and electrocardiogram recordings. High speed, plain paper facsimile provides a telematic service for the transfer of patient records, database references etc. At the heart of the system is a computer controlled switching matrix that allows complete networking between satellite sites and the hub. The system is also compatible with most types of communication systems: telephone, cable, microwave and satellite. This system required substantial capital funding in its creation and may not yet be cost effective. However, it demonstrates the potential and advantages of an integrated system. There is growing recognition of the need to incorporate other forms of medical information management into telemedicine solutions as well as to standardise telemedicine encounters (Goldberg, 1996).

The manner in which the clinical data is collected and the form it is communicated in, will impact on the medical consultation and result. Medical assessment questionnaires have been used as a method of collecting a complete clinical picture from a remote site. These structured data forms result in structured data collection. The remote practitioner, in completing the questionnaire, undertakes a standardised medical examination. The questionnaire can be pitched commensurate with the experience level of the remote practitioner (e.g. medic, nurse or GP) (Maclean, 1994). These structured clinical data collection methods can contribute to the data on which decision support is based (Sutton, 1989).

Instead of being used mainly in single speciality projects, telemedicine technologies require to be used in an integrated manner to support whole systems of healthcare (Jardine, 1999). The linking of applications within a remote health care centre has the potential to increase benefits, both social and economic (Clough, 1998). An integrated telemedicine workstation would incorporate all the necessary equipment, comply with standards and ensure data protection, confidentiality and security (Goldberg, 1996).

Integrated systems are essential for extreme remote and inaccessible areas (e.g. the Antarctic). The NASA Health Maintenance Facility is a prime example of an integrated computerised medical decision support system capable of providing for the majority of requirements. The system provides video, audio and data communications between the medical officer on the space station and ground based medical personnel (Gardner, 1989).

Telemedical and remote medical decision support has also been trialed for a number of other medical specialities, for example: endoscopy (Pedersen, 1995), opthalmology (Papakostopoulos, 1997), trauma (Tachakra, 1999), minor injuries (Benger, 1999a), home monitoring (Allen, 1996b), community nursing (Macduff, 2000), access to primary care information (Amundsen, 1999), foetal ultrasound services (Fisk, 1995), expert clinical consultation and conferencing (McLaren, 1993), maternity services (Boddy, 1994), information for patients and carers (Kiley, 1998a) and follow-up (Harno, 1999).

3.0 OPPORTUNITIES FOR TELEMEDICAL INTERVENTION

Telemedicine and information technologies in general, have been applied to the majority of medical specialities with varying degrees of success. As discussed earlier there are a number of barriers to the introduction of telemedicine: medico-legal issues, standard medical procedures and general issues, which affect the introduction of any new technology. Remote health care could be viewed as a medical speciality in its own right. The provision of medical care within remote communities and at remote work sites has been undertaken with some difficulty, the distance to medical services being the main factor. Patients may have to travel vast distances to receive treatment, or communities and organisations have to bear the high cost of having a doctor on site or in the community. However doctors are becoming less and less attracted to the rural or remote practices as this can easily lead to medical isolation and increased stress. Telemedicine could be viewed as the ideal application for the remote health care scenario. Telemedicine is a two-fold remedy, providing both care and the potential for medical education. Telemedicine is frequently provided on site through the aid of an intermediary. The doctor will guide the intermediary through examination and treatment. The intermediary will have some medical training, depending on the location of the clinic. For example, in a remote community hospital, a GP may contact a specialist for medical decision support on treating a suspected broken bone.

The application of high-speed data to remote health care in this context, means that the high level medical provider is separated from the patient by distance, and that an intermediary is providing aid at the point of care. The intermediary seeks medical decision support from the specialist, through a high-speed data communications link.

The specialist provides advice on diagnosis, examination and treatment. Treatment may be an interim measure while evacuation proceeds, or may be more permanent, negating the requirement for evacuation.

Three remote health care scenarios have been considered during this study, viz. a remote community hospital, a merchant marine vessel and an offshore oil installation. These three scenarios differ in (a) the distance and time required for evacuation, (b) the facilities where the patient is being treated and (c) the skill level of the intermediary. However, all have similarities in the way in which telemedicine can be applied to provide medical decision support. Telemedicine technologies have been applied and evaluated for these three diverse, but broadly similar applications. The applications differ in the standard of medical care available, the communications mediums available and the technology applied. However they are similar in their remoteness and requirement for high quality medical decision support.

For each of these scenarios, the objective has been to evaluate the effectiveness of the telemedical intervention and ensure evidence-based medicine. Telemedicine may use the latest in communications technology, but evidence must show whether this method of medical aid is effective. Leading edge technology may not always be the best application. In each application an attempt has been made to match the user requirements of the remote site to the technology applied. Tried and tested tools and procedures can be applied to the provision of medical decision support before resorting to "state of the art" technologies which have yet to show their worth.

3.1 Remote Communities (SAVIOUR Project).

Present trends in the provision of community health care in Europe have resulted in the centralisation of medical expertise in large urban hospitals. However the population distribution in Europe is such that a significant number of inhabitants are geographically isolated from the large urban centres, none more so than the remote communities of Scotland. The result is inevitably, inequality of access to medical services. As medical services become ever more sophisticated, this inequality is becoming increasingly unacceptable (Armstrong, 1994). This inequality of access contrasts with the European Community and G8 Nation's pursuance of "healthcare for all" and "equal access to healthcare".

Potentially, inhabitants of the remoter regions of countries like Scotland, will be required to attend the large urban hospitals if their GP is unable to diagnose or treat their ailments. This sometimes lengthy excursion is time consuming, expensive and can put patients at greater risk. Further it is becoming more difficult to recruit GPs to work in these remote practices where continuing medical education and professional isolation are felt to be a problem. Healthcare providers are investigating the use of nurse led minor injury units for remote communities (Darkins, 1996). To ensure high quality healthcare in the remote communities, access to the highest quality medical advice must be possible.

Telemedicine and medical decision support are offering new approaches to providing high quality medical services to the total population of Europe. The European Community has recognised the potential of healthcare telematics and has funded a number of telemedical and medical decision support activities for remote communities.

The provision of healthcare services within the United Kingdom over the last few years has been undertaken by the Healthcare Trusts. These trusts operate individual hospitals or a number of hospitals or healthcare services over a given area. Within the Grampian and Aberdeen area, there are two large trusts, which provide slightly differing healthcare services to the same population. The Aberdeen Royal Hospitals Trust (ARHT) operates the large urban specialist hospital, which provides all the specialist facilities for the Grampian region. The services range from A&E, dermatology and radiology, to intensive care and primary care departments. All specialist facilities are centralised on one site.

The second trust in the Grampian Region is the Grampian Healthcare Trust (GHT), which operates all the community and outlying health services as well as general health care services such as maternity, residential homes and some primary care services. A community hospital operated by GHT would find it necessary to use the specialist facilities offered by ARHT. Taking emergency care as an example, the community hospital will operate a basic casualty department, either General Practitioner (GP) or nurse led. This casualty department will treat as many patients as possible within the community hospital. Those that cannot be treated using the facilities of the community hospital will have to be transferred to the A&E department of ARHT.

This is the first remote health care scenario to which telemedicine and the transfer of high-speed data has been applied (Chapter 4). The EC-funded SAVIOUR project (the Study of the Application of Video Image Transfer, Orthopaedics up to Rehabilitation) aimed to utilise off the shelf telemedicine technologies to provide GPs with medical decision support, and provide high quality patient care within the community.

The GP at the community hospital was able to receive medical decision support of casualty cases and to ensure the treatment of the patient in the community without transfer. The objectives were to provide increased clinical information flow, enable quick and appropriate treatment in the community, and save patient transfers. A by-product of this clinical information transfer and communication link was the continuing medical education of the GP. In this scenario, an A&E consultant using videoconferencing, teleradiology and telepresence provided the decision support, and the intermediary or person treating the patient was the General Practitioner.

3.2 Merchant Marine Environment (MERMAID Project).

Merchant marine vessels are remote work sites and have medical needs such as any other. Access to these work sites is restricted because of their movement and the environment in which they operate. International legislation requires that there is a medical attendant and medical facilities on board these vessels and that there is a means of communicating with medical services onshore. The numbers of personnel on board and the restricted facilities available for treatment mean that the medical attendant on board can give limited medical support.

Currently in the merchant marine scenario, the primary point of contact for an injured or ill seafarer would usually be the First Officer, who is the medical attendant residing onboard. The First Officer has undergone a basic medical training course and has a textbook for reference during an emergency. In the case of an emergency, the first officer has the capability to call a shore-based doctor for support. The medical support for the marine industry is currently provided by a radio-based system, directed via the coastal radio stations to the appropriate medical centres. CIRM, the Italian Radio Medical Centre, one of the oldest in the world, has responded to over 36,000 calls for medical assistance since its inception in 1935 (Parrish, 1997). A significant number of these have resulted in saving expensive and time-consuming evacuations. The evacuation of personnel as a result of a medical emergency is an expensive and potentially dangerous undertaking. Evacuation can be by diversion of the vessel to the nearest port, by helicopter or by another sea-going vessel.

The European Commission has recognised that "the use of long distance medical consultation methods constitutes an efficient way of contributing to the safety and health" of maritime personnel (EC, 1992). The G7/G8 Nations have also proposed and undertaken research into the provision of a "24 hour multidisciplinary, multilingual, global emergency telemedicine service" (Lareng, 1995).

This is the second remote health care scenario to which telemedicine and the transfer of high-speed data has been applied (Chapter 5.0). The EC funded MERMAID project (Emergency Medical Aid through Telematics) is aimed at improving the clinical information transfer between a sea going vessel and the shore based doctor. The present radio communication will be improved by implementing structured data collection and transmission, creating a network of decision support sites and on board multimedia guides. The FO was provided with an application, which increased the clinical information collection and transmission. The shore based doctor, having increased clinical information together with images, video and audio clips is able to provide better decision support and advice on treatment and diagnosis. The aims were to improve the quality of medical care and reduce the number of evacuations.

The First Officer is still the responsible medical attendant on board and acts as intermediary between patient and doctor. The MERMAID application utilises technology, IT and communications equipment, already residing on board to provide the improved medical service. Applied software improved and structured the clinical information gathering and transmission.

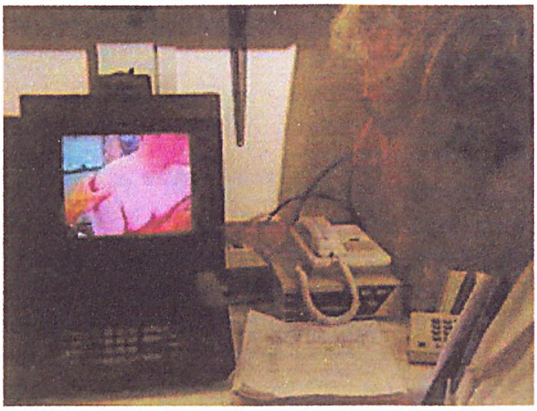
3.3 Offshore Oil Installations Medical Decision Support.

The offshore oil and gas industry undertakes potentially hazardous activities, in an equally hazardous environment. The procedures and legislation ensure that offshore installations have high safety standards and relatively low incident rates. Accidents offshore, as in most engineering industries unfortunately do occur, and regulations ensure that a medical decision support service is provided.

Offshore, the primary source of medical expertise on board installations is the offshore medic. The offshore medic is a qualified nurse or equivalent. There is obviously a skill difference between the offshore medic and the maritime industries' First Officer. However a medical decision support system is still and essential part of the service. Professional medical organisations, not only provide the offshore medic, but also the medical decision support, with doctors on call 24 hours. In an emergency, the shore-based doctor is contacted via telephone and provided with clinical information by the medic. The doctor then advises on patient management and whether there is a requirement for evacuation. In Aberdeen the doctors respond to medical emergency calls daily, and there is on average one medical evacuation per day on scheduled flights. There is approximately one dedicated medical evacuation from the North Sea installations every week (Horsley, 1998). Offshore medical emergency evacuations are undertaken on dedicated helicopter flights or on scheduled helicopter flights, depending on the severity of the injury/illness.

This is the third remote health care scenario to which telemedicine and the transfer of high-speed data has been applied (Chapter 6). A number of studies have been undertaken to improve the current clinical information transfer between the rig medic and the shore-based doctor. Studies to improve the mobile phone based medical decision support system provided to the offshore medic using structured data collection, image transmission and videoconferencing have been undertaken. The studies have implemented both "high tech" and simple solutions. An application, which uses existing IT and communications mediums to improve service provision, has been investigated.

4.0 MEDICAL DECISION SUPPORT FOR REMOTE COMMUNITIES.



4.1 Background to the SAVIOUR Project.

The primary purpose of this telemedical application was to provide medical decision support to general practitioners operating in the casualty department of a remote community hospital, from A&E specialists. The study established and evaluated a telemedicine workstation link, providing two-way communications between a small GP based community hospital and a large trauma centre. The link facilitated the transfer of essential clinical information between the GP and the specialist consultant who was able to advise on patient management. The workstation comprised of telecommunications and medical equipment that was commercially available at the commencement of the study and required little, if any integration. The workstations consisted of a number of components: a teleradiology system, videoconferencing using videophones, and a telepresence system. The system was developed for use over ISDN2 and INMARSAT A.

The study revolves around a remote community hospital (RCH) which acted as a "satellite" for the Large Urban Hospital (LUH) the "hub". The community hospital that previously referred patients to the urban hospital however can now reduce the number of potential referrals using the telemedicine workstations.

A telemedicine workstation was established within the casualty department of the RCH and linked into the accident and emergency department of the LUH. Patients were transferred regularly between the two medical centres.

The use of the workstation during the clinical trial period of one year was assessed through the use of questionnaires and analysis of the teleconsultations. Following every telemedical consultation evaluation, questionnaires were completed by the consultant in the LUH, and by the GP in the RCH. Responses to questionnaires detailed (a) the injury to the patient, (b) the reason for the consultation, (c) the equipment used during the consultation, (d) the ease of use of the equipment and difficulties encountered, (e) the predicted outcome of telemedical consultation, (f) the actual outcome, (g) the patient management (transferred to the LUH or not) and (h) the patient response to telemedical consultation.

The evaluation of the telemedicine workstation focused principally on the integration of the system into current services and the interaction of the practitioners with the technology of the telemedicine workstation. The teleradiology component of the workstation underwent professional evaluation by radiologists.

4.2 Location of Telemedicine Workstations.

4.2.1 Remote Community Hospital.

The remote community hospital (RCH) is in Peterhead, a coastal town, approximately 60 km north of Aberdeen, Scotland. The town and the remote community hospital facilities are described in Journal Articles 1 & 2 of Appendix A. The casualty department of the RCH treats approximately 1300 patients per month (May 2000 data).

Attendance Type	No of Patients
New Attendees	723
Review Cases	152
New GP Acute Cases	393
GP Acute Review Cases	30
Total	1298

Table 4.1. RCH Casualty Department attendance May 2000.

GP acute cases are those patients who, although not suffering serious injury required to be treated immediately.

The casualty department has permanent nursing staff, together with the on-call doctor. The duty doctor is not only on call for the casualty department but has to attend to GP acute house calls and ward calls. The casualty department is comprised of 2 treatment rooms, for non-acute trauma cases, and a resuscitation room, for the management of emergencies. The telemedicine workstation was sited in the resuscitation room.

The patient passage through the remote community hospital, prior to the introduction of the telemedicine workstation, is outlined in Figure 4.1.

Patients being presented for treatment by the GP in the casualty department fell broadly into three categories:

1. The injury or illness was severe and required the facilities of the A&E Department of the LUH to ensure proper treatment of the patient. The patient was therefore transferred to the LUH for treatment, management and review. The patient could be admitted to one the specialist wards of the hospital for observation.
2. The injury or illness, although not minor, was capable of being treated by the GP using the facilities of the RCH. The patient was treated, managed and reviewed (if necessary) in the RCH. The patient could be admitted to the general ward of the community hospital for observation, depending on the extent of the injury.
3. There may be a number of injury or illness cases, which can be presented at the community hospital that the GP may not immediately be confident on patient management. Given the appropriate decision support from the LUH, the GP could access the experience of the consultants and be advised or get confirmation of patient management. It is these "grey area" or "decision support" cases which are targeted for telemedical intervention and medical decision support.

4.2.2 Large Urban Hospital.

The Accident and Emergency department of Aberdeen Royal Infirmary (ARI) provides the normal point of referral for the RCH. By European standards, the geographical area served by the city's medical services is extremely large. The area served by ARI and facilities of the A&E department are described in Journal Articles 1 & 2 of Appendix A.

The A&E Department is one of the few of its type that provides follow-up clinics within the department. The department is able to treat 90% of attendees within the department, with only 10% being referred to other departments of the hospital. Radiological facilities are provided exclusively for the department and operate 24 hours a day. The department x-rays approximately 70% of attendees.

The decision support, second opinion and advice provided to the RCH was handled by one of the three consultants, two registrars and two senior house officers of the A&E department.

All patients presenting at the department are treated, whether or not the injury/illness is strictly casualty. GP referrals are often due the technical nature of the injury or the equipment needed for the management of that injury, or inexperience in the management of specific injuries.

Referrals from Peterhead during the night may not be due to the inexperience of the GP, but due to the restrictions the RCH facilities have placed upon the actions the GP can take.

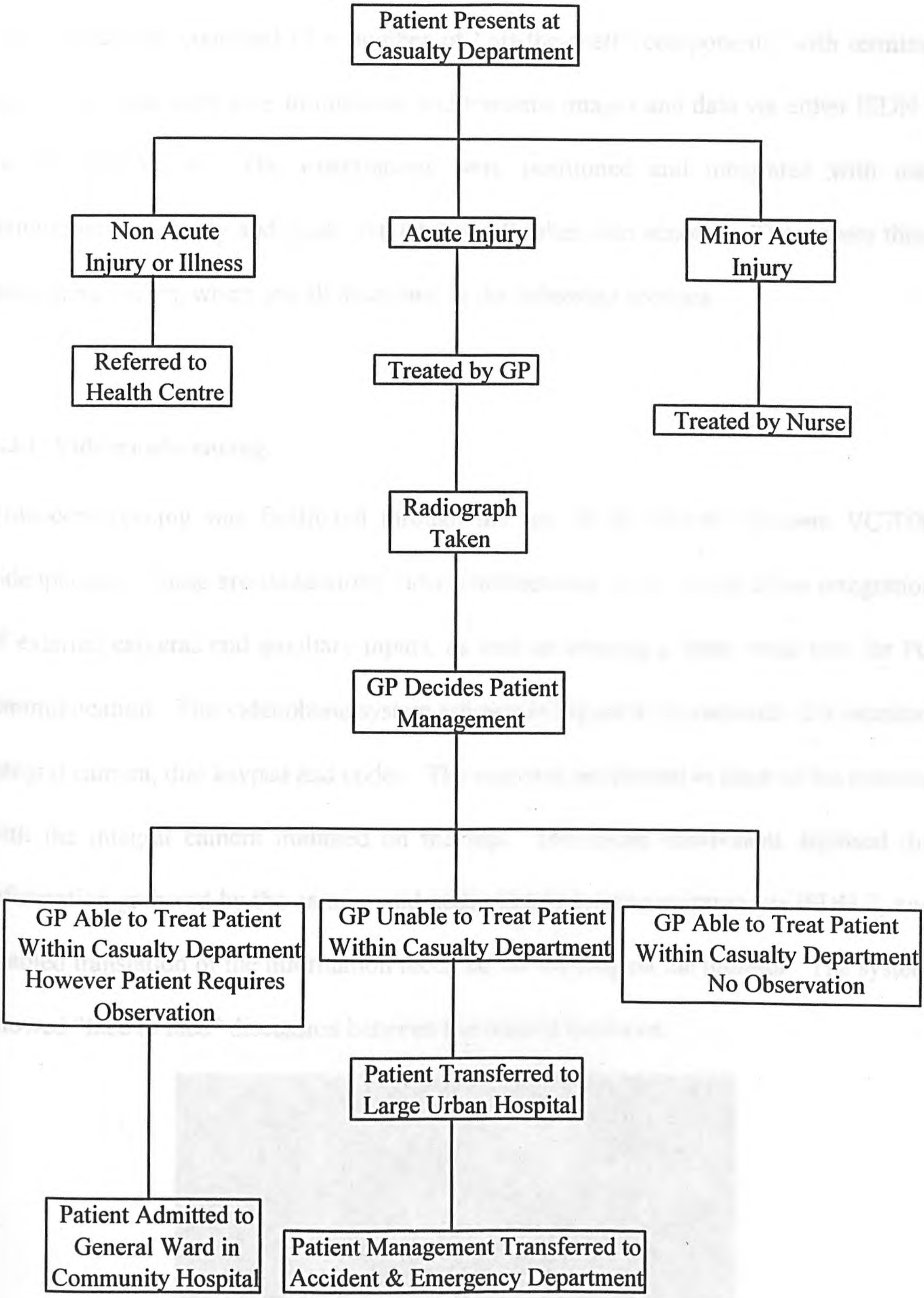


Figure 4.1. Patient passage through casualty department at remote community hospital.

4.3 Telemedicine Workstation Equipment.

The workstation consisted of a number of "off-the-shelf" components, with terminal equipments that were able to integrate and transmit images and data via either ISDN 2 or INMARSAT A. The workstations were positioned and integrated with user requirements, security and space availability, all taken into account. There were three main components, which are all described in the following sections.

4.3.1 Videoconferencing.

Videoconferencing was facilitated through the use of the British Telecom VC7000 videophones. These are stand-alone video conferencing units, which allow integration of external cameras and auxiliary inputs, as well as offering a clear serial port for PC communication. The videophone system (shown in Figure 4.2) consisted of a monitor, integral camera, dial keypad and codec. The user was positioned in front of the monitor with the integral camera mounted on the top. The codec component digitised the information gathered by the camera and audio inputs for transmission via ISDN 2, and enabled translation of the information received for viewing on the monitor. The system allowed "face to face" discussion between the remote locations.

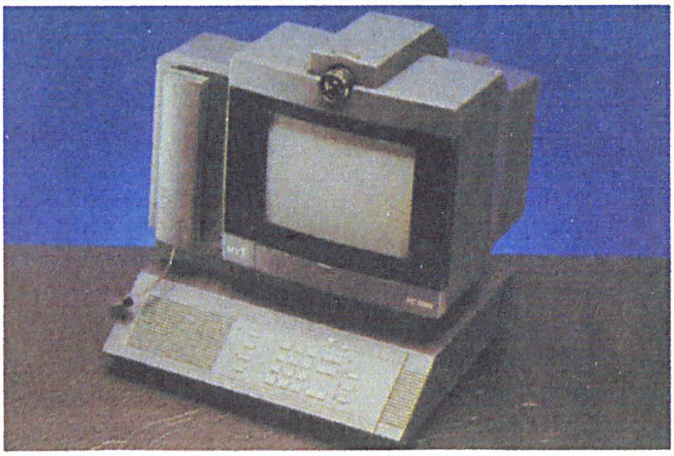


Figure 4.2. VC7000 Videoconferencing unit.

The procedure for utilisation of the VC7000 was as follows: before initiating a videoconference, the user checked focussing and light conditions by using the self-view facility. Any external video inputs were also tested in the same manner. The VC7000 has a small menu driven system, which allows the user to check the call quality and communication mediums. The call was initiated by either lifting the handset and dialling, as with a conventional phone, or using the "hands free" facility. The VC7000 supports interfaces so that additional audio and video devices can be used. The use of the VC7000 is described in Journal Articles 1, 2 & 5 of Appendix A. The technical specification of the videoconferencing equipment is shown in Appendix B.

4.3.2 Telepresence.

The telepresence system, which was utilised during the clinical trial periods, was the CamNet Headset. The CamNet system allowed the consultant at the specialist centre to be "virtually" present and "looking over the shoulder" of the GP at the remote site. CamNet enabled the consultant to view exactly what the remote GP was viewing, and to monitor patient and practitioner actions and responses.

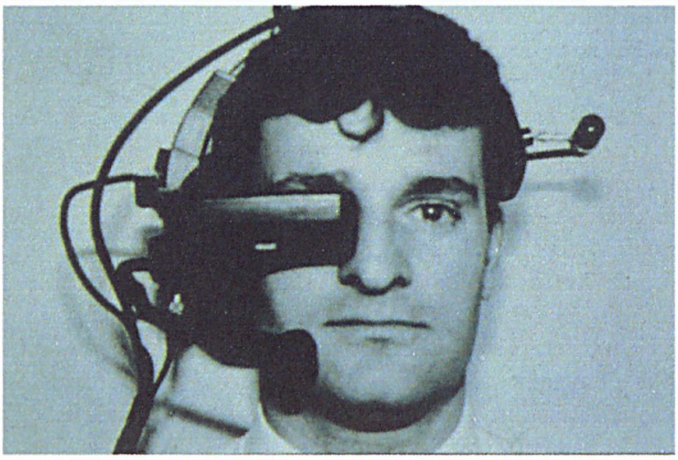


Figure 4.3. CamNet Headset.

The telepresence headset and its functions are described in Journal Articles 1, 2, 3 & 5 of Appendix A. The technical specification of the CamNet headset is shown in Appendix C.

4.3.3 Teleradiology.

The teleradiology system, which was utilised for the purposes of the SAVIOUR study, was the Image Data Corporation Photoscan system from the US. The system is made up of two main components, the Photoscan digitiser and the Multiview PC with high-resolution monitor. The functionality, application and specification of the teleradiology equipment are described in Journal Articles 1 & 2 of Appendix A. The technical specification of the teleradiology equipment is shown in Appendix D.

4.3.4 Costs of the Telemedicine Workstation.

The purchase and installation costs of the telemedicine workstation are detailed in Journal Article 3 of Appendix A. The overall cost of the telemedicine workstations (RCH and LUH) for use over ISDN was £65,634 (at time of installation, 1995).

4.4 Transmission Mediums.

The data (teleradiology, videoconferencing and telepresence images) were transferred via either the ISDN using two 64 Kbits/s channels (ISDN 2) or via the INMARSAT A satellite communications system using a unit configured for high-speed data transfer (HSD) at 64 Kbits/s. The medical decision support system was demonstrated over the satellite system to prove its potential for service provision to any remote region. Both transmission mediums have previously been described (Section 2.3). The use of the mediums in this context, and the equipment used has been described in Journal Articles 1 & 2 of Appendix A. The configuration of the system for clinical data transmission of INMARSAT A is shown in Figure 4.4. The technical specification of the satellite communication equipment is shown in Appendix E.

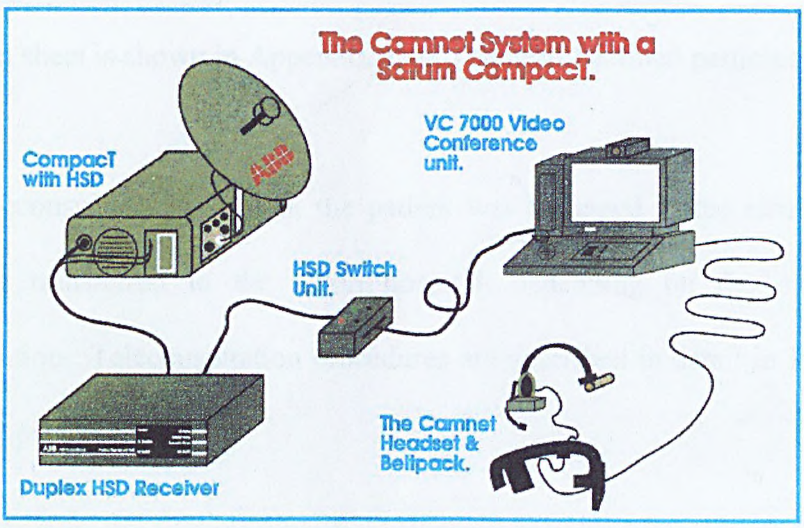


Figure 4.4. Equipment Integration with the Satellite Communications System.

The costs of the Saturn CompacT Mobile Land Earth Station and interface unit, demodulators and suitable cabling are detailed in Journal Article 3 of Appendix A. When added to the costs of the telemedicine workstations, the cost of purchasing and installing for use over INMARSAT A was £97,580 (at time of installation, 1995).

4.5 Clinical Trial Period Procedures.

The responsibility for the identification of the clinical requirements for inclusion of a patient in telemedical consultation, was with the GP at the RCH. The GP assessed the patient's injuries and/or illness in light of the facilities available at the RCH. The facilities are limited in terms of consultant back up, plastering facilities and restricted x-ray facilities. The GP decides on patient management with these restrictions in mind.

The GP is capable of identifying the patients who are appropriate for inclusion in the clinical trial, not only for the purposes of research but also to the benefit of the patient. The patient was informed of the purpose of the teleconsultation, the possible benefits and the details of the project. The patient was provided with an information sheet and requested to consent to participation in the clinical trial. A copy of the patient information sheet is shown in Appendix F. No patients declined participation.

Once a teleconsultation occurred, the patient was managed in the remote community hospital or transferred to the urban hospital, depending on the outcome of the teleconsultation. Teleconsultation procedures are described in detail in Journal Articles 1 & 2 of Appendix A.

4.5.1 Staffing.

The telemedicine workstation did not have dedicated staff at either location. The frequency of teleconsultations, (3 per week) would not have justified this. However, if the system was to be expanded to other RCHs, then the increased calls received by the LUH may justify a dedicated telemedicine consultant.

4.5.2 Teleconsultation Procedures.

Procedures were adopted in both the RCH and the LUH to ensure smooth operation of the telemedicine workstation without disruption of other departmental routines and priorities.

The following describes a typical clinical scenario using telemedicine:

- A patient presented at the casualty department of the RCH with an injury/illness that required immediate trauma care and management.
- The patient was examined by the duty doctor who assessed the patient's injuries and considered patient management in light of the facilities and services available within the RCH. The GP may then decide to have a teleconsultation with the LUH A&E consultant to gain medical decision support.

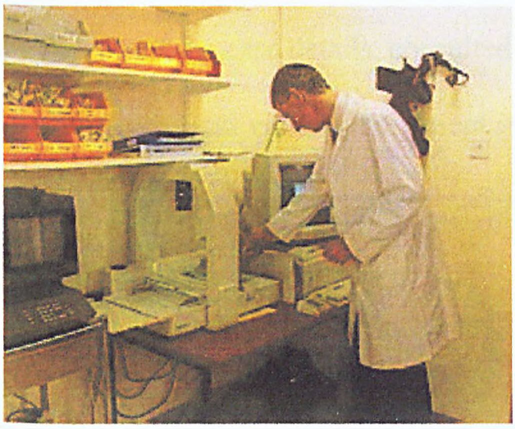


Figure 4.5. Digitisation and transmission of radiograph by GP.

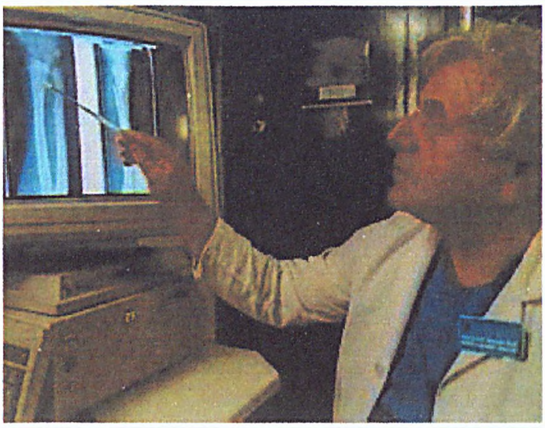


Figure 4.6. Examination of transmitted radiograph by A&E consultant.

- A telemedical consultation between the two sites was usually initiated with the transfer of a digitised radiograph. Due to the positioning of the telemedicine workstation at the LUH, the consultant was telephoned and asked to go to the workstation and examine the transmitted radiological image.

- The A&E consultant then initiated a videoconference with the RCH. Patient details and case history were then discussed in a face to face videoconference. The consultant could also discuss the details with the patient via videoconferencing. If the patient's injuries were such that the consultant required a patient examination or examination of the affected area, this was achieved using telepresence.

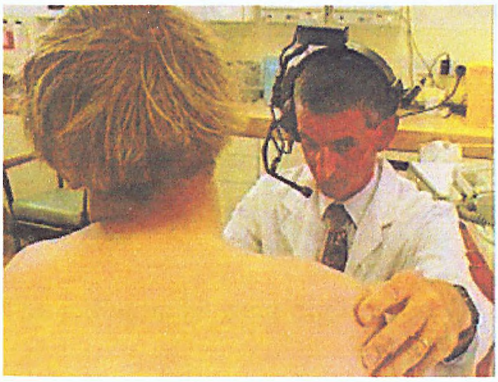


Figure 4.7. Patient examination by telepresence.

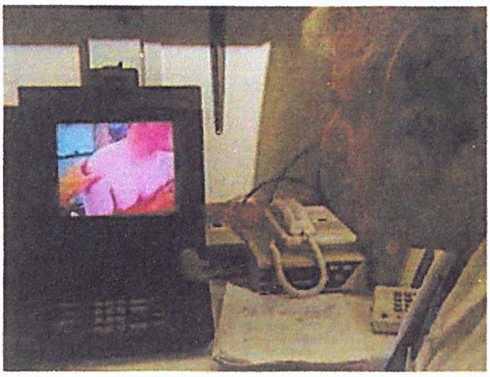


Figure 4.8. Consultant viewing telepresence examination.

- Having all the case details, consulted with both GP and patient, viewed the digitised radiograph, and viewed the patient injuries, the A&E consultant advised the GP of the RCH on patient treatment and management or advise on patient transfer and patient management during transfer.

Figure 4.9. Consultants giving advice on patient management.

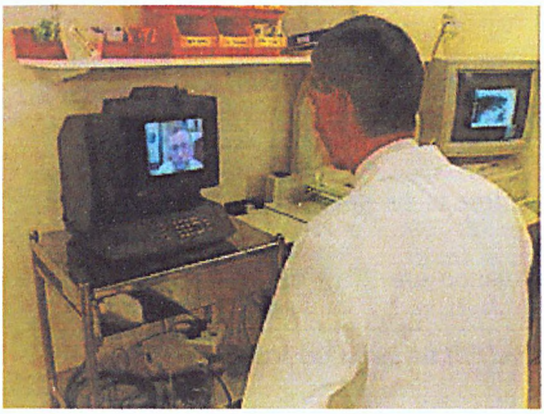


Figure 4.10. GP discussing patient management with consultant.

- At this stage the legal responsibility still remains with the GP. Discussion with all parties resulted in the medico-legal responsibility remaining with the GP. As previously discussed, medico-legal responsibility has remained a barrier to the widespread distribution of telemedical services. However in this instance both parties agreed. The GP was required to decide ultimately what the treatment should be and where it occurs. If the patient was transferred, then the responsibility was also transferred, as would occur with any other patient transfer.

The radiographs were digitised in the casualty department of the RCH. Once digitised, the radiographs were immediately stored on the teleradiology workstation hard disk. Backups could be taken and stored in a computer disk safe as required. Digitised radiographs were identified and marked by the same code number, which the original radiograph was given by the Health Board Trust. The digitised radiographs were transmitted the A&E Dept. of the LUH and automatically stored onto hard disk of the LUH teleradiology workstation. Digitised radiographic images of patient consultations were stored at both sites, and in the same form.

The content of the teleconsultations, videoconferencing and telepresence examinations were not recorded, the system acting only as a medium for conducting an examination from a distance and not as a record of the examination itself. The GPs and consultants involved with the teleconsultation recorded details and consultant opinion on the normal paper-based system. The GPs complete an accident and emergency attendance card for every patient seen in the casualty department of the RCH, either by teleconsultation or by normal methods. The card included case history, examinations, observations, actions (x-rays etc.) and treatment. The GP marked on the A&E card that a teleconsultation had occurred, and included consultant's recommendations. The following flow diagram shows the passage of a patient through a telemedical consultation.

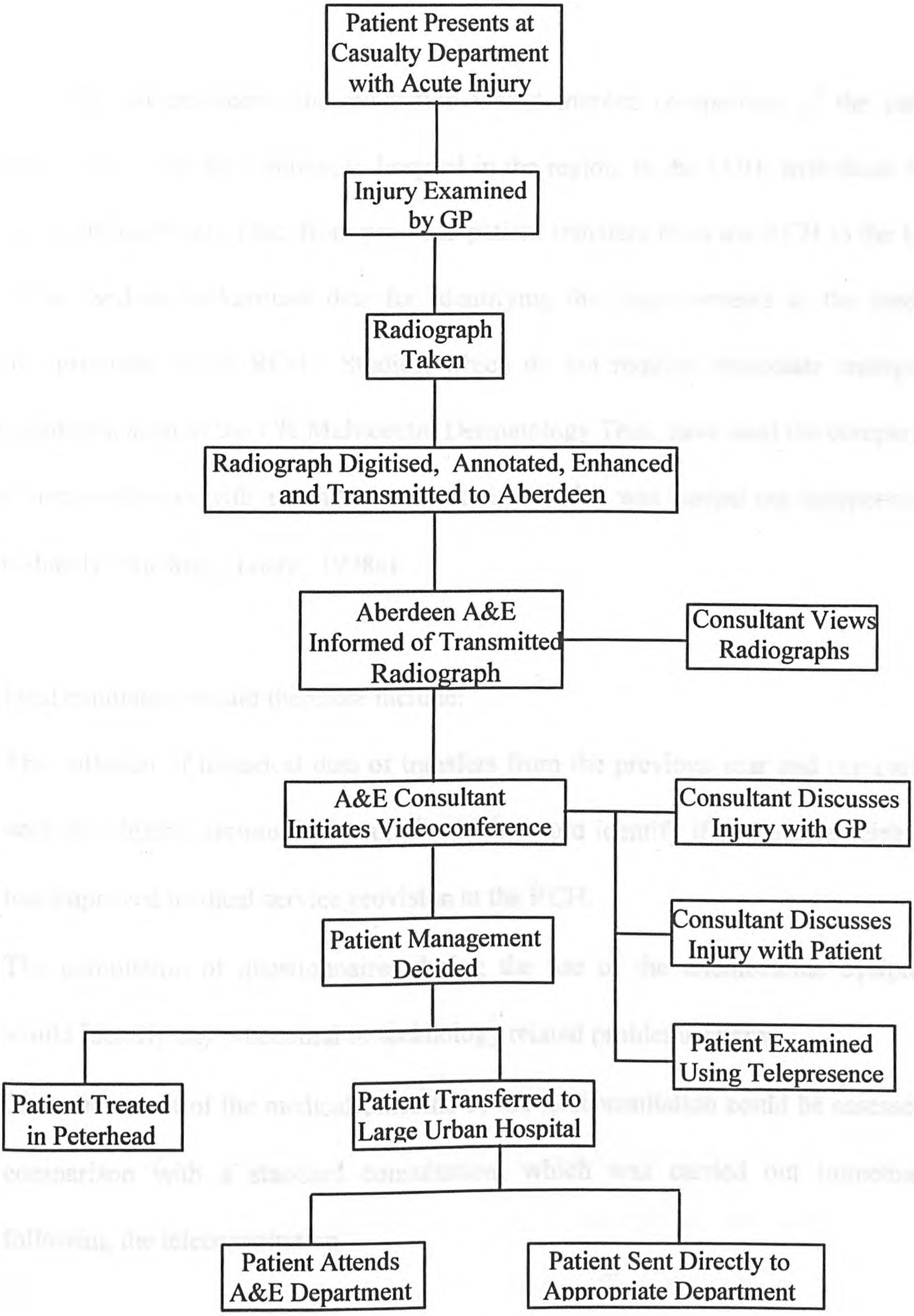


Figure 4.11. A Telemedical Consultation.

4.5.3 Teleconsultation Evaluation.

The evaluation of the teleconsultations and the telemedicine link was undertaken through the use of questionnaires and semi-structured interviews with the clinical staff involved.

Under ideal circumstances, the evaluation would involve comparison of the patient transfers from a similar community hospital in the region, to the LUH, with those from the RCH at Peterhead. Data from previous patient transfers from the RCH to the LUH could be used as background data for identifying the improvements in the medical service provided at the RCH. Studies, which do not require immediate emergency consultations, such as the UK Multicentre Dermatology Trial, have used the comparison of a teleconsultation with a standard consultation, which was carried out independently immediately following (Loane, 1998a).

An ideal evaluation would therefore include:

- The collation of historical data of transfers from the previous year and comparison with the similar community hospital, which would identify if the telemedicine link had improved medical service provision at the RCH.
- The completion of questionnaires during the use of the telemedicine equipment would identify any procedural or technology related problems arising.
- The assessment of the medical outcome of the teleconsultation could be assessed in comparison with a standard consultation, which was carried out immediately following the teleconsultation.

As a consequence of the nature of the injuries that are seen in a casualty and A&E environment, combined with facilities available at the RCH, the evaluation methodology outlined above was adjusted, and a pragmatic approach adopted.

