Medical Assistance at Sea

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Abstract

The MEDASHIP project makes available a telemedical service on-board of cruise ships and ferries improving the medical care of passengers and crew members. For the telemedical communication satellite-based technology is used as satellite communication offers the required broad geographic coverage, high transmission capacity and mesh-topology. The interactive video communication system WoTeSa / WinVicos used in the project has been designed especially for medical applications. The telemedical service has been tested on three ships with the possibility to connect to three land-based hospitals. As medical services general tele-consultation, tele-sonography and tele-cardiology were performed.

1 Introduction

Telemedicine services are becoming increasingly common and already have a number of land-based applications [1,2]. The main objective of the service which has been developed by the MEDASHIP project is to supply integrated solutions for medical consultations on-board of ships. Up to now ships could obtain medical advice via radio, however ships hosting doctors on board very seldom contact these centers because they cannot transfer a large amount of information about the patient and therefore do not see any improvement in the diagnosis. Available broadband satellite communication technologies could supply advanced telemedicine services such as telediagnosis, teleconsultation and telemonitoring. A telemedicine system for "first and second opinion" linked to a specialized medical center can contribute to solving various types of emergencies. This could also contribute to a patient being able to continue to be treated by the physician on-board and to avoid an expensive and difficult evacuation of the patient if the illness is diagnosed correctly and a crisis not overestimated.

The satellite-based telemedicine service of MEDASHIP addresses both passenger ships, ferry boats and cruise ships, and merchant vessels and is intended to provide travellers and crew members with an effective medical assistance in cases of emergency and in all those cases where the on board medical staff requires second opinion. During the validation phase the service was tested on board of three ships (ferry 'Superfast 12', cruise ships 'European Stars' and 'Olympia Explorer') with the possibility to have it connected to three land medical centers. The land medical centers for the validation phase are Sotiria Hospital in Athens, Evangelico Hospital in Genova, and University Hospital Charité in Berlin (**Fig. 1**).

The main pathologies of medical cases for the passengers on board the European Stars are graphically represented in **Fig. 2**. A large number of cases are about common and "routine" diseases (nausea, flu, cough, etc.) but there is a high number of cases were telemedicine can support the on board doctor (colic, contusions, allergic reactions, etc.). The physicians of the

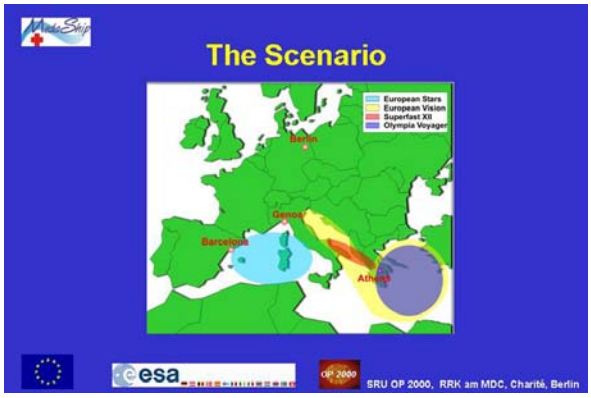

Fig. 1 MEDASHIP network: an Italian ship (European Stars) and two Greek ships (Superfast 12 and Olympia Explorer) are linked via satellite with the reference hospitals in Athens (Sotiria Hospital), Genoa (Evangelico Hospital) and Berlin (University Hospital Charité)

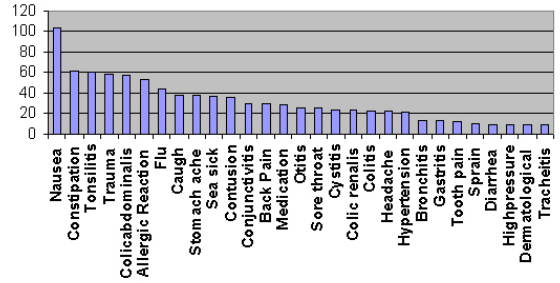

Fig. 2 Diagram of the main medical cases for passengers on board the European Stars

ashore hospitals evaluated the cases where they could have intervened with their diagnosis and second opinion. A large number of cases could have been further investigated with the MEDASHIP telemedicine system.

The MEDASHIP Consortium consists of D'Appolonia S.A. (I), Eutelsat (F), NCSR Demokritos (GR), Avienda (UK) and Charité (D). The project is co-funded by the EU (TEN-TELECOM Contract No. C27271). Further information can be found at http://www.medaship.com/.

