

**EUROPEAN SPACE AGENCY  
CONTRACT REPORT**

The work described in this report was done under ESA contract.  
Responsibility for the contents resides in the author or organisation that prepared it.

# Preface

# Final Report

This is the final report on the project *Telemedicine via Satellite Services*.

The project is funded by European Space Agency (ESA).

The main aim of the project is competence building in the field of satellite-based telemedicine. As a result, The National Centre of Telemedicine, Tromsø University Hospital (NCT), will gain experiences in order to develop telemedicine services to other parts of the world by means of global satellite services.

This report is written by:

- Project manager Ms. Eli Larsen, National Centre of Telemedicine, Tromsø University Hospital.
- Ms. Tove Soerensen, Manager of International XX at the National Centre of Telemedicine, Tromsø University Hospital.
- Mr. Erik Otto Evenstad, Senior Advisor at Telenor Research and Developing, Tromsø.

This report consists of 3 separate part. These are:

1. Work Package 1 Report. (Chapter 2 – 9)
  - Investigation of existing and future satellite systems.
  - Collection of information on telemedicine services and pilot projects based on satellite communication.
2. Work Package 2 Report. (Chapter 10 –14)
  - Description and evaluation of Practical test.
3. Work Package 3 Report. (Chapter 15– 26)
  - Project description.

The report starts and ends with an overall introduction (Chapter 1) and a concluding Remarks (Chapter 27)

University Hospital of Tromsø, 00-02-29

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Eli Larsen

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Erik Otto Evenstad

## EUROPEAN SPACE AGENCY CONTRACT REPORT

The work described in this report was done under ESA contract.  
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## Abstract

The main aim of the project is competence building in the field of satellite-based telemedicine. As a result, The National Centre of Telemedicine, Tromsøe University Hospital (NCT ), will gain experiences in order to develop telemedicine services to other parts of the world by means of global satellite services.

Following studies and test have been accomplished in order to gain the main aim:

1. Existing satellite systems, describing 9 selected systems.
2. Future satellite systems, describing 10 selected systems.
3. Future satellite systems. A short description of 16 systems.
4. Satellite systems used for telemedicine purposes. A selection of 5 projects are shortly described.
5. The new multimedia service from Inmarsat has been investigated. There have been accomplished several tests on a WorldCommunicator delivered by the Norwegian company Nera. The M4-service offers ISDN from “anywhere” in the world covered by the spot beams from the Inmarsat satellites. This terminal can therefore be used for telemedicine purpose where mobility is a key element. Mobile satellite ISDN terminal may be used for medical assistance on board e.g. fishing boats, catastrophe teams, remote field hospitals, etc.
6. Finally a telemedicine project has been described; A mobile telemedicine including a satellite communication unit. This With a view to proceed with new telemedicine projects concerning satellite services.

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# 1 Introduction      Final Report

Telecommunications are fundamental building blocks in telemedicine. Due to the limited communication infrastructure in parts of the world, telemedicine services must be realised by means of satellite communication. It is not expected that ground-based communication links in areas of interest for pilot projects will provide neither sufficient capacity nor availability for telemedicine services. In Scandinavia telemedicine services are mainly based on ISDN. Therefore adaptation to satellite communication must be developed and secured.

The main aim of the project, '*Telemedicine via Satellite Services*', has been competence building in the field of satellite-based telemedicine. Further, it was expected that the project would result in improved general knowledge at the National Centre of Telemedicine (NCT)<sup>1</sup> on satellite services and capacity, as well as expert knowledge on how this can be incorporated into telemedicine applications.

The final result of the project was to produce knowledge on how telemedicine applications designed for ISDN can be adjusted to satellite communication technologies. From investigations made in the project, NCT should be able to provide technical descriptions for the systems.

The project has been carried out as a combination of a literature study and discussions with experts in the field of satellite communication. In addition a practical demonstration of regular telemedicine services performed over an established satellite connection was performed. The latter part was of uttermost importance in order to gain hands-on experiences in the practical set up of telemedicine services by means of satellite communication.