The purpose of the evaluation was to monitor the use and functionality of the telemedicine workstations in real cases. In the community medicine scenario, the teleconsultations occurred in dealing with emergency and casualty cases. These are real "live" cases, in which the patient will require immediate treatment to alleviate suffering. Casualty and emergency cases must be treated quickly and efficiently for the benefit of the patient. These real emergency telemedicine cases cannot be subject to independent re-examination immediately afterwards. Radiographs used as part of the teleconsultation were independently reviewed by radiologists to assess the diagnostic quality of the teleradiology service.

The RCH was a newly refurbished, purpose built facility, the first of its kind in the region. This further restricted the evaluation in two respects. Firstly, no similar community hospital was available for comparison in the region. Secondly, the previous years data would not be directly applicable, as facilities at the RCH had changed.

The teleconsultations were assessed through the use of questionnaires, designed to elicit as much information from the clinical staff within the limited time available to them. The resulting questionnaires show satisfaction with equipment and information received and opinion of clinicians on medical outcomes. The GP and the A&E consultant provided assessment of whether patient transfers and patient care had been improved.

Evaluation methodology in an emergency scenario such as this is limited due to the fast response times required by patients and the limited time available to clinicians. Data not included on questionnaires was collected during semi-structured interviews with clinical staff from both centres.

The following tasks were undertaken for the study:

- questionnaire design
- training provision
- data collection and analysis
- interviewing
- evaluation of results.

4.5.4 Questionnaires.

A number of questionnaires were designed to gather the appropriate quantitative and qualitative data regarding the teleconsultation and use of the telemedicine workstations (Oppenheim, 1966; Denscombe, 1982).

Questionnaires were filled out by clinical staff at both sites, the RCH and LUH. The questionnaires were very similar for both sites, regarding the use of equipment, however extra questions were asked of the general practitioners. Patient details were recorded to ensure that all information had been recorded for trial requirements. The patient injury or illness was stipulated. Comments on the ease of use and problems encountered when using the telemedicine workstation equipment were gathered by means of a series of multiple choice questions and grading scales on ease of use. The clinicians were asked to give their "context free" patient management techniques. These refer to the patient management that would have occurred if the telemedicine workstation had not been available for use. Clinicians also stipulated the patient management that had occurred and whether this had changed as a result of the teleconsultation.

Finally the clinicians were asked to answer the following five questions:

1. Adequacy of the information received.

   Rated on a 1 to 5, "poor to good" scale, the remote site GPs rated the adequacy of the information or patient management suggested by the consultant from the specialist centre.

2. Usefulness of the teleconsultation episode.

   Rated on a 1 to 5, "not-useful to very useful" scale, remote site GPs rated the overall use of the particular teleconsultation.

3. Confidence level that advice is appropriate.

   Rated on a 1 to 5, "unconfident to very confident", remote site GPs rated their confidence level in the advice provided by the A&E consultant was appropriate to the management of the patient.

4. Did this teleconsultation save a patient transfer.

   Simple "yes or no" statement on the possible savings in patient transfers.

5. If the patient was transferred, did the patient require to attend A&E.

   Although the patient may still have required to be transferred to the urban hospital, the teleconsultation may have made it possible for him/her to be accepted straight into a ward or attend an out-patient clinic. This final question merely asks whether this has been facilitated.

The final versions of the questionnaires that were completed by the clinical staff are shown in Appendices G and H. The original questionnaires were updated following comments from the clinical staff.

4.6 Results and Evaluation.

This sections details the use and evaluation of the telemedical workstations and the results of the teleconsultations that have occurred during the clinical trial period. These results have been published and are shown as Journal Articles 1 & 2 of Appendix A.

4.6.1 Usage of the Telemedicine Workstations.

The overall statistics for the teleconsultations, which have occurred during the one-year clinical trial are given in the tables below..

Total Number of Teleconsultations	120
Number of Teleconsultations using Teleradiology	116
Number of Teleconsultations using Videoconferencing	76
Number of Teleconsultations using Telepresence	4
Number of Patient Transfers Saved	70
Number of Patients Transferred Directly to Specialist Ward*	3
Number of Patients entering General Ward at Remote Site+	1

Table 4.2. Teleconsultation Statistics.

* Patients who have required treatment at the LUH. However, due to the teleconsultation, they were transferred directly to the specialist ward and did not require to attend A&E.

\+ Patients treated within the RCH, but who required observation overnight, and were therefore admitted to the general ward within the hospital at RCH.

In teleconsultations, which proceeded without videoconferencing, clinical data transfer and patient management occurred via the analogue telephone channel. The majority of the presentations were incidents of minor trauma. However there were a small number of infections presented and two medical presentations of obstructive airway disease and renal colic.

Injury	No of Cases
Medical presentations, e.g. renal colic	2
Fractures, e.g. fracture of head of humerous	28
Possible fractures, e.g. possible fracture of spinous process of T1	19
Miscellaneous injuries, e.g. neck injury	51
Sprains, e.g. inversion injury of ankle	4
Open wound/lacerations, e.g. head injury with cut eyebrow and face	2
Miscellaneous, e.g. loosening of dynamic hip screw causing pain	9
Crush injury, e.g. crush injury to foot	3
Infection, e.g. infected hand	2
Total	120

Table 4.3. Presentations for Teleconsultations.

Teleconsultations commenced with the digitisation and transmission of one or more radiographs in 116 cases (97%). Having received the digitised radiographs, the specialist consultant initiated a videoconference in 76 teleconsultations (63% of the total). The telepresence component of the telemedicine workstation was used in only four teleconsultations (3%) (Armstrong, 1996b).

4.6.2 Evaluation of the Videoconferencing System.

Videoconferencing was found to be useful in describing wounds, the placing of slings and collars, the positioning of dressings, and so on. The fact that the patient could interact with the consultant was also beneficial and allowed the consultant to gain more first-hand knowledge of the case in hand. During a teleconsultation, the GP frequently consulted appropriate specialists and senior consultants who were present in the A&E Department at the time.

There were felt to be no real problems with picture quality, although some minor problems occurred when the integral camera was not focused correctly, or the user attempted to position himself/herself too close to the camera.

If the camera was properly focused, the transmitted images were of good quality and considered adequate for diagnostic purposes. Many of the teleconsultations involved consultant-patient interaction as well as consultant-GP interaction. The freeze-frame facility was often used to view specific regions or injuries. The patient would be seated in front of the integral camera and the injury displayed if possible.

Both the RCH and the LUH found the videophone to be useful. Comments from the LUH suggested that the teleradiology was the key to the consultation but, with familiarisation, the usefulness of a direct interview with the patient became more apparent. From the GPs' point of view, videoconferencing provided reassurance that the specialist had a complete clinical picture.

The GPs' and consultants' scores for the overall usefulness of the videoconferencing (in 76 teleconsultations) are shown in Table 4.4. Doctors rated the usefulness on a scale of 1 to 5, "one" indicating "not being useful" for the individual teleconsultation and "five" indicating "very useful".

Location of Doctor	Mean Score	SD	No. of Ratings
LUH	4.2	0.9	61
RCH	4.7	0.6	69

Table 4.4. Usefulness of Videoconferencing (in 76 Teleconsultations).

4.6.3 Evaluation of the Teleradiology System.

<u>4.6.3.1 User Assessment of Teleradiology Clinical Trial.</u>

The quality of radiographic image was felt to be adequate and even excellent for the purposes of the GPs. The software and user interfaces were very easy to use. Scanning was a simple operation, although the digitiser required frequent calibration to maintain quality.

The GPs at the RCH and the consultants from the LUH A&E Department scored the images for both quality and usefulness.

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.3	0.9	87
RCH	4.7	0.7	107

Table 4.5. Teleradiology Image Quality Score (in 116 Teleconsultations).

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.4	0.9	87
RCH	4.6	1.0	107

Table 4.6. Teleradiology Image Usefulness Score (in 116 Teleconsultations).

4.6.3.2 Professional Evaluation of Transmitted Radiological Images.

Digitisation of plain radiographs has not met with universal approval by radiologists as there is no recommended standard of what resolution or degree of image manipulation is acceptable for diagnostic purposes.

Professional radiologists undertook an assessment of the radiological aspects of the teleradiology link between the RCH and the LUH. The radiologists who were independent of the clinical trial, were approached to evaluate the accumulated x-rays films and digitised images at the end of the clinical trial period. The aim of the radiologists was to give a non-biased evaluation of the system from a radiological perspective.

Professional Evaluation.

The accredited radiologists evaluated digitised and analogue film images and assessed their diagnostic usefulness. Seventy-five sets of images were available for assessment.

Two experienced radiologists reported on both sets of images. The film images were reported in a standard fashion using standard facilities and recording of the reports. The digital images were viewed on the monitor that was situated within the A&E Department. The site of the monitor was deemed sub-optimal for viewing conditions by the radiologists in respect to its position in a busy office area with inadequate facilities for viewing the image in a darkened environment. However, these were the conditions under which the equipment had been used during the clinical trial period.

There was at least 6 weeks between reporting sessions to avoid any bias due to previous knowledge of the images. When analysing the digital images, an assessment of image quality was also recorded.

Comparison of the reports was then made between each observer for both the digital and analogue images. A scoring system was devised where a score of 1 was given to total agreement, a score of 2 was given to partial agreement and a score of 3 was given to disagreement. This scoring system assumes that the analogue image produced by the radiographer from the RCH is the benchmark and that the digitised image produced and transmitted is being evaluated compared to that benchmark. The case mix of digitised images represented a broad spectrum of the workload that would involve the link between such a regional trauma centre and a RCH.

Results.

Of the total of 150 images digitised there was an agreement in reporting, or scoring of 1 in 75% of the cases. An assessment of the group of 25% missed or partial agreements, indicated that the digital teleradiology system performed badly in certain areas. Subtle linear non-displaced fractures, bony texture, soft tissue abnormalities and radiographs such as chest x-rays, cervical spines and facial bones transferred poorly.

A subjective assessment of image quality of digitised images reported poor quality and lack of contrast in several specific images such as cervical spine, facial bones and chest radiographs.

From the radiologists' initial evaluation of the teleradiology system, it appears that the inherent resolution, both spatial and contrast, appeared to preclude it from being used as a primary diagnostic teleradiology system. The workstation was designed as a dual videoconferencing and teleradiology link, as an aid to further management of patients and in this role, it performed very well. The over-riding problem with the system is that its inherent spatial resolution and contrast resolution is not of sufficient quality to use as a primary system.

The evaluations of diagnostic teleradiology systems that work in practice, especially in regard to trauma centres, indicate that a high-resolution system with a spatial resolution probably of between 2 and 3 line pairs per mm with high contrast resolution and monitors capable of good spatial resolution is required.

Insufficient resolution is a recurring problem in A&E Departments that try to link a peripheral centre for evaluation of radiographs from a distant site.

With the teleradiology system used within this telemedicine workstation, the loss of information that is accrued would lead to a loss of diagnostic features in linear non-displaced fractures and subtle soft tissue periosteal and bony texture abnormality. Although the workstation was not designed as solely a teleradiology link, it is important that the clinicians using the system are made aware that the loss of information is significant and that subtle fractures, subtle abnormalities, alterations in bony texture and that certain types of radiographs are unsuitable for transmission.

4.6.4 Evaluation of the Telepresence System.

The injuries examined by telepresence were:

- injection reaction of the hand,
- crush injury to the foot,
- infected bursitis,
- possible fracture of the left ankle.

The headset was felt to be very cumbersome to put on and wear. The wearer was often distracted from the patient's problems and injuries in attempting to obtain good pictures, so that the GP was not providing the best quality of care.

The pictures transmitted to the LUH were of reasonable quality and adequate for decisions on patient management to be made and, in the few cases where it was used, the equipment was said to be very useful. However, the GPs did not rate the image quality or value as high as for those received or transmitted directly from the integral camera of the videophone.

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.0	1.4	2
RCH	3.3	0.6	3

Table 4.7. Telepresence Image Quality Score (in 4 Teleconsultations).

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.3	0.6	3
RCH	3.7	1.2	3

Table 4.8. Telepresence Image Usefulness Score (in 4 Teleconsultations).

4.6.5 Evaluation of the Teleconsultations.

4.6.5.1 Patient Management.

Seventy patients out of 120 were managed at the RCH without referral. Analysis of these consultations indicated that referral would have taken place without teleconsultation. Thus, in spite of the lack of certain facilities at the community hospital (e.g. a plaster technician), the number of patient transfers was significantly reduced.

Of the patients who were viewed via teleconsultation, and were required to attend the LUH, three were transferred directly to the appropriate specialist clinic for definitive treatment, and were not required to attend the A&E Department.

The radiography department of the RCH is a daytime facility, so those patients presenting out with this period were still required to travel to the LUH in spite of the telemedicine link.

4.6.5.2 Quality of Information.

The GPs and consultants scored the value of each teleconsultation using the questionnaire. The ratings indicated that both the GPs and the consultants were very satisfied with the information they received. Both the GPs and the consultants had confidence in the information they received through the teleconsultations, and therefore confidence in the information and advice provided.

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.5	0.8	84
RCH	4.7	0.7	97

Table 4.9. Acceptability of Information Received (in 120 Teleconsultations).

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.6	0.6	84
RCH	4.7	0.7	95

Table 4.10. Confidence in Advice (in 120 Teleconsultations).

Medical Practitioner	Mean Score	SD	No. of Ratings
LUH	4.2	1.0	84
RCH	4.7	0.7	95

Table 4.11. Usefulness of Teleconsultation (in 120 Teleconsultations).

The ratings indicated that both sets of users felt that the majority of teleconsultations had improved patient care.

4.6.6 Evaluation of the Communication Mediums.

The telecom operator originally assigned only one dial-up number for the single ISDN line. The routing of calls was controlled using multiple subscriber numbering to ensure that the terminal equipments were speaking to the appropriate equipment at the other site. Each piece of terminal equipment was allocated a separate exchange line number, and these numbers were entered as pre-set values in both the terminal adapters and the videophones.

When the images and data were transmitted via satellite communications, connection was much more difficult to achieve and maintain. The image quality was poorer than that achieved when the data was transmitted via ISDN 2. The transmission rate was only 64 Kbits/s when using the high-speed data capabilities of the INMARSAT A system. This was effectively equivalent to one ISDN channel being used, and the quality of the image was therefore reduced. The clinicians all commented on the reduced quality images. However they were still able to receive sufficient clinical information to advise on patient management.

4.7 Costs and Benefits of the Telemedicine Workstation Link.

The costs, savings and benefits of the telemedicine workstations have been discussed published as Journal Article 3 in Appendix A.

4.7.1 Teleconsultation Costs.

4.7.1.1 Transmission Costs.

The ISDN network was used for the majority of the clinical trial period. The transmission costs (at 1996 levels) are shown below;

Line Rental (Both Sites)	£1454
Line Usage (Both Sites)	£336
Total Transmission Costs	£1790

Table 4.12. Transmission Costs.

ISDN Line usage costs, or call costs, are relatively low compared to line rental. The average costs per consultation for the 120 teleconsultations, using ISDN alone, were £2.80 for call costs and £12.12 for line rental, which is cheaper than transporting a patient by ambulance for one mile.

The cost of the telemedicine workstation equipment per consultation was £547. The equipment is capable of further usage, however, and using a reasonable approximation of 1000 teleconsultations per year, each consultation would then cost £66 in equipment costs, £2.80 for call costs and £1.45 for line rental, totalling £70.25.

4.7.1.2 Training.

The workstation components were relatively straightforward and simple to use, and the teleradiology system actually included on-screen reminders. Clinical staff from both sites were given tutorials and demonstrations in workstation use and fault finding. On site technical assistance was provided for the first three weeks at the RCH. This ensured proper use of the system, backed up the demonstrations and reassured staff using the systems.

The tutorials in the use of the system were supported and reinforced at various points through the clinical trial period to ensure continued appropriate use of the system.

The telemedicine workstation remains in use at the present sites. In the long term, the clinical staff at the RCH are considering further training (e.g. plastering techniques) so that the patients can be treated within the community hospital.

4.7.1.3 Staffing.

Neither the RCH nor the LUH have found it necessary to increase the staffing levels or the change staffing conditions as a result of the implementation of the telemedicine workstations. As mentioned above, staff have been required to undergo training in the use of the system. However, use of the system or the training has not impinged on normal duties or training requirements.

4.7.1.4 Patient Treatment Costs.

The costs incurred for patient treatment depended very much on the result of the teleconsultation. If the patient needed to be transferred to the LUH for treatment, either to the trauma centre or directly to a specialist unit, then this transfer was normally undertaken by the ambulance service. If the patient was treated within the RCH then the transfer-ambulance costs were saved. In some cases there were further treatment costs within the RCH.

One of the most common forms of treatment following telediagnosis was the application of a plaster cast. The GPs did not routinely apply plaster casts before the telemedicine workstation was introduced but were able to apply casts to certain injuries and save patients transferring to the LUH as a result of the medical decision support. The application of a cast obviously has a time implication for the GP but is very time efficient for both the patient and the consultant.

The GPs stated that using the teleradiology and telemedicine equipment appeared to take longer than a normal consultation. Time is a valuable resource to the practice. The extra time spent in casualty dealing with a teleconsultation, incurs an extra cost to the practice or RCH. The duty doctor is paid for the number of patients he or she sees.

The time taken to perform a teleconsultation and the time taken for a normal consultation was compared. For a small sample, the average normal consultation (total time the patient was in the casualty department, including the taking of an x-ray) took 77 minutes, whereas a teleconsultation (total time) was on average 84 minutes long. There was a seven-minute difference, not significant if over half the patients who are seen by teleconsultation do not require to be transferred to the trauma centre.

4.7.2 Probable Savings.

The telemedicine workstations used to connect the RCH with the LUH provided very tangible benefits from their use in the provision of trauma care;

- Savings from reduced travel costs of specialists.
- Savings from reduced evacuation costs of patients.
- Savings on hospital accommodation of patients that can be treated remotely.
- Savings on hospital processing costs of patients that can be treated remotely.

The GP practices and healthcare departments within the healthcare trusts in the UK are gradually going through the process of becoming fundholders. Fundholding means that within a National Health Service funded by UK central government, the departments or practices are responsible for their own financial planning and charging systems. The GP practice at the RCH, which provides the on-call doctor for the casualty department is presently undergoing this process.

This means that if a patient presents at the RCH casualty department, or is referred there by the GP, then the practice will be responsible for the costs, which this presentation incurs. If this patient is then transferred to the LUH, the GP practice of the RCH is not only responsible for the transfer costs, but must also pay for the consultant time and nursing staff provision of the A&E Department, plus the subsequent patient management costs.

Patients are presently transferred to the LUH at no cost to the GP Practice or RCH, there are of course, significant costs in healthcare to the patient. Ambulance costs and consultant and other LUH costs are covered by the local health board.

Once total fundholding comes into operation, the RCH will be able to reduce the cost of patient transfers to the LUH using the telemedicine workstation link. There will still be a cost to the RCH in terms of treating the patient in house, plus the LUH will charge for a teleconsultation. These costs will still be significantly less than those for transferring patients and treating them at the LUH.

4.7.3 Quantitative Benefits.

4.7.3.1 Cost Benefits and Savings in Patient Transfer.

The telemedicine workstations provided very tangible cost benefits from their use in the provision of trauma care. Savings arose from reduced travel costs of specialists, reduced evacuation costs of patients (ambulance costs), on hospital processing costs and accommodation of patients that can be treated remotely.

4.7.3.2 Transport Costs.

At the time of the clinical trial period, the cost of transferring a patient from the RCH to LUH by ambulance was believed to be £15 per km. The RCH is 60km north of the LUH, so each patient transfer could cost in the region of £900 each way. Through the use of the telemedicine workstation, 70 patient transfers have been saved, realising possible savings of up to £126,000 in transport costs alone.

4.7.3.3 Consultant Time.

Consultant time is one of the most expensive items in the provision of healthcare. Waiting lists depend on the availability of facilities but also on availability of consultants. By using videoconferencing, the consultant input to each episode has been reduced. Time was saved, for example, by avoiding repeated initial examinations of injuries when patients were referred to consultants.

4.7.3.4 Patient Waiting Time.

Previously, the transferred patient would have undergone two periods of waiting, one in each hospital, as well as the time taken to travel between hospitals. Teleconsultation reduced this to one waiting period.

4.7.4 Qualitative Benefits.

Although qualitative benefits of a telemedicine system such as this have a perceived value, the actual value can be more difficult to determine. In some instances the value of these benefits may be estimated. The following were identified as benefits highlighted in the clinical trials.

- Patients had access to more specialised levels of care within the community with GPs able to contact consultant-level decision support when treating cases of minor trauma. Patients received a faster and more expert diagnosis and treatment, a reduced number of examinations, avoided the inconvenience of travelling to another hospital or physician and could return to work or home life with less disruption.

- Remote GPs were able to access consultant-level decision support for all advice on injury management, while keeping patients within their care. This allowed a fundholding GP to maintain control of the costs of patient treatment.
- Non-urgent cases were treated appropriately at the RCH and patient waiting times at the LUH were reduced.
- The videoconferencing link provided an on-call specialist and consultant-level backup system for GPs. It promoted dissemination of advanced technological and clinical knowledge into the community hospitals.
- The telemedicine workstations enabled the GPs to consult quickly with specialists of the LUH many miles away, without the costs and risks of transporting an ill or injured patient for a long distance.

The videoconferencing and telemedicine workstation provided an ideal forum for the provision of standardised clinician and nurse training.

Throughout the clinical trial period, GPs commented on the learning and training attributes of the teleconsultations. Having discussed an patient injury with a consultant, if a similar injury was presented again, the GPs felt confident enough to treat without referral or teleconsultation. In this manner, the actual number of teleconsultations would be expected to drop over time due to the virtual on-line teaching effect.

4.8 Summary Discussion.

The application of telemedicine technologies to the provision of medical decision support in remote communities has been successful. The SAVIOUR project has demonstrated that a low-cost combination of telemedicine equipment, available off-the-shelf can be used now to make positive contributions to healthcare. The problems encountered were not technical but cultural, and highlighted the need for changes in organisational procedures to allow both the optimal use and further development of telemedicine. Following the demonstration of the benefits, the telemedicine link continues in service provision, and the network will be expanded to include other community hospitals within the health care region.

Telemedicine workstation links such as this have proved many social and economic benefits for the patients in the community and the clinicians of the hospitals.

During the clinical trial period, on average, three patients were seen per week by teleconsultation. Over half of these teleconsultations negated the need for the patient to be transferred to the large urban hospital for treatment. These patients have received high quality patient care within their own community, and have not required an unnecessary journey. The patients who have required treatment at the specialist centre, were transferred with the knowledge that the consultant already knew of the injury and was aware of the treatment required. Many of these patients were given treatment at the remote community hospital prior to the transfer, making the journey more comfortable and less painful. Some patients were transferred directly to the appropriate department without requiring a further examination at the A&E department. The increased level of communication which this technology provides, gave a more complete clinical picture to the consultant or specialist, and enabled effective patient management.

Staff at the RCH began to acquire new skills rather than refer patients, having previously received advice on the management of similar cases. The GPs participating in the trial remarked on the training effect of the teleconferencing, which is simultaneously conducted with actual patient care. Their participation in the consultation between patient and specialist had an obvious educational benefit. This is additional to the potential the link has in the provision of continuing medical education.

The complete system, videoconferencing, teleradiology and telepresence were used in combination in minor trauma treatment. This was an integrated system, made up of these components in order to aid medical decision support. The equipment, which was installed at the RCH and LUH, was specifically "off-the-shelf" systems that would require little or no physical integration. A result of this was that the workstations were found to be large and took up excessive space because of the number of individual units required. Future workstations will require to be streamlined. All clinicians indicated their satisfaction with the system. The image quality was an issue but deemed satisfactory.

The image quality of videoconferencing over ISDN 2 was still not ideal and had to be optimised with careful attention to lighting. The clinicians were satisfied that the images received, in combination with other clinical information were adequate for diagnostic purposes. Audio quality was commented on, and required upgrading to ensure that no errors were introduced. The quality of the audio is equally as important as the images during a videoconference in keeping with the findings of Goldberg (1996) and MacDuff (2000).

In spite of the relatively low resolution of the teleradiology system, it achieved a high level of acceptability to the users for the purposes of decision support.

CamNet proved to be less useful than expected in linking the GP to the specialist. It has, however, been used effectively when the remote practitioner was not medically qualified, thus fulfilling its purpose of transporting expertise to a remote site (see Section 6). CamNet is no longer in use at the RCH.

The procedures used to initiate a teleconsultation at the specialist centre operated satisfactory in that there was minimal disruption to departmental routine. However, this was a small trial. A higher frequency of calls, as would be expected with expansion of the service will require dedicated staff and space. The telemedicine workstation in the A&E Department was placed within a secure area near consulting offices. The procedures that have been adopted by the consultants and GPs in initiating a teleconsultation have taken this positioning into account and the results were very encouraging.

Unfortunately the A&E consultants felt that the consultations were GP led and driven, and the system may possibly as a result have been under-utilised. Certain components of the workstation e.g. the CamNet headset, that the GPs felt were not useful were discarded at the discretion of the GP.

The consultant was rarely allowed or able to speak to the patient. This was unfortunate since information gathered from the patient could be useful to the specialist as well as to the GP. The consultants were always provided with a subjective evaluation from the GP, which could have precluded the use of videoconferencing. The GP interpretation of the symptoms may prejudice the consultant's patient management. The logistics of videoconferencing needs to be reviewed in the light of this experience.

The benefit of this trial has been to raise awareness in the clinical staff on the potential for improved patient care and clinical teaching with advances in telecommunications. The project used enthusiastic clinicians and enforced realistic procedures for the use of the system. These procedures combined with technical backup ensure the success and continued use of the service. The procedures enforced ensure that the service is not specific technology dependant.

Telemedicine will be of benefit to most countries in helping to cut health care costs. In almost every country, it is believed that more than half the cost of running hospitals is spent on what are essentially hotel services : bed, breakfast, lunch, and evening meals. If patients are saved transfer to these hospitals through the use of telemedicine, then the majority of these extra service costs will be saved. Some patients can be treated in the community and reside within their own homes while being treated.

Although the telemedicine costs today are not low, countries with high health care costs are interested in the prospect of telemedicine as a way to reduce costs and demands upon hospitals. Finding a way to provide reliable access to high-quality health care at reasonable cost is an urgent problem in Europe today, and solutions should be pursued as they become feasible. In some localities, the existing telecommunications infrastructure is adequate to launch or expand ongoing efforts; in others, substantial improvements to network intelligence and bandwidth will be required to achieve many of the benefits. The health care industry must work with the telecommunications industry to achieve development of telemedicine serves throughout Europe and indeed the world.

Telemedicine has the possibility to provide access to centres of excellence for various specialities theoretically from anywhere in the world. Telemedicine can allow the scarce resources of specialised and expensive equipment to be shared by a greater number of patients. Doctors may no longer be restricted by geographical boundaries, international specialists could spread their skills across continents, even to battlefields, without ever leaving their own hospitals.

Future telemedical workstations based on the one used in this scenario, will utilise integrated components ensuring compatibility and practical use of the limited space available in these environments. The project should use simple and effective components, being used as part of an integrated service, combining effective clinical information gathering, telemedicine technologies, appropriately qualified and trained staff, procedures, protocols and suitable facilities.

5.0 MEDICAL DECISION SUPPORT FOR THE MARINE INDUSTRY.

5.1 Background to the MERMAID Project.

Long haul transportation merchant ships resemble closed, isolated, remote communities and work sites, and their medical needs must be addressed accordingly. Vessels at sea should be completely self-reliant. This means that all the medical needs of a ship's personnel must be fulfilled with the minimum of outside help, which would be very expensive to provide in high seas. When medical emergencies arise, the means and the knowledge necessary for handling them must reside on board.

The world merchant fleet (greater than 100 gross tonnage) is huge at approximately 62,000 ships (Lloyds World Fleet Statistics, 1997), and in 1991 it was estimated that 1,240,000 seafarers were employed on these vessels (Vuksanovic, 1991). There is no requirement for a qualified physician on board a ship unless the crew exceeds 100 in number. In reality it is only research vessels, warships and cruise liners that are required to carry physicians on board.

A ship can be a dangerous working environment. The architecture is hard, with steel ladders, deep holds and tanks, moving equipment and massive engines. The ship is subject to violent rolling and pitching, wet and slippery conditions, noise, vibration and fumes. This physical environment results in slips and falls, burns and related injuries (Couper, 1998). There are a large number of occupational hazards within the shipping industry, such as chemical, physical, ergonomic, biological and personal safety. Accidents and injuries are common on board merchant vessels (Vuksanovic, 1991). Accidents can account for 20% of the medical problems encountered, with 70% of theses being caused by human error (Vuksanovic, 1993; Fulvio, 1998). The IMO are investigating the causes of these accidents to ensure that as many as possible cannot be repeated (IMO, 1998). However in the meantime, casualties must be treated on board when an accident happens or illness occurs. The UK P&I Club, who provide assurance for the maritime industry stated that crew injury accounted for 23% of claims made (UK P&I Club, 1994). Crews on board tankers face higher degree of risk of acute health problems arising from their greater exposure to hazardous substances (Patel, 1998a).

A study of fatalities among polish seafarers showed an average annual incidence rate of 1.32 per 1000 personnel employed between 1985 and 1994 (Jaremin, 1996). The most frequent causes of deaths (85%) were, circulatory system diseases, injuries, poisoning and sea catastrophes. The study indicated that the number of personnel employed on board merchant vessels was falling. The number of fatalities was however constant.

An analysis of diseases among Australian seafarers has shown that presentations and consultations were primarily for musculo-skeletal diseases (27%) and respiratory diseases (26%). Circulatory disease presentations constitute only 4% of consultations (Patel, 1997).

Nielson (1997) reviewed data from a number of countries and estimated the number of fatalities from disasters, occupational accidents, illness etc during a five-year period, 1990-1994 as follows;

- 0.415 fatalities per 1000 seafarers as a result of disaster/accident to the ship.
- 0.055 fatalities per 1000 seafarers reported missing at sea.
- 0.367 fatalities per 1000 seafarers as a result of occupational accidents.
- 0.419 fatalities per 1000 seafarers as a result of illness.
- 0.096 fatalities per 1000 seafarers as a result of unexplained circumstances, e.g. suicide.

Some of these fatalities could be avoided with the provision of adequate medical training backed up with the provision of high quality medical decision support and relevant clinical information transfer.

Studies have shown that seafarers have an increased risk of morbidity over those who work on onshore industries (Roberts, 1997). Merchant seafarers are engaged in a notoriously hazardous occupation. Seafaring is a unique form of employment that can expose the seafarer to health risks, which are not commonly associated with other occupations.

When a serious medical emergency occurs, however, the seafarer is as effectively isolated from the shore-based doctor as an astronaut in orbit (Urner, 1984). Some medical expertise as well as medical supplies must reside on board. When the crew is less than 100 in number, the ship has the obligation to carry a medical attendant on board who is responsible for medical care and treatment on the vessel (ILO, 1994). This medical attendant role will be undertaken by one of the ship's senior officers, possibly the ship's master but more likely the First Officer (FO). The crew of a merchant vessel must rely on this "layperson" for medical treatment when qualifications are compared to that of a paramedic or physician found ashore. Moreover, the medical attendant must not only provide first-aid treatment, but is responsible for the patient until recovery or until evacuation to the nearest port, another vessel or by air. This continued treatment might be for several days.

There are three factors that affect the level of medical care aboard ships whose crew number less than 100:

- The level of medical training of the designated medical attendant.
- The quality and content of the ships medical chest and medical guide.
- The ability to make effective use of radio-medical services. (Patel, 1998b).

The FO is required to undertake a training course to become the medical attendant, as stipulated in the IMO STCW 1995 Convention (IMO, 1996). Unfortunately, the length and quality of the training course varies considerably (Patel, 1998). In the UK the course lasts 32 hours and is primarily theory, whereas the US course runs over 280 hours.

The provision of a medical chest and the means to obtain radio-medical assistance are rendered useless if the medical attendant does not have the necessary skills and knowledge to use them. Through the introduction of STCW 1995, and the auditing thereof, medical attendant training and seafarer training in general is improving.

The medical guide most frequently used, and often used as the printed matter for medical attendant courses is the International Medical Guide for Ships (WHO, 1988) or a national equivalent thereof e.g. The Ship Captains' Medical Guide (Department of Transport, 1983). These guides suggest treatment and methodology in dealing most eventualities from injections and burns, to pregnancy and death, as well as recommending the contents of the medical chest.

The maritime industry presently relies on radio VHF communication for the provision of radio-medical assistance. On the whole the communication is unstructured and basic. The medically responsible person relies heavily on the International Medical Guide for Ships for first aid and medical information. The textbook frequently suggests that if in doubt or if the injuries or illness are serious enough, then radio medical assistance should be sought. CIRM, the Italian Radio Medical Centre, one of the oldest in the world, has responded to over 45,000 calls for medical assistance since its inception in 1935 (Amenta, 1999). A significant number of these calls have resulted in saving expensive and time-consuming evacuations. Evacuation or diversion to the nearest port was recommended in 15% of cases assisted.

Medical emergencies can easily evolve into critical situations, managed by inexperienced personnel. Thus European Council Directive 92/29 proposed that "the use of long distance medical consultation methods constitutes an efficient way of contributing to the protection of the safety and health of workers" (EC, 1992), while

Council Directive 93/103 concerning minimum safety and health requirements for work on board fishing vessels, further strengthened the medical aid provisions (EC, 1993). The G7 Nations also proposed the provision of a 24-hour multilingual, multidisciplinary, global emergency telemedicine service (Lareng, 1995). This system or service would provide an emergency medical aid service for remote work sites, regions and communities, ensuring equal access to medical service from anywhere on the oceans.

The MERMAID project, funded by the European Commission, proposed the use of new telecommunications technologies to ensure that emergency medical aid was provided for the merchant marine industry. MERMAID improved on the present VHF radio based system, and provided merchant vessels with high quality medical care on board. MERMAID has been adopted as the basis for the G7 Nations "24 hour, multilingual, multidisciplinary, global emergency telemedicine service".

The IMO is also starting to look closer at the role that telemedicine and telemedical advice centres can have in the provision of medical assistance at sea (IMO, 1998). The IMO has issued a draft circular that addresses the use of telemedical advice centres assisting captains in providing the right treatment for an injured or sick seafarer, or to help resolve a situation where evacuation is difficult or impossible.

5.2 Medical Decision Support for Merchant Mariners.

The merchant marine industry primarily comprises of the large transportation vessels travelling large distances to deliver cargo. These vessels include oil tankers and container ships as well as offshore supply vessels. The number of crew residing on board these vessels continues to reduce for economic reasons, and is relatively small for the size of vessel, usually below 30 personnel. These vessels do not include the cruise liners, research vessels and warships that have much higher levels of medical expertise as required on board by international law.

In an emergency or in a case of illness on board a merchant vessel, it is normally the FO who is responsible for providing medical support on board the vessel. The FO must have undertaken a training course as part of his or her training. The courses, which an FO undertakes amount to between 26.25 and 289 hours, depending on nationality (Patel, 1998b). This training teaches the FO to undertake any first aid that is required on board the vessel, distribute drugs as appropriate, administer drugs by injection and how and when to apply intravenous drips. These functions are augmented first-aid skills only. Although these qualifications are part of the job requirements, they do not constitute the FO's primary function on board.

The Ship Captains' Medical Guide (Department of Transport, 1983) prompts the FO to seek radio-medical assistance if necessary. For every merchant vessel there is a medical decision support process. At present, the medical support for sea-going vessels is provided through a radio-based system. Decisions on treatment are not taken with only the present injury and illness in mind. Consideration must be given to the ship location at sea, the nearest port for possible diversion that has proper medical facilities, fuel supply, speed, wind, weather and sea conditions, and whether indeed the FO is able to contact the shore based medical decision support (Urner, 1984). All these factors influence decisions on treatment. The FO and shore based medical support must be able to communicate as much relevant information between them as possible.

5.2.1 Present Situation in the United Kingdom.

The United Kingdom complies with the requirements of EC Directives 89/391, the Introduction of Measures to Encourage Improvements in the Health and Safety of Workers at Work (EC, 1989) and 92/29, the Minimum Safety and Health Requirements for Improved Medical Treatment on Board Vessels (EC, 1992). These are translated into UK regulations in the form of Statutory Instruments and Merchant Shipping Notices issued by the Maritime and Coastguard Agency (MCA), formerly the Marine Safety Agency. The MCA is the UK government body that is responsible for regulating the merchant marine industry, as well as all other marine activities. It does not have jurisdiction over the Offshore Oil and Gas Installations, which are regulated by the UK Health and Safety Executive (HSE) Offshore Division.

The Merchant Shipping and Fishing Vessel (Medical Stores) Regulations (Department of Transport, 1995a) ensures the UK Government's compliance with EC Directive 92/29. The regulations state an important categorisation of seagoing vessels;

- *Category* A - Seagoing or fishing vessels, with no limitation on length of trips.
- *Category* B - Seagoing or sea-fishing vessels making trips of less than 150 nautical miles from the nearest port with adequate medical equipment.

- *Category* C - Harbour vessels, boats and craft staying very close to shore or with no cabin accommodation other than a wheelhouse.

Each of these three categories of vessel is required to carry different contents to their medical chests as laid out in EC Directive 92/29 and DOT Medical Stores Regulations. The medical chests for these three categories of vessels are detailed within Merchant Shipping Notice No. M.1607 (MSA, 1995a). The use of all the equipment stipulated in the medical indent is described within The Ship Captain's Medical Guide (Department of Transport, 1983). Merchant Shipping Notice (M.1633) (MSA, 1995b) states that doctors offering advice to seagoing vessels should be aware of the category of vessel, and therefore the medical indent on board, and prescribe treatment appropriate to that indent.

EC Directive 92/29 and the Merchant Shipping (Ships' Doctors) Regulations (Department of Transport, 1995b) state that all vessels with a crew of more than 100 personnel are required to carry a doctor on board to deal with medical problems. This relates also to cruise vessels where there are a large number of paying passengers.

The medical training of deck officers in the Merchant Navy and Fishing Fleet is outlined within the Merchant Shipping Notice No M.813 (Department of Trade, 1977) and Marine Guidance Notice MGN 6(M) (MSA, 1997). First Aid at Sea certificates are a requirement of any candidate who wishes to qualify for a certificate of competency as first mate, second mate, mate, skipper or second hand. A candidate wishing to qualify for the issue of a certificate of competency as Master must have attended a Ship Captain's Medical Training Course and be in possession of the appropriate certificate (valid for five years). The course syllabi are shown in Appendix I. The courses have been further ratified through the introduction of the STCW 1995.

5.2.2 UK Maritime Emergency System.

The current working practice is explained in the broadest of terms in a chapter of the Ship Captain's Medical Guide under the heading of External Assistance. This chapter covers the following topics; Radio medical advice, Medivac service by helicopter, Ship to ship transfer of doctor or patient, and communicating with doctors. MERMAID affects only two of these topics, viz. radio medical advice and communicating with doctors.

This *Radio Medical Advice* stipulates that radiotelegraphy is possible from anywhere in the world, and discusses what information should be exchanged to ensure the full and proper treatment of the patient and injuries. The category of medical indent must be made clear to the doctor and also any deficiencies in that indent which may affect the treatment of the patient (e.g. medications used in the treatment of another patient). Medical advice can be obtained from a shore-based doctor or from a doctor present on another ship in the vicinity e.g. a cruise ship or vessel with more than a crew of 100 personnel.

Communicating with Doctors. This section merely suggests that a letter covering medical and personal details of the patient should be sent to the doctor along with the patient, if evacuation is deemed necessary. The Ship Captain's Medical Guide does not go into any detail in describing how this service is provided.

If an accident occurs on a vessel, operating within UK waters or within radio contact of the UK, which requires medical consultation by radio, then a medical radio distress call or urgency call is sent out (2182 kHz and 500 kHz). The distress call is received and processed by the coastal radio station, which connects the ship's medically responsible person to a shore-based doctor. Alternatively the vessel with the medical problem may call ships in the vicinity enquiring if any carry a doctor on board, and the medical consultation will take place between vessels.

Depending on the outcome of the medical consultation, the Coastguard will be given the responsibility of evacuating the patient from the vessel, or transporting a doctor to the vessel.

There are eight coastal radio stations in operation at present. However, in the UK, only the Stonehaven Coast Radio Station and the Land's End Coast Radio Station have the responsibility of listening for calls on the 2182 kHz frequency for medical emergencies and advice. Stonehaven Radio has responsibility for the area from the Isle of Man, round clockwise to the Wash. Land's End Radio has responsibility for the remaining area. These two coastal radio stations connect the vessels through to doctors at the following two establishments: the Accident and Emergency Department of Aberdeen Royal Infirmary, Scotland, and the Royal Navy Hospital, Haslar, in Plymouth, Southern England. Stonehaven Radio will normally direct calls to Aberdeen and Land's End Radio to Haslar.