2 Materials and Methods

2.1 Medical Devices of MEDASHIP

As new additional equipment two videocameras, an electrocardiograph (ECG) and an ultrasound (US) equipment are used. The first videocamera is used for videoconference, which is a vital telemedicine service for performing general visits as it allows the physician at the land hospital to see the patient and therefore perform a better consultation. The second camera serves as document camera for the digitization of analogous patient data and the transmission to the consulting physician. The ECG-device will be useful for cardiovascular pathologies representing one of the most common and easy examination that can be performed. Diagnostic ultrasound can be useful for gynecology, obstetrics, abdomen, etc.

The quality of the video output of the ultrasound (US) instrument plays a key role for the selection. As the US video is coded by the WinVicos (Wavelet-based interactive video communication system) system for satellite transmission it needs to have sufficient quality to start with. Extensive tests of the quality of the transmitted video with different US systems have revealed that a composite video output does not have a sufficient video quality for medical second opinion. It shows that at least an S-video output of the US system is required for a satisfying overall performance.

The electrocardiograph (ECG) medical system is a 12 channel ECG system and equipped with a network interface card for the connection to a LAN-network. Using IP-based protocols this allows for a complete remote operation of the device (control, data acquisition, data analysis) with a special software run on a PC. This makes the EKG-2000 system extremely suitable for use in MEDASHIP.

2.2 Communication System

Traffic-intensive applications such as teleconsultation, telediagnosis require real-time interactivity of the audio and video stream. High quality of images and video transmission require a bandwidth of 512 kbps up to 1 Mbps. For security the bandwidth (transfer delay and quality loss cannot be afforded for medical data) as well as the confidentiality of patient data have to be guaranteed.

Satellites offer high transmission capacity, interactive connections, interoperability with terrestrial infrastructure, reliability and costs independent of the distance. Therefore, considering the mobility of the ships and the bandwidth requirements, only satellites are the most fitting infrastructure for the envisaged maritime telemedicine services.

The ships are equipped with a VSAT-terminal consisting of:

- Indoor unit (Linkway) modulating the data stream for transmission and demodulating the received data;
- Outdoor unit consisting of RF package transmitting the signals to the antenna, Ku-band stabilized platform, on-deck antenna (Seatel), antenna control unit, radome, GPS receiver and radar filter.

In the hospitals respective VSAT-terminals are installed.

WinVicos (Wavelet-based interactive Video communication system) is a high-end interactive video conference system providing real-time video, still-images and audio transmission. The system has been designed with interactive medical applications in mind, i.e. tele-consultation, second opinion, telementoring, teleteaching, etc. For video compression WinVicos employs a hybrid speed-optimized wavelet codec (PACC, patent Deutsche Telekom DE 197 34 542 A1).

WoTeSa (Workstation for Telemedical Applications via Satellite) is the hardware on which the WinVicos system is operated. The hardware requirements are met by an IBM-compatible PC with Pentium IV processor (≥3 GHz), 512 MB RAM, two Osprey video capture cards and two cameras as live video source and document camera. The S-video and composite video inputs of the Osprey video capture card can be directly connected to the different medical equipment

(**Fig. 3**). Details about WinVicos and WoTeSa have been described elsewhere [3,4].

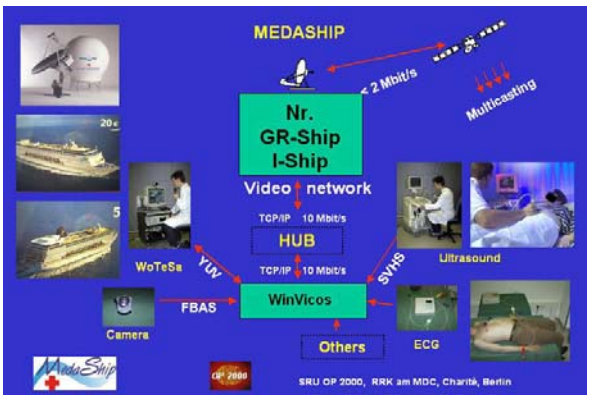

Fig. 3 Video network on-board of the ships. Video cameras, ultrasound medical device and ECG-device are connected to satellite terminal via WoTeSa / WinVicos.

3 Results and Discussion

3.1 Medical Applications

Teleconsultation

The live camera on-board of the ship can be used to transmit the image of the doctor who is leading the examination on-board of the ship or the image of the patient when being questioned by the land-based expert. It can also be used to show the land-based expert an injured part of the patient's body which he needs to see for his consultation. Thus a very realistic and effective live communication is possible (**Fig. 4**).