Activities in the project have been performed as followed:

1. Existing global satellite services have been investigated regarding availability, speed, costs etc.
2. Future global satellite services have been investigated regarding availability, speed, costs etc.
3. Information on telemedicine services and pilot projects based on satellite communication has been sought.
4. A practical demonstration of telemedicine via satellite communication was accomplished.
5. A satellite-based telemedicine project has been described. Partners for a mobile telemedicine project have been considered.

Throughout the project findings have been reported and evaluated in collaboration with ESA, Norwegian Space Centre and institutions and companies with an interest of this study.

Part 1 of the Final report describes the activities of work package 1 (WP1). The aim of WP1 was to investigate existing and future global satellite services regarding availability, speed, costs etc. Also information on telemedicine services and pilot projects based on satellite communication was collected. WP1 took place from 1 March – 30 June 1999.

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<sup>1</sup> The National Centre of Telemedicine (NCT) was former called 'Department of Telemedicine' (DoT).

Part 2 of the Final report describes the activities of WP2 where a practical demonstration of telemedicine via satellite communication was conducted. For the practical test, a mobile ISDN satellite terminal the so-called World Communicator delivered by NERA, was used. WP 2 took place from 1 July – 30 September.

Part 3 of the Final report is a project description of a mobile telemedicine unit. WP3 took place from 1 October – 29 February.



Telemedicine via Satellite Services – Work-Package 1

**Project:** Telemedicine via Satellite Services

This report is the first out of three on the project *Telemedicine via Satellite Services*. The aim of work-package 1 is to:

**Contract:** 13489/99/NL/S

1. Investigate existing global satellite services regarding availability, speed, costs etc.

**Authors:** Eli Larsen

2. Investigate future global satellite services regarding availability, speed, costs etc.

**Recipient:** ESA

3. Collect information on telemedicine services and pilot projects based on satellite communication.

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## 2 Preface

## Work Package 1

This work-package report is the first out of three on the project *Telemedicine via Satellite Services*.

The project is funded by European Space Agency (ESA).

The main aim of the project is competence building in the field of satellite-based telemedicine. As a result, The Department of Telemedicine, Tromsø University Hospital (DoT), will gain experiences in order to develop telemedicine services to other parts of the world by means of global satellite services.

This report is written by project manager Ms. Eli Larsen at the Department of Telemedicine, Tromsø University Hospital. All information is collected and systematized by her.

Consultant Mr. Erik Otto Evenstad at Telenor Research and Developing has contributed as well. He is an experienced satellite researcher.

The information has mainly been gathered from the Internet. The information gathering has taken place from March to June 1999.

The report consist of five parts:

7. Introduction.
8. Existing satellite systems, describing 9 selected systems.
9. Future satellite systems, describing 10 selected systems.
10. Future satellite systems. A short description of 16 systems.
11. Satellite systems used for telemedicine purposes. A selection of 5 projects are shortly described.

Tromsø 99-06-30

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Eli Larsen

## **3 Introduction      Work Package 1**

### **Background**

Telecommunications are fundamental building blocks in telemedicine. Due to the limited communication infrastructure in parts of the world, telemedicine services must be realized by means of satellite communication. It is not expected that ground-based communication links in areas of interest for pilot projects will provide neither sufficient capacity nor availability for telemedicine services. In Scandinavia telemedicine services are mainly based on ISDN. Therefore adaptation to satellite communication must be developed.

### **History**

Geostationary satellites orbiting the earth at the speed of earth's rotation at 22,300 miles above the earth appear to be fixed in the sky. With three such satellites, radio signals can be beamed from any part of the world to any other part in the world. Satellites revolutionized international communication. Instantaneous news coverage from any part of the world became possible. However, in the 1960s, very few countries had the technological know-how to build and launch satellites. Hence INTELSAT was formed in 1964 as cooperative of several nations to share satellite communication technology. Inmarsat was established in 1979 to serve the maritime industry by developing satellite communications to improve safety and ship management.