Figure 5.1 shows the procedure undertaken by the First Officer during a radio-medical consultation.

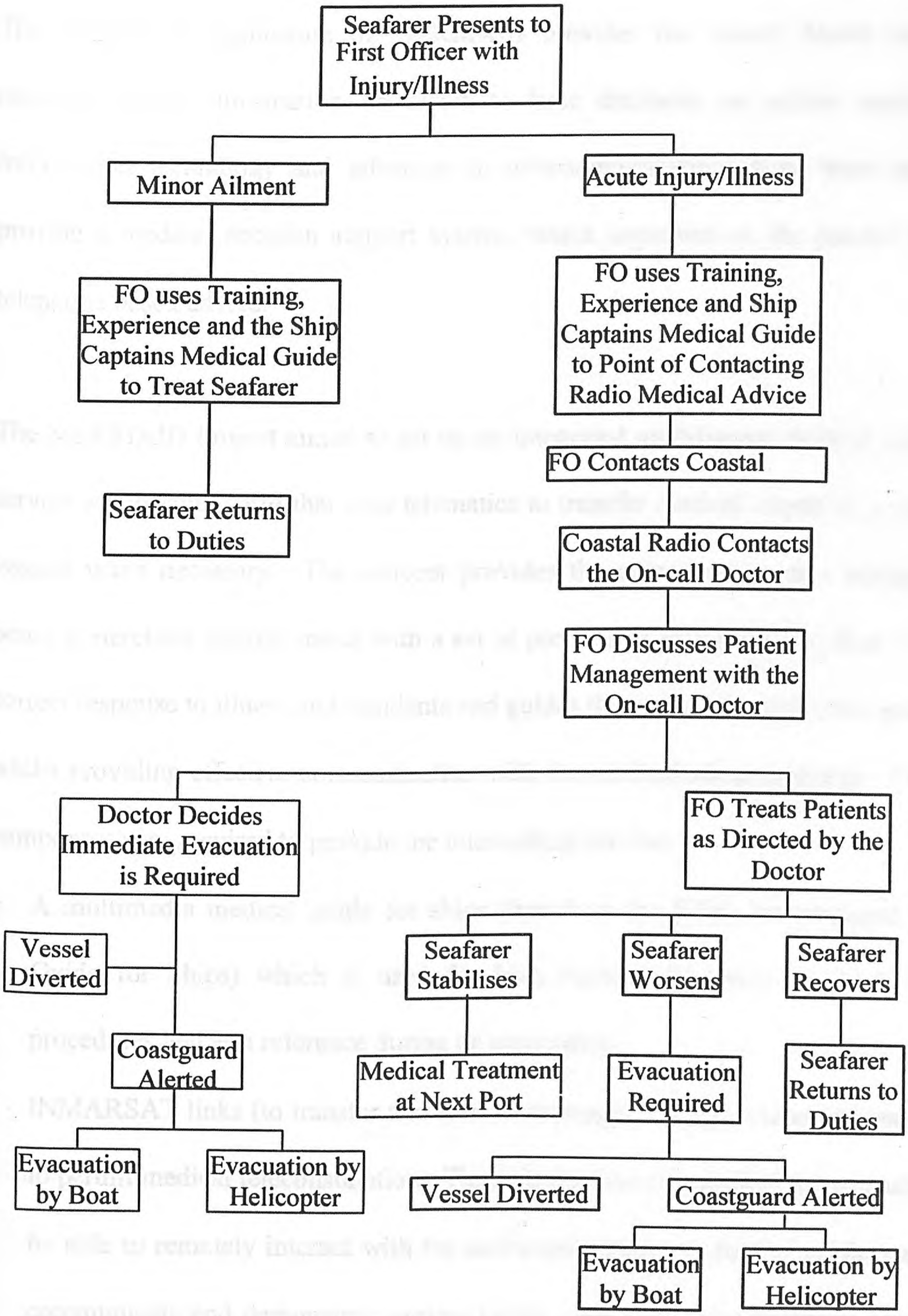


Figure 5.1. Radio Medical Consultation Process.

5.2.3 Benefits of the MERMAID System.

The telemedical application of MERMAID provides the on-call doctor with more relevant clinical information on which to base decisions on patient management. Information technology and advances in telecommunications have been applied to provide a medical decision support system, which improved on the present radio, or telephone based advice.

The MERMAID Project aimed to set up an integrated multilingual medical emergency service around the world that uses telematics to transfer medical expertise to sea borne vessels when necessary. The concept provides the person acting as a paramedic on board a merchant marine vessel with a set of procedures and guidelines that ensure the correct response to illness and accidents and guides this person through these procedures whilst providing effective communication with the medical teleconsultants. Two main components are required to provide the telemedical service:

- A multimedia medical guide for ships (based on the WHO International Medical Guide for Ships) which is used for both training the crew for basic medical procedures and as a reference during an emergency.
- INMARSAT links (to transfer and receive messages, images, video and sound data) to permit medical teleconsultation. Through this link the medical teleconsultant will be able to remotely interact with the multimedia guide so that he or she can better communicate and demonstrate certain health care procedures to the crew members that act as paramedics, improving the effectiveness of the intervention.

The MERMAID System was been developed as far as possible to use communications equipment and IT that already resides on board the vessels. The result is a software package, which is loaded onto a PC connected to the INMARSAT communications system. The system is scalable and able to use whatever bandwidth is available to transmit the necessary information.

The application is made up of a number of modules, viz. messaging, image, audio, video, medicine chest, report generators and multimedia guide, which work together with a number of databases, including crew details, drugs on board, drug expert system, and the multimedia guide, to provide the FO with the appropriate medical data and communication system to a shore based doctor or teleconsultant.

The messaging system on the Sea Vessels (SVs) will communicate initially with the Ground Central Station (GCS) in Greece. The GCS will then determine which of the Medical Care Centres (MCCs) should be capable of dealing with the SVs request for assistance. The choice of MCC will depend upon the origin of the SV, location, language spoken on the SV or of the FO and casualty and the availability of the MCC.

There are three types of report generator, "Green, Blue or Red", which correspond to various health situations. The FO completes a Green status report if he/she is treating a minor ailment that does not require advice from the teleconsultant. A Red status report is completed if the FO is treating injuries that have resulted from an accident. The Blue status report is completed if the FO is treating some sort of illness. The completion of a Green status report will not lead to communication with the teleconsultant at the medical centre, however Blue and Red status report forms require the teleconsultant to be contacted as procedure.

5.2.4 Analysis of User Requirements and Functional Specification.

In order to improve the medical decision support provided for the Merchant Marine Industry, it was necessary to ascertain the level of technology, personnel and communications equipment on board merchant vessels. The requirement of the vessel operators for the provision of a medical decision support service had to be present and proven before the creation of the application was possible.

A questionnaire was created to collect information from the Operators of Merchant Vessels regarding the number of vessels, the communications on board, medical decision support services, which were in place, accident levels and the requirement for a telemedical service. The questionnaire is shown in Appendix J. The questionnaire was sent to a total of 36 UK registered ship operators. These operators were identified from the Lloyds Register of Ship Owners/Managers/Operators 1995 (Lloyds, 1995). A total of 10 relevant replies from UK Registered Companies were received. Questionnaires were sent by each of the MERMAID Consortium members to the shipping operators registered in their respective countries (Lloyds, 1995). A total of 445 questionnaires were circulated, and 87 replies were received (20%). The amalgamated results of all questionnaires collected are as follows.

The companies that responded to the questionnaires owned or managed a total of 1853 vessels. The various types are listed in Table 5.1.

TYPE OF VESSELS	NUMBER
CONTAINERS	210
RO-RO	25
TANKERS	405
MULTIPURPOSE	35
REEFER	91
PASSENGER FERRIES	3
CAR CARRIER	20
PRODUCT CARRIER	13
CRUDE CARRIER	2
BITUMEN CARRIER	2
CEMENT CARRIER	13
GENERAL CARGO	343
CARGO REFRIGERATED	14
CABLESHIP	12
LIVE STOCK	5
TWEEN	11
STANDBY	19
BULK CARRIER	285
OFF SHORE SUPPORT	38
VLCC	24
LPG	86
FPSO	1
ETHYLENE	10
GAS CARRIER	24
OTHER	161
TOTAL	**1853**

Table 5.1 – Types of vessels operated by the MERMAID User Group.

The nationality of crews and officers was wide and numerous. The list is given below.

NATIONALITY	OFFICERS	CREW
AFRICAN	10	
AUSTRALIAN	2	
AUSTRIA	5	
BANGLADESHI		120
BELGIAN	200	30
BRITISH	1189	1183
BURMESE	109	117
CHINESE	97	173
CROATIAN	135	60
CYPRIOT	2	2
IVORY COAST		15
CUBAN	11	17
EGYPTIAN		12
FIJIAN		60
GERMAN	385	50
GREEK	680	453
INDIAN	2622	1901
INDONESIAN	5	41
IRISH	1	
ITALIAN	498	815

JAPAN	263	193
LATIN AMERICAN	75	150
LATVIA	1	1
MEXICAN		105
MOROCAN		98
NEW ZEALAND	64	93
NORWEGIAN	253	730
PAKISTAN	243	
PHILIPPINES	1906	8643
POLISH	347	575
ROMANIAN	9	15
RUSSIAN	423	1657
SCANDINAVIAN	405	884
SINGAPOREAN	6	20
SOUTH AFRICAN	1	
SPANISH	86	15
SRI LANKAN		140
SWEDISH	144	154
THAI	50	213
UKRANE	23	32
VIETNAMESE	1	2
ZAIRIAN	15	25
Not specified	254	241
Not specified Europeans	685	1949
TOTAL	**11205**	**20984**

Table 5.2 – Nationality of Crew and Officers.

The nationality of both crew and officers is very mixed. The mixture of nationalities within a crew creates problems for the provision of any language-based service such as a medical decision support service. The service must be able to link a medical attendant through to a suitably medically qualified person, who also speaks the same language as the attendant.

The vessels all used more than one communications system for the general ship and emergency communication as well as data transfer with the head office. The communications systems that were used are shown in Table 5.3 and Figure 5.2.

Type	Number of Vessels
INMARSAT A	>1020
INMARSAT B	>79
INMARSAT C	>695
Intelest	11
High Speed Data	126
Modem	>251
Telephone	>1037
Fax	>923
Radio/Telex	70
INMARSAT -M	3
MARINET	34
TOR	2
Mobile Telephone	16

Table 5.3 – Telecommunications equipment on board SVs.

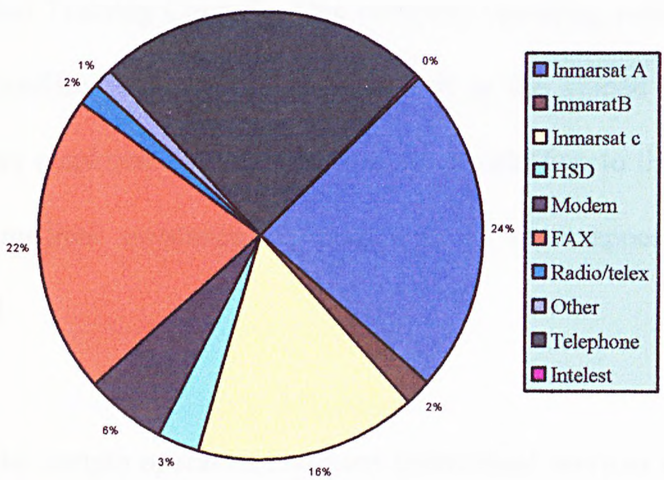


Figure 5.2 – Telecommunications equipment on board SVs.

However only 343 vessels in this sample (18,5%) were fitted with Global Maritime Distress and Safety System (GMDSS).

The majority of respondents (85%) currently use personal computers on board their vessels on a regular basis, but only 76%, utilise telephones and facsimile equipment on board. Only 48% are currently using modems for the transfer of data from or to their vessels.

At the time of the survey, those using PCs were operating them in DOS or Windows 3.11 environments. However one operator had already installed Windows '95. When questioned, other operators were considering upgrading.

90% of the operators stated that they used the first officer (FO) to act as the medical attendant on board their vessels. The remaining operators used crew staff to provide medical assistance on board. All of these officers are trained to first aid level only (Ship captain's Medical Training Course). One company operating cable ships also implied that they had qualified doctors on board, as well as the trained officer. 16% of the sample operators employed a crew staff member in addition to the officer responsible for providing medical assistance. This member of crew appears to be trained to paramedic level.

Two thirds of the sample operators had used telemedical services within the preceding three-year period, covering a total of 575 incidents. Most of the teleconsultations took place (in descending order) using English, Greek, Italian and Portuguese. These incidents were restricted to the three types: sudden illness (212), accidents concerning only one individual (371) and accidents concerning more than one individual (3).

Some of these incidents were very serious, with 80 resulting in immediate evacuation of the casualty, and 116 incidents were felt to be of a severe nature. However a further 211 incidents dealt with minor problems and the remaining incidents were felt to be of a routine nature.

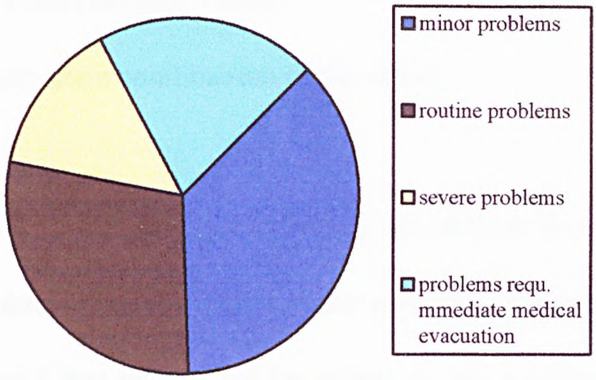


Figure 5.3 – Medical Incidents on Board Merchant Vessels.

Unfortunately two patients died due to the distance from appropriate shore based medical services, and medical evacuation not being possible.

Once medical decision support had been sought from the radio medical assistance provider, the majority of patients showed improvement;

- 89 patients showed improvement following radio-consultation and did not require evacuation.
- 167 patients showed improvement but required further "conventional" medical attention at a later date (i.e. on return to port).
- 82 patients showed no improvement.

The sample of operators used have set up procedures for the provision of medical assistance on board their vessels. If an accident or illness occurs which requires emergency medical assistance on board the ship, the medically responsible person on board will contact:

- The centre in the country of origin of the ship 29%
- The centre in the country whose shore you are nearest to 43%
- The centre with the expertise related to the medical issue regardless of location 26%
- The International Radio Medical Centre 2%

(A number of operators use a combination of the above).

50% of the operators who responded expressed an interest in a 24-hour emergency, multilingual and multidisciplinary telemedicine service. However only 75% of those positive responders said that they would be willing to pay a subscription fee for such a telemedicine service.

Functional Specification.

The questionnaire data shows that during a three-year period, 1853 ships required telemedical assistance on 575 occasions. This translates into a 10% probability of a vessel requiring telemedical assistance within any one year, or approximately 6000 cases worldwide per year (Lloyds, 1997), for this class of vessel (>100 Tonnes). The Danish Institute of Maritime Medicine (Nordseth A, 1998) estimates that there are between 15,000 and 20,000 marine telemedical calls per year. These figures confirmed a definite market for a maritime telemedicine service.

The questionnaire data highlighted the adequacy of the marine communications infrastructure for telemedicine. However, the MERMAID concept of marine telemedicine required High-Speed Data capability, and it appeared that only a small number of vessels at that time could take advantage of this. For this reason, the MERMAID telecommunications programme was adapted to accommodate all users; INMARSAT A, B, C or M users.

Finally, the MERMAID telemedical approach was proposed as a multilevel approach:

- A basic level at which a general communication system is adopted that includes a medical record and a help/guidance system (designed with all the INMARSAT communication system in mind).
- A second level at which more enhanced and technically sophisticated features are employed e.g. interactive video, sound, data transmissions etc. These features would only be available to users of INMARSAT A and B.
- Lastly, the development of training and education modules for seafarers is included, as they constitute the firmest basis for the correct practice of telemedicine at sea.

Patel (1998) suggests that training and evaluation are essential in ensuring seafarers are provided with sufficient knowledge concerning the application of new technology, to enable them to use it correctly in an emergency and states that "Telemedicine technology has far been in advance of the human ability to utilise it correctly. This has been developed to aid correct diagnosis by shore based medical experts at hospitals and at radio-medical centres, which provide medical assistance to ships. Although it will be some time before telemedicine is provided on all ships, medical training and education needs to be prepared for such developments".

5.2.5 Overall Configuration of the MERMAID System.

The MERMAID concept provides the medical attendant on board a merchant marine vessel with a set of procedures and guidelines that ensure his or her correct response to illnesses and accidents and guides them through these procedures whilst providing effective communication with the medical teleconsultants. In all but the so-called "minor" cases, the FO is advised to seek outside help and advice and will act as the teleconsultants eyes, ears and hands.

The results of the communication user analysis (Anogianakis, 1996b) showed that the INMARSAT C system (using simple text communication) should be included in the MERMAID application. The exchange of data between vessel and shore will be dependent on the equipment on board. The application supports INMARSAT A & B links for voice, data, still photo and live video transmissions, as well as INMARSAT C for text communication.

The application works as follows (as is shown schematically in Figure 5.4):

- Step 1 : The FO on the SV decides if it is a case of a minor ailment, illness or an accident. The questions asked and the data required in each case are different. Guidelines are provided to assist the decision whether to call a teleconsultant or not.
- Step 2 : A medical record is created with the following information: the patient's condition, information acquired through the applications' guidance, information on the vessel and crew (obtained from the local database to reduce the information the FO has to gather in an emergency) and information on the vessel's stock of medicine.

- Step 3 : The application guides the FO to provide information about the patient history and examination, and to provide pictures and data for communication.
- Step 4 : The data is sent to the teleconsultant at the MCC through the appropriate INMARSAT system. The teleconsultants' replies are dependent on the communication means as well. A scaleable system ranging from simple text (INMARSAT C) to full videoconferencing (INMARSAT A or B with HSD) is supported by the MERMAID system.
- Step 5 : The teleconsultant from the MCC replies to the FO on board the SV. The teleconsultant may suggest a course of treatment, ask for more clinical data (e.g. an image, an ECG, an audio or video clip), or guide the FO through a procedure. The teleconsultant is able to enter the multimedia guide and use the procedures to aid the FO.

There are three modes of operation in the software:

1) *Offline Operation.* In this mode the user has no connection at all with the GCS or any MCC. The program executes local jobs, that is, jobs that only require access to the on-board database, e.g. settings of the program, the multimedia medical guide, crew records, drugs, green status reports etc.

2) *Messaging or Indirect Communication.* In this mode the SVs send email messages to the MCCs through a mail server that resides in the GCS. Communication is initiated by the SV sending a blue or red status report and the response by from the MCC. As well as a report form, an email message can contain text, static images taken by a digital camera, sound and video clips. In this mode the teleconsultant in the MCC can request more information from the SV, remotely launch the multimedia medical guide to show

to the FO or SV user how a certain medical process can be accomplished or simply send a small answer informing him or her of the required procedure to treat the injury.

3) *Conferencing and Online Communication.* In this mode there is a direct communication between the SV and the MCC. This mode is normally initiated by the MCC after receiving a red status report about an accident from an SV or whenever the teleconsultant at the MCC decides that an online examination is necessary. This mode can also be initiated by the SV if medical conferencing is urgently required. The SV can query the server in the GCS to see which MCCs are currently logged in and available, and start a conference with any of them.

The off-line and messaging modes can be implemented to SVs using all kinds of connections including the low speed connections of the INMARSAT C system. The conferencing and online examination can only be undertaken by those SVs that have the bandwidth to support videoconferencing INMARSAT A and B with HSD.

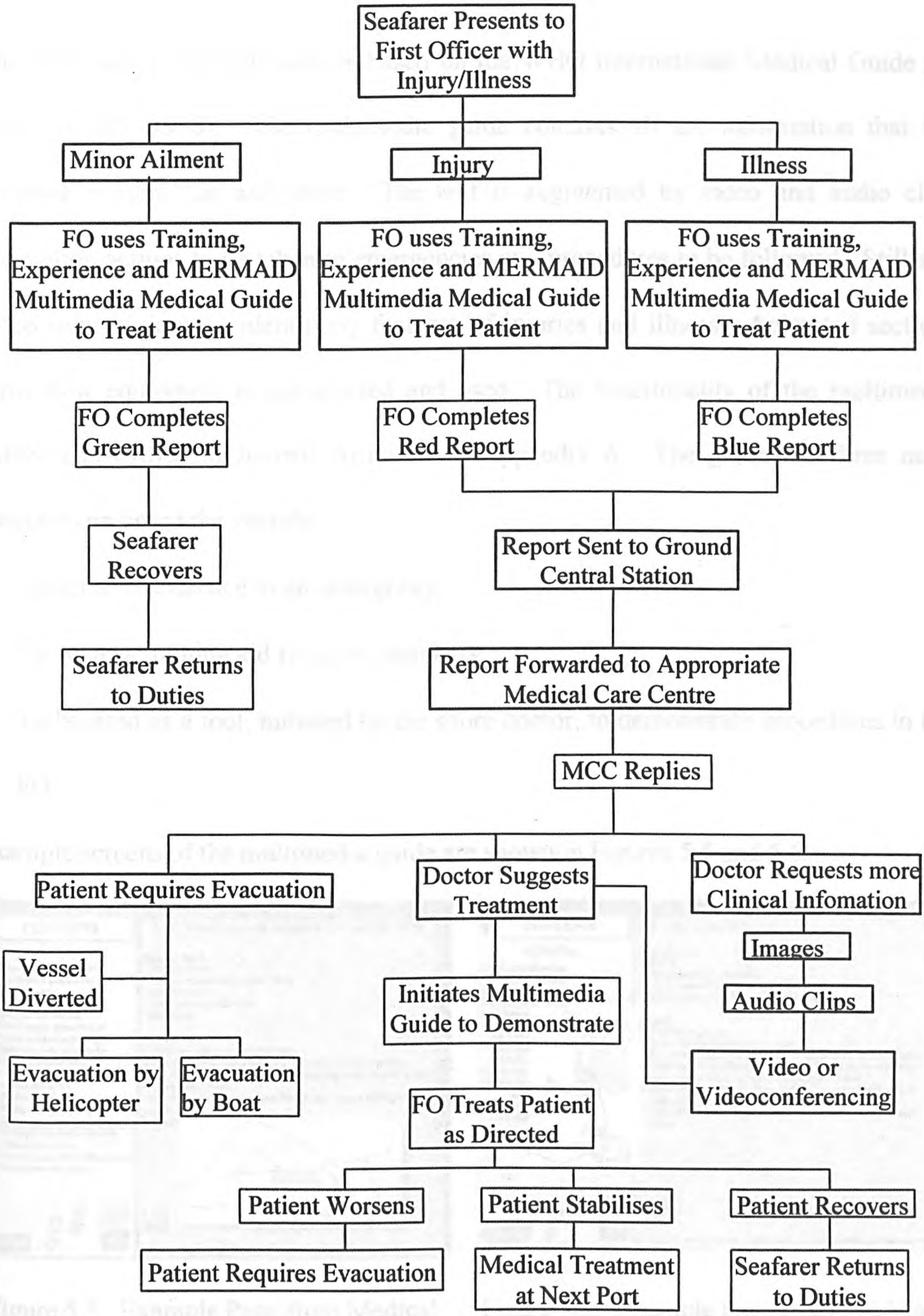


Figure 5.4. MERMAID Teleconsultation Process.

5.3 The Medical Multimedia Guide.

The multimedia medical guide is based on the WHO International Medical Guide for Ships (WHO, 1988). The multimedia guide contains all the information that the textbook version has and more. The text is augmented by video and audio clips illustrating actions to be taken in emergencies and procedures to be followed. Still and video sequences show identifying features of injuries and illness. Animated sections show how equipment is constructed and used. The functionality of the multimedia guide is described in Journal Article 4 in Appendix A. The guide has three main functions on board the vessels:

- To act as a reference in an emergency.
- To act as a training aid for crew members.
- To be used as a tool, initiated by the shore doctor, to demonstrate procedures to the FO.

Example screens of the multimedia guide are shown in Figures 5.5 and 5.6.

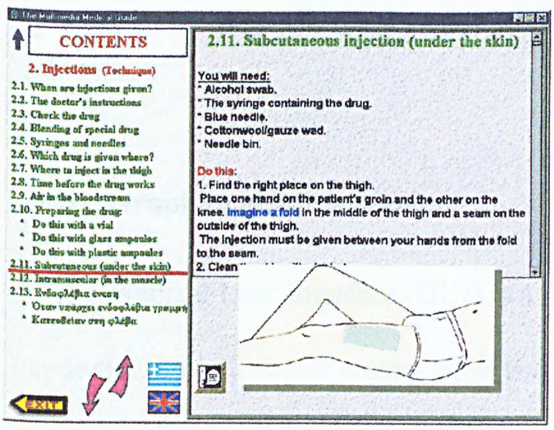


Figure 5.5. Example Page from Medical Guide – Subcutaneous Injection.

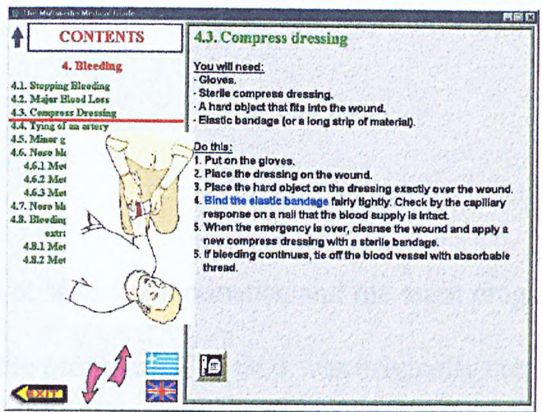


Figure 5.6. Example Page from Medical Guide – Compress Dressing.

5.4 Modules of the MERMAID Telemedicine Workstation Software.

The telemedical application is made up of a number of components;

- Graphical User Interface
- Medical Report Generators
- Image Module
- Audio Module
- Video Module
- Drugs Module
- Drug Expert System
- Crew Member Module
- Messaging System
- IP Based Audio Phone
- IP Based Video Phone
- International Module
- Expert System

5.4.1 Graphical User Interface.

The Graphical User Interface (GUI) is a set of visual components, and the main program code that initialises and creates objects of the program. The GUI was originally created in two different applications; Windows 95 and HTML. The purpose of this was to assess the advantages and aesthetics of the two solutions. The Windows 95 backbone to the program was adopted to ensure easy and proper management of the system by the

GCS. However some of the aesthetics and visuals of the HTML application have been adopted into the Windows GUI to ensure a user-friendly interface.

The GUI is a typical Windows 95 user interface made as simple as possible. Since the GUI must be user-friendly, the display of labels in different languages is critical. For this reason, no messages are hard-coded in the GUI. Instead, the display of messages in the desired language is accomplished through the interaction of the GUI with the International module, which produces messages in several languages. Each service offered by the program (for example: the crew database service, the mailer's send/receive/view dialogs, the medical guide, the medicine chest, etc.) has its own part of user interface. The initial screen of the application is shown in Figure 5.7.

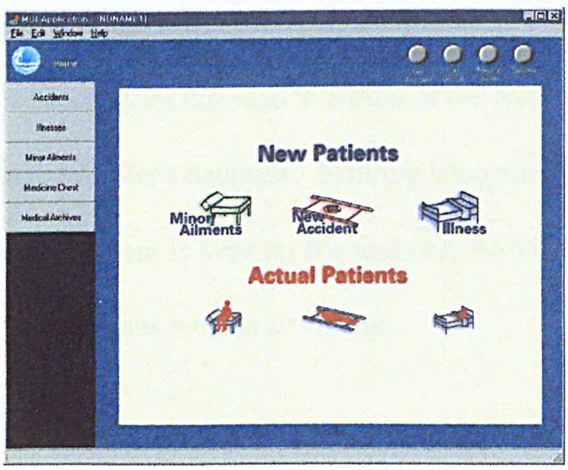


Figure 5.7 – MERMAID Front Page.

5.4.2 Medical Report Generators.

As already stated, there are three report generators for minor ailments, accident and illnesses. The minor ailment report is for internal or on-board use only and does not result in a message being sent to the doctor. The green status report includes questions used for an examination by the Family Medical Guide, produced by the American

Medical Association (Clayman, 1994). These questions try to identify the patient illness/injury from the symptoms. If no conclusion is reached or the conclusion is that it is a serious case, then the FO is advised to seek help from a teleconsultant.

The green "minor aliment" report process is as follows:

- A set of questions is required to be answered by the paramedic.
- The questions may lead to a treatment like "rest/no duties". No other action will be taken.
- If the questions lead to drug prescription, then the Drug Expert System (Section 5.4.7) will be launched to check for conflicts.
- If the questions lead to a requirement for a doctor's advice, that advice will be sought by the MCC through blue or red status report.
- If the green status report does not lead to a blue or red status report, the green report is just recorded in the Mailer's database. Nothing is transmitted.
- The green status report form is kept on file and may be transmitted as part of a later consultation if the symptoms worsen or change.

The red and blue reports result in messages being sent directly to the on-call medical support. The medical report generators are a series of basic medical questions designed to provide the on call doctor with more clinical information. The questions start by obtaining basic information about the crewmember that is injured and the location of the vessels as shown in Figures 5.8 to 5.10. Details of the accident and the injuries are obtained before more complex medical questions are asked, including information on the pulse rate, conscious level, breathing and so forth, Figure 5.11. The questions are asked in simple form, and a choice or responses provided. Question sources and their purpose are discussed in Journal Article 4 in Appendix A.

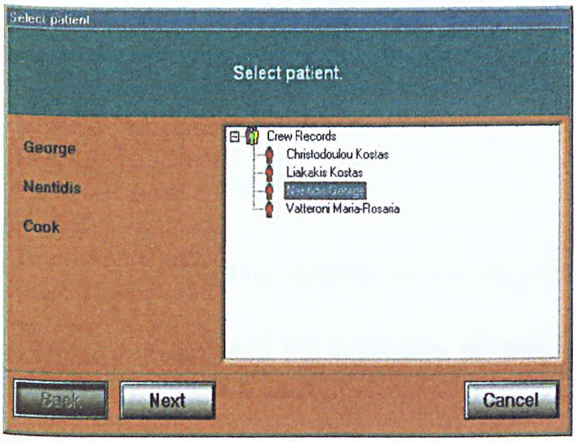


Figure 5.8 – Selection of patient from crewmember database.

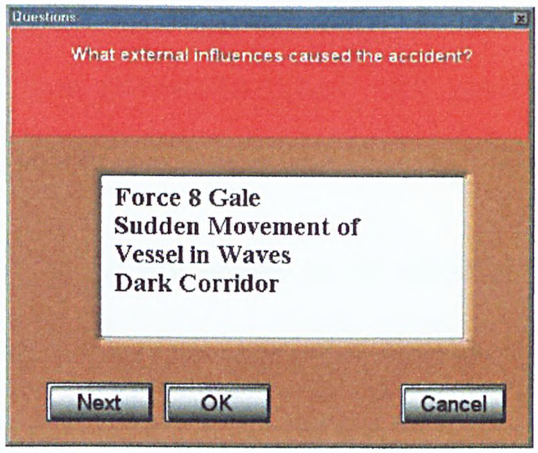


Figure 5.9 – Cause of accident.

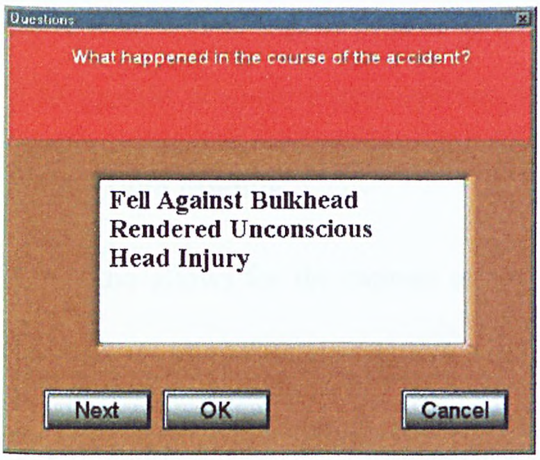


Figure 5.10 – Consequences of the accident.

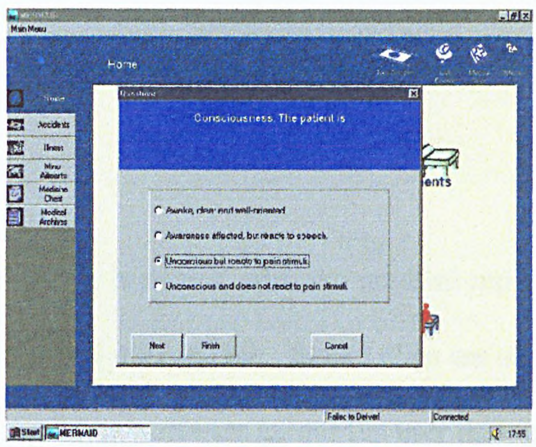


Figure 5.11 – Assessing the conscious level of the patient.

The questionnaire has been implemented so that the FO can complete as many parts/sections as possible or is able to and then transmits the report as an attachment. There are no sections that **must** be completed before transmission. If the FO does not have certain data, the report can still be sent.

More specifically it contains:

- An inventory of the ship's stock of drugs arranged in groups according to EU 92/29.
- An inventory of the ship's stock of medical equipment in accordance with EU 92/29.
- Information about the medical substances on board. This includes an overview of the specific substance, indications, contra-indications, dosage, cautions, side effects, and interactions.

During a teleconsultation, the teleconsultant can use the drug module of the SV to be informed of the drugs available to the FO. The module provides an *Attachment Wizard* and an *Attachment* that enables the MCC to request a list of drugs currently available on the SV. This drug module uses the same drug database used by the Drug Expert System.

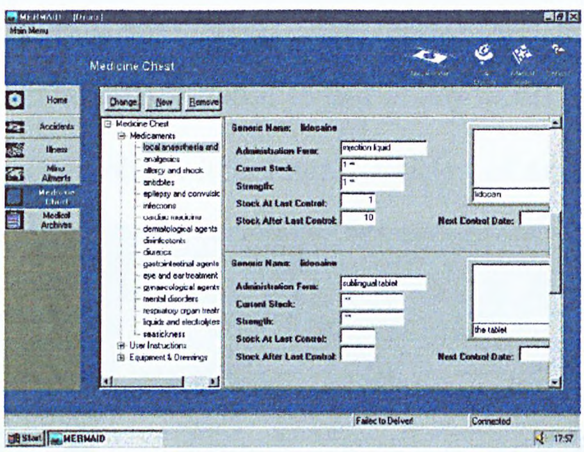


Figure 5.12 – Drugs Module (Medicine Chest).

The purpose of this database is to:

1. Reduce the possibilities of administering the wrong drug through presentation of information concerning the particular substance and by having a direct correspondence between classes of drugs and storage locations on board.

2. Assist the FO on board in controlling the stock of medical supplies.

3. Ease the communication between doctors at radio medical and FO on board.

5.4.7 Drugs Expert System.

The drug expert system ensures that there are no conflicts between drugs that are prescribed and those that the patient may already be taking. The drug expert system is described within Journal Article 4 in Appendix A.

5.4.8 Crew Member Module.

The crew member module is responsible for handling the crew general data records and medical history records. It is a database that offers the possibility of adding, removing, or updating crew records (Figure 5.13). The module acts an archive for patient information. This information is included as part of any report sent to the MCC. The crew member module is described within Journal Article 4 of Appendix A.

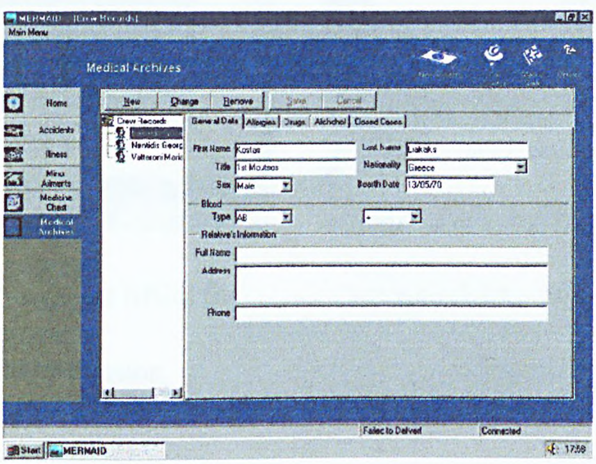


Figure 5.13 – Crewmember Module (Medical Archives).

5.4.9 Messaging System.

The messaging system is a scaleable service capable of utilising whatever bandwidth and hardware is available. The marine scenario is limited by the bandwidth capabilities of the INMARSAT system. Some vessels now have INMARSAT B with HSD capabilities (64 Kbits/s), which is the bare minimum for videoconferencing applications. However the scaleable capability of the messaging system means that anything from the basic 9.6 Kbits/s INMARSAT C network up to the HSD can be used for appropriate clinical information transfer. A schematic of the messaging system is shown in Journal Article 4 of Appendix A.

The medical reports that are generated are sent directly to the appropriate medical centre (Figure 5.14).

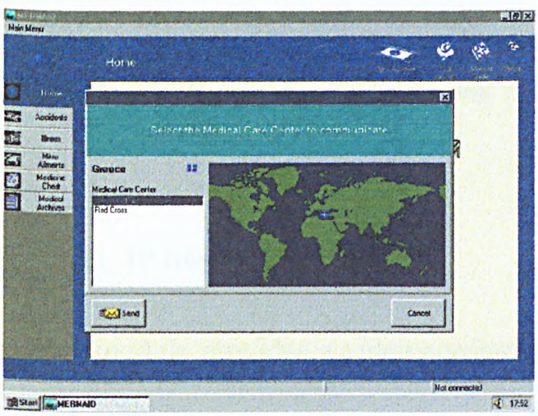


Figure 5.14 – Choosing an MCC for Medical Communication.

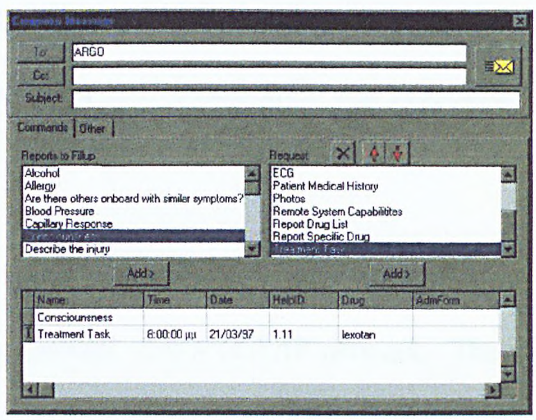


Figure 5.15 – MCC Screen, Doctor Preparing to Reply.

The on-call doctor replies immediately (Figure 5.15) requesting further information, progress reports, requesting pictures, audio or video sequences or advising on patient management.

With the blue and red status reports transmission of a message is an absolute requirement. Once the report is generated it is stored and sent to the MCC. These reports are sent as *Attachments* to *Messages*.

5.4.3 Image Module.

The image module allows for the capture of digital still images by an off-the-shelf digital camera, and the inclusion of that image in a medical report or in response to a request by the on call doctor. High quality digital images can be taken of the injury to complement the accident report. The software guides the medic through the use of the digital camera. The functionality of the image, audio and video modules is discussed in Journal Article 4 in Appendix A.

5.4.4 Audio Module.

The audio allows for the capture of audio clips for inclusion with the medical report. The capture of audio clips requires a sound card and microphone. Sound clips are used to illustrate breathing sounds and heart rate. Again the software guides the user through use of all auxiliary equipment. The audio module is capable of recording, storing and forwarding sound clips as *Attachments*. The image, audio and video modules are only used when there is appropriate equipment already on board.

5.4.5 Video Module.

The video module allows for the capture of video clips for inclusion within the medical report. The video clips are created using a digital video camera or a PC based videoconferencing camera. Video clips can be useful to show the movement or movement restrictions of certain injuries. The software guides the user through use of all auxiliary equipment. The video module provides the user with opportunity to transmit video clips using *Attachments*. A frame grabber, the Osprey 1000, provides video and audio capture and compression in a variety of formats. The Osprey allows most video based multimedia applications, such as store and forward, as well as on line videoconferencing (Section 5.4.11). The Osprey allows the simple integration of hardware and software through standard industry interfaces. The grabber supports the majority of ITU standards that ensure that any communication protocol can be used.