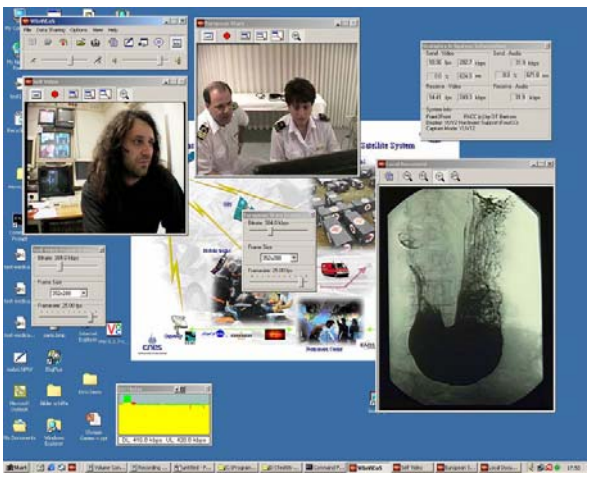

Fig. 4 Interactive telecommunication between ship European Stars and University Hospital Charité. Two live video streams and a document are transmitted.

Electrocardiography

The ECG system is connected to WoTeSa on board the ship and can be controlled by the physician from this workstation. Via an application sharing software also the expert can control the ECG system from the land-based workstation. The main menu with all functions of the ECG as well as the patient's ECG are transmitted to the expert. Thus the expert and the physician on board can jointly analyse the ECG report (**Fig. 5**).

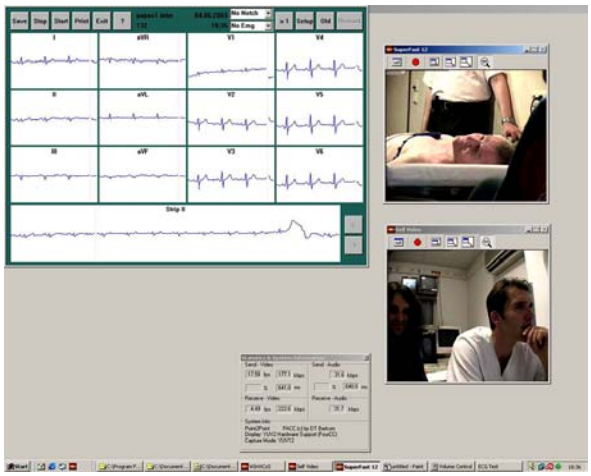

Fig. 5 Tele-electrocardiography: the 12 channels of the ECG-device on-board of the ship are transmitted to the reference hospital. All functions of the ECG-device can be remotely controlled.

Telesonography

The S-video output of the US equipment is directly connected to the Osprey video capture board. Satellite transmission tests have shown that not only still images can be transferred but also live ultrasound investigations can be transmitted at 500-700 kbps (**Fig. 6**).

Fig. 6 Telesonography: A medical doctor at the University Hospital Charité is consulting an ultrasound examination of a patient on-board the cruise ship.

Document camera

With a document camera analogous patient data can be captured and digitized by WinVicos as a document. For example X-ray or CT-images can be cap-

tured from an illumination board and displayed locally and transmitted.

Non-medical Applications
WoTeSa / WinVicos has not only been designed for telemedical applications but is also suitable for general teleconferences. WoTeSa / WinVicos can thus be used for private teleconferences or for corporate teleservices where especially the functionalities of white board, chat, file transfer, etc. can be useful for telementoring and teleeducation of the crew.

Data Security
Unlike open network satellite equipment technologies Linkway uses a proprietary acquisition and synchronisation technique making signal interception and decoding virtually impossible. Data Security is also assured by the coding algorithm of the WinVicos software. The transmitted data can only be decoded by this software.

3.2 Business Plan

A market analysis reveals that the cruise shipping market is growing. The shipping companies are interested in telemedical services as they can improve the quality of medical care on-board dramatically. Currently cruise ships carry a doctor on-board who is usually a general surgeon or physician but who has no specialist medical expertise. However, a significant number of medical problems arising among passengers and crew members on-board require specialist medical knowledge before decisions about how to treat the patient can be made. The MEDASHIP consortium and subsequent the MEDASHIP company provide a new service compared to competitors to organisations which need to provide medical services to passengers and crew members. MEDASHIP offers medical services consisting of telecardiology, telesonography and teleconsultation and technical services consisting of on-board installation and integration.

4 Conclusions

An increasing number of medical cases on-board of ships requires specialized medical knowledge. The MEDASHIP system supplies telemedical services (teleconsultation, second opinion, etc.) by a broadband satellite link between large ships and land medical expert centers. The system allows passengers and crew members the best medical care avoiding high additional costs. General teleconsultation, telecardiology and telesonography are realized. In the MEDASHIP project the availability of the telemedical services is evaluated and the costs analysed.

5 Literature

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