### **Today**

As multimedia services accelerate, in terms of number of applications, services and users worldwide, the need to increase the reach, capacity and capabilities of telecommunications networks is becoming a major priority. Indeed, more and more people require high-speed connections and more sophisticated equipment.

### **Development**

It appears to be a good cooperation between satellite operators and equipment developers. Satellite systems and terminals/equipment are marketed simultaneously. The development of complete satellite systems seem to accelerate. Several new systems are under development.

### **Terminal, fixed and mobile**

Using satellite communication leads to a lot of advantages for the user, especially for the mobile user. Systems can be located wherever on the earth with some limitations in the polar area. Voice communication can be established worldwide, including the arctic and the Antarctic region. By the satellite communication equipment, you can be connected to the terrestrial network or to another satellite communication user. The establishing of the network is done easily and fast.

In case of emergency situations in areas without terrestrial network, satellite communication is usually the fastest and easiest way of establishing contact between the area and a hospital.

### **Handheld terminals**

In the latest years, several narrow band mobile systems have been developed, like Iridium and Inmarsat Mini-M. In the near future, several handheld terminals will appear on the market. ICO, Globalstar and Ellipso are coming up with small handheld terminals and will make the competition at the world-wide-phone market harder. Hopefully, this will decrease the price-level for the users. Small, handheld satphones will meet the telemedicine needs in remote and isolated areas. Especially small phones which additionally can send data by plugging them into, a personal computer, will be useful for telemedicine purposes.

### **Internet via satellite**

Internet via satellite is the fastest growing sector within satellite communication. Several of the new satellite systems coming up, stake a lot on this market. The potential is huge, extending from big concerns to small office/home office (SOHO). It is possible to obtain broadband communication to Internet via a simple installation to a personal computer. Skybridge and Teledesic are two representative future systems in this sector.

### **VSAT**

Very Small Aperture Terminal, VSAT has got a big volume in the satellite communications industry worldwide. The increased use reflects the global trend towards smaller, more intelligent and less expensive earth stations. VSAT networks are especially attractive in order to meet remote, rural and thin-route requirements.

Several satellite communication providers offer Demand Assigned Multiple Access (DAMA) capabilities by coordinating VSAT links among earth stations in the network to access the transponder based on actual usage requirement and on demand thus users have no need to fixed links permanently. This feature enables Bandwidth on demand, as well as By circuit / By minute Pay as you use scheme. This will be particularly useful for voice and video conference applications. The DAMA technology will help share transponder resources and make efficient utilization of frequency spectrum as well as reducing space segment cost and inventory for users (pay as you use). Moreover, the standardized equipment and operational parameters allow cross network connections and thus enhance the functionality of the VSAT service.

### **Prices**

Satellite communication is known to be expensive. Indeed communication from point to point is expensive, but in many places there are no alternatives to satellites. A point to multipoint connection competes with alternative solutions. Hopefully, the increasing number of new systems will force the prices down.

## **4 Telemedicine via satellite. Future perspective.**

In this report we will describe a limited assortment of existing and near future satellite systems. The services offered from these systems range from low speed services like voice to multimedia services based on high-speed data transmission.

Telemedicine enables patients to interact simultaneously with their family physician and a faraway specialist without having to leave their community, or allows specialists to diagnose, or guide a difficult operation from a remote area. Another example of satellite systems to be used for telemedicine solutions is transmission of images and data from a medical facility, such as an operating theatre or a doctor's office, to physicians and/or students at remote sites. Such services may require full-motion video and a higher resolution than solutions offered today.

### **Telemedicine – future perspectives**

Several of the existing and future satellite systems are assumed to be used for telemedicine services, and we believe that satellite systems in general will be an important element of future advanced telemedicine solutions. Satellite systems therefore will play an important role in meeting the demand for telemedicine services including broadband applications.