5.4.6 Drugs Module.

This module provides a user interface for handling the database of drugs available on the SV. The drug and equipment content of the medicine chest is governed by legislation within Europe. However it appears not to be standardised. The drug module acts as stock check of the drugs and equipment held on board a ship or platform. The doctor can gain access to the drug module to ensure that a drug, which is prescribed, is available on board the vessel. There have previously been cases where the on-call doctor has prescribed a drug, which has not been available on board (Parrish M, 1997). This drug should have been carried according to legislation. Unfortunately the doctor was unaware of which drugs the vessel carried. The drug module of the MERMAID avoids this problem. The medical attendant updates the database as drugs are used on board and can be used for stock assessment (Figure 5.12). The ship's medical database is a relational database containing information about not only the drugs but also the medical equipment on board.

Initially the SV does not communicate directly with the MCC. The first message is always sent to the GCS, and after checks is routed to the appropriate MCC. The second and subsequent messages of a teleconsultation are routed directly to the MCC. The authentication, checking and message routing is handled by the messaging system software.

5.4.10 IP based Audio Phone.

This module is responsible for offering an audio conferencing channel over a TCP/IP network. For the implementation of this module, Microsoft's conferencing tool NetMeeting was considered. However, NetMeeting offers audio conferencing only for bandwidth speeds of 14400bps or more. The maximum speed of normal INMARSAT lines is 9600bps. Audio conferencing is important because in cases when the SV uses the line for message communication to the GCS and MCC, the line cannot be used for voice calls. Since sound quality was not the issue, an IP based audio was proposed.

5.4.11 IP based Videophone.

This module provides a video conferencing channel over a TCP/IP network. The video and audio processor described in the video module (Section 5.4.5), which captures and compresses the images is capable of being used for the video conferencing mode using Microsoft's' NetMeeting or a similar facility (Figure 5.16). NetMeeting offers various conferencing capabilities, including video conferencing. Both PictureTel and Intel (producers of video conferencing equipment) support NetMeeting. The NetMeeting SDK was used for the implementation of the video conferencing, together with the frame grabbers and cameras that were utilised. The application is able to support video conferencing on laptops as well as standard PCs.

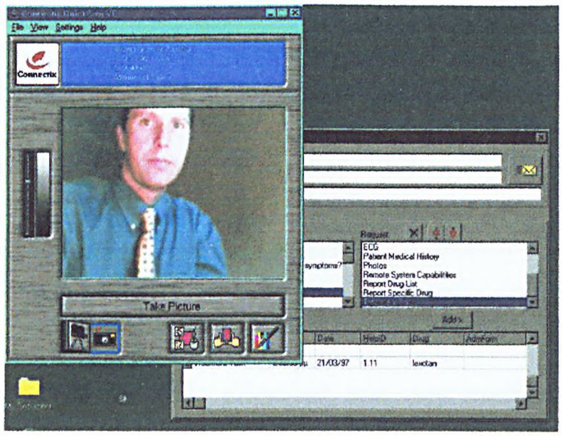


Figure 5.16 – Videoconference Progressing During Teleconsultation.

5.4.12 International Module.

This module holds strings and spoken messages in different languages. It is responsible for returning the correct string and the correct sound clip depending on the language that is selected.

5.4.13 Expert System Component.

The expert system component is a *simple cases drug consultant* (SCDC) that offers assistance to the FO on board during the green procedure. SCDC is a decision support system whose purpose is to advise the user in cases where communication with the teleconsultant at the MCC is not considered necessary and minimise the possibility of human error. Its role is to ensure that all necessary factors have been considered and to offer as safe as possible a procedure for an appropriate drug selection in those simple cases.

SCDC operation can be divided into two phases:

- In the first phase, the system prompts the user for the patient's symptoms and diagnoses the disease that the patient suffers from. It should be noted here that the system's capabilities for diagnosis are limited in the sense that only small classes of diseases that belong to the 'green' procedure are handled.
- In the second phase SCDC proposes a suitable treatment for the diagnosed disease based on:
    1. The patient's particular needs, allergies, age, past medical record etc.
    2. Drug information such as indications, contra-indications.

Finally, after determining the suitable treatment, SCDC displays additional information concerning the medical substance used, such as side effects, cautions etc., in order to provide the user with as much as possible information about the drug used.

5.5 The Telemedicine Workstation Equipment.

The application software has been described in detail. As previously stated, the purpose of MERMAID was to utilise as far as possible hardware already available on board vessels for display and transmission. This was one of the main reasons for the creation of the scaleable transmission potential, enabling users to use existing communications mediums or upgrade to one that suited their purpose. This section describes the minimum and optimal hardware requirements for the Telemedicine Workstation on board the SV, the hardware of the GCS and MCCs, and the communication mediums that can be used.

5.5.1 Sea Vessel Telemedicine Workstation.

The user analysis showed that the majority of Merchant vessels have high quality and up-to-date IT facilities on board. The telemedical application requires the following minimum to function: a Desktop PC Running Microsoft Windows 95 with the following configuration:

- 90 MHz clock.
- 16M of RAM.
- 1G Hard Disk Space.
- CD-ROM Drive.
- 9600bps Modem.
- Supporting Software.

A system configured as above would provide a simple and effective application for medical decision support from a teleconsultant. There would be restricted use of the advanced components however. The teleconsultant would not be able to request sound and still or video images to be taken and sent to the MCC. Adding the following hardware would enhance the functionality of the system:

- A Digital Still Image Camera (e.g. Chinon).
- A Digital Video Camera (Windows 95 Compliant) and Card (e.g. Osprey 100).
- An Audio Card (Windows 95 Compliant) and Microphone.

These three additional items of hardware for the PC would allow the capture and transmission of still and video images and well as sound clips. They will also enable audio and videoconferencing should the teleconsultant require these facilities. These three items of hardware are becoming standard items of equipment being supplied with a desktop PC, and should therefore soon become common place on board sea vessels. Digital cameras are already commonly used on offshore oil and gas installations for engineering as well as medical problems.

5.5.2 Communications Link.

The messaging system supports INMARSAT A, B, C, M, Mini-M and HSD links between the SV and the GCS. The communication between the MCCs and GCS is achieved using PSTN and ISDN links. The supported communication links and corresponding hardware requirements are displayed in Figure 5.17.

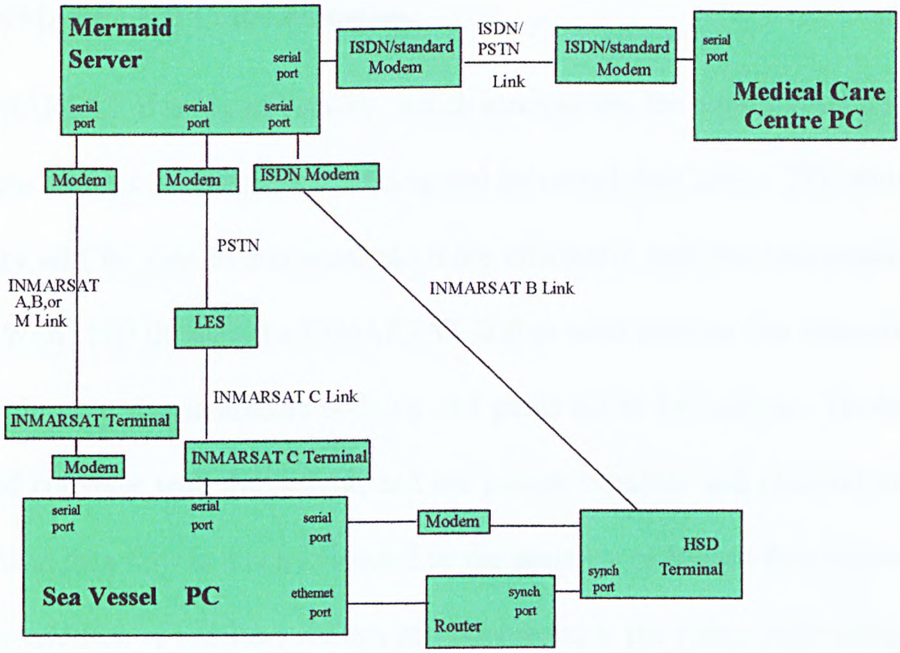


Figure 5.17 - Configuration of MERMAID Communication Links.

The choice of communication links will be governed by that which is available on board the vessels. The applications' functionality is dependent of the type and the speed of communications link used. If multiple communications links are available on a ship, the medical attendant may choose any of the available links to connect to the MCC by setting the correct options from the communications menu of the GUI.

The choice of a specific type of communications link is dictated by desired speed and cost effectiveness. Consideration is given to:

- HSD links transfer data at a rate of 64kbits/sec,
- INMARSAT A and B links at 9600bits/sec,
- INMARSAT M and Mini-M links at 2400bits/sec, and
- INMARSAT C links at a maximum speed of 600 bits/sec.

Cost is proportional to speed and includes hardware purchase, installation expenses, and fees for use of the link.

5.5.3 INMARSAT B Communication.

The INMARSAT-B ship earth station, which incorporates the duplex HSD transmission, will allow 64kbits for videoconferencing and increased data flow. SVs with the HSD capability will be able to communicate more efficiently with the teleconsultant at the MCC. With HSD through the INMARSAT B ship earth stations, the teleconsultant can see exactly what the paramedic is doing and guide his or her actions. He (or she) can view and converse with the patient, and see patient reactions and physical movements. The clinical data flow is much increased by the presence of face-to-face communication. With the addition of auxiliary camera and telepresence, the videoconferencing becomes a valuable addition in transmitting complete clinical information from the SV.

5.5.4 Configuration of the Ground Central Station.

The connections between the SVs, GCS and the MCCs establish a TCP/IP Intranet. The SVs connect with modems, and the MCCs with ISDN routers. The core of the Intranet is the GCS presently located at BIOTRAST SA. in Thessaloniki, Greece. A 3640 Cisco router with 8 ISDN ports and 8 serial ports has been installed. One ISDN port is used for connecting the GCS in BIOTRAST office with the 7500 Cisco router in the Aristotelian University of Thessaloniki where the satellite antenna is installed and where the satellite links terminate. Other ISDN ports are used for connecting the BIOTRAST office with the MCCs. One port is available for connecting with SVs via a high-speed connection. The 8 serial ports are connected to modems that SVs use for connecting to the GCS through normal telephone lines and connection speeds from 2400bps (INMARSAT M) to 9600bps (INMARSAT A and B). The routing of all calls from SVs to MCCs and vice versa is handled centrally by a single Cisco router.

5.5.5 Medical Care Centre Telemedicine Workstation.

The MCCs require a desktop PC of similar specification to that used on the SV. The MCC PC is connected to the GCS through an ISDN connection and Modem. The MCC workstation is manned 24 hours/day or has an alert system to inform the on-call teleconsultant that a message has been received.

5.6 Demonstration Sites.

5.6.1 Virtual Demonstration Sites.

The working copies of the developed MERMAID application and the Medical Guide for Ships software were installed at two virtual demonstration sites. The SV and MCC was installed with a local LAN link at both sites and operated for demonstrations and running realistic scenarios during offshore paramedic and maritime medic training. The purpose was to verify that the application actually works in practice, to identify any problems in installation procedure and operation and to perform a thorough testing of the demonstrator program. The testing regime used was representative of the use and situations expected in practice by the final users. Program bugs were found, and rectified and comments were made about the application functionality and effectiveness.

Following the thorough testing of the application at the Virtual Demonstration sites, the "debugged" applications was installed on a number of SVs for evaluation during a ten month trail period. The Telemedicine Workstations were implemented with six SVs and one MCC for the trial period.

5.6.2 Sea Vessels Demonstration Sites.

The Telemedicine Workstation was installed on five oil tankers belonging to the Greek registered shipping company, Eletson. The ships were the "Skiropoula", "Kandilousa", "Salamina", "Stavronisi" and the "Samothraki". These vessels are all oil tankers that operate on world-wide routes.

The oil tankers all have the same general set-up. The personnel on board are made up of 14 crew and 7 officers. The officers are normally all Greek, whereas the crew is a mixture of Greek and Bangladeshi. There is a minimum of three personal computers on board, connected via a LAN. The medical attendant has access to one of these computers, which is also connected to the communications equipment. The communications equipment is located behind the bridge and is capable of the following transmission over: VHF and MH/HF Radio, Cellular/Mobile, INMARSAT A, INMARSAT B and INMARSAT C. None of the vessels in this demonstration phase were equipped with HSD capabilities, although most are scheduled to have this type installation provided.

All six vessels installed the application in the specifically equipped medical emergency room. The emergency room contains an examination bed, medicine chest, first-aid material and other medical tools necessary to treat an accident or illness.

The hardware used was similar in all SVs and comprised the following:

- PC-Pentium 166, with 16 MB RAM, 1.2 GB hard disk and colour 14'' monitor.
- Video card Ospray1000, which supports compression.
- Chinon ES3000 digital still image camera.
- Windows 95 compliant audio card.
- Desktop teleconferencing camera, microphone and a set of speakers.
- Satellite transceiver and the appropriate computer interface.

The software components of the system installed on the ships were operating under Windows 95. The components that were installed are the following:

- SV module program.

- Multimedia Medical Guide for ships.
- Medicine chest database.
- Medical archives database.
- Audio and video software plug-ins.
- Communication drivers.

After initial installation and set-up, full testing of all functions was performed, in order to make sure that everything operated properly. On completion of the installation, members of the crew were trained in the use of the system. Training consisted of the following topics:

- Familiarisation with the user interface.
- Choosing a medical centre and establishing a connection.
- Completing the initial report.
- Sending and receiving audio and video messages.
- Using videoconferencing.
- Maintaining and using the medical archives.
- Using the Multimedia Medical Guide.

An encouraging fact that arose during this training period, was that paramedical staff, doctors and in general staff without much experience in the use of computers showed a remarkable ability in the use of the system. Learning was fast and all trainees were able to operate effectively the telemedical tools. The trainees effectively used the Medical Archives and Medicine Chest databases and the Multimedia Medical Guide.

5.6.3 Medical Care Centre Demonstration Site.

A fully operational MCC was established in Greece, in order to support the telemedical application. The site was implemented in the General Clinic of Thessaloniki.

The necessary hardware and software components were installed, comprising the following items:

- Personal computer.
- High-speed modem for connection with the communication server.
- MCC module of the MERMAID software, including user interface, drivers and utilities
- Teleconferencing camera and microphone.

A group of doctors of the General Clinic was trained in the use of the application. Firstly, they were made familiar with the user interface and the use of all the screens and options of the software. They were trained to successfully perform the complete procedure that is needed to provide assistance to an incident occurring on a ship. Specifically, the doctors were trained to carry out the following tasks:

- To respond to a call from a ship and interpretation the initial information sent.
- To send reply messages requesting additional information and examinations required.
- To provide guidance, by instructions in text form, by using video and audio messages, or by reference to the Medial Guide.
- To use the audio-visual hardware and the software driving modules.

After the completion of the training phase, the doctors of General Clinic in Thessaloniki were assigned the task of using the MERMAID system in order to provide telemedical assistance to ships on a permanent basis. For this purpose, the system was operated on a 24-hour basis. The shifts of doctors in the General Clinic were arranged so that a doctor trained to the use of the system is always present.

5.7 Evaluation of the Telemedicine Demonstrator.

The evaluation of the demonstrator was undertaken in three distinct phases. Firstly the MERMAID participants, both technical and medical, evaluated the software to eliminate errors and discrepancies with the user requirements. Secondly the application was installed on one SV and utilised in scenarios and routine care by the crew and MCC. Finally the application was installed on the remainder of the SVs. The use of the application was monitored over a ten-month trial period. The FOs, crew and medical care providers were questioned regarding the performance and acceptance of the application in the provision of medical decision support.

The performance of the application was to be evaluated during real case consultations. The nature of the work and the frequency of accidents and illnesses reported on merchant marine vessels indicated that real cases would be encountered during the clinical trial period. These, combined with the treatment of minor ailments by the FO on board would test the application in "vivo". As with the community medicine scenario, the methodology for evaluation of the system was limited due to the nature of the consultation and the other work duties required of the FO.

Ideally, the teleconsultations would be evaluated through a number of means. Firstly, the vessels that were using the MERMAID application would be compared with a group that did not have the communication facilities on board. Secondly, data from previously recorded medical treatments on board the vessels would be examined for comparison with the clinical trial period consultations. The teleconsultation itself and the impact on the users (clinical staff, FOs, and crew members) would complete questionnaires providing opinions on the functionality, operation and the services provided. Finally, the teleconsultation would be independently reviewed at the time by completion of a second consultation by conventional means (radio medical advice) to assess concurrence of diagnosis and treatment.

As already stated, evaluation methods were restricted due to the very nature of the consultations and the nature of work on board the vessels. A control group of vessels was not identified, as the organisation that operated these vessels did not possess similar vessels undertaking similar activities during the clinical trial period. Data concerning specific ships and the medical consultations, treatments and evacuations that have occurred on board are difficult to obtain. This data may be available for legal and insurance purposes but was not made available for this research.

The injuries and illnesses, which would be treated via teleconsultation, were emergency cases. The immediateness of the diagnosis and treatment required precludes the use of a secondary consultation. The treatments prescribed in the teleconsultation must be acted upon to ensure patient care.

Therefore the most effective way to evaluate the application of the MERMAID system was through (a) the use of software reviews, to remove application errors or deficiencies, and (b) using questionnaires completed by application users and beneficiaries.

The following tasks were undertaken for the study:

- A user requirements analysis.
- The identification of suitable functions for teleconsultation as a result of the community medicine study.
- The creation of medical assessment questions based on the facilities to be provided, equipment residing on board and qualifications of FO.
- The operation of a virtual demonstration site, running scenarios and demonstrations for offshore medics.
- Software reviews.
- Questionnaires, evaluation and analysis of teleconsultations and user opinion.

5.7.1 Software Reviews.

Software reviews were conducted by the institutions responsible for the individual components of software and the virtual demonstration sites. Software reviews were seen as one of the most important monitoring activities. Reviews served as a filter for the software engineering process, removing defects while they are relatively inexpensive to find and correct. The formal technical review or "walkthrough" was a stylised review meeting that has been shown to be extremely effective in uncovering defects. Each of the virtual demonstration sites used the software in the sequences in which it would be used in a real scenario. The software was tested by users with a technical background in terms of software quality, efficiency and system robustness. The correct operation of all functions was checked out and the reliability of the communication path at open sea has been tested. Results were used by the developers of the software to correct the errors and improve the quality.

The application was utilised and checked by medical users to ensure the medical content, context and language.

5.7.2 Testing of Software on a Limited User Group.

The system was operated by one SV demonstration site. The application was evaluated by potential final users, that is crew members without technical background, in realistic scenarios. The complete installation and operation of the system on a SV was intended to demonstrate the functionality of the system and the absence of critical last-minute problems in practice. It also gave the opportunity for technical staff to test the software efficiency and robustness in realistic circumstances and verify the functionality of all components in the sea environment.

Representatives of all user groups including doctors, paramedics and members of the crew, were asked to comment on the usability and effectiveness of the system. They also commented about the entire concept of MERMAID and the functionality of the particular system design. The impact on the crew morale and the confidence that the telemedical system will actually offer effective services were discussed. What was important was that these opinions resulted after actually seeing the system working in practice.

In order to collect data by users on the verification of the application, a questionnaire-like report form was distributed for completion to all user groups. Different forms were given to technicians, doctors, paramedical staff on board and potential patients. The reports required comments by the users on the following topics:

Technicians.

- Correct functioning of all procedures, buttons and hardware drivers.
- Reliability and effectiveness of communication links.
- Efficiency of software and system configuration.
- Reliability, stability and error handling of the software.

Doctors and Paramedical Staff.

- Usability of software.
- Sufficient functionality and suggestions about additional functions.
- Reliability and error tolerance of system.
- Effectiveness of the application in real situations.
- Appropriateness of the application to the incidents occurring in practice.

Patients.

- Quality and effectiveness of care provided by the MERMAID telemedical application.
- Confidence that the system will be sufficient in an emergency case.
- Impact on the crew morale.

5.7.3 Testing of the Application during the 10-Month Demonstration Period.

The MERMAID system was then installed on the remaining SVs. This ensured that experience of system use was obtained from real users in practical emergency management. This evaluation differs from testing by technicians or users on first contact with the system. Paramedic staff and crew members had the opportunity to see the system in action on board, to be trained to its use and to evaluate it when it was first installed and once the system had been operational for ten months.

The users were asked questions regarding the quality of the system and its applications. The quality factors that were set are the following: efficiency, effectiveness, reliability, outcome on the health and safety of the maritime workers, effect on crew morale, cost and cost vs. performance.

5.8 Results and Effectiveness of the Demonstrator.

5.8.1 Software Reviews.

A training session for installation technicians was undertaken. The purpose was to allow potential technical and medical users to get familiar with the developed software, to have the software tested by them and to note faults and weaknesses, provide constructive remarks and contribute to subsequent improvement. This was an opportunity for evaluation of the system by a number of people of differing backgrounds, and participants were asked to complete evaluation forms shown in Appendix K. In this way, apart from informal testing and suggestions, specific data were collected in a systematic way about the quality of the system.

The application was simulated, installing the software modules in different PCs acting as virtual sites, one as an MCC and others as SVs, communicating over a LAN. A server was used to handle the message interchanges.

The results of the software review undertaken at the training session are summarised below:

- Several comments were made by the participants regarding the layout of the software. There was duplication of icons and functions on screens. Complaints were also expressed about the user instruction window and the equipment and dressings section of the medicine chest because, in some cases, not all the information is within the viewing area.
- The Medicine Chest displayed some incorrect information for certain drugs. However it was concluded that this was not actually a bug. The information that

was seen during the training session was actually inserted in the Medicine Chest while testing the functionality. In a real life situation the paramedic on the ship will insert the correct information.

- Within the medical archives, nationality could only be entered as "Greek" and was corrected to incorporate all other European Nations as well as other common crew nationalities.
- A method of backing up the databases associated with the medicine chest and medical archives was found necessary, since they both contain information, which is updated by the medic on board and is not only extensive, but also valuable on board.
- A fundamental error was noted concerning the collection of initial medical data. Responses to questions asked about patient condition e.g. conscious level, were not sent to the MCC, only the pre-entered data e.g. allergies was transmitted. This was quickly corrected to ensure that all answers were received on the other side.
- Editing items in the "Accidents" screen was no longer permitted
- A method should to alert the doctor at the MCC that a message from a ship has been received was identified as a requirement. The simplest idea, as suggested at the Training session was, the MCC site software should be capable of initiating a call to a pager, which the doctor carries and informs him/her that a MERMAID Message awaits him/her.
- Finally there were a few suggestions on additional screens or functionality. The addition of such new features is under consideration. The suggestions made were:
    - A temperature report was required.
    - A diagnosis report was required.
    - The name of the doctor and the paramedic should be communicated.

- Printing of received messages should be supported.

The functionality of the Multimedia Medical Guide was evaluated, and it was reported that it functioned effectively and all the required information is included. Moreover, the implementation allowed for easy updates, in case the information contained in the Guide required expansion (e.g. the changing of procedure for resuscitation). Pictures and video functioned properly and were found to be helpful and complete.

Two virtual demonstration sites were created. One location undertook the training of fishermen and merchant seamen, and the other of offshore medics. The telemedical application was set-up as in the training session. The MERMAID application was demonstrated and utilised as part of the medical training. Medics took part in medical scenarios using the system. The resulting general comments are the following:

- The overall functionality of the MERMAID software meets the requirements, which were originally sought after.
- All of the components, which were envisaged, are present and function as expected.
- The medical content appears acceptable.
- The user interface can be improved regarding the general layout and the set-up of buttons on the screen.
- Some software bugs were reported.

5.8.2 Testing of Software on a Limited User Group.

A significant number of reports were collected from technicians (5), doctors (7), paramedics (10) and crew members or patients (20) that used the MERMAID application on board the Salamina sea vessel demonstration site. The processing of these reports showed the following:

<u>The Opinion of Technicians.</u>

All functions of the application, both SV and MCC, were working properly and fulfilled the requirements set by users at the commencement of the project. Open sea operation was verified as satisfactory and all message types were exchanged with the MCC. Representative scenarios were tried out, verifying the full functionality. Several suggestions were made for improving the layout of the user interface.

Regarding reliability of communications, although during initial installations several problems occurred and the establishment of successful satellite connection required some effort, it was reported that such problems were easily solved by the communications officer on board. A reliable communication link was easily achieved, both between SV and GCS through satellite and between GCS and MCC through ISDN.

<u>The Opinion of Doctors and Paramedics.</u>

The medical staff reported that the telemedical application was easy to use and could be operated effectively without particular IT skills. Functions were well defined and effective in providing direct solutions to medical problems on board. The medical guide was found complete in terms of content and practical to use. Interesting suggestions were made about the user interface layout and the incorporation of additional features. These suggestions were taken into account for improving the system. However, none of them indicated a critical deficiency.

Testing of the application in realistic situations proved the ability of the system to provide effective assistance on board. The ability of doctors and paramedics to successfully handle the computerised communication system was shown.

The Opinion of Patients.

The comments from the crew, who are potential patients, differed from the medical staff. The patients were interested in neither the appearance of the user screen nor the technical specifications. The most important factor was the final effectiveness of the system and the capability to provide substantial assistance to them. This depended heavily on the design and reliability of the system, and on the training of the people who use it.

Crew members saw the telemedical application as an important addition to the safety standards of the ship. Having seen the system working on board, all expressed the opinion that it increased the quality of medical care, which is something that was required and was important to them.

The existence of the telemedical application was reported to have a considerable impact on the crew morale. The application created the feeling that patients were not entirely isolated and that the medical care that was or would be provided to them would be of much greater quality. However they realise that such a system can not provide a 100% reassurance and there would be cases when telemedical care was not enough and hospital facilities were necessary.

5.8.3 Testing of the Application during the 10-Month Demonstration Period.

During the 10-month demonstration period, no serious accident or critical illness for which teleconsultation was used was reported by any of the sea vessels. However, several incidents of minor illnesses and ailments occurred. In these cases, the staff on board made use of the application, consulting the Medical Guide and Medicine Chest. The medical records of the patients were accessed before treatment and updated after the incident.

In a few cases, contact was also established with the MCC and the attendant doctors gave medical advice. Although none of these cases were severe and the advice given was not critical, it was a useful experience for the evaluation of the system and a verification of its effectiveness. It allowed the crew members to maintain familiarisation with the use of the system.

Differing questionnaires were again distributed to technicians, medical staff and potential patients. The concluding results from the questionnaires completed by the users are summarised as follows:

<u>Efficiency.</u>

The system efficiency was evaluated for all its components, namely the ship user interface, medical centre user interface, communication, medical archives and multimedia medical guide. The evaluation reports highlighted the following:

- The response time was low in all functions

- The system operated satisfactorily on a low cost personal computer. Hardware requirements were small (PC with 16 MB RAM, 1GB disk space, CD-ROM, modem).
- Teleconferencing was possible and satisfactory.
- Playback, recording, transmission and storage of audio and video messages performed well.
- The Multimedia Guide was complete and operated fast without requiring extensive storage resources.
- Medical archives and the Medicine Chest were efficiently implemented.

<u>Effectiveness.</u>

Most of the users reported that the telemedical application was capable of performing intended tasks and provided essential assistance on board. More specifically;

- Technicians reported that the functionality was well designed
- Communication between SV and GCS was sufficient within bandwidth restrictions and easily established.
- Communication between MCC and GCS through ISDN was found 100% satisfactory.
- User screens, buttons and modules were found quite easy to learn and use by 60% of reviewers (of all user groups) and very easy to use by 40% of them. However, 20% reported that the appearance of the buttons and screens could be made more attractive.
- Regarding the effort and time required to perform the most common tasks, it was agreed that the minimum had been achieved.

- All doctors stated that the medical content of the forms used and the information in the medical archives were complete. Some doctors suggested a few additions to the Medical Guide but its content was in general found to be complete.

Reliability.

At the first stages of installation, a few problems occurred in the software modules (some functions did not work properly) and in the communications system (satellite connection was not stable). However, these problems were soon solved and the relative experience was gained.

No significant reliability problems were found during the operation on ships. The confidence of the reviewers that the system will work when required, as measured for each component separately, was:

- 80% for SV hardware and software.
- 95% for MCC hardware and software.
- 65% for the communication links.
- 85% for the human operators.

Outcome on the Health and Safety of the Maritime Workers.

The merchant seamen including the medical attendant were asked whether a telemedical system on board could really offer adequate assistance. This question was asked of telemedicine in general, and then system specific.

95% of the seafarers found that the MERMAID application had a substantial effect on the medical care on board. MERMAID was felt to reduce the risk of death, facilitate the care of common illnesses, encourage healthy living and allow direct treatment of accidents at a higher level than first aid.

100% of paramedic staff felt comfortable with the new system, were willing to use it anytime and would continue to do so. Although the intention of the system was to transfer the majority of responsibility to the distant doctor, 20% of the paramedic staff still feared that they would be charged with additional tasks.

60% of the seafarers would prefer a doctor on board, although this has never been possible for the size of their ships. The other 40% were comfortable with the telemedical system. No-one was satisfied with the conventional situation.

The quality of care provided using the MERMAID application was **worse for 0%** of the users asked, **same for 0%, just better for 30%** and **much better for 70%.**

The use of MERMAID was found, according to the case, as

- Fairly useful for the cases of common illnesses and small injuries.
- Very useful for heavy illnesses, because of the need for reliable diagnosis and treatment.
- Critical for emergency cases and certain accidents.
- Not useful at all in some cases, which were not specified.

Effect on Crew Morale.

The seafarers commented on the positive effect that the telemedical system had on crew morale. Most seafarers agreed that;

- Their health is one of the most important concerns on board.
- The feeling of isolation during a trip is intense.
- Conventional communication by phone is not sufficient for any serious medical treatment.
- The MERMAID application, as seen by them "in action" was indeed a reassurance.

Cost and Cost vs. Performance.

The cost of the MERMAID system was found to be from "reasonable" to "minimum". The reason for this was its efficiency, the small cost of hardware needed and the use of existing infrastructure on communications.

Taking into account the assets of the system and the possible savings from its use by the Ship Company, it was concluded by the evaluation procedure that cost versus performance relation was very favourable.

5.9 Expansion of MERMAID into a Commercial Service.

Application of the MERMAID system beyond the initial scope of operation and demonstration sites has improved the quality of service provided to remote communities as well as work sites (e.g. sea going vessels).

Since the conclusion of the 10-month trial period, MERMAID Telemedicine Workstations have been installed on board a further three oil tankers belonging to the Varnima Corporation of Greece. These workstations have been installed to provide a functional service for the seafarers and not as part of a research project. The oil tankers are the "Kriti Wave", the "Kriti Star" and the "Kriti Land". These three vessels operate world-wide.

The flexible and scaleable MERMAID system can be applied in any isolated region, not just in the maritime scenario it was originally developed. The flexible software can be used with communication links other than satellite, such as ISDN lines or leased lines. The Medical Guide is suitable for providing illustrative instructions to paramedic staff of all basic treatment tasks. Small modifications and amendments are required for transforming the maritime-oriented medical guide to a general purpose guide. The MERMAID system has therefore been applied in two remote or inaccessible areas viz. a prison and the remote communities of Canada.

<u>Prison Scenario.</u>

The MERMAID system, with very small modifications, was selected by the Greek Ministry of Justice to be used for telemedical assistance to prisoners in all prisons throughout the country. The system is currently installed in the prison of Koridalos and is expected to be expanded to all rural prisons.

Housing 1700 regular prison inmates, the Koridalos Prison is one of the largest incarceration systems in Greece. New prison units are located in rural areas throughout Greece which and tend to be located far from medical referral centres where tertiary care is normally available.

Greek law guarantees inmate access to primary care services at their unit and access to speciality-care services consistent with community standards. The cost of transporting inmates and public safety are important considerations. The corrections system bears the entire cost of transporting the patients for healthcare services.

The use of telemedicine shows promise to solve significant practical problems and to have an impact on cost savings, security and quality of care. Additionally, the system will be closely monitored in order to evaluate the medical outcome, economic impact, and user satisfaction.

The goal of the Koridalos implementation of telemedicine, therefore, is to identify and develop approaches necessary to achieve an optimally efficient and effective telemedicine program for all Greek prisons. Useful information is expected to be derived from the operation of the system, which will lead to the expansion of the network to an advanced national system of telemedicine. Five areas are under investigation: patient care, technology, support systems, evaluation, and non-clinical applications.

Remote Canadian Communities.

The country of Canada has many characteristics that make it a promising ground for the development of telemedicine. Many villages exist, mainly at the northern part, with very few inhabitants. It is almost impossible that these villages fully utilise the services of a doctor and inhabitants have to travel to the closest medical centre for medical treatment or advice. Travelling is to these distant destinations is expensive and can be difficult or impossible during a large part of the year, due to weather conditions.

Another important characteristic is that health care delivery has a local nature. Regional health authorities, a relatively new entity in the Canadian system, have become a very important influence on health care delivery. Responsibility for the population within their geographic boundary, as well as for individuals who require special services that are available within regions falls now to the 16 health authorities.

The MERMAID system, as a complete and successful telemedical system has been installed for demonstration purposes in the city of Alberta in Canada. It was presented to local representatives of rural areas and of organisations responsible for health care delivery in these areas. It was clear during the presentation that the designing, capabilities and specifications of the system are particularly suited to the situation at hand. Following the presentation, the initial installation of MERMAID in 50 villages in the area of Alberta has been discussed.

The multimedia medical guide for ships may require modification for particular emphasis on local health problems such as arthritis, diabetes and alcoholism.

5.10 Summary Discussion.

Sea going vessels are hazardous environments with many occupational health risks. The medical service currently provided to the merchant marine industry and to seafarers in general appears basic; communication is unstructured and many service providers are language-specific. There is no global medical emergency scheme.

The provision of highest possible quality medical care to the merchant seaman is becoming enshrined in European and International Law, and the International Maritime Organisation is currently investigating the use of telemedicine to help improve the provision of medical care on board vessels and improve the health of seafarers in general.

The provision of medical care is not the problem per se. As with all remote health care, the problem is one of logistics, and the separation of the patient and doctor. The provision of medical decision support on board sea-going vessels is an ideal application for telemedicine.

Circulatory system diseases together with fatal sea disasters are the major causes of death on board ships, together with fatal sea disasters. The evacuation of a casualty is either by diversion of the vessel, or by helicopter rescue. Both these actions are costly and possess an element of risk.

There are three factors which can affect the level of medical care on board a sea going vessel viz. the level of training of the medical attendant, the medical indent and the effective use of radio-medical or medical decision support services. The provision of a medical indent and medical decision support are rendered useless without someone who is trained to use them. The medical indent is dependent upon the category of the ship and the cargo carried. All ships should carry the minimum required. The medical attendant should be familiar with all items and drugs stocked otherwise it is not worth carrying them.

Relevant to the use of telemedicine facilities is the recognition that the first officer is the medical attendant on board the ship, and is basically an advanced first aider. The training standards of this advanced first aider are variable. Different countries worldwide demand differing standards although they supposedly work to the same text. Together with the fact that being the medical attendant is not the primary role of the First Officer, medical decision support is paramount.

The present VHF radio-medical support is provided through the coast radio stations to the nearest medical support or hospital. This service is not based on medical speciality or language of the crewmember or medical attendant.

The MERMAID application has been shown to be easy to install as it uses existing hardware and communications. The software is simply installed from a CD-ROM.

MERMAID has been demonstrated to improve on the present radio-based service and:

- Structures the clinical information collection.
- Formalises the information flow.
- Allows for greater clinical information flow.

- Creates a dialogue between medical attendant and doctor.
- Puts in place procedures to ensure the correct information is communicated in a timely fashion.
- Uses existing technology and communications to attain these improvements. The scaleable system allows users of varying bandwidth and hardware capabilities to use the system to the best of their abilities. The MERMAID application is particularly portable, as it does not depend on specific hardware.
- The system is capable of supporting videoconferencing if appropriate, and the high-speed data communications bandwidth is available.

The MERMAID application met the user requirements and equipment specifications defined at the start of the project. MERMAID ensures that the First Officer, treating a patient, is connected to the nearest, of a particular discipline, speaking the appropriate language, medical provider. The MCC will be dependent on language, patient injury/illness and position of the vessel.

Information regarding the individual patients requires to be entered only once. Information on allergies and general background information are stored in the medical archives and can be drawn out when appropriate. The clinical information flow includes details of patient history being sent to the shore-based doctor. The doctor is therefore made aware of previous incidents and how they affect the present. Through the Medicine Chest of the MERMAID application, the shore-based doctor knows what types and levels of drugs are carried, and what stocks remain on board. The drug expert system ensures that no contradiction exists between prescribed drugs.

The MERMAID application improves on the content and access to the medical guide. The Multimedia Medical Guide encompasses more functions than the original textbook; education, reminder, reference and can be activated by the shore-based doctor.

The functionality was attained in all modules of the application. The application functioned correctly at the demonstration sites. Messages and reports were sent and advice provided. Images, sounds and clips were been transferred. No communication errors were encountered during the demonstration period. However the function's response time was felt to be slow and could be improved. The service was hampered by the bandwidth available for use, and the lack of dedicated specialist at MCC. With the expansion of the service, the medical care provider will employ a dedicated specialist.

Software reviews were undertaken at the virtual demonstration site and on board one sea-going vessel. The reviews evaluated the software and the system as a functioning whole. The system was reviewed and proven to be user-friendly and easily acceptable by personnel of differing backgrounds, including technicians, medical attendants, doctors and crew (potential patients). The software review and evaluation has ensured that all errors have been eradicated.

Training in the use of the system was provided on installation at the six sea-vessel demonstration sites. Shore-based doctors were easily trained in providing medical advice over communications mediums, as well as in the use of the technology.

The graphical user interface was accepted and commented on as user friendly. All users were satisfied with the "look" and functionality. However, patients/crew members were not so concerned with the look and ease of use of the system, as about the potential outcomes. The system was felt by all the crew to provide vital assistance and assurance during medical emergencies. The medical decision support service was a good addition to the health and safety of the vessel and crew. The majority of the crew felt that the quality of health care had been improved with the presence of the MERMAID application.

Users stated that they were very confident in using the system following limited training and familiarisation. With the system operated satisfactorily on a low-cost computer, the technical staff felt that there was good and sufficient communication on the restricted bandwidth available. Medical attendants and doctors were able to easily handle computerised communication of the clinical information required. Medical staff were satisfied with the complete content of the medical reports and questions asked.

The MERMAID application was stated to have a substantial effect on the medical care on board the demonstration sea vessels. Both seafarers and doctors felt very confident in using the system and would continue to do so after the demonstration period had finished. The majority of the crew were comfortable with the provision and use of a telemedical system to provide medical decision support on board although most would also have preferred a doctor on board permanently. However this is neither economically practical nor legally required. The MERMAID application cannot and does not guarantee the health of those on board, but does substantially improve on the present radio based system, and improves the quality of medical decision support provided.

The market for a telemedicine remote decision support services on board ships is enormous. There are an estimated 62,000 ships over 100 tonnes that would benefit from such a system. The anticipated market is estimated to be between 15,000 and 20,000 medical consultations from merchant marine vessels per year.

The use of MERMAID continues to expand with further sea vessels already installing the software and requesting medical decision support from the MCC. The MERMAID application can be adapted for use by other levels of medical qualifications of the end user, such as a nurse or medic. The system therefore has potential applications on-shore with minor amendments. MERMAID is expanding into other areas where remote medical decision support is required such as prisons and remote communities.

The system can be further improved by the addition of appropriate equipment, training and decision support. Cardiac arrest, as with the population in general, is noted as one of the major causes of death in the maritime environment. Without quick defibrillation, the casualty's chances of survival quickly diminish. Defibrillators are now available for use by non-medically trained personnel and may be of great benefit on board merchant vessels (Lexow, 1997).

Illness is responsible for 80% of medical consultations from merchant marine vessels at present. Stricter employment health screening would hopefully reduce these figures and reduce the risk of ill health at sea.

The MERMAID software is to be distributed free on CD-ROM. Users will be charged for the provision of medical decision support services, on a monthly/annual fee plus a per consultation payment.

There were no serious accidents or illnesses on board the demonstration sea vessels that required treatment and teleconsultation during the clinical trial period. The use of emergency scenarios by both the MCC and the SVs may have tested the application to a greater extent. Further evaluation using emergency medical scenarios before application would be necessary.

6.0 OFFSHORE MEDICAL DECISION SUPPORT.

6.1 Background to Telemedicine Offshore.

Technological advances in the offshore oil and gas industries have made extraction of these energy sources possible in increasingly remote environments. This in turn has created the need for large numbers of personnel to live and work in these remote areas, often in hazardous environmental conditions.

Like the merchant marine industry, the offshore industry demands a high standard of health care for its employees. To achieve this, a system has been evolved which is designed to cope with the particular problems.

The central problem is more logistical than medical, and concerns the time and distance that often separate the doctor onshore from the offshore patient. It may take many hours for the doctor to get to the worksite, and if the patient happens to be a saturation diver in a pressure chamber at a simulated depth of 180m, the doctor is then faced with a wall of steel that separates him from the casualty (Norman, 1985).

Telemedical care has been provided using the telephone systems since the first offshore installation was created. However this decision support system is crude and may not provide the onshore doctor with sufficient clinical information on which to advise on treatment, diagnosis and the requirement for evacuation. A simple telemedical service has been applied to aid the clinical information flow between doctor and medic and doctor and patient, reducing the risk to personnel and reducing the number of costly medical evacuations.

North Sea Natural Gas first came ashore in 1967, but it was not until June 1975 that North Sea Oil flowed. Since then the number of fields has expanded enormously, and will continue to do so with the development of the West Shetland Fields. By 1998 there were 186 offshore fields in the North Sea, 98 of which were producing oil. The Brent and Forties fields remain the largest encountered. In 1996 the United Kingdom was producing 128 Million Tonnes of oil per annum, and responsible for 4.15% of the world oil production (UKOOA, 2000a).

The most recently published census showed that there were 23,000 personnel working offshore in 1997. On the day of the "headcount census", 12,105 were actually offshore (Inland Revenue, 1997).

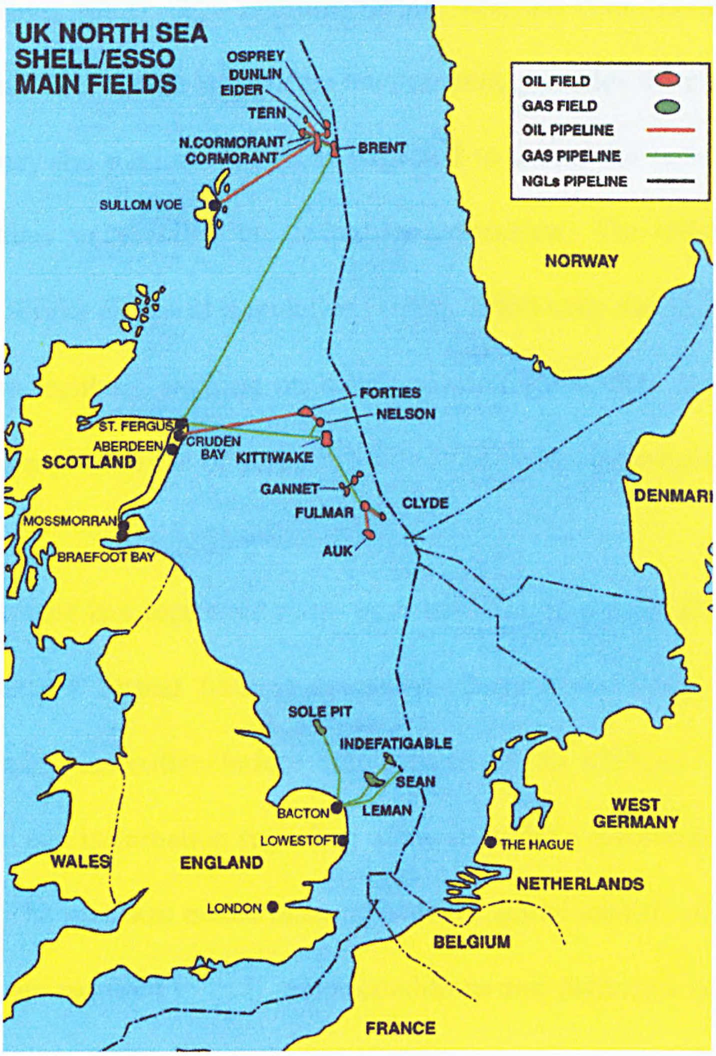


Figure 6.1 – Oil and Gas Fields of the North Sea.

Offshore personnel must be provided with a high quality medical service. Like the merchant marine industry and the remote communities, the people working in these areas expect to receive services equivalent to those of the large urban centres. Studies have shown that the personnel working offshore experience significantly higher levels of anxiety than those working in similar positions onshore (Parkes, 1992). These anxieties, together with the remote and harsh working environments, provide the potential for accidents and illness (Cox, 1982). The National Health Service does not extend beyond the low water mark and so medical services offshore are the responsibility of the operating companies. Each worksite must have a medical presence (Phillips, 1987). The platform medic, who has been trained extensively to prepare for work in a remote and hostile environment, provides the primary care focus. In an emergency the platform medic is expected to assess the patient, carry out life saving procedures and stabilise the patient for evacuation. The Offshore Installations and Pipelines Works First Aid Regulations (HSE, 1989) state that any installation with over 25 people regularly working on board, requires a full time medic. If there are fewer than 25 people, the use of properly trained first-aiders is permitted.

The platform medic is a registered nurse or Armed Services equivalent. The platform medic undertakes a further training course to obtain a certificate approved by the Health and Safety Executive before employment on an offshore installation. The course syllabus and information regarding offshore medic's qualifications are shown in Appendix L. The platform medic must manage the initial care of all emergencies. In addition, they are required to treat minor conditions and perform a counselling role in the absence of other professionals (Phillips, 1987).

The medical advisory committee of the United Kingdom Offshore Operators Association (UKOOA) provides guidelines for the standards of fitness to work offshore (UKOOA, Medical Advisory Committee, 2000b). Medical providers to the offshore operators issue offshore medical certificates, which comply with UKOOA standards. Offshore workers must possess an offshore medical certificate as well as an offshore combined survival training and fire-fighting certificate before being allowed offshore. This health screening helps to prevent the employment of those with potentially high-risk medical problems. The platform medic therefore has to deal with the wide variety of diseases and problems that might be expected to occur in a screened working population.

Originally, as a statutory requirement, access to a qualified medical practitioner was required for advice on the administration of prescriptions (Department of Energy, 1976). Beyond this basic requirement, the operating companies employed medical practitioners to provide general advice to offshore medics, to receive medical evacuees, to escort patients ashore and to provide a link to the National Health Service. These services, together with the training and health and welfare services for the offshore industry have been tightened by further legislation (Department of Energy, 1984 and 1989; Health and Safety Commission, 1998).

Evacuation on the grounds of illness or accident, will normally take place by routine helicopter flight or mobilisation of a dedicated helicopter flight. Data collected from a sample of North Sea Oil Operators has shown that almost 10% of medical evacuations occur on dedicated helicopter flights. This figure has remained constant for over a decade, with only the ratio of illness/accident evacuations changing (Horsley, 1998).

These emergency flights are never arranged without full consultation with the installation manager, the platform medic, the supporting doctor and the helicopter pilot. While this type of flying is expensive, the most important factors to consider are whether the patients' condition justifies a special flight, whether the conditions are suitable for a flight, and whether all the risks been considered (Anderson, 1994).

Even in a serious medical emergency, the decision on whether to evacuate a patient is not taken lightly. There may be considerable risks both to the patient and to the personnel involved in the evacuation and considerable costs to the operator. A study of medical evacuations by helicopter or "mercy flights" showed that a number of flights broke basic flight safety rules, and put further personnel at risk (Lane, 1983).

6.2 Medical Decision Support Offshore.

There is a skill difference between the offshore medic and the maritime industries' First Officers. However, a medical decision support system is still an essential part of the service. Offshore operators utilise medical service providers to provide the offshore medic, and medical decision support, with doctors continuously on call. The shore-based doctor is contacted via telephone and provided with clinical information by the medic. The doctor advises on patient management and whether there is a requirement for evacuation. In Aberdeen the doctors respond to medical emergency calls daily, and there is on average one medical evacuation per day on scheduled flights. It is estimated that there is one dedicated medical evacuation from the North Sea installations every week (Horsley, 1998).

As far back as 1980, the requirement for an effective two-way communication system was seen as essential for the provision of adequate medical services offshore (Martin, 1980). The Memorial University Hospital in Canada applied "telemedicine technology" in providing medical decision support to the offshore community off the Labrador and Newfoundland coast. The offshore drilling sites were linked into a teleconference system using the Avik B satellite system (House, 1980). This satellite system was expensive and used primarily for telemedicine research projects. The medical decision support was provided a voice network only, similar to that used in the North Sea at that time, and still today. The system had the potential for further data transfer.

Medical service provision in a remote environment can work only if the medical attendant on the spot can communicate with the specialists. However, medicine on the rigs, and remote health care in general, has several facets (Anderson, 1994; Martin, 1980; Norman, 1988a):

- Training, of the remote practitioner, first aiders and shore based doctor.
- Communication, with a doctor or specialist, who has relevant experience. Medical and Specialist availability, to forward the decision support communication to a specialist if necessary.
- A safe and efficient means of evacuation in an emergency.
- Medical Indent, and knowledge of the content of the medical indent by all parties.
- Continuing Research, to improve the communication, the indent and remote health care services.

Snow (1980) suggested that doctors providing medical support to offshore installations, should spend time aboard to appreciate the environment under which the medic is working.

The current medical support system involves the platform medic being able to contact a shore-based on-call doctor 24 hours a day. Communication occurs via the ubiquitous conventional telephone and fax systems. The medic describes case history, symptoms, treatment to date, and examinations undertaken. Acting on this unstructured information, the doctor advises on treatment, patient management and the requirement for evacuation. The doctor has not been able to view or examine the patient and is only able to obtain information from the patient through the medic acting as an intermediary. With the information received from the medic, the doctor may "err" on the side of caution, and recommend evacuation soon or immediately, depending on the severity of the injury or illness.

The description of injuries over the radio by the platform medic determines the subsequent management by the doctors (Phillips, 1987). A platform medic's ability to note and communicate clinical findings in the language of medical doctors is most important (Martin, 1980). Efficient referrals depend on good communication between the platform medic and the doctor. Patient stabilisation before departure is essential because in-flight procedures are difficult and the flying time may be as long as three hours (Phillips, 1987).

6.3 Medical Evacuations.

A retrospective study of offshore medical evacuations from 1976 to 1984 showed that a shore-based doctor was consulted before only 40% of the evacuations undertaken (Norman, 1988b). Procedures have since been put in place by the majority of offshore operators to ensure that the medical decision support is consulted before evacuation. In this early study 7.7% of the evacuations were made on dedicated flights. A similar percentage were evacuated due to dental problems. By far the most common cause of evacuation was due to suspected fractures. Only 4% of the evacuees required immediate admission to hospital. Space is seen as at a premium offshore, and personnel whose injury or illness prevented them from working are often evacuated, even though their management is well within the capability of the rig medic (Norman, 1988b).

Before 1980, evacuation on medical grounds was largely dominated by injury, with illness accounting for only 20% (Anderson, 1994). The percentage of illness steadily increased throughout the eighties, until in 1988, the percentages of injury and illness were equal, and in 1989, illness exceeded injury for the first time. The percentage rate is now in the region of 60:40% (Horsley, 1998). This may reflect a more experienced workforce, which knows how to avoid injury, but the increasing illness factor could reflect the ageing workforce (Anderson, 1994).

Approximately 90% of medical evacuations are accommodated on normal, scheduled flights, and many evacuations are of only minor medical significance. It should be remembered that what seems to be of little or trivial importance onshore may well assume different significance offshore, or indeed in any remote location. There are no light duties on offshore installations, and 48 hours is probably the maximum period that an employee could be excused duties (Anderson, 1994). It is preferable for patients to be evacuated than for them to remain offshore, where they could be a hazard to themselves and their colleagues, particularly in an emergency.

Helicopter medical evacuation has been proven as the most efficient method of providing the patient with the appropriate care when needed. The evacuation of casualties during military encounters has proven the helicopters effectiveness. Deaths per 100 casualties dropped from 4.5 during WW2, to 2.5 during the Korean War and further to 1.5 during the Vietnam War when the American Air Force undertook casualty evacuation by helicopter (Leese, 1984). However in the offshore environment, helicopters are not only seen as a means of evacuating personnel in medical emergencies, but also the transportation to work. Travel by helicopter is another occupational hazard for oil operators (Martin, 1980).

Dental problems were formerly a prominent cause of evacuation. The UKOOA medical guidance drew attention to the need for regular dental surveillance and certification (UKOOA, 2000b). A dental certificate is now required as part of the offshore medical examination and certificate. This has significantly reduced the number of dental medical evacuations.

From September 1993 until September 1994 there were 689 reported evacuations from a sample of Northern North Sea Oil and Gas Operators. The majority of these evacuations were undertaken on scheduled helicopter flights (94%), with only 36 evacuations requiring a dedicated flight. The ratio of dedicated to scheduled flights has not changed significantly since 1987. On this period, 69% of evacuations were classified as illness, including dental cases. A total of 75 evacuations were undertaken solely for dental reasons. This equates to 11% of the total evacuations (Horsley, 1996).

The changing pattern of illness and injury may be due to a number of factors:

- Changing patterns of work offshore, from exploration to production.
- Increased safety regimes.
- Stringent standards of medical care.
- Ageing workforce.

Scheduled evacuations for illness were primarily due to digestive or respiratory problems, which include dental cases. Injury reasons for evacuation on a scheduled flight were for musculoskeletal problems (54%), which encompassed fractures, dislocations, sprains and strains. No evacuations were undertaken as a result of crush injuries, twelve for contusion and fourteen for foreign bodies in the eye.

Twenty-two personnel were evacuated for illness reasons on dedicated flights. The illnesses included ischaemic heart disease, appendicitis, respiratory infections, etc. and 14 personnel were evacuated on dedicated flights for reasons of injury. Again the majority of evacuations were for fractures, strains and sprains, two were for open wounds, and one for a foreign body. Personnel transported by dedicated helicopter flight were all evacuated within 24 hours.

Consultation with the shore-based doctor was sought in 88% of the evacuations undertaken by scheduled flights and in 97% of the dedicated evacuations. These figures have improved over the recent years, and show increased medical involvement in the decision-making process (Horsley, 1996).

Once repatriated, the patients were treated by a number of establishments. Of those patients evacuated on scheduled flights, 32% were treated on hospital, 30% by their own GP and 25% by a medical agency. The remaining 13% were treated by a dentist. Of those evacuated by dedicated helicopter flight, 82% were treated in hospital, 9% were seen by a medical agency, and 9% by their GP.

The majority of patients evacuated from offshore installations do not require on-going medical treatment. Patients attending the hospital following evacuation normally only receive A&E treatment before being discharged. There are obviously some critical cases where continuing hospital treatment is necessary.

6.4 Offshore Telepresence.

Increased clinical information transfer or the transfer of live or still images of the patient could allow the shore-based doctor to make a better informed judgement on diagnosis and treatment. Where medical evacuation is required it may be safely delayed for a routine flight if a more complete clinical picture is available. Even a fractional reduction in unscheduled medical evacuations could create great savings for the operator and reduce the personnel put at risk.

Differences in skill levels between a community GP and an offshore medic may allow the successful application of a telepresence headset in this remote environment. Telepresence may be more applicable to the offshore medic in aiding medical decision support in an emergency.

A trial of a telemedicine and telepresence system supporting this study was undertaken with the aid of British Petroleum Exploration. The object of this trial was to assess a telemedicine system installed as a decision support tool for the offshore medic. The benefits expected were:

- Decision support for the installation medic.
- Higher quality patient care.
- Better-informed judgement by the shore based specialist.
- Better use of scheduled helicopter flights for medivacs.
- Reduced number of dedicated medivacs.
- Other possible uses of equipment e.g. engineering inspection.

The telemedicine system consisted of videoconferencing and telepresence. The INMARSAT communications system was installed on the BP Forties Bravo Platform. The platform, installation, equipment and procedures are described in Journal Article 5 in Appendix A.

The equipment was installed in the sick bay and placed under the control of the platform medic. The system operated during onshore office hours, when the shore based medical support was present at the medical support offices. Outwith these hours, the offshore medic resorted to the phone based decision support service.

6.4.1 Telemedicine System Equipment.

The telemedicine system equipment was similar to that installed within the Casualty Department of the RCH and described in Section 4.3. The system utilised the same components, but did not incorporate teleradiology services. Radiology is not a function performed offshore. However such a service could be incorporated into a remote worksite such as an Antarctic Base where radiology services exist (Lenihan, 1996b). The video conferencing, telepresence and INMARSAT communication equipment are discussed in Journal Articles 1, 2 & 5 in Appendix A, and their technical specifications shown in Appendices B, C and D respectively.

6.4.2 Offshore Telemedical Consultations.

Following a period of training for the participants, a three-month trial was conducted with a mixture of real and simulated medical presentations. A large number of video communications and discussions were undertaken to ensure medics and operators were completely acquainted with the system and call-up procedures. The trial was not designed to test a particular hypothesis, but to gain experience in the use of the equipment, to highlight problem areas and to determine whether it provided the shore-based doctor with additional useful information.

The consultations were monitored via a modified Medical Assessment Questionnaire (Haston, 1993) to include assessment of the technology used. Both platform medic and shore-based doctor assessed the benefits of using the telemedicine system. A sample questionnaire is shown in Appendix M.

The majority of teleconsultations lasted between 5 and 15 minutes. During this period, each case history was discussed with the rig medic, the patient observed via telepresence and/or videophone, and the diagnosis and appropriate actions formulated.

<u>Consultation 1.</u>

A patient presented with a severe and worsening headache following a blow to the head two days earlier. Weather conditions at the time prevented a medical evacuation. The shore-based doctor was able to speak to the patient via the videophone, and observe patient body language and mannerisms. The cause of the headache was diagnosed as minor illness, which was to be reassessed after 24 hours. The outcome of this incident was that both patient and rig medic were reassured and a dedicated medivac avoided. In this event the patient was evacuated on a routine scheduled flight the next day.

Consultation 2.

A patient presented with a severe hand injury. The shore-based doctor was able to view the injured hand and speak to the patient via the videophone. The doctor was clearly able to observe the injury, which was an amputated right distal phalanx middle finger with obvious muscle, nerve and vascular damage. The advantage during this consultation was that the patient was able to be seated in front of the videophone and speak to the doctor directly. The injury was considered an acute emergency that required immediate medivac.

Consultation 3.

A patient presented with a painful right elbow. By using the videophone and telepresence headset the medic was able to show the shore-based doctor the painful areas and ranges of movement possible (flexion and extension). Visual display of the affected elbow enabled diagnosis of muscle strain that required reassessment after 24 hours and to be updated only if necessary. Medical evacuation was not necessary.

Consultation 4.

A patient presented with severe stomach ache. The shore-based doctor was able to direct and observe the medic's actions during an abdominal examination, via the telepresence headset. The doctor found it extremely useful to be able to see patient reactions to the abdominal examination, and was able to diagnose acute appendicitis, requiring immediate evacuation. The consultation highlighted the need for proper focussing and maximising the lighting conditions prior to video communication.

Consultation 5.

A patient presented with an injured hand. The shore-based doctor was able to examine the patient and injury using videophone and telepresence. The medic was observed palpitating the lesion and putting the wrist through a full range of movements both passive and active. Very clear and useful images of the hand were obtained, with the medic able keep the head camera steady. A diagnosis of ligament sprain of the left wrist was made, a minor injury to be reassessed in 24 hours and updated only if necessary. Medical evacuation was avoided.

Consultation 6.

A kitchen worker was presented with an abdominal wound. The patient had been boning meat when the knife slipped causing a penetrating abdominal wound with internal bleeding. The shore-based doctor was able to view the nature and extent of the wound via videophone and telepresence. The patients' state and reactions were also observed and used as a gauge of severity. Clear images of the wound and patient were transmitted from the headset camera. The injury was diagnosed as a very serious problem, which required continual reassessment. The doctor was able to advise the medic on interim treatment while the medical evacuation was initiated. The A&E department could be advised of the incoming injury.

Consultation 7.

A patient was presented with a compound fracture, which was sustained when he fell down some stairs. The shore-based doctor examined the patient using both videophone and telepresence. Extremely clear pictures of the wound were obtained from the telepresence headset when the medic's head was still and centred. The injury was considered an acute emergency that required evacuation on the next available flight.

Consultation 8.

A male patient presented with a deformed right elbow joint. The shore-based doctor was able to view and assess injury and joint movement via the videophone and telepresence system. Very clear images of the injury and movement were displayed to the doctor. The consultation demonstrated good use of the telepresence system, however no action was required as this was a scenario case, with the injury being the result of an accident 39 years earlier.

Consultation 9.

A patient was presented who had sustained a severe crushing injury to the left foot. The shore-based doctor examined the patient and wound using the videophone, telepresence headset and a fixed camera that was interfaced with the auxiliary input of the videophone. Clear images of the wound and patient reactions were received via the videophone and telepresence systems. Better images were received from the fixed camera but compromised on positioning and audio capabilities. The platform medic was advised to monitor the vital signs, administer saline, recommended doses of drugs and to connect the appropriate intravenous lines. This injury was assessed as an acute emergency requiring immediate medical evacuation.

Consultation 10 (A scenario).

A male patient (the platform medic) was presented, initially complaining of headache and sickness, and then blurred vision. A first aider who required urgent help in dealing with the medic who was rapidly losing consciousness initiated the communication. The shore-based doctor examined the patient using the telepresence headset. Extremely good sound and vision was received and the doctor was able to observe patient reactions and to request first aider actions. The patient was losing consciousness, there was minimal verbal response, patient was restless, twitching with a stiff neck and slight fever. A possible diagnosis was inter-cranial bleeding (a sub arachnoid haemorrhage). An immediate medivac was advised.

6.4.3 Assessment of Offshore Telepresence.

In the majority of cases the shore-based medical practitioner was able to form a better diagnosis and be sure of the appropriate actions to be taken with the aid of the video link. The use of the telepresence headset enabled the practitioner to view the patient in the sick bay and "focus in" on the injury. The telepresence headset enabled movement to be viewed and patient reactions to be observed. The platform medic was reassured by the "presence" of the shore-based doctor.

The types of scenarios and medical cases presented tended to be based on major medical problems and traumas, rather than the more routine incidents of illness and injuries encountered by the platform medics under normal circumstances.

The telemedicine system enabled more confident diagnosis and on-call second opinion, and with minor training the system appeared user friendly. However a number of potential improvements to the system were identified;

- A light pointer to orientate the headset video camera.

- Training in positioning and holding steady the headset video.
- A context high quality video camera to link up to the videophone.

The telemedicine system proved to be of value in decision support for the platform medic, as well as ensuring more confident diagnosis by the shore-based medical practitioner.

At the end of the trial, the overall conclusion reached by the participants was that the telemedicine equipment significantly increased the quantity and quality of clinical information available to them. Decisions on patient management, particularly the decision to evacuate were facilitated. It was noted that the less expert user, in this case the rig medic, gained a stronger sense of support and benefit than the more expert shore based doctor did. This factor is very similar to that seen in the remote community telemedicine service previously described, where the GPs obtained greater reassurance through video consulting than the consultants did.

6.4.4 The Future of Telepresence Offshore.

Increased clinical information transfer improved greatly on the PSTN and VHF radio communication systems hitherto used. Unfortunately, although health and welfare rates highly with the offshore operators, other factors rate higher. As can been seen from Table 6.1, the telepresence system employed was very expensive (in year of installation, 1996).

Component Piece of Equipment	Cost (£ Sterling)
Videophones (BT VC7000) (x2)	11,710
CamNet Telepresence System	18,190
ISDN Line Installation (x2)	303
Mobile Land Earth Station (Saturn CompacT) (including HSD)	31,715
Total Cost Telepresence Workstations using INMARSAT A.	**61,918**

Table 6.1 – Costs of Offshore Telepresence Equipment at time of Installation.

The costs of implementation of such a system on a number of installations was too high for the oil operators to consider, even offset against the estimated costs involved in the dedicated evacuation of a patient. A dedicated helicopter flight can cost upwards of £10,000. There are also high communications costs with the INMARSAT A system, using high-speed data can cost approximately £10 per minute. With consultations lasting between 5 and 15 minutes, £50 to £150 per consultation was felt to be too expensive for the operators.

The benefits of increased clinical information flow were proven. However a method of providing more clinical information with less hardware costs was required.

6.5 Telemedicine and Digital Images Offshore.

The technology which is available and used on a regular basis offshore is often ground breaking and innovative. The communications that are being applied offshore are improving constantly, and most installations are using PSTN equivalents for communication with head office and shore-based support. Some organisations are moving to ISDN or equivalent to transmit the high volume of drilling data to the shore. Many offshore employees now have email communication with the whole of the company and some have regulated Internet access. Digital cameras are also appearing frequently on board offshore installations, primarily for engineering and inspection use. These recent improvements in communication mediums and hardware available on board the offshore installations can be applied to improving the remote health care provision.

Studies of the medical evacuations from offshore installations have shown that up to 75 medivacs are undertaken each year solely for dental problems. The implementation of a Dental certificate as part of the UKOOA Offshore Medical certificate has improved the dental hygiene offshore, however dental problems are still frequent. The use of simple telemedicine technology for remote dental problems was investigated.

6.5.1 Remote Dentistry Offshore.

A dental study in 1986 showed that the dental health and hygiene of the offshore population was poor (Hahn, 1987) with 30% of the respondents admitted to not receiving regular dental care. The dental abnormalities that were found, were more likely to occur in those not receiving regular care or those who believed that they did not require treatment. The study showed that in one year, one offshore operating company had 45 personnel evacuated for dental problems. The study suggested that the cost of providing regular dental care for offshore personnel would reduce costs by between 60% and 70%.

The Teledent project has shown the potential for remote diagnosis in dentistry, transmitting images for second opinion by a dental consultant. Both dental practitioner and specialist were satisfied that the system, transmitted via ISDN permitted the exchange of sufficient information for accurate diagnosis (Cook, 1997).

Shell UK Exploration and Production employs a dentist to look after the dental hygiene of its worldwide work force. The dentist undertakes regular examinations for occupational health reasons, but also teaches medics about potential problems and provides advice to medics facing problems offshore.

A study was undertaken to investigate the potential of digital cameras and PC based videoconferencing used on board offshore installations to provide remote dental decision support. The North Cormorant platform was chosen as a test site. North Cormorant is a launched steel jacket installation capable of drilling and producing 180000 barrels of oil per day. North Cormorant is home to 228 personnel.

Figure 6.2 – Shell North Cormorant Installation.

The medic on board the North Cormorant installation has access to email, a Kodak Digital DC120 Camera and PC based Sharevision Videoconferencing. Dental images were taken using the digital camera and transmitted back to the shore-based dental support as an email attachment. Images such as shown in figures 6.3 and 6.4 were transmitted.

Figure 6.3 – Overall Image of Bared Teeth.

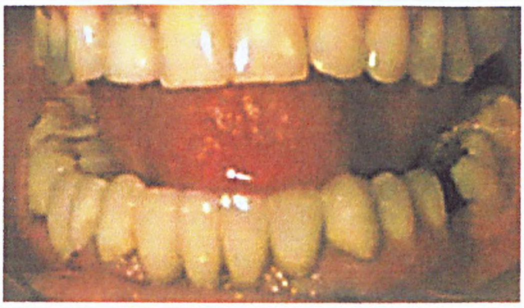


Figure 6.4 – Dental Image.

The dentist was provided with addition patient information within the email, and the shore-based dentist deemed the images sufficient for diagnostic purposes.

The PC based Sharevision Videoconferencing operating over the analogue PSTN equivalent network was deemed unsuitable for dental purposes, as the slow scan refresh rate did not provide sufficient quality images. However the Sharevision system did allow white-boarding. The medic was able to conference with the medic, displaying the digital image on one section of the screen, and patient details on the other. The dentist and medic were each able to annotate the image with the other able to view annotations, and allow further discussion.

Further medical images were taken using the digital camera and transmitted back to a shore-based doctor for examination. Images including those shown in figures 6.5 and 6.6 were transmitted.

Figure 6.5 – Transmitted Image of Eye.

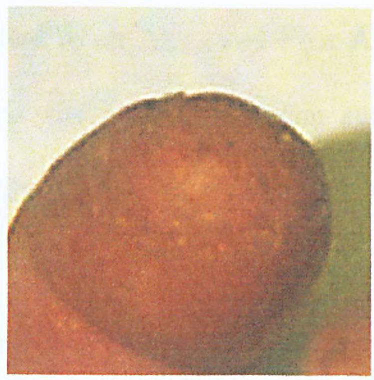


Figure 6.6 – Transmitted Image of Finger.

These images were deemed to be of acceptable quality for the diagnostic purposes by the shore-based doctor. The Kodak range of digital cameras does not allow the user to look through the lens of the camera, and the viewfinder and lens are offset by approximately 5cm. This makes the taking of close-up images of fingers, eyes and injuries, very difficult. Special attention must be paid to the lighting conditions when taking close images.

The transmission and acceptance of these digital camera images from the offshore medics has shown the benefits of simple increases in clinical information communication.

6.5.2 Potential for Simple Medical Decision Support Offshore.

The evolution and changes in working practices within the oil industry means that some installations are operating with fewer and fewer personnel on board. Legislation requires that, for installations with twenty-five or greater personnel on board, a platform medic is required. Less than twenty-five personnel on board means that the operator can reduce the medical attendant on board to an Advanced First Aider. A number of operators are looking to telemedicine and medical decision support to maintain high standards of health care on board these and other installations. The Advanced First Aider has similar qualifications and experience to that of the First Officer on board a merchant vessel. The Advanced First Aider is not able to carry out a clinical examination to the same level as the offshore medic. Following discussions with an Advanced First Aider using the present PSTN based system, the shore-based doctor may be more likely to err on the side of caution and request evacuation of the patient. Offshore operators wish to use telemedicine technologies to maintain high levels of clinical information transfer, provide reassurance to the crew, and reduce, or maintain the number of medical evacuation flights.

Although the number of personnel on board these installations is falling, the level of technology available on board continues to increase. Multimedia computers, digital cameras and the potential of videoconferencing are present. Communication mediums however may be reduced, or not improved. The telemedicine technology must rely on a PSTN based system. The use of medical assessment questionnaires, together with digital images sent as email attachments, backed up by high quality teleconferencing may be the best approach.

6.6 Summary Discussion.

Telemedicine support has been provided offshore since the first provision of medical support on board offshore installations. The telemedical support has used telephone and fax systems very efficiently to date. As a result, high standards of medical care are generally provided on board the offshore installations without doctors present on location. The good medical decision support system and procedure that is operated at present can be enhanced through increased clinical information and image transfer.

The platform medic is the medical care provider on board, undertaking treatment of, and evacuating when necessary, a **screened** workforce. The platform medic is an all rounder and must manage the medical emergencies, provide a GP type clinic, and should act as a counsellor when required. Illness has now been identified as the most significant cause of presentations to the offshore medic. This has increased the importance of the "Fitness to Work" certificate promoted by UKOOA. A properly medically screened workforce will reduce the incidence of illness offshore. Only 20% of the consultations that the medics deal with resulted in evacuation from the installation. The majority, four-fifths, are for minor ailments and can be treated easily by the platform medic without the requirement for medical decision support. Evacuations may occur for what may appear innocuous reasons to the onshore personnel. There is no such thing as light duties offshore. If a person is unable to perform his/her duties, then he or she will be evacuated to ensure that patient is not a liability in an emergency.

Helicopters are the main and effective evacuation medium. However, they transport personnel to the installations and are a source of hazard in themselves. In considering evacuation of a patient, one must be aware that helicopter evacuation is risky in certain circumstances. There has been at least one helicopter disaster where the helicopter was ditched/crashed during a medical evacuation in bad weather. Fortunately 90% of medical evacuations occur on scheduled helicopter flights.

Saving a dedicated medical evacuation can save a minimum of £10,000. The evacuation may not be saved. However, better use of scheduled flights may be possible.

The CamNet headset used to investigate offshore consultation again proved difficult to operate, and to maintain good images for the shore based medical support. The CamNet headset and videoconferencing over the INMARSAT A system was identified as being too expensive for offshore medical decision support.

Platform medics, doctors and dentists have deemed digital camera images satisfactory for diagnosis and treatment purposes. The transfer of digital images for decision support offshore operated best when coupled with the communication of relevant clinical information e.g. in the form of a medical assessment questionnaire. The shore-based doctors were therefore able to receive information and base decisions on a more complete clinical picture.

PC based videoconferencing systems operating over the PSTN network or equivalent were found to be not suitable and did not provide high enough quality images for medical decision support.

Dental problems make up 10% of offshore medical evacuations. The dental problems are not medical emergencies and can be eliminated by regular dental examinations. The dental certificate is a very important part of the fitness to work offshore certificate, and has reduced the number of evacuations required for dental problems.

A telemedicine or medical decision support service offshore provides reassurance to both the medic and patients/crew. As in other situations, merchant ships and remote communities, it was found that the remote practitioner appears to receive and gain much more reassurance from a teleconsultation than the shore-based doctor does.

The application (procedures and basic technology) proposed for use offshore, is a system that can be applied to any remote location where medical decision support is required comprising: a digital camera, communications (email) and a standardised medical assessment questionnaire. Service improvements to a "value added service" should be achievable at no extra cost. The suggested improvements to the medical decision support services can be achieved through the use of existing equipment and communications mediums. No additional hardware should be required on board the offshore installation.

When the personnel on board drops below 25 people, a platform medic is no longer required by law, and an advanced first aider acts as medical attendant. In this situation, the MERMAID application, in its present form, may be applicable. An adapted version of the MERMAID software could be applied for the offshore environment; the questionnaire or reports would then be adapted for the level/qualifications of the medical attendant. The MERMAID Multimedia Medical Guide would be rewritten or adapted, based on the contents of the rig medic course.

The medical decision support provider must have a dedicated computer facilities and procedures in place to deal with all foreseeable emergencies. The doctors viewing the transmitted clinical information and digital images are presently office based. However mobile communications and portable IT equipment can ensure that the doctor can receive and provide medical decision support from any shore based location.

For best results of medical decision support services, a need for doctors to be trained and experienced in providing advice over the communications system was identified. In addition, there is a strong argument for doctors to be made aware of the facilities, and indeed the way of life and living in general offshore, in order to appreciate better the constraints and feelings of those being treated.

A review of the technology, hardware, software and communications mediums that are used and available on board offshore installations is required. Knowledge of the technology used offshore and the exact platform medic (user) requirements will ensure the provision of a simple but effective medical decision support system for the medics, using existing equipment and provided at no extra cost.

In conclusion, as with other remote health care medical decision support, the offshore service should be made up of a number of facets;

- Efficient communications.
- Knowledge of the medical indent.
- Procedures.
- Specialist availability.
- Suitably trained personnel at both sites.
- Clinical information transfer.
- Continuing research and analysis to improve the system/service provision.

7.0 DISCUSSION.

Telemedicine technologies and high-speed data communications have been applied in three remote health care scenarios. Each application has proved successful, but each with certain barriers, obstacles and problems that have been overcome. This study has demonstrated the benefits that can be accrued from the use of telemedicine in medical decision support, and highlighted the aspects that should be taken into account in its provision.

Jardine (1999) suggested that new approaches to healthcare delivery are needed if the NHS is to continue providing a comprehensive and quality service. It has been demonstrated that telemedicine and telecare can effectively provide some of these changes.

The prime consideration must be how the use of technology will add value to the service being provided as part of the healthcare system for a community or group of patients. Within each of the scenarios studied, telemedicine application met the users needs.

Telemedicine will be of benefit to most countries in helping to cut health care costs. It has been identified that in almost every country more than half the costs of running hospitals is spent on what are essentially hotel services viz. bed, breakfast and other meals. If patients are saved transfer to these hospitals through the use of telemedicine, then the majority of these extra service costs will be saved.

Finding a way to provide reliable access to high quality health care at reasonable cost is an urgent problem in Europe today, and solutions must be pursued as they become feasible. In some localities, the existing telecommunications infrastructure is adequate to launch or expand ongoing efforts; in others, substantial improvements to network intelligence and bandwidth will be required to achieve many of the benefits.

Although telemedicine costs today are not low, countries with high health care costs are interested in the prospect of telemedicine as a way to reduce costs and demands upon hospitals. In the United States it has been estimated that between $36 Billion and $40 Billion could be saved if the health care industry were to use efficient telecommunications and telemedicine technologies (Little, 1992). This study has shown that high savings in transport costs alone can be realised through the use of telemedicine.

The health care industry serves virtually every individual, through public or private organisations, throughout Europe. The telecommunications industry has a similar local/national base. These two industries must work together in developing pilots, trials and implementations necessary to enable the full range of benefits to flow to those who are served by the health care industry nation-wide.

The more health care can become decentralised and administered efficiently in low cost settings such as community hospital clinics with telecommunications links, the less dependant patients become on expensive assets based sites such as hospitals for speciality care.

Cost Effective Telemedicine.

Cost effectiveness, or the demonstration of, remains a focal issue for researchers and health service providers. This study has not demonstrated definitive cost effectiveness in all three applications. The community hospital telemedicine service continues to provide medical decision support, and is expanding to other remote community hospitals in the region. The telemedicine equipment has been upgraded and made simpler to use. The other two applications viz. the marine and offshore environments, are operated as commercial services and in some respects must therefore demonstrate cost effectiveness. The maritime medical service is expanding and being installed on further ships. The components of this system have potential for other areas, and have been installed within a prison setting, and have application in remote Canadian communities. Telemedical support continues to be provided to the offshore industry using mobile telephones. This service is only one but nevertheless a key component in the effective provision of remote health care in this industry. The medical decision support component does have potential for improvement through the application of simple telemedical technologies.

The benefits of telemedicine and medical decision support appear obvious and were highlighted within Chapter 2 of this study. The benefits to the patient are simple to identify: reduced travel time, reduced time away from work, and faster treatment. They are however, difficult to place a cost or gain against. The benefits for the health care provider may also appear obvious: reduced travel time for consultants, better use of hospitals beds and resources, and high quality care provided in the community. But again, costs and financial benefits have been difficult to calculate. Some authors (Lancet, 1995; Hakansson, 1999; De Maeseneer, 1995) have called for further evidence of cost effectiveness and cost effectiveness studies have demonstrated the impracticability of some telemedicine research projects. However, this may be the point. It is research projects that are evaluated, and these rarely demonstrate cost effectiveness. Telemedicine technologies have a number of potential applications for the healthcare provider, but are frequently applied in only one sphere, and evaluated. The costs of telemedicine technologies can be spread across a number of applications, as are done with other medical technology advances, and teleconsultations can become more cost effective. Cost effectiveness evaluations should be undertaken only once an application has entered full service provision, only then can the true costs and benefits be analysed. Understanding the full financial effects of telemedicine systems on payers, providers and patients has been hampered by the lack of data from full-fidelity systems operating at a steady state. The vast majority of telemedicine systems have yet to achieve their full potential in serving their target populations and are operating well below capacity. The evaluation of telemedical services should include the assessment of patient management advice provided by telemedicine in comparison with conventional consultation. The diagnostic accuracy of telemedical applications has been and should be evaluated in comparison with conventional consultation. However, the evaluation should not be solely of the technology, but of the telemedicine process.

Telemedicine may be a difficult tool to evaluate, due the continually changing technology and infrastructure in which it is placed. The purpose of the application of telemedicine to the provision of remote health care must be made clear at the time of implementation. Telemedicine may not and has not been applied only to save costs, but also to ensure equity of access to health care services. Healthcare providers may use telemedicine in the provision of health services to ensure that all members of the community have access to these services, and cost effectiveness is therefore not applicable. Telemedicine services may have to be utilised because health care providers may be legally required to prove that they have done all within their power to treat a patient. In the future there may be malpractice threat from the non-application of telemedicine. There are many groups for whom telemedicine may be cost effective including society, third party payers, health providers and patients. It may be important and difficult to distinguish between groups in an economic evaluation.

Barriers to the Application of Telemedicine.

There are other barriers to the implementation of telemedicine and medical decision support for remote areas, apart from the demonstration of cost effectiveness. At present there appears to be few technological barriers to the implementation of telemedicine technologies. The newer and more refined technologies are proving highly effective and demonstrating clinical effectives in many areas e.g. teleradiology. The barriers that exist are non-technical and are primarily personal and organisational issues related to the changes required to take advantage of the technology.

One of the first faults in the application of telemedicine is application on the basis of geography rather than user needs. The actual user need for a telemedicine service must be identified and defined to ensure that the service is required, and what that service should include in terms of medical specialities. The location and users will define the telemedical service requirements, which should not be entirely based on previous applications in other areas.

Barriers to the implementation of telemedicine were discussed within Chapter 2.0. These barriers are primarily due to entrenched medical practitioners who have failed to visualise the benefits and potential that information technology can have in the provision of medical services. In respect to medico-legal issues, clinicians and health care organisations owe a duty of care to the patient irrespective of the systems they use to deliver the health care. Further, the confidentiality of a telemedicine system is no worse than that of a conventional systems, most of which are based on paper records.

Merrell (1998) suggests there is more to the failure of telemedicine projects than technology luddites, cost and the law. There are a number of requirements for successful telemedicine programs, missing one of these will result in failure. These requirements are:

- Telemedicine must be applied to an identifiable need.
- The need must be characterised by the resources available at the site of need.
- Provision of appropriate but simple technology <u>and</u> training.
- The information transmitted must capture the clinical situation accurately and in a manner that the specialist can recognise, analyse and interpret correctly.
- Transmissions in either direction must be completely confidential.
- The response must be comprehensible, comprehensive and compatible with the resources of the remote site.