Telemedicine will become more important in all fields and levels in medical care. Communication by satellite will quickly bring telemedicine solutions to an advanced standard. As a result, it is important to spread information on satellite communication systems to the medical community.

The need for communication by satellite in health services can shortly be described in the following:

- Mobile units for emergency care, eg. natural catastrophies.
- Mobile units in vessels and aircrafts.
- Mobile units to be used in home care. The patient is kept home and a nurse or doctor can read the electronic patient record while visiting. New information, text, images or sound, can be put into the database. In some cases, it could be interesting to have a permanent installation and do some monitoring of the patient.
- Mobile or semi-permanent telemedicine gateways at locations where normal infrastructure is absent or existing quality of telecommunication system is not acceptable.
- Assistance in regular healthcare in developing countries.

It may be preferable and also profitable to use satellite communication systems in areas as described above. In a time-limited project, it is realistic to involve satellite communication within one or several of these fields. However, a trade off between service expenses and benefits by using satellite systems have to be evaluated from case to case. When it is socio-economic profitability, we believe extended use of satellite systems will become a reality in local and world wide health community.

## **5 Existing satellite systems**

In this chapter it will be described some of the existing mobile and fixed satellite systems and operators. The systems are presented in this order.

- INMARSAT
- INTELSAT
- EUTELSAT
- Orbcomm
- AMSC
- Iridium
- Shinawatra Satellite Public Company Ltd. (Thaicom)
- Optus
- PanAmSat

## **5.1 Inmarsat**

Inmarsat was established in 1979 to serve the maritime industry by developing satellite communications to improve safety and ship management. Inmarsat currently operates a global satellite system which is used by independent service providers to offer an unparalleled range of voice and multimedia communications for customers on the move and in remote locations.

While continuing to perform its original mandate, Inmarsat has since expanded into land, mobile and aeronautical communications.

More than 150,000 people worldwide is using Inmarsat-based mobile communications.

### **Ownership**

Inmarsat is owned by signatories.

### **Satellite system parameters**

The Inmarsat system include 4 geostationary satellites. Each satellite covers up to one third of the Earth's surface and is strategically positioned above one of the four ocean regions. Every time a call is made from an Inmarsat mobile satphone it is beamed up to one of the satellites. On the ground, distributed all around the world, giant communications antennas are listening for the return signal, which they then route into the ordinary telephone network. When someone calls an Inmarsat customer, it happens the same way - only in reverse. This land stations are called Land Earth Stations (LES), or gateways. Eik Land Earth Station provide the satellite traffic in the Scandinavian area.

Frequency:

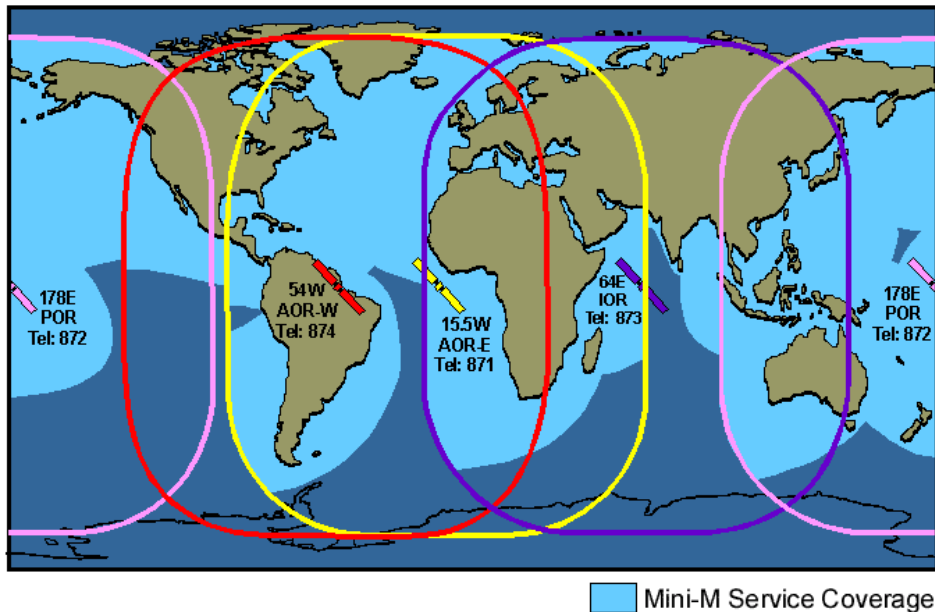
Uplink 1626.5 - 1649.5 MHz and 1626.5 - 1660.5 MHz

Downlink 3600.0 - 3623.0 MHz and 3600.0 - 3629.0 MHz

## Coverage area

With the exception of Mini-M, all Inmarsat systems have global coverage, except north/south of 81 degrees.

Mini-M has some restrictions illustrated in the coverage map. Priority is given to the terrestrial areas.



## Services including costs

Inmarsat A: Voice, fax, telex and data up to 64 kbit/s

Inmarsat B: Voice, fax, telex and data up to 64 kbit/s

Inmarsat C: Store and Forward, 600 bit/s

Inmarsat M: Speech 4800 bit/s and data

Inmarsat Mini-M: Speech 4800 bit/s and data

Inmarsat M4: High speed data, 64 kbit/s ISDN

Charge Tariffs from Inmarsat Standard Services depends on several parameters. These are:

- Land Earth Stations (if routed to a terrestrial network)
- Equipment
- Time of day (peak/off-peak)
- Position (on the earth)
- System (Inmarsat A,B, M, C, Mini-M,)(M4 are coming up these day)
- Service (Voice, fax, data-transmission, etz)
- Transmitter/Receiver (mobile to fixed, fixed to mobile, mobile to mobile)
- Duration (minutes, except Inmarsat C; per 256 bits)

It would lead too long to present all the prices, but some examples will give an idea about the price level.

Example (prices per minute):

Inmarsat A, Voice, fax & data at Peak-time from mobile to fixed, calling from Europe: \$5.80

Inmarsat A, Voice, fax & data at off-peak from mobile to fixed, calling from Europe: \$3.75

Inmarsat B, Duplex High Speed Data at peak-time from mobile to fixed, calling from Europe: \$1140

Inmarsat B, Duplex High Speed Data at off-peak from mobile to fixed, calling from Europe: \$6.50

## Terminals

All Inmarsat-systems are available in a lot of fixed and mobile (marine and voyager) terminals. Inmarsat Mini-M supports the smallest of mobile terminals, the Worldphone.

Terminal manufactures are NERA, Thrane&Thrane and IN-SNEC



**Nera WorldPhone (ca. \$ 3000)**



**IN-SNEC Globalis B Portable**

## 5.2 INTELSAT

Founded in 1964, INTELSAT was the first organization to provide global satellite coverage and connectivity. Today INTELSAT owns and operates a global communication satellite system providing capacity for voice, video, corporate/private networks and Internet in more than 200 countries and territories.

### Ownership

INTELSAT has 143 member countries and Signatories. The two biggest are COMSAT Corporation, United States (Investment Share; 19.8 %) and Telenor Satellite Services AS, Norway (Investment Share; 5.6 %)

### Satellite system parameters, earth stations

INTELSAT has a fleet of 19 spacecraft in geostationary orbit: the INTELSAT V/V-A, INTELSAT VI, the INTELSAT VII/VII-A and the VIII/VIII-A. The newest generation of INTELSAT spacecraft, the INTELSAT IX series, is in production.

#### A closer look at INTELSAT VIII:



INTELSAT VIII

INTELSAT VIII has a capacity of 22,500 two-way telephone circuits, three TV channels and up to 112,500 two-way telephone circuits with the use of digital circuit multiplication equipment. It has a 14 - 17 years lifetime depending on launch vehicle. Lifetime around 15 years are normally for a geostationary satellite.