As Wootton (1998) states "If telemedicine is to be developed to its full potential then the structure of organisations will have to alter". The manner in which a telemedicine application is managed, and how the application of telemedicine will change the way in which health care service provision must be taken into account.

Management of Telemedicine Implementation.

The organisational obstacles must be overcome, as the technology is only as effective as the ability of the users to adopt and apply it. Examining the telemedicine implementation from an organisational perspective there are a number of items that may appear to be lacking that would influence the development of telemedicine within any organisation. These absences can include perceived central leadership, strategic goals, technological information, scheduling responsibility, poor communication on introduction and the organisation of members whose scope of work will change. These items suggest a lack of user involvement and planning. Innovations in the application of telemedicine need to be matched by innovation of the organisation's communication, structure and procedures.

The successful implementation of telemedicine and informatics technology requires correct application of change management principles. Clear objectives must be stated and supported by all. Procedures will change for the present. With the application of any technology the manner in which actions are undertaken are likely to change. Departments within a healthcare organisation will have to communicate and consider each other's requirements. For example, IT departments have to consider the requirements of clinical departments when implementing an IT policy that includes telemedicine. Previously, within hospitals, IT departments provided services primarily for administrative and managerial departments. The clinical departments have different information needs that must be taken into account. The IT policy or strategy must also consider the interface with regional and national if not international telemedicine solutions, and not just a local area network interface.

The management of change requires that affected staff are involved from as early a stage as possible, that the change is planned, properly implemented and monitored and evaluated post implementation. Restraining forces should be identified and countered. Driving forces should be used to their maximum and assets for change motivated to generate solutions.

Telemedicine is about people, not technology. Without the people, a telemedicine application will fail. Practitioners, at the remote and central site must be involved, enthusiastic and understand the purpose of the telemedical intervention. The technology should be transparent to these people.

Telemedicine Strategy.

Recent political speeches have brought telemedicine to the fore in the UK. However, the response to the Government's commitment to improving inequalities in health care has been cool. Local cost savings on the application of telemedicine have been seen, but thorough economic analysis, has suggested only marginal cost benefits. The successful application of telemedicine in the UK requires a major change in existing patterns of service delivery and the decentralisation of the delivery of healthcare. There is not yet a clear telemedicine strategy for the United Kingdom, and this must change to ensure continued effective application that result in the provision of a medical service through telemedicine. The telemedicine implementations within this study have shown that medical decision support application needs to be managed like any other significant change in the manner care is delivered. A telemedicine policy would aid the implementation of this change.

During the 1990s the interest in economic evaluation of telemedicine has increased. Hakansson (1999) identified telemedicine projects that had undertaken some evaluation of the project. However only 10% of evaluations had included some sort of economic evaluation, and the majority of these have been modest.

Telemedical Application.

Goldberg (1996) stated "teleradiology and telemedicine have the potential to contribute to the dramatic changes that are taking place in the health care environment. This is a growing demand for equitable and affordable access to high quality health care". However the telemedical applications that are most widespread at present are those that do not require face-to-face interaction, or can proceed easily without face-to-face consultations. This emphasises the barriers to the implementation of telemedicine as a healthcare service delivery system. If the conventional consultation is changed beyond its present form, medical practitioners appear to inhibit the process. The actual process of the consultation is required to change, and to ensure that this is done efficiently and smoothly, the change process must be effectively managed.

Most studies of telemedicine have only evaluated its structure and function, with few examining even the subjective impact on doctors and patients, let alone the impact on clinical decisions or actions, such as prescribing.

Telemedicine will change the location at which a number of types of medical care are provided. In the community, the patient will be more likely to stay at home (telehealth), or require only the short journey to their local GP or community hospital. Clinical staff will be required to travel less. Travel to a remote specialist tertiary centre for tests and diagnosis should be reduced, and when required, prior planning and preparation will reduce the length of stay. The increase in the availability of information to both clinicians and patients and their carers will allow expertise to be more easily available.

Telemedicine Application for Developing Nations.

To date there has been no practical application of telemedicine within the developing world. Telemedicine may have the potential to provide health care services for the developing countries in the same manner as the developed nations, especially for rural communities. The communications infrastructures are being put in place and the cost of technology is decreasing and such applications are becoming more economical. There have been no pilots or trials implemented to demonstrate telemedical applications in these countries. However, it is not clear whether such applications would be based on user needs or merely for research purposes. Telemedicine may not provide a benefit if the medical infrastructure is not present. Devolving medical care to the rural community is impractical if the proper facilities are not present. Likewise, resources may be better applied to conventional public health care measures, such as providing medial supplies, education, clean drinking water and proper sanitation.

Requirements for Telemedicine.

Telemedicine services have been discussed and essential requisites identified. Four elements have been identified: (1) geographical separation between client and provider, (2) telecommunications technology to establish communications and interaction, (3) a complete system for the delivery of care developed, including a division of labour and specialisation among providers and staff, and finally, (4) the need for all the clinical maintenance and operational functions within the system to be staffed with qualified personnel whose training is uniquely suitable for this mode of practice. These final two points are possibly the most important, but yet overlooked. The implementation of telemedicine technology is relatively simple: the remote patient is present and the telecommunications technology is available. Unfortunately, the impact that providing telemedicine services has had on departmental practices and the training of staff are issues that do not appear to have been adequately addressed in community telemedicine.

A radical rethink of the manner in which healthcare is delivered in the UK must be forthcoming for telemedicine to develop. Some managers may inhibit the application of technology in healthcare provision, as they believe that funds for patient care will be drained. Most telemedicine practitioners believe in the benefits and the cost effectiveness that it can offer, but the evidence must be forthcoming and positive to drive service application rather than ad hoc research forward.

Telemedicine applications must move from research to service. Sustained use of telemedicine applications is dependent on the needs, people involved and the technology. The numbers of users or numbers of consultations will determine the success of the telemedicine service. Telemedicine systems are expected to achieve sustained use in communities with higher physician to populations' ratios and greater consumer knowledge and support of telemedicine. Rural physicians are deemed more likely to use telemedicine services if they have previous knowledge or experience with the provider of specialist services or strong relationships with the providing physicians.

The continued success may depend upon the application of simple and effective, low cost telemedicine projects using mediums such as PSTN and the Internet in a store and forward format.

Simple and Effective Applications.

High powered and innovative technology does not appear to be the answer to remote health care. The utilisation of stable and ubiquitous mediums such as the telephone may and have proven to be as efficient. Early studies by Moore (1975) compared telephone and television consultations, and showed no significant difference in diagnosis or treatment. However television (video) consultations proved to be significantly longer. A study comparing a number of differing telemedicine mediums of the time, demonstrated no significant differences in over 1000 cases. Evidence suggests that the telephone is just as effective a technology for telemedicine, and has to date be under-utilised. The new telemedicine pioneers may not have learnt the lessons that were noted in early telemedicine studies.

In 1992, Puskin suggested that the acronym, KISS should be applied to the implementation of telemedicine in remote health care. KISS stands for "keep it simple stupid". The ambitious, large-scale implementations though not doomed to failure, however have a greater potential to do so. Puskin (1992) has also suggested a number of factors which should be taken into account when starting or implementing telemedicine or remote medical decision support: the use of existing telecommunications infrastructure, at least at the beginning, the need to create a flexible system, the need for user involvement and insurance of the continuity of the service in the absence of subsidy, the human infrastructure development, the training of the users and finally good management and co-ordination.

Telemedicine in Trauma Care and Minor Injuries Management.

Telemedicine in the UK over the last five years has been particularly effective when applied to remote minor injury clinics. Pressure on accident and emergency departments is increasing annually, and minor injury clinics and community casualty departments are being used as a means of alleviating this pressure. Minor injuries clinics with telemedical support to emergency nurse practitioners can provide high quality care in the community and reduce the number of patients that require treatment at the accident and emergency departments. Likewise, medical decision support for GPs in community hospitals can reduce the number of patients requiring transfer. Minor injuries telemedicine addresses a demonstrable need to concentrate expertise while still delivering care locally. The provision of telemedical support to an emergency nurse practitioner at a minor injuries clinic is identical to the support required and provided to the offshore medic and remote military field medic, and the same principles and procedures applied.

Protocols for minor injuries telemedical services are essential to decide what treatment and management can be undertaken by the remote practitioners. Protocols have been pioneered by the Healthcare Trusts in Cornwall and Middlesex (Benger, 1999b; Tachakra, 1997). These protocols in some ways mimic the medical assessment questionnaires (MAQ)(Haston, 1993), Ship Captains Medical Guide (Department of Transport, 1983) and the MERMAID application. They act as a procedure that the remote practitioner undertakes in the examination and treatment of a patient. The minor injuries protocol suggests which injuries can be managed at the clinic, which require consultation by telemedicine and those where the patient must be sent to the A&E department. This is the same process which a First Officer on board a sea vessel would undertake using the Ship Captains Medical Guide. The guide would suggest treatment or communication with the shore doctor. The MERMAID application has improved on this process. The medical assessment questionnaire uses the same principles as the protocols in the collection of clinical data. A medical assessment questionnaire or a protocol is essential in the provision of telemedical support in ensuring that a standardised medical examination is undertaken by the remote practitioner and that all relevant clinical information is transmitted to the consulting doctor. Only then will the consulting doctor be able to ensure effective treatment and management. Telemedicine is a means to ensure the collection and transmission of this information effectively. These MAQs and protocols will need to be produced with the qualifications of the users and the remote facilities in mind.

<u>Telemedicine for Remote Communities.</u>

The application of telemedicine technologies for decision support in community health care service provision was successful. The telemedicine workstation saved 70 patient transfers during the clinical trial period. The cost effectiveness was proven for this workstation using the ISDN 2 network. The telemedicine technologies, with the exception of telepresence, were deemed satisfactory for clinical diagnostic purposes in trauma care management. The components were used as part of an integrated system, and no one component provided the sufficient clinical information for providing advice on patient management. Clinicians, both GPs and Specialists, found the technology satisfactory. The technology was simple to use, and aided the specialist in providing effective care.

Obstacles to the implementation were organisational and required procedures of use and protocols to be formulated to ensure minimal disruption to departmental routine and the treatment of other patients.

Patients received high quality patient care within the community hospital, and no patient was refused treatment by telemedicine. This type of scenario and such protocols have ensured that the service has been expanded for the benefit of other community hospitals within the health care region.

The regional healthcare trust has expanded the network of community hospitals with telemedical access to the A&E Department. Six community hospitals used a telemedical system to access medical decision support from A&E by 1998. Plans are currently being implemented to expand the network to a further 31 establishments including nurse practitioner led clinics. This expansion would not have been possible without the documented success of the original link undertaken as part of this thesis.

Telemedicine for the Merchant Marine Industry.

Medical decision support for the merchant marine industry has been improved through the application of software and utilising the existing communications infrastructure. The provision of a reliable and efficient medical support service is essential for these inaccessible work sites. The MERMAID application has improved on the reference information that resides on board, and has presented the advisory service in an easier and interactive format. The communications software has created procedures for the collection and transmission of clinical data. The shore-based doctor is provided with a complete clinical picture, and can effectively interact with the medical attendant and request further appropriate information.

The MERMAID application was successfully demonstrated on board six merchant vessels and at two virtual demonstration sites. Users of technical and medical backgrounds tested the application. The application was widely accepted and successfully used to provide effective medical decision support. The software is to be provided free of charge, and medical services charged for on a teleconsultation by teleconsultation basis. The medical multimedia guide has further application as a stand-alone medical guide. The communication component can be adapted for differing levels of end user, and can therefore be applied to other remote sites for medical decision support.

<u>Telemedicine for the Offshore Industry.</u>

Medical decision support is provided for the offshore industry in an efficient and simple manner. The new developments in telemedical technology and telecommunications, many of which are already available offshore, can be utilised to add value to the service.

The CamNet headset again proved ineffective in providing appropriate and cost effective aid for the offshore medic. Simple and effective methods such as digital cameras and medical assessment questionnaires are more applicable in this environment. Videoconferencing could help provide vital support and reassurance for the medic, but must be of sufficient quality to transmit images of diagnostic quality.

Applications such as MERMAID can be adapted for this environment and this level of medical attendant. However the communications and medical decision support service should be used as a component of an all-encompassing remote health care service, which includes: training, medical supplies, specialist availability, procedures and support.

Telemedicine for Communities, Mariners and Offshore Workers.

Telemedicine and medical decision support has ensured that patients have received high quality care at the primary point of care. Patients have been provided with consultant level support in all three scenarios, and many have been saved an unnecessary journey. Patients, who have required treatment at the specialist centres, were transferred with the knowledge that the consultant already knew of their injury/illness and was aware of the treatment required. Many of these patients were given treatment at the remote site prior to transfer making the journey more comfortable and less painful.

Although telepresence has not proved its expected potential in any of the applications within this study, improvements to the system and other applications were examined. The CamNet system image qualities have been improved and the head-mounted camera replaced by a high definition hand-held digital camera with monitor.

The provision of remote health care services should be made up of a number of components, of which medical decision support or telemedicine is only one. The components should include training (for personnel at both ends of the link), appropriate medical equipment (including drugs), reliable technology and communications, plus the medical decision support service. Some organisations have proved the benefits of using medical assessment questionnaires to ensure the accuracy and efficiency of clinical information gathering and transfer. These systems should in future be geared towards the qualifications of the remote practitioner and the location. The three scenarios studied, provided medical support services to three distinctly different levels of medical practitioner. Acknowledgement needs to be made of the fact that a service aimed at the GP would not be suitable for the First Officer on board a merchant vessel.

A medical decision support should be made up of a number of facets:

- Suitably trained personnel at both sites.
- Efficient communications.
- Procedures.
- Specialist availability.
- Clinical information transfer.
- Knowledge of the medical indent.
- Continuing research and analysis to improve the system/service provision.

Efficient communications and reliability of the communications link is essential in the provision of a telemedical service. A back-up or supplementary system must be available in case the primary link fails (e.g. satellite failure, link severance or server malfunction). In each of the three scenarios evaluated, the originating service, e.g. the radio medical assistance in the marine scenario, was maintained as the back-up. Within these scenarios the original service will not be removed as they provide reliability and security of service.

Telemedicine and remote medical decision support are ideal applications for screened isolated populations, such as offshore workers, merchant seamen and Antarctic bases. These populations are screened to exclude the potential for serious illnesses. Application for telemedicine in such circumstances, providing support to a remote worksite, should show immediate cost benefits.

The three scenarios studied within this thesis demonstrated that a low cost combination of off-the-shelf telemedicine technologies and existing telecommunications infrastructure could be used to make positive contributions to healthcare. Problems encountered are frequently not technical but cultural and managerial, highlighting the need for changes in organisational culture and procedures to allow both optimal use and further development of telemedicine. The use of procedures and protocols has ensured the implementation of telemedicine into service provision in the community and merchant marine environments. A simple and effective protocol is currently used in the offshore industry. Further application of telemedicine technologies would improve this service. However resistance remains among entrenched medical providers.

Telemedicine has the possibility to provide access to centres of excellence for various specialities theoretically from anywhere in the world. Telemedicine can allow the scarce resources of specialised and expensive equipment to be shared by a greater number of patients. Doctors may no longer be restricted by geographical boundaries, and international specialists can spread their skills across continents, even to battlefields, without ever leaving their own hospitals.

Future Scenarios.

The future of healthcare should be that of a seamless health care system, which makes both patient and practitioners lives easier with on line appointment systems, patient records securely accessed by appropriate people, remote consultations and follow-up, test results on line and the majority of primary care conducted in the community.

Within a few years health care providers should be able to see patients at remote sites using desktop and notebook computers in a mobile wireless configuration. Clinicians should be able to select interactive video or store and forward modes as required. Simple intuitive software shells should allow seamless access to pertinent patient records, radiographs, pathology slides, pharmacy information and billing records. Instant access to online libraries of medical information, diagnosis and treatment algorithms, and patient instructional materials should be available. Referral to specialists and allied health personnel would be done by computer-based scheduling. Patient information would be stored in archives that can be accessed by authorised medical personnel anywhere in the world. Privacy and security would be provided by encrypting data and restricting user access by means of passwords. This vision of a totally integrated telemedical system still exists. This solution is technically feasible today. However as previously mentioned, the barriers to implementation are not technical but procedural. This integration of components into the desired service will finally prove the effectiveness of telemedicine and ensure the provision of high quality medical care to all.

A potential network for the future provision of telehealth and telemedicine is through interactive television. Consumers are now able to order goods using the interactive TV.

This medium provides opportunities to deliver healthcare to peoples homes. Possibilities include provision of health information, appointment booking and monitoring of vital sign.

The future of telemedicine services lies with the application of the Internet and mobile telephony in the provision of clinical information transfer. These communication media combined with simple capture and viewing techniques and structured history and transmission formats, will ensure increase telemedicine uptake.

8.0 CONCLUSIONS AND RECOMMENDATIONS.

The originality of this study lies in the application of telemedicine technologies in the three remote health care scenarios involving emergency or trauma care. In the community medicine scenario, this is the only study of its type in the UK targeting the link between the Community Hospital GP and A&E Consultants for casualty support. In the maritime medicine scenario, the improved service using existing communications and hardware is novel. In the offshore scenario, slow-scan television as a decision support tool has been trialed, but the simple telemedicine technologies implemented within this study have not. Each application is novel in its use of an integrated system to improve remote medical service provision.

Each of the scenarios studied have analysed a telemedicine scheme that allows communication between two professional levels within the healthcare structure. The commonality between the two levels in each scenario influences the clinical information that can be communicated. This in turn influences the telemedical equipment required to be implemented and the medical equipment and training provided at the remote site.

The cost of implementing a telemedicine system does not conclude upon installation. The purchase costs can be a major factor influencing implementation. However the cost of service operation also requires consideration. Ongoing training costs, communications costs and costs of performing treatments at the remote site will require some re-distribution of healthcare service funding. Some organisations implementing a telemedicine service are restricted in their funding and the level of service that can be provided, both in terms of telemedical equipment and the treatment provided at the remote site. In applications such as the offshore scenario, the implementation and running costs of a commercial service may not be as critical to the organisation e.g. large oil companies, as within a National Health Service.

This research study has identified important features within each of the scenarios where telemedicine was implemented. Figure 8.1 shows a decision support framework that should be considered in the application of telemedicine for the provision of remote health care. The flowchart is primarily written with the remote site in mind however many of the issues raised are applicable to the specialist centre viz. communication infrastructure, training, telemedicine equipment, clinical protocols and structured clinical information gathering systems such as Medical Assessment Questionnaires.

This flowchart identifies some of the most important features that should be considered in implementing a new telemedical service e.g. for an oil/mineral exploration site in Greenland. A new system application team should consider the issues raised and investigate the most appropriate levels of equipment, staff and communications for their scenario.

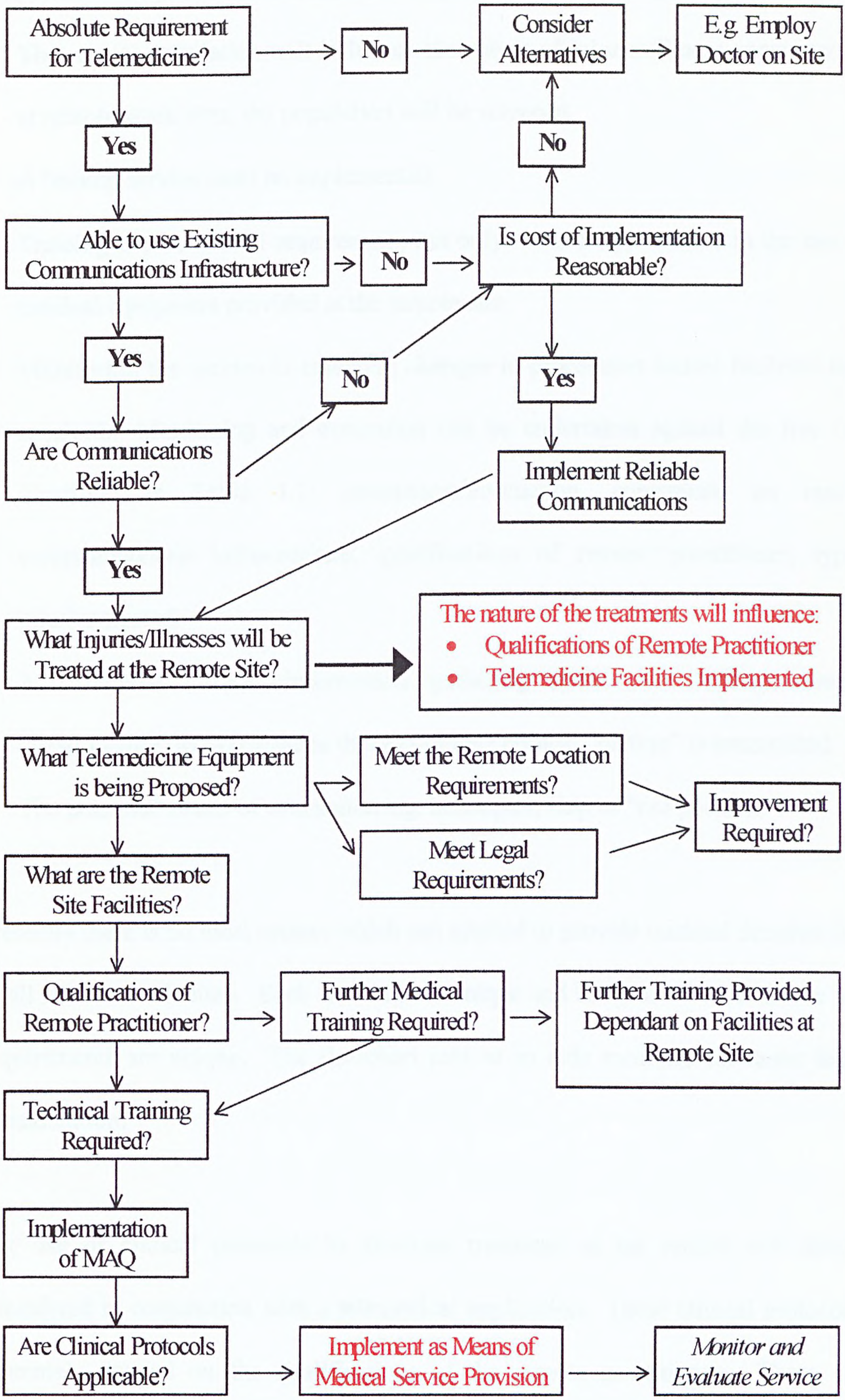


Figure 8.1: Telemedicine Implementation Considerations.

Some additional points which should be considered when looking using this flowchart:

- The remote population will influence the nature of injuries/illness encountered e.g. at remote work sites, the population will be screened.
- A backup service must be implemented.
- Training is an essential requirement, not only technically, but also in the use of the medical equipment provided at the remote site.
- Monitoring the service is essential; changes in procedures and/or facilities may be required. Monitoring and evaluation can be undertaken against the five criteria identified in Table 1.1: remoteness/evacuation, constraints on resources, communications infrastructure, qualifications of remote practitioner, types of injuries treated.
- A structured clinical information gathering system or medical assessment questionnaire (MAQ) ensures that a complete clinical "picture" is transmitted.
- The potential means of evacuation e.g. helicopter, ship or "not possible"?

Presently there is no ideal system which can applied to provide medical decision support to all remote work sites. Each work site is unique and therefore the healthcare service requirements are unique. The flowchart acts as an aide memoire for items requiring consideration.

The use of clinical protocols in directing treatment at the remote site should be considered in conjunction with a telemedical application. These clinical protocols will ultimately depend on the qualifications of the remote practitioner. These clinical protocols are similar in some respects and should augment the information provided by such sources as the International Medical Guide for Ships (World Health Organisation, 1988) and the MERMAID Multimedia Medical Guide.

Future work should consider the rise and use of the Internet for the provision of healthcare services and healthcare information. The Internet provides a ubiquitous communication infrastructure with common international standard protocols. Healthcare portals are being used increasingly as an information source by patients and should be considered by clinicians as an effective communication tool.

The legal implications of telemedicine service provision have been documented. However, telemedicine application is not presently required by law, but could become so in the future. An approved code of practice should be considered for telemedicine implementation and service provision.

Technically, telemedicine has no restrictions. Future improvements in video codec technology and compression techniques should be applied to telemedicine to ensure the provision of diagnostic quality images using the restricted bandwidths which are available and cost effective. The human-computer interface of telemedicine applications should be investigated to ensure ease of use and required functionality. Advancing technology such as artificial intelligence and expert systems to aid telemedicine intervention require investigation. A queriable database providing possible clinical outcomes will also be a useful tool for remote practitioners.

The use of non-clinical staff to provide on site medical support e.g. the first aider on board an offshore installation or a first officer on board a merchant vessel is becoming increasingly more common. The duties which these personnel can perform, even with medical decision support requires investigation.

Evaluation of telemedicine services that have reached full service provision should take precedent over evaluation of research projects and limited usage systems.

Finally, the management structure in the implementation of telemedicine services requires further investigation. Implementing telemedicine services often requires changes within the organisations, and the manner of how these changes are managed and leads the application into full service provision should be analysed for the benefit of future interventions.

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Appendix A

Journal Articles

Copies of the following journal articles are enclosed:

1. **Armstrong I, Haston W**. 1995. The SAVIOUR Project: A Review. *Journal of Telemedicine and Telecare;* 2(Suppl.1): 84-86.

2. **Armstrong I, Haston W**. 1997. Medical Decision Support for Remote General Practitioners using Telemedicine. *Journal of Telemedicine and Telecare;* 3(1): 27-34.

3. **Armstrong I, Haston W**. 1997. Costs and Benefits of a Telemedicine Link for a Remote Community Hospital. *British Journal of Healthcare Computing and Information Management;* 14(6): 14-16.

4. **Armstrong I**. 1999. Telemedical Lifeline. *Safety at Sea International,* January 1999.

5. **Armstrong IJ, Haston WS, Maclean JR**. 1996. Telepresence for Decision Support Offshore. *Letter to the Editor, Journal of Telemedicine and Telecare;* 2(3): 176-177.

Article 1.

The SAVIOUR project: a review

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Europe has many inhabitants geographically isolated from large urban centres. Since specialist medical services are located in such centres, inequality of access is the result. The SAVIOUR project was funded by the AIM subprogramme of the EU, as part of a larger project on biosignal transfer between specialist centres (BRITER, AIM Project A2050). The primary purpose of SAVIOUR was to establish and evaluate a telemedicine demonstration project between a small GP-based community hospital and a large trauma centre.

A number of telecommunication applications were combined:

(1) for remote consultation,
(2) to facilitate clinical information transfer,
(3) to examine the user–equipment interface,
(4) to identify organizational obstacles which would obstruct the development of telemedicine.

This small pilot project serves as a model for any remote site or community where the patient may be referred and transported to a specialist centre. This pilot restricted the specialist assistance to minor trauma cases presenting at a small casualty department in a community hospital.

The GP-based community hospital participating in the trial is in the town of Peterhead, Europe's busiest white-fish port, and a local agricultural centre, with industrial links to the offshore oil and gas industry. The town has a population of 20,000 and is situated 60 km north of Aberdeen. The town is not well served by transport links. There are no air, ferry or rail links and the main road south to Aberdeen is not dual carriageway, typical journey times being 60–90 min.

The community hospital is closely linked to the health centre, which serves a local population of 30,000. Facilities, which are of a very high standard, include:

(1) a 30-bed subacute admissions ward, with nursing support,
(2) a 6-bed maternity unit,
(3) outpatient clinics for visiting consultants,
(4) physiotherapy, occupational therapy and speech therapy,
(5) daytime radiography services.

The casualty department, with two treatment rooms and a resuscitation room, treats 1300 patients a month, about half being new patients. Up to three patients a day are referred to the accident and emergency department in Aberdeen.

The specialist centre of the SAVIOUR project is the accident and emergency department of the Aberdeen Royal Infirmary. By European standards, the geographical area served by this hospital is very large and includes the Orkney and Shetland archipelagos. Mainland journeys to Aberdeen are commonly more than four hours by road and, in winter, disruption to all transport services is not uncommon. As well as the Grampian Region and the Northern Isles, Aberdeen acts as a servicing centre for the offshore oil and gas industry, accepting patients from a large area of the North Sea.

From this brief description of the background of the project, it should be clear that even a small reduction in the number of patient journeys, so that only essential journeys are undertaken, will result in enormous savings both financially and in quality of life.

Methods

The workstation equipment consists of a number of 'off-the-shelf' components. The equipment communicated via either ISDN 2 or an INMARSAT-A satellite link. The workstations were positioned with respect to user requirements, confidentiality and available space. The 'remote' end was in the resuscitation room in the community hospital; the 'specialist' end was close to the senior consultant's office in the accident and emergency department of Aberdeen Royal Infirmary.

Videoconferencing used the BT VC7000 videophone with external camera and auxiliary input. Radiographs taken and processed in the community hospital were digitized using the Image Data Co Photoscan, a low-cost X-ray film scanner capable of digitizing and displaying images at a resolution of up to 10 line pairs per mm. The digitized radiographs were transmitted via ISDN to a Multiview PC and high-resolution monitor at the specialist centre. Annotation, image enhancement and zooming could be performed at both sites.

CamNet, a videoconferencing system developed by BT and ABB Nera, was part of the workstation. This equipment is marketed as a telepresence system. Telepresence is described as transporting expertise to a remote site. The term has been used in a number of marketing exercises and with different meanings. In this project, it provided the remote GP with a facility for performing examinations of a patient which could be observed by the specialist. The equipment consisted of a head-

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mounted miniature video camera with a noise-cancelling microphone. The CamNet headset sends images back through the codec of the videophone to which it is attached with a 30 m cable.

ECG recordings were sent over ISDN 2 using the SCP-ECG protocol developed during the AIM-funded project OEDIPE (AIM #2026) and further developed during the BRITER project (AIM#A2050), of which SAVIOUR is a part.

The telemedicine equipment operates through the ISDN 2 network. The ISDN 2 basic subscriber interface (basic-rate interface or BRI) provides the user with two 64 kbit/s B channels for data transmission and a 16 kbit/s channel normally used for setting up and managing calls. Two items of terminal equipment were connected to the ISDN 2 line: the videophone and the terminal adapter. Incoming calls were directed to the specific item of terminal equipment using multiple subscriber numbering.

The terminal adapter acts as an ISDN modem for the PC of the teleradiology equipment. Numbers can be stored by the terminal adapter, allowing easy dialling and connection. A single-port version of the terminal adapter was utilized, operating over one 64 kbit/s B channel. Digitized images from the teleradiology equipment were transmitted through the terminal adapters, using preconfigured ISDN numbers. ECG signals were transmitted from the same PC as the digitized radiographs using the Windows terminal program. The VC7000 unit utilizes both B channels for videoconferencing, although it is possible to use one channel, albeit with reduced quality. It is, therefore, possible to transmit video and teleradiology images simultaneously.

In order to ensure that similar telemedicine facilities could be utilized without access to the ISDN network, part of the project was aimed at using a man-portable INMARSAT-A groundstation at the remote end. Some development was required to integrate the teleradiology transmission via INMARSAT. INMARSAT offers only one 64 kbit/s channel and therefore the VC7000 video transmission was reduced to the single 64 kbit/s channel available on INMARSAT. The unit chosen for this project was the Saturn Compact Mobile Satellite LES (Land Earth Station). For the purposes of videoconferencing, telepresence and teleradiology, duplex connection with 64 kbit/s in both directions was used. For this, an external modem was required. The teleradiology equipment has a synchronous RS-232 port which required conversion to V.36 for INMARSAT transmission.

The trial was conducted to address a number of questions. These were answered using forms completed by the user for each consultation using the workstation equipment.

Results

Over the trial period, 120 teleconsultations took place. The majority of the presentations were minor trauma; a smaller number were infections and two medical presentations were obstructive airway disease and renal colic. Teleradiology was used in 116 of the consultations. Although a separate professional evaluation of the quality of digitized radiographs has been commissioned, the users, i.e. the GP and the accident and emergency department consultants, were asked to score the images on both usefulness and quality. On a simple ascending scale of 1–5, their respective mean ratings were 4.71 and 4.26 for image quality and 4.62 and 4.43 for image usefulness.

A procedure was established to ensure minimal disruption to staff at the accident and emergency department in Aberdeen. A teleconsultation was initiated by sending the radiograph to Aberdeen, where it was stored on the PC. A normal telephone call was then made to alert the accident and emergency staff that a consultation was required. Accident and emergency staff at Aberdeen then inspected the radiograph and initiated a videoconference at their convenience. Although teleradiology met with considerable approval by staff at both ends of the link, some of the negative remarks are worth noting:

(1) radiograph sent in wrong rotation,
(2) nobody answering in Aberdeen; room locked,
(3) poor original radiograph,
(4) non-appearance of radiograph in Aberdeen after sending,
(5) 20-minute wait for Aberdeen consultant,
(6) difficulty enlarging image,
(7) difficulty with ISDN connection,
(8) distortion of radiograph on scanning.

Videoconferencing using the VC7000 videophone was used in 76 of the teleconsultations. Because of the procedure set up to minimize disruption, the pace of patient throughput at Peterhead resulted in some teleconsultations being delayed until Aberdeen had responded to a request for consultation.

Both the remote community hospital and the specialist centre found the videophone to be useful. Comments from the specialist centre suggested that the teleradiology was the key to the consultation but, with familiarization, the usefulness of a direct interview with the patient became more apparent. From the GPs' point of view, videoconferencing provided greater reassurance that the specialist had a more complete clinical picture.

CamNet, the head-mounted external video camera, was used only four times. The presentations were:

(1) post-chemotherapy reaction at injection site,
(2) crush injury to the foot,
(3) infected bursitis of left elbow,
(4) injury to left ankle.

Although the CamNet headset allowed hands-free examination of patients, there is no doubt that in this situation the headset was cumbersome and time consuming to fit. In the few cases in which it was used, however, the equipment was said to be useful. There were a number of practical problems, even with the relatively user-friendly videophone. There were problems with connection, sudden loss of voice or picture, and complaints on the quality of the image. With the satellite link, there was difficulty in making the initial connection and some problems with the sound and image breaking up.

The advice given to the GPs was recorded for all teleconsultations. Advice was categorized as 'context free' and 'actual'. Context-free advice took no account of the available facilities at

Peterhead for patient management. For example, if there had been a plaster clinic at Peterhead then a number of patient referrals would have been unnecessary. Actual advice took account of the facilities. In spite of the lack of certain facilities at Peterhead, the number of patient transfers was significantly reduced. Seventy patients out of 120 teleconsultations were managed at Peterhead without referral. Analysis of these consultations indicated that referral would have taken place without teleconsultation.

Discussion

All of the equipment used for this trial was 'off the shelf'. The purpose of the trial was not to integrate or improve the equipment, nor to experiment with modification. The purpose was to examine the impact of teleconferencing and the interaction of the users with the equipment. While the teleradiology equipment has reached a high level of acceptability to the user, the interface of the equipment with the ISDN still requires improvement. The image quality of videoconferencing over ISDN 2 is still not ideal and had to be maximized with careful attention to lighting. CamNet proved not to be a useful application in this context. It has been used effectively when the remote practitioner, a paramedic on an offshore oil platform, was not medically qualified, thus fulfilling its description of transporting expertise to a remote site.

A notable outcome of this trial was the potential impact of teleconferencing on the organization of both sites. At the specialist end, the procedure used for setting up a conference worked well in that there was minimal disruption to departmental routine. However, this was a small trial. A higher frequency of calls would require dedicated staff and space. At the remote end, retaining the patient on site after receiving appropriate advice could only be accomplished if the facilities for management were available. Plastering has already been mentioned. In fact, during this trial, staff at the remote end began to acquire new skills rather than refer patients, having received advice or reassurance on management. Nevertheless, organizational impact is a complex issue. Patients retained at the remote site who require bed care will also require nursing and associated support. Currently, radiography at Peterhead is a daytime facility only. Patients seen out of working hours, therefore, will continue to be referred in person.

The GPs participating in the trial remarked on the training effect of the teleconferencing. Their participation in the consultation between patient and specialist had an obvious educational benefit. A benefit of the trial has been to raise awareness in the clinical staff of the potential for improved patient care and clinical teaching with advances in telecommunications.

Acknowledgements: This project was funded by the AIM Subprogramme, DG XIII/F of the EC and was conducted in collaboration with ABB Nera, Robert Gordon University, Aberdeen Royal Hospitals Trust, British Telecom and Aberdeen University. The project would not have been possible without the enthusiastic help of both the nurses and doctors at the Peterhead Community Hospital and Aberdeen Royal Infirmary.

Article 2.

Original article

Medical decision support for remote general practitioners using telemedicine

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Summary

A telemedicine link was set up between the casualty department of a remote community hospital and the accident and emergency department of a large urban hospital. The telemedicine link comprised teleradiology, videoconferencing and telepresence. The system was connected by ISDN (128 kbit/s) and also by a satellite link (64 kbit/s). During a one-year clinical trial, 120 teleconsultations took place between the community hospital and the specialist trauma centre, 110 using ISDN and 10 using the satellite link. Teleradiology was used in 116 teleconsultations, videoconferencing in 76, and telepresence in four. Survey results indicated that both the general practitioners running the community hospital and accident and emergency consultants felt that teleconsultation had improved patient care. Communication between clinicians using the telemedicine link avoided the transfer of 70 patients, representing an estimated cost saving of £65,000.

Introduction

Telemedicine[1] and more specifically teleradiology[2-4] are the bases of the SAVIOUR project (Study of Video Image Transfer, Orthopaedics up to Rehabilitation), which is evaluating a telemedicine link between a small community hospital and a large trauma centre[5] at the Aberdeen Royal Infirmary, a 1000-bed hospital with two accident and emergency departments: adult and paediatric. The adult department treats approximately 55,000 new attenders each year and the paediatric department treats approximately 21,000 new attenders each year.

The remote community hospital was in Peterhead, a small coastal town 60 km north of Aberdeen, in Scotland. The town is the largest centre of population in the local district, with a population of approximately 20,000 people, mainly employed in the fishing, agriculture, and gas and petrochemical industries. Transport connections to Aberdeen are poor. There is no local airport, no passenger ferry service and no rail service. The road link to Aberdeen is single carriageway for most of its length and public transport services by road are infrequent. In good conditions a typical car journey would take 45–60 min, while public transport would take 75–90 min (Fig 1).

The community hospital provides a 24-hour casualty service. General practitioners (GPs) supply the medical cover, including the on-call doctor for the casualty department. The casualty department treats approximately 1300 patients per month (Table 1). A radiology

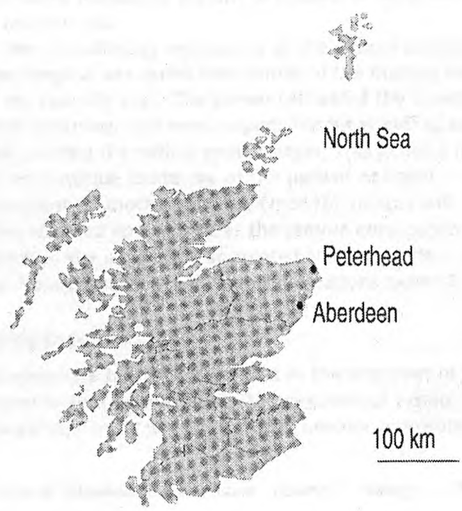

Fig 1 The site of the SAVIOUR project. The road link between Aberdeen and Peterhead is mainly single carriageway.

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Table 1 Casualty presentations at the Peterhead Community Hospital during a typical month

Attendance type	No. of patients
New attenders	647
Review cases	146
New GP acute cases	476
GP acute review cases	23
Total	*1292*

service is provided by the community hospital during normal working hours. Outside these times, non-acute trauma patients are asked to return the following morning for a radiograph. Acute trauma patients attending at night are transferred to Aberdeen by ambulance.

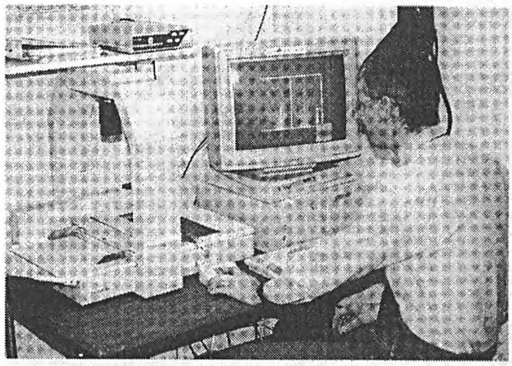

Fig 3 Teleradiology transmitting station. Digitizer and PC with high-resolution display.