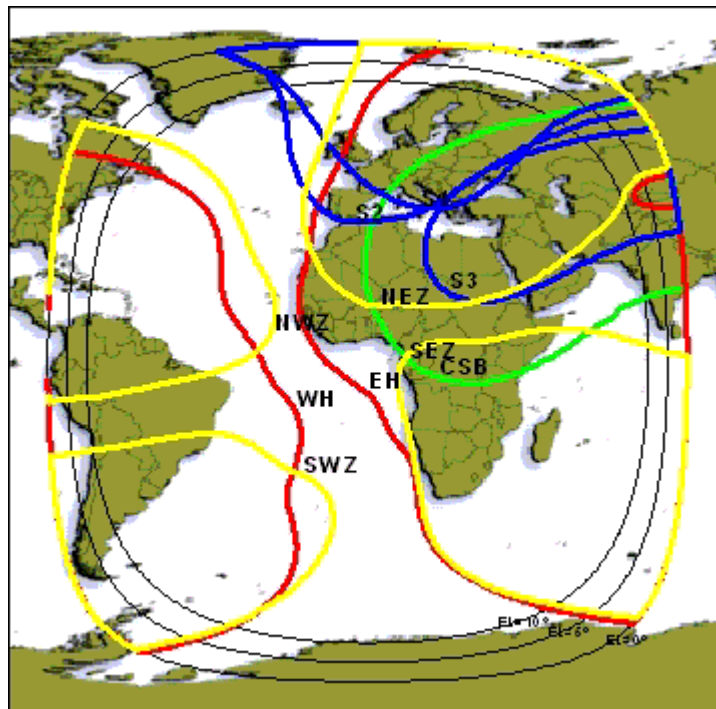
### Earth stations

The more than 2,000 fixed earth stations accessing INTELSAT are the essential links to INTELSAT's global connectivity and service. Earth stations are owned and operated either by a government entity in each country, or by other entities and businesses authorized by the government or Signatory. No matter who the owner is, however, earth stations need to meet a certain level of technical and operational capability, before accessing the INTELSAT system, in order to maintain the system's integrity and guarantee good quality service.

## Coverage area

INTELSAT has a global satellite system:

- Atlantic Ocean Region; serving the Americas, the Caribbean, Europe, the Middle East, India and Africa with satellites at orbital locations ranging from 304.5° E to 359° E.
- Indian Ocean Region; serving Europe, Africa, Asia, the Middle East, India and Australia with satellites at orbital locations ranging from 33° E to 66° E.
- Asia Pacific Region; serving Europe, Africa, Asia, the Middle East, India and Australia with one satellite, currently located at 72° E. APR1 at 83°E is expected to be available for operation by these days.
- Pacific Ocean Region; with coverage of Asia, Australia, the Pacific, and the Western part of North America with satellites at orbital locations ranging from 174° E to 180° E.



**INTELSAT 707 at 359.0°E Satellite Coverage Map**

This coverage map shows a typical footprint of a satellite with several transponders. At this satellite there are a total of 42 in C-band and 28 in the Ku-band. The requirement for the receiver is depending on where - in which zone - it is located. The zone marked S3 has a much more powerful signal than the WH-zone. Together with the received power, the signal data-rate will determine the size of the antenna and the receiver-sensitivity.

As all geostationary systems, there is coverage up to about 81 degrees north and south.

## Services including costs

The satellites can be used to transmit images, sound and data in analog or digital format, from anywhere to anywhere in the world. Bandwidth options range from 100 kHz to 150 MHz, and customers can choose to lease capacity for only 10 minutes or up to 15 years.

## **Terminals, VSAT**

The user must be authorized to use INTELSAT satellite services from an earth station. There are two basic means of accessing the INTELSAT system. Either through earth stations that have been type-approved by the manufacturer, or through an earth station that requires individual verification testing. No civil mobile telephone service is available on INTELSAT. Small and relatively cheap equipment is available for the «lightweight» satellite communication user, named Very Small Aperture Terminal, VSAT.