Methods

Telemedicine workstations were placed in the resuscitation room of the casualty department at the community hospital, and beside the senior consultant's room in the accident and emergency department of the specialist centre. The workstations comprised videoconferencing units, a teleradiology system and a telepresence system. The system was developed for use over ISDN (at 128 kbit/s) and also tested using INMARSAT A satellite communications (at 64 kbit/s) (Fig 2)[6]. The telemedicine link was evaluated over a clinical trial period of one year.

Videoconferencing

Standard commercial desktop videotelephones were used (VC7000, BT). The videotelephone provided interfaces for additional devices, such as auxiliary

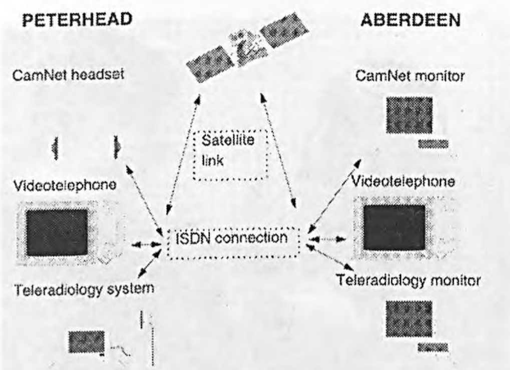

Fig 2 System architecture.

cameras (for telepresence), slide-to-video converters, document readers, extra display monitors and PCs.

Teleradiology

The teleradiology system comprised two main parts: the film digitizer and a PC with a high-resolution monitor (Photoscan, Image Data Corp) (Fig 3). The digitizer had a maximum resolution of 10 lines/mm at 256 shades of grey. Films up to 35 cm × 42.5 cm could be digitized.

The receiving PC and high-resolution monitor enabled both display and enhancement of the scanned images. An entire patient study could be viewed on screen. The monitor had a 1024 × 1024 pixel, non-interlaced video display.

The system allowed the viewing, annotation and enhancement of images on screen. The user could control the image contrast, brightness, orientation, negative/positive as well being able to perform zoom functions, displaying regions of interest at up to 400% of original size.

The teleradiology equipment at the remote community hospital was under the control of the nursing staff of the casualty unit. The nurses calibrated the system every morning, and were responsible for scanning and transmitting the radiographic images. This allowed the GP to continue treatment of the patient or begin treatment of another patient. Once the images had been scanned and viewed at the remote community hospital, the image was annotated and transmitted to the trauma centre via the communications network.

Telepresence

Telepresence has been described as the transport of expertise to a remote site[7]. The telepresence system in the present study was the CamNet headset, a prototype system developed by British Telecom and Nera Telecommunications. The CamNet headset was worn by the GP and enabled a consultant to view exactly what the remote practitioner was viewing (Fig 4). It simultaneously transmitted pictures and speech to the consultant. The headset consisted of four components: a miniature camera, eyepiece viewer (a high-resolution miniature display screen a few centimetres in front of the user's eye), a microphone and headphones (Fig 5). The miniature display screen allowed verbal communications to be supported by visual aids — such as text, diagrams or images — which the consultant or specialist could send to the user from a PC. The camera, display monitor, microphone and headphone were supported via a waist-belt pack. The belt pack was connected to the auxiliary port of the videotelephone by a 30 m umbilical cable.

Communications link

Telemedicine data (teleradiology images, videoconference and telepresence images) were transmitted either via ISDN using two 64 kbit/s channels (ISDN 2) or via the INMARSAT A satellite communications system, configured for high-speed data transfer (64 kbit/s).

Up to eight items of terminal equipment can be connected to a single ISDN 2 line. To direct incoming calls to a specific item of terminal equipment, multiple-subscriber numbering (MSN) was used. This allocated separate exchange-line numbers to each item of terminal equipment connected to the ISDN 2 line. Since two items of terminal equipment (the videotelephone and the teleradiology system) were communicating over a single ISDN 2 line, MSN was used to assure correct connection.

The INMARSAT network provided two-way high-speed data (DHSD) (64 kbit/s) transmission. A transportable land earth station (Fig 6) was used to connect the community hospital with the accident and emergency department in Aberdeen. The DHSD capabilities of the INMARSAT network allowed connection to any terrestrial ISDN number at a data rate of 64 kbit/s. There were three main components for the transmission of telemedicine information with the satellite system: the land earth station, a DHSD receiver (to ensure a duplex 64 kbit/s connection with correct data flow) and a switching unit (to switch to 64 kbit/s on initiation of the call).

The videotelephone connected the telepresence system to the chosen communications path. In order to connect the videotelephone to the satellite system an X21 to V36 converter (Nera) was used. The converter ensured that the correct common signals were passed between the two interfaces and also provided a buffer to counteract slight timing differences across the system.

The teleradiology equipment provided a synchronous RS-232 connection, which had to be converted

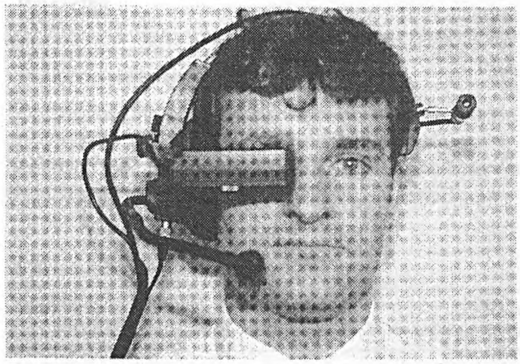

Fig 5 CamNet headset.

Fig 4 Telepresence equipment being used by a GP in the examination of a patient.

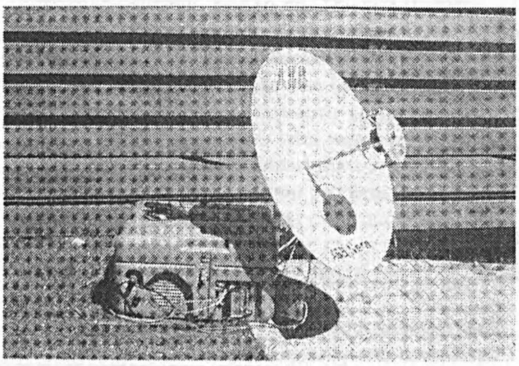

Fig 6 Transportable land earth station.

into the V36 required for the satellite. This was undertaken using a V36 to RS-232 converter (Black Box Ltd).

Teleconsultations

Patients presenting at the community hospital casualty department fell into one of four categories:

(1) non-acute injury or illness — these patients were seen by a GP during normal surgery hours;
(2) acute injury of a minor nature — these patients were treated by a nurse;
(3) acute injury, not an emergency — these patients were treated by the duty GP, but were able to wait for the doctor for a short period, for example if the duty doctor was out on a house call;
(4) acute injury, emergency — these patients required immediate treatment by the duty GP.

In the teleconsultations during the trial, patient-management advice and decision support were obtained for patients falling into categories 3 and 4 (i.e. patients with an acute injury requiring GP treatment).

A telemedical consultation between the two sites usually began with the transfer of a digitized radiograph. The consultant in Aberdeen was telephoned and asked to go to the workstation and examine the transmitted radiological image. The consultant then initiated a videoconference with the GP at the community hospital to discuss the patient details and case history. The consultant could also discuss the details with the patient. If the consultant wished to examine the patient, telepresence was used. The GP used CamNet and conducted the examination for the consultant. The consultant was able to direct the GP using the two-way audio link of the headset. Having seen all the case details, consulted with both GP and patient, and viewed the digitized radiograph, the consultant then advised the GP on patient treatment and management.

After a consultation, both consultant and GP completed a questionnaire (Appendix). The questionnaire[8,9] gathered information on the injury treated, equipment used, technical problems encountered, patient management and the transfers saved. Assessments were made on a five-point scale, with 1 representing not useful or inappropriate use, and 5 representing a very useful or very appropriate use.

Ethical approval of the study was obtained from the Joint Ethics Committee of the Grampian Health Board and the University of Aberdeen.

Results

Teleconsultations

During the one-year clinical trial (1994–95), 120 teleconsultations took place. The majority were for cases of minor trauma. However, two were for infections, one for obstructive airway disease and one for renal colic (Table 2).

Table 2 Injuries seen in teleconsultation

Injury	No. of cases
Medical presentations, e.g. renal colic	2
Fractures, e.g. fracture of head of humerus	28
Possible fractures, e.g. possible fracture of spinous process of T1	19
Miscellaneous injuries, e.g. neck injury	51
Sprains, e.g. inversion injury of ankle	4
Open wound/lacerations, e.g. head injury with cut eyebrow and facial abrasions	2
Miscellaneous, e.g. loosening dynamic hip screw causing pain	9
Crush injury, e.g. crush injury to foot	3
Infection, e.g. infected hand	2
Total	*120*

Teleconsultations commenced with the digitization and transmission of one or more radiographs in 116 cases (97%). Having received the digitized radiographs, the specialist consultant initiated a videoconference in 76 teleconsultations (63% of the total). In teleconsultations that proceeded without videoconferencing, clinical data transfer and patient management occurred using the ordinary telephone. The telepresence component of the telemedicine workstation was used in only four teleconsultations (3%)[10].

Videoconferencing

Videoconferencing was found to be useful in describing wounds, the placing of slings and collars, the positioning of dressings, and so on. The fact that the patient could interact with the consultant involved was also beneficial and allowed the consultant to gain more first-hand knowledge of the case in hand. During a teleconsultation the GP frequently consulted specialists and senior consultants who were present in the accident and emergency department at the time.

There were felt to be no real problems with picture quality. Some minor problems occurred when the integral camera was not focused correctly, or the user attempted to position himself/herself too close to the camera.

If the camera was properly focused then the transmitted images were of good quality and considered adequate for diagnostic purposes. Many of the teleconsultations involved consultant–patient interaction as well as consultant–GP interaction. The freeze-frame facility was often used to view specific regions or injuries. The patient would be seated in front of the integral camera and the injury displayed if possible.

Both the remote community hospital and the specialist centre found the videotelephone to be useful. Comments from the specialist centre suggested that the teleradiology was the key to the consultation but, with familiarization, the usefulness of a direct interview with the patient became more apparent. From the GPs' point of view, videoconferencing provided reassurance that the specialist had a complete clinical picture.

The GPs' and consultants' scores for the overall usefulness of videoconferencing are shown in Table 3.

Table 3 Doctors' rating of usefulness of the videoconferencing system (in 76 teleconsultations)

Location of doctor	Mean score	SD	No. of ratings
Specialist centre	4.2	0.9	61
Community hospital	4.7	0.6	69

Teleradiology

The quality of radiographic image was felt to be adequate and even excellent for the purposes of the GP. The software and user interface were very easy to use and described as 'foolproof'. Scanning was a simple operation, although the digitizer required frequent calibration to maintain quality. Fortunately, calibration was also simple.

The GPs at the remote community hospital and the consultants from the accident and emergency department scored the images for both quality and usefulness (Table 4).

Telepresence

The only injuries examined by telepresence were:

(1) injection reaction of the hand,
(2) crush injury to the foot,
(3) infected bursitis,
(4) possible fracture of the left ankle.

The headset was felt to be very cumbersome to put on and wear. The wearer was often distracted from the patient's problems and injuries in attempting to obtain good pictures, so that the GP was not providing the best quality of care.

The pictures transmitted to Aberdeen were of reasonable quality and adequate for decisions on patient management and, in the few cases where it was used, the equipment was said to be very useful (Table 5). However, the GPs did not rate the image quality or value as high as for those received or transmitted directly from the integral camera of the videotelephone.

Patient management

Seventy patients out of 120 were managed at the community hospital without referral. Analysis of these consultations indicated that referral would have taken place without teleconsultation. Thus, in spite of the lack of certain facilities at the community hospital (e.g. a plaster technician), the number of patient transfers was significantly reduced.

Of the patients who were viewed via teleconsultation, and were required to attend the specialist hospital, three were transferred directly to the appropriate specialist clinic for definitive treatment, and were not required to attend the accident and emergency department as would normally have been the case.

Table 4 Quality and usefulness of teleradiology images (in 116 teleconsultations)

Subject	Image quality score			Image usefulness score		
	Mean	SD	No. of ratings	Mean	SD	No. of ratings
Consultant	4.3	0.9	87	4.4	0.9	87
GP	4.7	0.7	107	4.6	1.0	107

Table 5 Telepresence usefulness and image quality (in 4 teleconsultations)

Subject	Image usefulness score			Image quality score		
	Mean	SD	No. of ratings	Mean	SD	No. of ratings
Consultant	4.3	0.6	3	4.0	1.4	2
GP	3.7	1.2	3	3.3	0.6	3

Table 6 Value of the teleconsultation (in 120 teleconsultations)

Subject	Acceptability of information received			Confidence in advice			Usefulness of teleconsultation		
	Mean	SD	No. of ratings	Mean	SD	No. of ratings	Mean	SD	No. of ratings
Consultant	4.5	0.8	84	4.6	0.6	84	4.2	1.0	84
GP	4.7	0.7	97	4.7	0.7	95	4.7	0.7	95

Quality of information

The GPs and consultants scored the value of each teleconsultation using the questionnaire. The ratings indicated that both the GPs and the consultants were very satisfied with the information they received (Table 6). Both the GPs and the consultants had confidence in the information they received through the teleconsultations, and therefore confidence in the information and advice provided. Finally, the ratings indicated that both sets of users felt that the majority of teleconsultations had improved patient care.

Equipment–user interface

The quality of the image viewed on the videotelephone monitor was occasionally poor, but was easily corrected by ensuring adequate lighting and retraining in focus techniques. When the images and data were transmitted via the satellite link, connection was much more difficult to achieve and maintain. Ten of the 120 teleconsultations took place using the INMARSAT A system. Video quality was poorer than that achieved when the data were transmitted by ISDN 2, since the data rate was equivalent to a single ISDN channel. The clinicians all commented on the reduced quality of video images, but were still able to obtain sufficient clinical information and satisfactory images to advise on patient management. Teleradiology image transmission continued to work well and image quality was good.

Discussion

Patient transfers

Throughout the clinical trial the system was used regularly by the remote community hospital. Between two and three patients per week were presented by teleconsultation, and over half of those patients were saved the journey to the specialist trauma centre. The resultant cost saving was estimated as £65,000. Patients treated in Peterhead received high-quality care within their own community. The patients who required treatment in Aberdeen were transferred with the knowledge that the consultant was already aware of the injury and the treatment required. Many of these patients were given treatment at the remote community hospital before the transfer, making the journey more comfortable.

Consultant and GP opinions

The study was beneficial in raising the awareness of the clinical staff of the potential for improved patient care, clinical teaching and economic benefits resulting from telemedicine. The GPs were satisfied with the information and advice they were given, and were aware of the usefulness and benefit to the patient that the teleconsultation provided.

The improved communication that this technique provided gave a more complete clinical picture to the consultant. At the community hospital, retaining the patient on site after receiving appropriate advice could be accomplished only if the facilities for management were available (e.g. plastering facilities). During the study, clinical staff at the community hospital began to re-acquire skills rather than refer patients. Patients retained at the remote site who required bed care also required nursing and associated support. Radiography at the community hospital was a daytime facility only. Patients seen after hours, therefore, had to be referred.

Another major benefit was the continuing education of GPs, which occurred simultaneously with patient care.

Equipment

All clinicians indicated their satisfaction with the image quality of both radiographs and video. The images were felt to be of diagnostic quality within the context of the telemedicine workstation use. While the teleradiology equipment was judged acceptable by the users, the interface of the equipment to the ISDN still required improvement. The teleradiology system was by far the most effective component of the workstation. The GPs were not fully trained in the examination of radiographs, but were able to obtain specialist trauma expertise when required. Despite these benefits, the GPs considered the teleradiology equipment was time consuming to use, and required the justification of transfers saved to continue use.

The image quality of videoconferencing over ISDN 2 was not ideal and was improved by careful attention to lighting. A disadvantage of the videoconferencing system was that the patient could hear the developing opinion of the consultant, whether good or bad. The audio connection itself was judged to be of poor quality when using the hands-free facility, and the users had to be aware of potential voice clipping. This can be overcome by upgrading the videotelephone.

The system may not have been used to its full potential. The communication was mainly between consultants and GPs, who have a common language. When the GP described the illness or injury, the consultant was familiar with the terms used. There was, therefore, not so much benefit to be gained from the use of the telepresence equipment. However, the consultant did frequently wish to conduct an interview with the patient, to discuss symptoms and so on, but was inhibited by professional etiquette.

Telepresence proved not to be a useful application in the present study. It has been used effectively when a paramedic on an offshore oil platform was not medically qualified, thus fulfilling its aim of transporting expertise to a remote site[11]. The telepresence system was more complex to use than the videotelephone, and required quite frequent use or training to maintain knowledge of the system. A number of technical enhancements would have made the system more user friendly, such as being able to view the consultant and/or a self-view image on the small monitor of the eye piece. The system would not have been so cumbersome to wear if the connection to the videotelephone had been via a wireless link rather than with an umbilical cable.

A number of patient injuries and injury descriptions were shown using the integral camera of the videotelephone. This proved a much easier option than telepresence and resulted in equally good image quality and patient management procedures.

Teleconsultation procedures

A notable outcome of this study was the effect teleconsultation had on the organization of both sites. At the specialist centre a procedure was followed to set up a teleconsultation that ensured minimum disruption to departmental routine. However, this was a relatively small study and a higher frequency of calls would have required dedicated staff and space.

Because the consultant was rarely allowed or able to speak to the patient directly, there was a perception that the consultations were led by the GP. Normally, the process is led entirely by the consultant. A new approach would be required to overcome this problem: on referral, all information would be delivered to the consultant. The consultant would have full control over the system, and would be provided with specific information on request. The GP should have seen, examined and spoken to the patient. This would be repeated by the consultant to confirm the information, possibly involving examination by telepresence. Separate or independent decisions would be made on management. This approach raises questions about responsibility and highlights the need to consider best practice in new methods of medical telecommunication.

The telemedicine workstation link, with the exception of the telepresence component, remains in operation, and runs as a routine service between the two hospitals.

Acknowledgements: We thank the consultants of Aberdeen Royal Infirmary Accident and Emergency Department and the general practitioners of Peterhead Community Hospital for their support throughout the clinical trial. We also thank Mr Patrick Barnes (Nera Telecommunications Ltd), Dr Fintin Wallis (Aberdeen Royal Infirmary), Martyn Riley and Iain Richardson (Robert Gordon University) for their contributions to the study. The study was funded by the European Commission 3rd Framework Programme, under the Advanced Informatics in Medicine subprogramme, Project A2050 – BRITER.

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Appendix. Questionnaire

Confidential: Project Teleconsultation Report Form (Peterhead v2.0)

Consultation episode number:
Consultation date:
Consultation time:
Peterhead patient number (from radiograph):
Patient name:
Date of birth:
Is the patient a Peterhead-registered patient? Yes, no
If not, where is patient registered?
GP's name:
Peterhead doctor's initials:
Problems discussed:

For the sections below, please tick and answer relevant questions if equipment was used during consultation.

Use of teleradiology equipment — radiograph sent to Aberdeen

Technical problems: none, minor, major (specify)
Radiographic views inspected: indicate up to two views and rate image adequacy and usefulness on a scale of 1 (poor/not useful) to 5 (good/very useful)

Videoconferencing — doctor–doctor

Technical problems: none, minor, major (specify)
Usefulness: rated on a scale of 1 (not useful) to 5 (very useful)

Videoconferencing — patient–doctor

Technical problems: none, minor, major (specify)
Usefulness: rated on a scale of 1 (not useful) to 5 (very useful)

Use of head-mounted camera

Technical problems: none, minor, major (specify)
Feature of interest: indicate up to two features and rate image adequacy and usefulness on a scale of 1 (poor/not useful) to 5 (good/very useful)

Context-free advice

Assuming any relevant facilities, equipment or skills available at Peterhead CH

Actual advice given

Overall

Rate the following on a scale of 1 (poor/not useful/unconfident) to 5 (good/very useful/confident):

Adequacy of information received
Usefulness of this teleconsultation episode
Confidence level that advice is appropriate
Did this teleconsultation save a patient transfer?
If the patient was transferred, did he/she attend an accident and emergency department? Yes, no

Comments

Article 3.

Costs and benefits of a telemedicine link for a remote community hospital

Iain Armstrong and **Wendy Haston** report on some quantitative and qualitative benefits from an experimental videoconferencing, teleradiology and telepresence link in northern Scotland.

Iain Armstrong

Dr Wendy Haston

A telemedicine workstation link was established between the casualty department of a GP-based remote community hospital (RCH) in Peterhead, 60 km north of Aberdeen, and the accident and emergency department of a large urban hospital (LUH), Aberdeen Royal Infirmary. The link was established under the EC-funded SAVIOUR project (Advanced Informatics in Medicine subprogramme). This low-cost link, applying 'off-the-shelf' technologies, was evaluated in terms of saved patient transfers and the costs and benefits for the remote community hospital.

Peterhead is a busy coastal town which acts as a supply centre for the offshore industry. Transport links between Peterhead and Aberdeen are relatively poor and journeys can take up to one and half hours. Patients who cannot be treated at Peterhead are frequently transferred to Aberdeen for treatment. The telemedicine workstation link provided the GPs in the RCH with consultant-level decision support from the A&E department of the LUH.

Equipment

The system was developed for use over the ISDN 2 network at a data transfer rate of 128Kbps and via the INMARSAT A satellite at 64Kbps. The link was operated for a clinical trial period of one year. The workstations consisted of three components:

- **Videoconferencing.** This was facilitated through the use of BTVC7000 videophones transmitting over ISDN.[1]
- **Teleradiology.** The Image Data Corp Photoscan system from the United States (Emed Truvel CCD Photoscan) was used. This consisted of two main components, the photoscan digitiser and the multiview PC with high resolution monitor. The multiview PC and high resolution monitor enabled display and enhancement of the scanned images. The images were transmitted via ISDN through a terminal adapter.[1]
- **Telepresence.** This used the BT CamNet headset, a prototype telepresence system produced jointly by BT and Nera Telecommunications. The headset is a lightweight, hands-free two-way audiovisual interface worn by the GP. It simultaneously transmits visual and speech information over digital networks (ISDN 2 and INMARSAT A with HSD).[1] It enables the consultant at the specialist centre to be 'virtually' present and 'looking over the shoulder' of the GP at the remote site, viewing exactly what the remote practitioner is viewing, and allows the consultant to monitor patient and practitioner actions and responses.

Consultations

From 120 teleconsultations throughout the clinical trial period, 70 patients were treated within the community hospital instead of being transferred to the LUH. The teleradiology and videoconferencing components facilitated efficient data transmission and information transfer between the two sites. The teleradiology system initiated 116 of the teleconsultations by the transfer of a digitised radiograph. Videoconferencing formed part of 76 teleconsultations. Both teleradiology and videoconferencing systems met with a high degree of user acceptance and continue to be used within the two hospitals.[2]

Telepresence proved to be of limited use within this clinical set up although it has proven its benefits in other medical situations.[3] The system was used only four times albeit with good results.

Costs

Equipment and transmission costs

The telemedicine workstation components were 'off-the-shelf', low-cost packages integrated into a functional workstation. Expansion of the link to other RCHs' transferring patients to the same LUH would spread the equip-

Table 1 Purchase and installation costs for both the telemedicine workstations

Videophones (BT VC7000) (x2)	11 710
Teleradiology system (photoscan and multiview) (x2)	33 074
Terminal adapters (Racal DAP4100) (x2)	2053
CamNet telepresence system	18 190
ISDN line installation (x2)	607
Total cost of installing the telemedicine workstations for use over the ISDN 2 Network (both sites)	£65 634
Mobile land earth station including HSD (Saturn Compac T)	31 715
Teleradiology interface unit	231
Total cost of installing the telemedicine workstations for use over the INMARSAT A Network (both sites) and ISDN	£97 580

ment and line rental costs of the LUH. The purchase and installation costs for the telemedicine workstations, at both the remote and specialist centres (1993–1995 prices), are shown in table 1.

The ISDN network was used for the majority of the clinical trial period.

Transmission costs were:

Line rental (both sites)	£1454
Line usage (both sites)	£ 336
Total transmission costs	£1790

ISDN Line usage costs, or call costs, are relatively low compared to line rental. The average costs per consultation for the 120 teleconsultations, using ISDN alone, were £2.80 for call costs and £12.12 for line rental, which is cheaper than transporting a patient by ambulance for one mile.

The cost of the telemedicine workstation equipment per consultation was £547. The equipment is capable of further usage, however, and using a reasonable approximation of 1000 teleconsultations per year, each consultation would then cost £66 in equipment costs, £2.80 for call costs and £1.45 for line rental, totalling £70.25.

Training

The workstation components were relatively straightforward and simple to use, and the teleradiology system actually included on-screen reminders. Clinical staff from both sites were given tutorials and demonstrations in workstation use and fault finding. On-site technical assistance was provided for the first three weeks at the RCH. This ensured proper use of the system, backed up the demonstrations and reassured staff using the systems. The tutorials in the use of the system were supported and re-enforced at various points through the clinical trial period to ensure continued appropriate use of the system.

Patient treatment costs

The costs incurred for patient treatment depended very much on the result of the teleconsultation. If the patient needed to be transferred to the LUH for treatment, either to the trauma centre or directly to a specialist unit, then this transfer was normally undertaken by the ambulance service. If the patient was treated within the RCH then the transfer-ambulance costs were saved. In some cases there were further treatment costs within the RCH.

average call and line rental cost per consultation is cheaper than transporting a patient by ambulance for one mile

One of the most common forms of treatment following telediagnosis was the application of a plaster cast. GPs did not routinely apply plaster casts before the telemedicine workstation was introduced but were able to apply casts to certain injuries and save patients transferring to the LUH as a result of the expert decision support. The application of a cast obviously has a time implication for the GP but is very time efficient for both the patient and the consultant.

Qualitative benefits

Although qualitative benefits of a telemedicine system such as this have a perceived value, the actual value can be more difficult to determine. In some instances the value of these benefits may be estimated. The following were identified by the participants as benefits highlighted in the clinical trials:

- Patients have access to more specialised levels of care within the community as GPs are able to contact consultant-level decision support when treating cases of minor trauma. Patients receive a faster and more expert diagnosis and treatment, a reduced number of examinations, avoid the inconvenience of travelling to another hospital or physician and can return to work or home life with less disruption;
- Remote GPs are able to access consultant-level decision support for all advice on injury management, while keeping patients within their care. This allows a fundholding GP to maintain control of the costs of the patient treatment;
- Patient waiting times at the LUH can be reduced by ensuring that non-urgent cases are treated appropriately at the RCH;
- The videoconferencing link provides an on-call specialist and consultant-level backup system for GPs. It promotes dissemination of advanced technological and clinical knowledge into the community hospitals;
- The telemedicine workstations enable the GPs to consult quickly with specialists of the LUH many miles away, without the cost and risks of transporting an ill or injured patient for a long distance. The location of the telemedicine workstation within the LUH ensures that any specialty can be dealt with and advised upon by an appropriate specialist or consultant.

Cost benefits and savings in patient transfer

The telemedicine workstations provide very tangible cost benefits from their use in the provision of trauma care. Savings arise from reduced travel costs of specialists, reduced evacuation costs of patients (ambulance costs), on hospital processing costs and accommodation of patients that can be treated remotely.

Transport costs

To transfer a patient from the RCH to the LUH by ambulance can cost £15 per km. The RCH is 60 km north of the LUH, so each patient transfer could cost in the region of £900 each way. Through the use of the telemedicine workstation 70 patient transfers have been saved, realising possible savings of up to £126 000 in transport costs alone.

consultant time is saved; patient time is saved

Consultant time

Consultant time is one of the most expensive items in the provision of healthcare. Waiting lists depend not only on the availability of facilities but also on available consultant time. By using videoconferencing, the consultant input to each episode is reduced. Time is saved, for example, by avoiding repeat initial examinations of injuries when patients are referred to consultants.

Patient waiting time

Previously, the transferred patient would have undergone two periods of waiting, one in each hospital, as well as the time taken to travel between hospitals. Teleconsultation reduced this to one waiting period.

Discussion

It is generally assumed that telemedicine will cut healthcare costs. It is believed that more than half the cost of running hospitals is spent on what are essentially hotel services: bed, breakfast, lunch, and evening meals.[4] If patients are saved transfer to these hospitals through the use of telemedicine, then the majority of these extra service costs will be saved.

The healthcare industry serves virtually every individual, through public or private organisations, throughout Europe. The telecommunications industry has a similar local/ national base. For telemedicine to grow, these two industries must work together in developing the pilots, trials and implementations necessary to enable the full range of benefits to flow to those who are served by the healthcare industry nationwide.[5]

Finding a way to provide reliable access to healthcare at reasonable cost is an urgent problem in Europe today, and solutions should be pursued as they become feasible. In some localities, the existing telecommunications infrastructure is adequate to launch or expand ongoing efforts; in others, substantial improvements to network intelligence and bandwidth will be required to achieve many of the benefits.[4]

Although the telemedicine costs of today are not low, a recent study by Arthur D Little in the United States estimated that between $36b and $40b could be saved if the healthcare industry in the US were to use more efficient telecommunications and telemedicine technologies.[5]

The more healthcare can become decentralised and administered efficiently in low-cost settings such as community hospital clinics with telecommunications links, the less dependent patients become on expensive asset-based sites such as hospitals for specialist care.

off-the-shelf telemedicine equipment can be used to make positive contributions to healthcare

The SAVIOUR project demonstrated that off-the-shelf telemedicine equipment can be used to make positive contributions to healthcare. The problems encountered were not technical but cultural and highlighted the need for changes in organisational culture to allow both the optimal use and further development of telemedicine.

Telemedicine has the potential to provide access to centres of excellence for various specialties from anywhere in the world. Scarce resources of specialised and expensive equipment can be shared by a greater number of patients. Doctors should no longer be restricted by geographical boundaries and international specialists could spread their skills across continents, even to battlefields, without ever leaving their own hospitals. ■

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Telecare for the elderly

BTHealth, working with the Anchor Housing Trust, has installed simple sensors in the homes of 60 elderly people to monitor key indicators such as movement and temperature change as well as the use of utilities (such as toilet flushes) or appliances such as kettles.

Information detected by the sensors is collected on computer and analysed for changes to the individual's normal patterns. If there has been no movement for a number of hours for example, the system alerts nominated carers by an automatic messaging system.

Article 4.

Telemedical lifeline

The European Commission's MERMAID Project has valuable experience to contribute to the future of maritime telemedicine. Iain Armstrong, Research Officer for RGIT Ltd's Centre for Health and Safety Sciences describes the initiative.

Telemedicine would greatly assist the treatment of a serious injury or life-threatening illness at sea. Photos: courtesy of Kvaerner Masa.

The IMO is presently preparing circular drafts on the role of telemedical advice centres and medical assistance at sea. This circular will look at the use of telemedical advice centres assisting captains in providing the right treatment for an injured or sick seafarer, or may help resolve a situation where evacuation is difficult or impossible. Global statistics on injuries and illnesses occurring in the merchant marine industry are not accurately reported, and this is causing concern. The costs of evacuation from vessels and offshore installations, or diverting ships are high. A telemedical application such as the EC-funded MERMAID Project may provide a solution.

The initial aims of the MERMAID Project were somewhat grand; "to provide a 24-hour multilingual, multidisciplinary, emergency telemedicine service". The final application is a scaleable system using the communications hardware available at the remote site, allowing the remote medic, first-aider, medical practitioner or lay-person, access to medical support in times of emergency. MERMAID has the potential to supply medical decision support to any remote site, e.g. remote work sites, remote communities, expeditions and remote travellers, and even round-the-world yachtsmen.

BACKGROUND

MERMAID was created in response to a number of international directives and discussions. The EC Directive 92/29 proposed that "the use of long distance medical consultation methods constitutes an efficient way of contributing to the protection of the safety and health of workers", while EC Directive 93/103 concerning minimum safety and health requirements for work on board fishing vessels, further strengthens the medical aid provisions. The G7 Nations proposed the provision of a "24-hour multilingual, multidisciplinary, global emergency telemedicine service". MERMAID has been adopted as the basis of this service, extending its influence from remote maritime medical assistance to any remote work site or community, anywhere in the world, which requires medical decision support and assistance.

TELEMEDICINE

Telemedicine has been defined as "medicine conducted when the patient is distant from the doctor". Telemedicine combines the use of information technology and telecommunications to allow medical information transfer between the patient and the doctor.

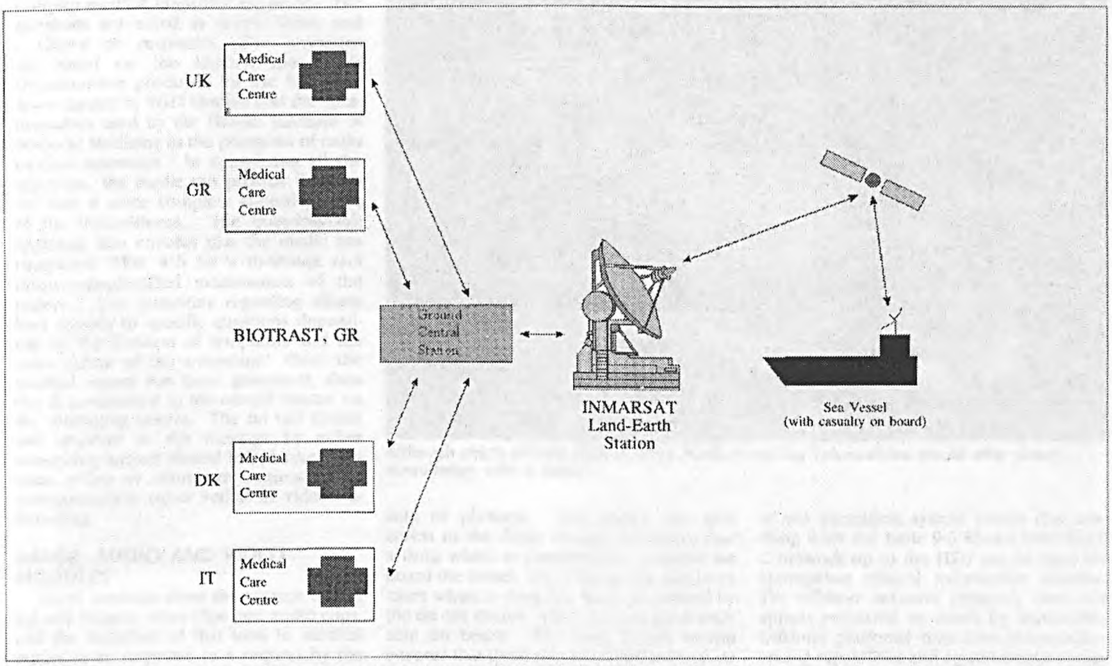
The doctor is provided with sufficient clinical information to make sound decisions on remote patient management. The MERMAID application, along with most other telemedicine applications uses an intermediary at the remote location to provide the clinical information for the doctor. The doctor is then capable of providing advice on patient management.

MARITIME MEDICAL SUPPORT

The primary point of contact for an injured or ill seafarer would usually be the First Officer, who is the medical support residing onboard. The First Officer has undergone a basic medical training course (2 weeks first aid plus some injection training). In the case of an emergency, the first officer has the capability to call a shore based doctor for support via a radio based system. CIRM, the Italian Radio Medical Centre, one of the oldest in the world, has responded to over 36,000 calls for medical assistance since its inception in 1935. A significant number of these result in saving expensive and time consuming evacuations.

OFFSHORE MEDICAL SUPPORT

Offshore, the primary source of medical expertise on board installations is the rig medic. The offshore medic is a qualified nurse with an additional medic qualification (4 weeks). There is obviously a skill difference between the offshore medic and the maritime industries' First Officer, however a medical decision support system is still an essential part of the service. Organisations such as RGIT Limited, not only provide the offshore medic, but also the medical decision support, with doctors



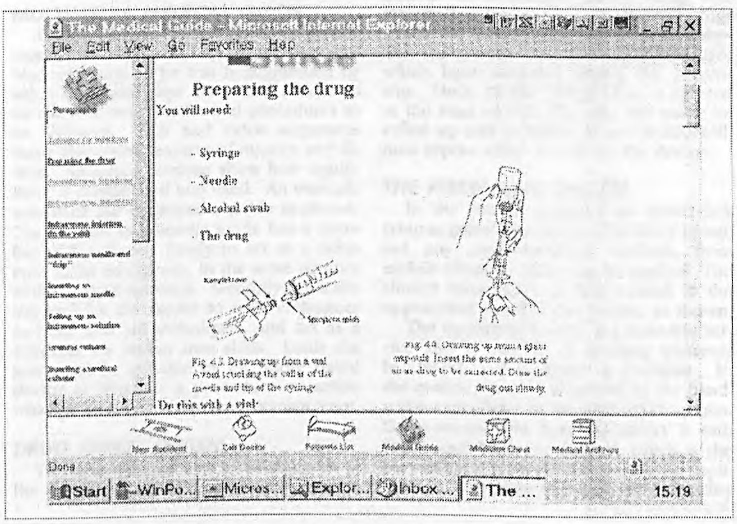
The messaging system is a scaleable service using whatever bandwidth and hardware is available.

on call 24 hours. In an emergency, the shore based doctor is contacted via telephone and provided with clinical information by the medic.

The doctor then advises on patient management and whether there is a requirement for evacuation.

In Aberdeen the doctors respond to medical emergency calls daily, and there is on average one medical evacuation per day on scheduled flights.

There is probably about one dedicated medical evacuation from the North Sea installations every week. These evacuations are not only expensive but potentially put more people at risk.



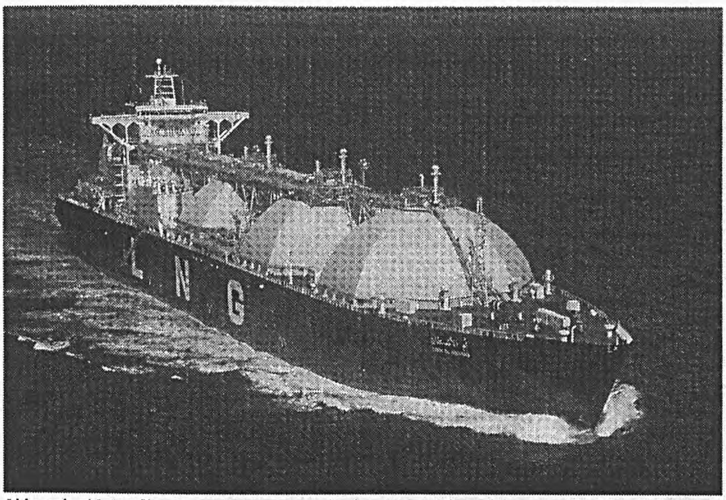
An example screen from the multimedia medical guide.

MERMAID

MERMAID aim to provide the on-call doctor with more relevant clinical information on which to base decisions on patient management. Information technology and advances in telecommunications have been applied to provide a medical decision support system which improves on the present radio or telephone based advice. The MERMAID application has two main components to provide emergency medical aid, a multimedia medical guide and a messaging system. The MERMAID multimedia medical guide is based on the WHO Ship Captains Medical Guide, and is for both training in basic procedures and as a reference during consultations. The guide is coupled with an effective communications and networking system which allows the first officer or offshore medic to transmit clinical information to the remote doctor for medical decision support. The MERMAID application is made up of a number of modules which will now be discussed.

MEDICAL REPORT GENERATORS

Depending on the severity of the injury or illness the medic is asked to complete a report on the patient condition. There are three categories; accident, illness and minor ailment. Accident and illness reports in messages being sent to the on call medical support. The other two reports result in messages being sent to the on call medical support. The medical report generators are a series of basic medical questions designed to provide the on call doctor with more clinical information. Details of the accident and the injuries are obtained before more complex medical questions are asked. The questions are asked in simple form, and a choice or responses. The questions are based on the Medical Assessment Questionnaire produced for the European Space Agency by RGIT Limited and the questionnaires used by the Danish Institute of Maritime Medicine in the provision of radio medical assistance. In completing all the questions, the medic can provide the doctor with a more complete clinical picture of the injury/illness. The questionnaire approach also ensures that the medic has completed what will be a thorough and almost standardised examination of the patient. The questions regarding illness lead directly to specific questions depending on the location of symptoms and the exact nature of the symptoms. Once the medical report has been generated, then this is transmitted to the on-call doctor via the messaging system. The on call doctor will respond to the message by either requesting further clinical information, pictures, video or sound, or request direct communication either verbal or videoconferencing.



Although ship's officers receive some medical training Telemedicine would offer direct consultation with a doctor.

IMAGE, AUDIO AND VIDEO MODULES

These modules allow the capture of digital still images, video clips and audio clips, and the inclusion of that item in medical report or in response to a request by the on call doctor. High quality digital images can be taken of the injury and complement the accident report. Video clips can be useful to show the movement or movement restrictions of certain injuries. Sound clips can illustrate breathing sounds and heart rate and strength. The software guides the operator through the use of the equipment. The image, audio and video modules are only used when there is appropriate equipment already on board.

MULTIMEDIA MEDICAL GUIDE

The multimedia medical guide, as already stated, is based on the Ship Captains' Medical Guide. The text is augmented by video and audio clips illustrating actions to be taken in emergencies and procedures to be followed. Still and video sequences show identifying features of injuries and illness. Animated sections show how equipment is constructed and used. An example screen of the multimedia guide is shown. The medical multimedia guide has a number of functions. Firstly to act as a reference in an emergency, in the same manner as the original textbook. Secondly as a training tool for the medic to train colleagues in basic first aid techniques, and act as a refresher for his/her own skills. Lastly the guide can be initiated by the shore based doctor to illustrate a procedure or action which is required for patient management.

DRUG EXPERT SYSTEM.

The drug module acts as stock check of the drugs and equipment held on board a ship or platform. The doctor can gain access to the drugs module to ensure that a drug which is prescribed is available on board the vessel. There has previously been cases where a drug has been prescribed by the on call doctor, which has not been available on board. The drug expert system ensures that there are no contra-indications between drugs which are prescribed and those which the patient may already be taking. The drugs and doses are stored on file and any possible contra-indications are brought to the doctors attention.

CREW MEMBER MODULE

The crew member module acts an archive for patient information. Initially all the crew member information is stored by the ships' medic. Information such as blood type and next of kin details are stored, along with information on; allergies, prescribed drugs which are being taken, alcohol consumption and previous accident and injury cases which have occurred during the present trip. Once all this information is entered at the start of trip, the data can easily be called up and included in any accident/illness report which is sent to the doctor.

THE MESSAGING SYSTEM

In the marine scenario the initial link (ship to ground station) is INMARSAT based, but any communication medium, from mobile phone to cable, can be applied. The clinical information is then routed to the appropriate medical care centre, as shown.

The messaging system is a scaleable service and is capable of utilising whatever bandwidth and hardware is available. In the marine scenario is limited by the bandwidth capabilities of the INMARSAT system. Some vessels now have INMARSAT B with HSD capabilities (64 Kbits/s) which is the bare minimum for videoconferencing applications. However the scaleable capability of the messaging system means that anything from the basic 9.6 Kbits/s INMARSAT C network up to the HSD can be used for appropriate clinical information transfer. The offshore scenario presently does not appear restricted as much by bandwidth. Offshore platforms now have videoconferencing capabilities and email/Internet access which can be used by the MERMAID messaging system as appropriate. The medical reports which are generated are sent directly to the appropriate medical centre.

The on call doctor replies immediately; requesting further information, progress reports, requesting pictures, audio or video sequences or advising on patient management. The on call doctor may in some circumstances, depending on the injury or illness request a telephone or videoconference with the patient and medic.

CONCLUSIONS

The MERMAID application has allowed much more clinical information to be forwarded to the on call doctor, providing a much better base for sound clinical decisions. The number of medical evacuations from both offshore installations and merchant ships will be reduced. There is not only a cost benefit of these reduced evacuations, the quality of care provided at these remote work sites has been increased, thus fulfilling some of the promises made by the EC, G7 Nations and the WHO, in their "healthcare for all" campaigns.

The MERMAID application is currently being evaluated aboard several Greek merchant vessels. The software is being closely evaluated at several virtual sites and demonstrated to offshore medics and marine industry medics (First Officers). The project is nearing completion, however requires further evaluation and development to ensure complete integration into both the offshore and marine environments.

Article 5.

Letter to the Editor

Telepresence for decision support offshore

Sir, We have tested a telemedicine system developed by Nera Telecommunications and British Telecom, with the aim of improving the medical decision making of paramedics working on offshore oil and gas installations.

There are up to 30,000 people living and working on installations in the UK sector of the North Sea. On most installations, primary care is provided by a nurse/ paramedic ('rig medic'), specially trained for work in remote and hostile environments. In a medical emergency the rig medics are expected to assess the patient, carry out life-saving procedures and stabilize the patient before evacuation. Dedicated helicopter flights are used to evacuate patients during medical emergencies, but these are always costly and may put medical and flight personnel at risk[1].

Currently, the rig medic is able to obtain 24 h advice and support from a shore-based doctor using the conventional telephone system. The rig medic, however, carries a considerable responsibility in the case of less clear-cut medical presentations. Faced with the choice of evacuating a patient or treating the patient offshore, the tendency is to err on the side of caution and arrange for evacuation. In a five-year study from a sample of offshore operators, over 300 dedicated medical evacuations took place[2].

Increasing the clinical information available to the shore-based doctor should allow a better decision to be made about the need for a dedicated medical evacuation. Even where medical evacuation is required, it may be safely delayed for a routine flight if a more complete clinical picture is available. Even a small reduction in the numbers of dedicated flights would significantly decrease risks and reduce costs.

Recent advances in telecommunications, and in particular the interfacing of ISDN with satellite communication systems, now enables dial-up videoconferencing from remote work sites to any location in the world.

In collaboration with BP, we carried out a trial of a simple videoconferencing system between an offshore platform, the Forties Bravo (Fig 1), and RGIT Limited in Aberdeen. RGIT Limited provides 24 h medical support to a number of offshore operators. The system used was a standard videoconferencing unit (VC7000, BT) sited in both the offshore surgery and the onshore consulting room (Fig 2). These were used in conjunction with a head-mounted external videocamera (CamNet), worn by the rig medic to aid in the examination of the patient. CamNet has been called a 'telepresence' system because it transports expertise to the remote site. It allows the shore-based doctor to conduct an examination using the rig medic as a surrogate pair of hands (Fig 3), or it can be used to obtain a fly-on-the-wall picture of the rig medic conducting an examination. The data link was provided through satellite communications (INMARSAT A) using a high-speed data service (64 kbit/s) with two-way voice and data transmission. Although most offshore platforms have their own satellite communications, a mobile land station with a high-speed data demodulator was used for this trial. Videocalls were initiated on the Forties Bravo platform, routed through a land earth station (Goonhilly), and directed to the shore-based doctor through the ISDN. Although the equivalent of only one ISDN B channel was used, the picture quality was good enough to be of clinical value.

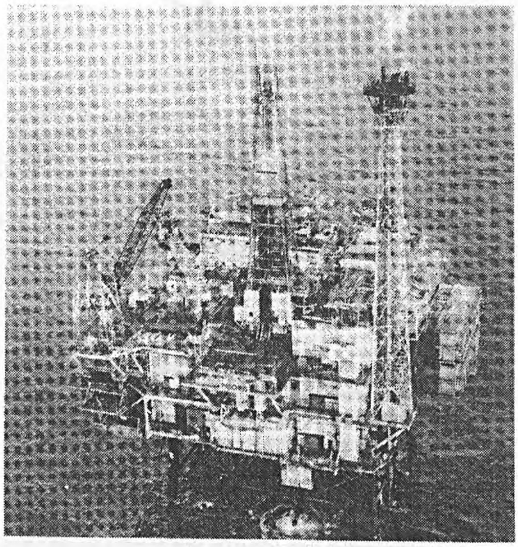


Fig 1 The Forties Bravo Platform.

After a period of training for the participants, a three-month trial was conducted with a mixture of real and simulated medical presentations. The trial was not designed to test a particular hypothesis but to gain experience in the use of the equipment, to highlight problem areas and to determine whether it provided the shore-based doctor with additional useful information. The test scenarios were selected to cover chest pain, abdominal pain, fever and trauma. The rig medics were also allowed to include trauma scenarios of their choice.

During the trial, only one potentially serious real case occurred. This was a patient with a worsening headache

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Journal of Telemedicine and Telecare 1996; **2**: 176–177

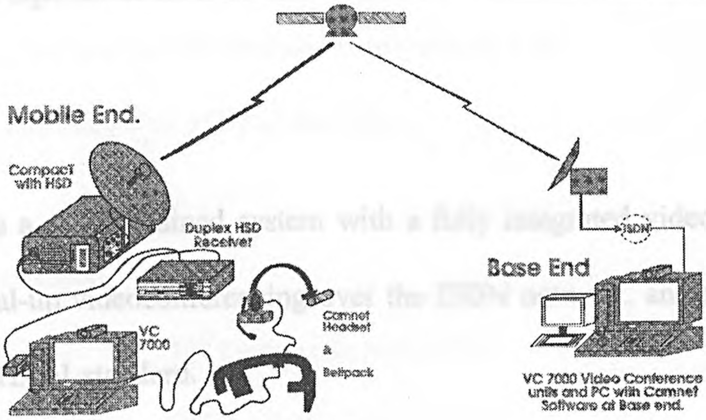

Fig 2 Outline of the system.

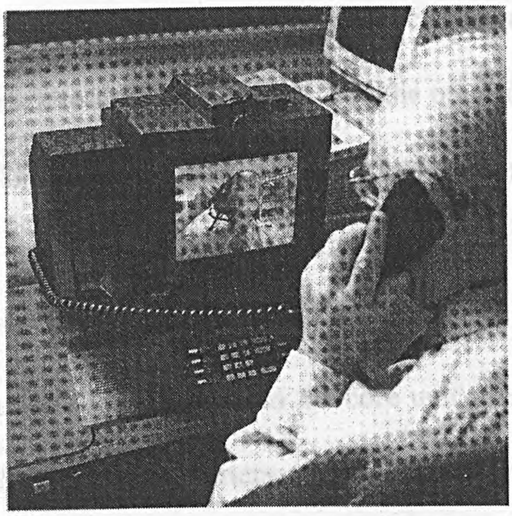

Fig 3 Equipment used by the shore-based doctor to conduct an examination through the rig medic, seen on his screen.

following a blow to the head two days previously. Weather conditions at the time would have prevented a medical evacuation and the rig medic was very concerned. Video consultation and examination by the shore-based doctor reassured the patient, rig medic and doctor that immediate evacuation was not required.

At the end of the trial the overall conclusion reached by the participants was that the telemedicine equipment significantly increased the quantity and quality of clinical information available to them. Decisions on patient management, particularly the decision to evacuate, were facilitated. It was noted that the less expert user, in this case the rig medic, gained a stronger sense of support and benefit than the more expert shore-based doctor. This has been noted in another telemedicine trial between general practitioners (GPs) and accident and emergency consultants, when again the less skilled GPs obtained greater reassurance through videoconsulting than the consultants[3].

Acknowledgements: We thank the rig medics, first-aid and communications staff on board the BP Forties Bravo platform for their enthusiastic support during this trial.

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Appendix B

Technical Specification of the VC7000 Videoconferencing System

Description

The VC7000 is a self-contained system with a fully integrated videocodec, providing high quality dial-up videoconferencing over the ISDN network, and is fully compliant with the CCIT H.261 standard.

The system is easy to install and can be set up for use by simply connecting two leads - one into the power socket, and the other into an ISDN 2 socket. It is portable (weighing 18kgs) and can be carried easily to another room/location for use.

The VC7000 also supports interfaces so that additional audio and video devices can be used to improve/add to the core unit's functionality such as auxiliary cameras; slide-to-slide video converters; document readers, and overflow monitors. Additionally a PC can be connected to the RS 232 port enabling voice/video and data to be transmitted simultaneously.

The system itself consists of a CRT monitor, integral camera, dial key-pad and codec. The user is helped though every stage of operation by an on-screen information system which also provides the user with set-up options, e.g. Quarter CIF or Full CIF; 64Kbits or 128Kbits working, wideband/narrowband audio etc.

The system will allow up to three people to be seated around the unit providing hands-free audio. Hands-free half-duplex audio comes as standard and can be easily upgraded to open audio by the addition of an audio conferencing unit.

The VC7000 will meet all BABT requirements.

Technical Specification		
Monitor/camera	10" colour monitor, RGB	
	CCD colour camera, PAL	
Keyboard	Part detachable numeric keypad	
	Special soft keys	
	LED indicators	
Key functions	Repeat/stored number	INFO
	Hands-free	Freeze picture
	Microphone OFF	Selfview
	Dialling keys (0-9, *, #)	Stop picture
	Send	Volume control key
	Disconnect	
Video	H.261 (CCITT Rec) (P x64, P =1 and 2)	
	CCITT H.221, H230 frame structure, synchronisation, configuration, control	
	CCITT H.242 Set-up procedures, change of mode, termination	
Picture resolution	Common Intermediate Format CIF (360 x 288 pixels)	
	Quarter Common Intermediate Format QCIF (180 x 144 pixels)	

Picture Frequency	FCIF video up to 15 pictures/s/QCIF up to 25 picture/s
Audio	CCITT G711 3.1 kHz 56 or 64 Kbits/s
	CCITT G722 7 kHz 48, 56 or 64 Kbits/s
	CCITT G728 3.1 kHz 16 Kbits/s
	Hands-free mode at 3.1 and 7 kHz
	Echo delay control : voice switching
Peripheral Interfaces	
Video Interfaces	Video input and output
	Composite PAL, 75 ohm, 1VP-P with BNC connectors
ISDN interface	1.420 (RJ 45 jack)
X21 interface	15 way 'D' connector
Data interfaces	V.24/V.11/RS232 9-pole D-sub
Audio interface	Audio input terminal:
	Signal level: 775 mV rms.
	Impedance: 400 Kohm phono socket
	Audio output terminal: signal level: 0-775 mV
	Impedance: Low phono socket
Diagnostics and Control	Automatic self-test at power-up
	Diagnostics menu
	RS232 interface for remote/on-site maintenance

Options

Peripheral devices	Graphics unit	PC
	Aux. camera	Slide-to-video
	Domestic TV	Videoprinter etc.

Power

Supply	220-250V AC, 50-60 Hz
Consumption	100 Watts (approx.)

Mechanical

Height	40cm
Width	38cm
Depth	40cm
Weight	18kg

Environmental

Operating Temperature	0°C to 40°C ambient temp
Humidity	10% to 90% (relative humidity)
Other	Storage and transport temperature -20°C to 60°C at an RH of 10-90% (non-condensing)

Safety Standards	EN60950 (Safety)	CISPR22B (EMC)
	BS6031 (Safety)	EN 55022 (EMC)
	BABT Approval Number NS/1000/5/N/603361	

Appendix C

Technical Specification of the CamNet Telepresence Headset

The CamNet Headset is connected to a belt pack, which contains an interconnection/power unit, a camera control unit and special PC to drive the Private Eye display. The headset is fitted with a single earpiece and volume control to allow the user to hear both the distant person and local speaker. The headset uses a noise cancelling microphone which has a preamplifier fitted in the associated Audio and Power Control unit. Also mounted on the headset is the camera, which feeds video to the remote expert through the external cameras input of the VC7000 and the Private Eye display.

The Private Eye provides a high resolution display (720 x 280 pixels) using red LEDs. The images displayed on the private eye are sent by the remote expert using a data transmission system provided by the VC7000.

Appendix D

Technical Specification of the Photoscan Teleradiology Equipment

Product Description

Photoscan is a new low-cost x-ray film scanner capable of digitising and displaying images at resolution of up to 10 line pairs per millimetre, the complete film scanner system includes:

- PhotoScan
- MultiView PC
- 19" Non-interlaced Display Monitor
- Digital Interface

Physical Features

Size	25"H x 22.5"W x 24"L (64cm x 57cm x 61cm)
Weight	48lbs (22kg)

Power Requirements

Power	<150W (<512 BTU/hr)	
Voltage	90-132V at 2 amps	180-254V at 1 amp
Frequency	48-62 Hz	

Variable Resolutions

Zoom Setting	Pixel Size (microns)	Lines per mm	Dots per inch
400%	99	10.0	256
200%	198	5.0	128
133%	297	3.3	85
100%	396	2.5	64
80%	495	2.0	51

Appendix E

Technical Specification of the INMARSAT A Satellite

Communications Equipment – NERA CompacT Land Earth Station.

Peripherals and Accessories

Peripherals, such as telefax and teleprinters can be connected to the Saturn CompacT.

Communication Facilities

- Direct dialling to the international switched Telephone Network
- Full message control from telephone instrument, local or remote
- Direct access to International Telex Network (option)
- Two ID numbers
- Private access/call accounting (with teleprinter version only)

Maximum time from commence assembly to on air 5 minutes

Environmental conditions

- Ambient temperature - Operating: -40°C to +55°C
- Humidity - Up to 95% at 40°C
- Vibration - INMARSAT spec
- Wind - Up to 17.1 m/sec
- Precipitation - Up to 10cm/hour

Physical features

- Equipment shock-mounted in custom-built unit
- Robust, moulded polyethylene case
- Rain resistant
- Weight 34kg
- Dimensions: 70cm x 60cm x 30cm

Power Requirements

- consumption

  - receive 75 W

  - transmit 150 W
- Voltages

  90-275 V AC

  12/24 V DC ± 10% (option-external inverter)

Options

- Teleprinter
- DC power supply (inverter)
- Telefax
- Data modems
- Heavy duty canvas carrying bag
- Transport wheels, Kit for wall mounted antenna
- Uninterrupted Power Supply (UPS)
- High-Speed Data (HSD)

Appendix F

Saviour Project : Information for Patients

Project Saviour is a one year project funded by the European Union. The purpose of the project is to set up and test an electronic link between Peterhead and Aberdeen. Using the link doctors in Aberdeen will be able to take part in consultations with patients in Peterhead, and give specialist advice where appropriate. You have been invited to take part in a trial of this equipment. Your consent to do so may lead to one or more of the following:

1) You may be asked to consult with a doctor in Aberdeen using a videophone - each person can see as well as hear the other person. The trial investigator will help you to use the equipment if necessary. Also your doctor in Peterhead may use a videophone to consult with the doctor in Aberdeen.

2) You may be examined by a doctor, nurse, or paramedic wearing a small camera. The doctor in Aberdeen can see whatever the person wearing the camera is looking at, and can talk to the person through a headphone.

3) Information recorded in Peterhead (such as X-ray pictures or heart traces) may be transmitted through a special communication link so that the doctor in Aberdeen can see the information displayed on a television screen.

4) You may be asked to give your opinion about the use of the equipment.

Please note:

You need not take part in the trial if you do not wish to do so, and you can withdraw at any time if you change your mind during the consultation.

The doctor in Peterhead will be responsible for decisions made about your care in Peterhead, whether or not you take part in the trial.

No tests or procedures (such as X-rays) will be done unless your doctor thinks they are necessary, whether or not you take part in the trial.

The information transmitted will not have your name on it, only a special code which will be kept confidential. Only the doctors involved and the trial investigator will know which X-rays (or other information) are yours. All of the transmitted X-ray pictures will be destroyed at or before the end of the trial. The original X-ray films will be stored in the same way they are now.

It is quite likely that your involvement in the trial will have no benefit for you on this occasion.

If you have any questions the investigator will be happy to give you more information, either at the time you are asked to take part, or later. You can contact the investigator at *Research Unit (Saviour Project Enquiry), RGIT Health, 338 King Street, Aberdeen AB2 3BJ.*

Appendix G

Saviour Project Large Urban Hospital Teleconsultation Report Form

CONFIDENTIAL **SAVIOUR Project Teleconsultation Report Form (ARI A&E v2.0)**

Consultation Episode Number : ____________ Consultation Date : ____________
(*provided by PCH Doctor*)
Consultation Time : __________

ARI Doctor Initials : ___________

Problems Discussed 1)______________________________

2)______________________________

Please ask the Peterhead Doctor the following two questions, and answer the subsequent questic yourself.

What is your opinion or diagnosis of the problems discussed : ______________________________

____

Without the videoconsultation opportunity, what would your normal patient management procedure have been :

____

____

For the sections below, please tick box and answer relevant questions if equipment was used during consultation.

☐ **Use of Teleradiology Equipment -** Radiograph sent to Aberdeen

Technical Problems *None Minor Major (Specify ....)*

Xray Views Inspected	Image Adequacy (Poor – Good)	Usefulness (Not Useful – Very Useful)
1)_______________	1 2 3 4 5	1 2 3 4 5
2)_______________	1 2 3 4 5	1 2 3 4 5

☐ **Videoconferencing** (Use of videophones)

☐ **Videoconferencing - Doctor-to-Doctor**

Technical Problems *None Minor Major (Specify ....)*

Usefulness (Not Useful – Very Useful) 1 2 3 4 5

☐ **Videoconferencing - Patient-to-Doctor**

Technical Problems *None Minor Major (Specify ....)*

Usefulness (Not Useful – Very Useful) 1 2 3 4 5

☐ **Use of Head Mounted Camera**

Technical Problems *None Minor Major (Specify ....)*

Feature of Interest	Image Adequacy	Usefulness
	Poor Good	Not Useful Very Useful
1)______________	1 2 3 4 5	1 2 3 4 5
2)______________	1 2 3 4 5	1 2 3 4 5

Context-Free Advice *(assuming any relevant facilities, equipment or skills available at Peterhead CH)*

1)____

2)____

Actual Advice Given

1)____

2)____

3)____

4)____

Overall

	Poor	Good
Adequacy of information received		1 2 3 4 5
	Not Useful	Very Useful
Usefulness of this teleconsultation episode		1 2 3 4 5
	Unconfident	Very Confident
Confidence level that advice is appropriate		1 2 3 4 5
Did this teleconsultation save a patient transfer?	Yes	No
If the patient was transferred, did patient require to attend A&E?	Yes	No

Comments

1)____

2)____

3)____

Appendix H

Saviour Project Remote Community Hospital Teleconsultation Report Form

CONFIDENTIAL **SAVIOUR Project Teleconsultation Report Form (Peterhead v2.0)**

Consultation Episode Number : ____________ Consultation Date : ____________

Consultation Time : __________ Peterhead Patient Number : __________ (from x ray)

Patient Name : ________________________ Date of Birth : __________

Is the patient a Peterhead Registered Patient? Yes / No

If not, where is Patient registered : ____________________ and GP's Name : ________________

Peterhead Doctor Initials : __________

Problems Discussed 1)____

2)____

For the sections below, please tick box and answer relevant questions if equipment was used during consultation.

☐ **Use of Teleradiology Equipment -** Radiograph sent to Aberdeen

Technical Problems *None Minor Major (Specify ....)*

Xray Views Inspected	Image Adequacy	Usefulness
	Poor Good	Not Useful Very Useful
1)______________	1 2 3 4 5	1 2 3 4 5
2)______________	1 2 3 4 5	1 2 3 4 5

☐ **Videoconferencing** (Use of videophones)

☐ **Videoconferencing - Doctor-to-Doctor**

Technical Problems *None Minor Major (Specify ....)*

Usefulness Not Useful 1 2 3 4 5 Very Useful

☐ **Videoconferencing - Patient-to-Doctor**

Technical Problems *None Minor Major (Specify ....)*

Usefulness Not Useful 1 2 3 4 5 Very Useful

☐ **Use of Head Mounted Camera**

Technical Problems *None Minor Major (Specify ....)*

Feature of Interest	Image Adequacy	Usefulness
	Poor Good	Not Useful Very Useful
1)______________	1 2 3 4 5	1 2 3 4 5
2)______________	1 2 3 4 5	1 2 3 4 5

Context-Free Advice *(assuming any relevant facilities, equipment or skills available at Peterhead CH)*

1)____

2)____

Actual Advice Given

1)____

2)____

3)____

4)____

Overall

Adequacy of information received	Poor Good	1 2 3 4 5
Usefulness of this teleconsultation episode	Not Useful Very Useful	1 2 3 4 5
Confidence level that advice is appropriate	Unconfident Very Confident	1 2 3 4 5
Did this teleconsultation save a patient transfer?	Yes	No
If the patient was transferred, did patient require to attend A&E?	Yes	No

Comments

1)____

2)____

3)____

Appendix I

Ship Captains Medical Training Course Syllabus

(Extracts from Merchant Shipping Notice No M.813 – Medical Training of Deck Officers in the Merchant Navy and Fishing Fleet)

The medical training of deck officers in the Merchant Navy and Fishing Fleet is closely related to the Ship Captain's Medical Guide, in order to assist officers to acquire a good working knowledge of the Guide for use in dealing quickly and effectively with emergencies requiring medical treatment which arise at sea.

A candidate wishing to qualify for the issue of a certificate of competency as Master must have attended a Ship Captain's Medical Training course and be in possession of the appropriate certificate, the examination for which was passed not earlier than three years before the date of the certificate of competency examination. A candidate who is not in possession of a valid Ship Captain's Medical Training certificate at the time of application for examination for the certificate of competency will be permitted to sit the examination but will not be issued with a certificate of competency until in possession of a valid Ship Captain's Medical Training certificate.

It is a requirement for admission to the Ship Captain's Medical Training course that a candidate be in possession of a valid First Aid at Sea certificate. Courses of instruction leading to the issue of a Ship Captain's Medical Training certificate embrace theoretical and practical training of a more advance nature than that required for the First Aid at Sea certificate, and are similarly followed by an oral/practical examination.

Applicants in possession of First Aid at Sea or Ship Captain's Medical Training certificates obtained in examinations held more than three years before the date of the certificate of competency examination for which they enter, will be required to complete a further medical training course as appropriate in order to re-sit the examination and obtain a valid certificate.

Examination Syllabus for the Ship Captain's Medical Training Certificate

(The whole syllabus to be based upon the Ship Captain's Medical Guide)

Sessions : - Two hours duration each.

1	Lecture	Poisoning: by alcohol, drugs, gases etc.
	Practical Demonstration	Treatment of poisoned patient. Method of use of the stomach washout.
2	Lecture	Venereal diseases. Alcoholism. Mental illness.
	Practical Demonstration	Preparation of smear slides for VD. Testing of urine with "Clinistix". Restraint of a violent patient.
3	Lecture	Medical emergencies: coronary thrombosis, stroke, pneumonia, diabetes, heat stroke, haematemesis, etc.
	Practical Demonstration	Observation of the patient. Temperature, pulse and respiration rate recordings. Simple nursing techniques. Injections. Control of pain.
4	Lecture	Surgical emergencies: appendicitis, peritonitis, bowel obstruction, urinary obstruction, etc.

	Practical Demonstration	Dressing of wounds and burns using "no touch" technique. Suture of wounds. Incision of abscess.
5	Lecture	Tropical and infectious diseases. (Malaria, dysentery, typhoid, smallpox, specific fevers, etc.)
	Practical Demonstration	Treatment of asphyxia. Resuscitation, respiratory and cardiac (revision). Use of breathing apparatus in rescue operations from ships tanks etc. Oxygen.
6	Lecture	General hygiene. General nursing. Emergency childbirth.
	Practical Demonstration	Sterilisation of instruments. Disinfecting. Film on emergency childbirth.
7	Lecture	Medical advice by radio. Signs of death. Medico-legal inquiries relating to death at sea.
	Practical Demonstration	Advanced nursing techniques – positioning of the patient in bed. Administration of fluid enemas. Washing of the patient. Cold sponging, etc.
8	Lecture	Description of medicines carried in scale II ships, with particular reference to the use of life-saving drugs. Antibiotics, Sulpha drugs, morphia etc.
	Practical Demonstration	Removal of foreign body from the eye. Application of eye drops and ear drops. Miscellaneous minor procedures.

Video films appropriate to the medical demonstration should be shown when possible.

Appendix J

MERMAID QUESTIONNAIRE FOR FLEET OWNERS AND/OR OPERATORS

Below there is a series of questions which will help us survey the current situation as it regards to the supply and demand of telemedical services worldwide. We would like to ask you to take the time to answer, to the best of your ability these questions. Even if your answers are incomplete, they will give us a good headway towards our goal.

In any case, your help will be publicly acknowledged and you will receive a copy of the series of reports that we plan to issue when our study is completed (approximately at the end of May, 1996).

The term telemedicine was coined in the 1970s by Thomas Bird and it refers to treating patients at a distance. It was not, however, until the 1980s that telemedicine began to get into the spotlight. Early examples of telemedicine were based largely on audio networking. Later the use of systems with two-way audio and one-way video capabilities came into use. Today, telemedicine brings effective medical care to populations inhabiting great expanses of land, much of which however are sparsely served by health care professionals. In other instances telemedicine is the only relief available to people working in remote and isolated locations, sometimes far away from places where qualified medical help can be found.

Telemedicine employs telecommunications networks to connect primary care physicians, specialists, and patients together. A telemedical application requires real-time communication in addition to conventional data exchange. Furthermore, communication systems which support integrated services are becoming more common in telemedicine as people get aquainted with telemedicine and their expectations for quality and effectiveness of telemedical services increase. Telemedicine, therefore, challenges us to rethink the ways in which medical services are provided and to use its techniques to address medical needs in situations where medical services are absent or in a short supply.

1. User identification

1.1 How many vessels does your company own and/or manage?

Own _______ Manage ______

1.2 What type of vessels does your company manage?

Type	Owned	Managed

1.3 What type of communication equipment are your vessels equipped with?

Type	Number of vessels
Inmarsat A	
Inmarsat B	
Inmarsat C	
Intelest	
High speed data	
Modem	
Telephone	
FAX	
Other (Please specify)	

1.4 Are your vessels equipped with GMDSS?

Yes ______ No ______

1.5 What nationality of Officers and Crew staff your vessels?

Nationality	Number of Officers	Number of Crew staff

1.6 What technology is available on board your ships?

1.6.1 Hardware

	Currently	In next 18 months
PC		
Telephone		
Fax		
Modem		

1.6.2 Software

	Currently	In next 18 months
Windows 3.11		
Windows '95		
Dos		
UNIX		
VMS		
Other (specify)		

1.7 Who provides medical assistance on board your ships

1.7.1 Who from the crew provides medical assistance in case of need?

Merchant marine officer ☐
Crew staff ☐

1.7.2 What qualifications does this person have?

Trained paramedic ☐
First aid training only ☐
Other ☐

1.7.3 When last did this person receive updated training

Year ________ Month ________

2. During the last three (3) years did someone in your organisation need telemedical services?

Yes ☐ No ☐

If yes, how many times?________

3. If your answer in "question 2" has been "yes", please indicate the language(s) that were mainly used during telemedical consultation?

		How many times
• English	☐	
• French	☐	________
• Greek	☐	________
• Italian	☐	________
• German	☐	________
• Spanish	☐	________
• Chinese	☐	________
• Russian	☐	________
• Arabic	☐	________
• Other (please specify)	☐	________

4. For the incidents described in "question 2", please describe in the following table their types and their frequency

	how many times
• sudden illness	________
• accident concerning one individual	________
• accident concerning more than one individual	________
• natural disaster	________
• act of war	________
• other (please specify)	________

5. Please classify the severity of the conditions described in "question 2" as they were initially perceived by the personnel on the scene

	how many times
• minor problems	____________
• routine problems	____________
• severe problems	____________
• problems requiring immediate medical evacuation	____________

6. What was the outcome of the telemedical intervention described in "question 2"?

	how many times
• substantial improvement, no further medical intervention required	____________
• improvement, further "conventional" medical attention required later	____________
• no improvement/ deterioration, medical evacuation necessary	____________

7. Please describe how do you normally handle an illness / accident requiring emergency medical assistance on board your ships. Do you contact:

	Yes	No
The centre in the country of origin of the ship?	☐	☐
The centre in the country whose shore you are nearest to?	☐	☐
The centre with the expertise related to the medical issue regardless of where it is?	☐	☐

8. Does your organisation have an interest for a 24h emergency, multilingual and multidisciplinary telemedicine service

Yes ☐ No ☐

9. Is your organisation prepared to pay a subscription fee for such a service?

Yes ☐ No ☐

Appendix K

MERMAID Software Review Evaluation Form/Checklist

System Engineering.	Are major functions defined in a bounded and unambiguous fashion?	
	Are interfaces between system elements defined?	
	Have performance bounds been established for the system as a whole and for each element?	
	Are design constraints established for each element?	
	Has the best alternative been selected?	
	Has a mechanism for system validation and verification been established?	
	Is there consistency among all system elements?	
Software Requirements Analysis.	Is information domain analysis complete, consistent, and accurate?	
	Is problem partitioning complete?	
	Are external and internal interfaces properly defined?	
	Does the data model properly reflect data objects, their attributes, and relationships?	
	Are all requirements traceable to system level?	
	Has prototyping been conducted for the user/customer?	
	Is performance achievable within the constraints imposed by other system elements?	
	Are requirements consistent with schedule, resources, and budget?	
	Are validation criteria complete?	
Software Design.	Are software requirements reflected in the software architecture?	
	Is effective modularity achieved? Are modules functionally independent?	
	Is the program architecture factored?	
	Are interfaces defined for modules and external system elements?	
	Is the data structure consistent with the information domain?	
	Is the data structure consistent with software requirements?	
	Has maintainability been considered?	
	Have quality factors been explicitly assessed?	
	Does the algorithm accomplish the desired function?	
	Is the algorithm logically correct?	
	Is the interface consistent with the architectural design?	
	Is the logical complexity reasonable?	
	Have error handling and "antibugging" been specified?	
	Are logical data structures properly defined?	
	Are structured programming constructs used throughout?	
	Is design detail amenable to implementation language?	
	Which are used: operating system or language-depend features?	
	Is compound or inverse logic used?	
	Has maintainability been considered?	

Coding	Has the design properly been translated into code? (The results of the procedural design should be available during this review)	
	Are there misspellings and typos?	
	Has proper use of language conventions been made?	
	Is there compliance with coding standards for language style, comments, module prologue?	
	Are there incorrect or ambiguous comments?	
	Are data types and data declaration proper?	
	Are physical constants correct?	
	Have all the items on the design walkthrough checklist been reapplied (as required)?	
Software Testing Plan	Have major test phases properly been identified and sequenced?	
	Has traceability to validation criteria/requirements been established as part of software requirements analysis?	
	Are major functions demonstrated early?	
	Is the test plan consistent with the overall project plan?	
	Has a test schedule been explicitly defined?	
	Are test resources and tools identified and available?	
	Has a test record-keeping mechanism been established?	
	Have test drivers and stubs been identified and has work to develop them been scheduled?	
	Has stress testing for software been specified?	
Software Testing Procedure	Have both white and black box tests been specified?	
	Have all the independent logic paths been tested?	
	Have test cases been identified and listed with their expected results?	
	Is error handling to be tested?	
	Are boundary values to be tested?	
	Are timing and performance to be tested?	
	Has an acceptable variation from the expected results been specified?	

Appendix L

Offshore Medic Information and Course Syllabus

(RGIT Limited, 1997)

All Offshore Medics must obtain a Certificate approved by the Health and Safety Executive before employment on an Offshore Installation. To qualify for this Certificate candidates must be Registered Nurses or have obtained an equivalent qualification in the Armed Services (e.g. CMT or LMA).

The full course is of 4 weeks duration and is divided into 3 Modules. Those attending the course for the first time must successfully complete all three modules. The certificate is valid for three years when a Refresher Course must be taken. The Refresher course is Module 1. Module 1 this the theory component, Modules 2 & 3 are the practical components of the course.

<u>The Offshore Medic</u>

As the only medically experienced person on board an offshore installation, the medic has the responsibility for providing all the medical needs of the crew. These locations may be isolated and often hours away from the nearest hospital.

Onshore there is a twenty four-hour advice centre and medical supervision, but on a remote installation, which may be cut off by foul weather, the offshore medic must be capable and have the expertise to handle all types of emergencies.

With the advent of stricter safety procedures, accidents are few and far between. However, acute illnesses still develop. These may vary from the common cold to a major heart attack or athletes foot to an asthma attack.

The training as an offshore medic is developed to cover most of the range of illnesses and complaints likely to be seen. It is however, mainly through past experience as a nurse or equivalent in the forces that the medic will be able to manage the range of ailments.

A busy offshore installation is not unlike a small village, which may have from 50 to 700 workers for whom the medic is responsible. Typically the medics work 12 hour shifts for 14 to 21 days and then be onshore for 14 to 21 days. Generally the offshore medic is not involved with medical duties for all of the time. Therefore other work such as general administration, accommodation allocation, radio operator or safety officer may be part of the role of a medic on an offshore installation.

In the UK Sector of the North Sea each, installation with more than 25 – 50 personnel on board has a legal requirement to have one medic on board, dependant upon the area and how close the installation is to shore.

The responsibility and capability of the offshore medic can mean life and death in certain circumstances. Therefore it is extremely important that they should receive the best training possible.

Offshore Medic Course Syllabus

Module 1 – Formal teaching covering a two week period.

The following subjects are covered with special reference to their relevance Offshore.

- History Taking and Clinical Examination
- Medical Conditions:
  - Eyes, Skin, ENT
  - Minor Illness, Dental Problems
  - Cardiology, Respiratory Emergencies
  - Abdominal Emergencies
  - Sexually Transmitted Diseases and Gynaecology
  - Psychiatry
- Trauma:
  - Head and Spinal Injuries
  - Burns, Hypovolaemic Shock
  - Musculoskeletal Injuries
  - Trauma Care and Triage
- Diving Medicine, Thermal Stress and Drowning
- Sudden Death Offshore, Drugs Problems
- Communications, Regulations, Medical Supervision
- Control of Substances Hazardous to Health
- Food Hygiene, Counselling Skills, Health Promotion

Practical Training includes;

- Basic and Advanced Life Support
- Airway Care, Cannulation, Catheterisation, Suturing
- Casualty Handling and Splinting
- Casualty Simulation Exercises

Module 2 – One week's attachment to a selected General Practice to gain experience of conditions seen in everyday Practice.

Module 3 – One week's attachment to an approved Accident and Emergency Department for practical experience.

Appendix M

Offshore Telepresence Medical Assessment Questionnaire

MEDICAL CONFIDENTIAL PLEASE CIRCLE APPROPRIATE ANSWER

Section 1 – Patient Details

1 NAME 2 DOB

3 DATE OF PRESENTATION 4 SEX MALE / FEMALE

5 JOB TITLE 6 EMPLOYING COMPANY

Section 2 – Comms used in Initial Referral of Patient

7 Technology Used Telephone / Videophone / CamNet / Fax

8 Time Spent on the Consultation <1 min / 1-5 mins / 6-10 mins / 11-30 mins / >30 mins

9 Have you any comments on the communications technology used in this case

Videophone :

CamNet :

Overall :

Section 3 – Appraisal of Incident

10 Body System Primarily Involved Cardio-vascular / Respiratory / Gastro-intestinal / Nervous / Other:

11 Urgency of Problem and when you would like an update on the situation from the medic

Acute emergency requiring immediate Medivac
Serious problem needing re-assessment and update in 10 minutes
Serious problem needing re-assessment and update in 1 hour
A problem but not urgent, re-assess and update in 6 hours
Minor illness, re-assess in 24 hours, update then only if necessary
Unimportant, reassure and discharge

12 The information most useful in helping formulate a differential diagnosis was

1

2

3

13 From this information, my differential diagnosis at this stage includes the following

1

2

3

14 In my opinion, the most likely diagnosis at this stage is

15 Comments on the medical aspects of the consultation

General

Knowledge Base

Section 4 – Evacuation Details

16 EVACUATED TO RGIT / ARI A&E / BP MEDICAL UNIT / GP / HOME / OTHER

Section 5 – RGIT Doctor Details

17 NAME AND SIGNATURE

18 DATE

Appendix N

Publication and Presentation of the Telemedicine Scenarios.

1. **Armstrong I.** 1995. Decision Support for Remote Medical Practitioners : within Round Table Debate involving both Telemedicine Centres and Prospective Users. *In : Proceedings of the World Congress on Telemedicine, for the Development of the Global Information Society for Health,* Toulouse, France, December 1995.

2. **Armstrong I, Haston W.** 1995. The SAVIOUR Project: A Review. *Journal of Telemedicine and Telecare;* 2(Suppl.1): 84-86.

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4. **Armstrong I, Haston W.** 1996. Medical Decision Support for Remote Communities and Work Sites. *Presentation at the Telemedicine in Wales : Progress and Potential Conference,* Cardiff, July 1996.

5. **Armstrong I, Haston W.** 1996. Emergency Medical Aid for the Marine Industry - The Mermaid Project. *In : Proceedings of the Fifteenth Leith International Conference, Aberdeen, Scotland, October, 1996.*

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7. **Armstrong I, Haston W.** 1997. Videoconferencing, Teleradiology and Telepresence in Trauma Care. *In: Proceedings of the Healthcare Computing Conference 1997 : Current Perspectives in Healthcare Computing,* Harrogate, March 1997.

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10. **Armstrong I.** 1998. Telemedicine for the offshore petroleum industry. *In the proceedings of Nordic Telemedicine and Maritime Medicine Congress,* Reykjavik, Iceland 1998.

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14. **Armstrong I.** 1999. UK Telemedicine Activities. *In the proceedings of The Information Society and Telematics Applications: an opportunity also for the Mediterranean Third Countries,* Catania, Sicily, Italy, April 1999.

15. **Armstrong I.** 1999. Telemedicine and emergency medical support on board offshore installations and merchant ships. *In the proceedings of the Fifth International Symposium on Maritime Health,* London, May 1999.

16. **Armstrong I.** 2000. Telemedicine - Simplicity is the key. *Journal of Telemedicine and Telecare;* 6(Suppl.1).