VSAT is the fastest growing sectors of the satellite communications industry worldwide. Their increased use reflects the trend towards smaller, more intelligent and less expensive earth stations. VSAT networks are especially attractive in meeting remote, rural and thin-route requirements.

**Cost-Effective:** Costs are independent of distance/terrain, and expansion costs are predictable. VSAT equipment can operate unattended and maintenance-free for a number of years, resulting in low operating costs. Hub facilities can be shared among multiple users and applications. A mature and competitive industry can supply increasingly flexible equipment and services at remarkably low prices.

**Flexibility:** VSATs can be customized to the customers needs and applications, and provide a high degree of security and network management and control. VSATs can be installed rapidly, and moved to new locations as needs change.

**Applications:** Business networks for hotel reservations, banking, retailing, news distribution internet and intranets specialized networks for international organizations wideband mobile and off-shore communications, remote/rural public telecommunications, telemedicine, distance learning, environmental and pipeline operations (SCADA) monitoring.

### 5.3 Eutelsat

EUTELSAT was established in 1977 to operate satellites for fixed and mobile communications in Europe.

#### Ownership

EUTELSAT has 47 European member countries and Signatories. The two biggest are British Telecommunications p.l.c. (Investment Share; 23.2 %) and Telecom Italia S.p.A. (Investment Share; 16.2 %).

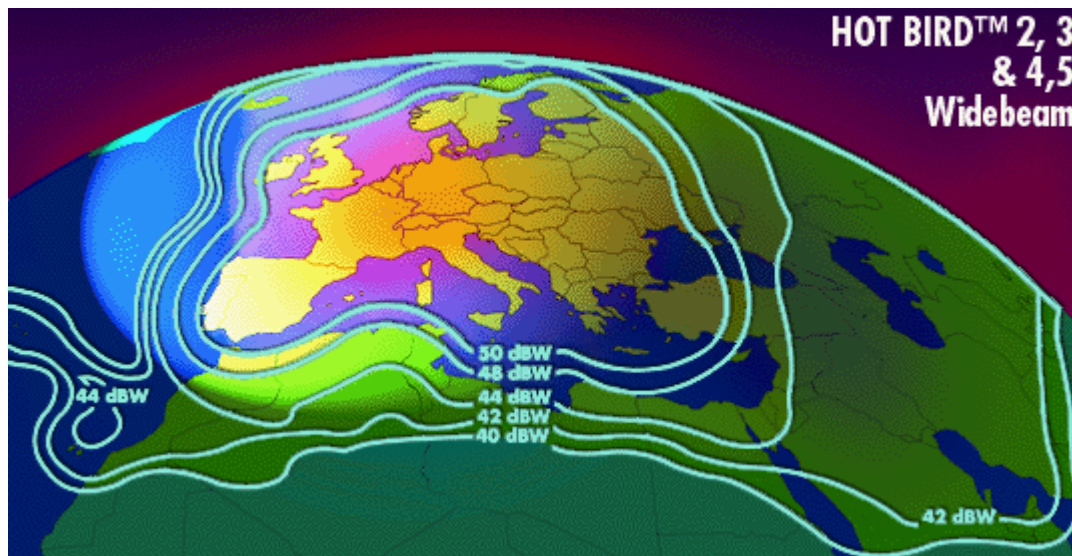
#### Satellite system

EUTELSAT operates over 200 transponders on 14 geostationary satellites. Five Satellites are under construction and remain to be launched.

#### Coverage area

The satellites provide full coverage of Europe and also take in parts of Africa and Asia, including the entire Middle East. Two of the satellites are equipped with a Steerable Beam which can be oriented anywhere visible from 13 degrees East, either northern or southern hemisphere.

#### Footprint:



#### Services including costs

Since 1995, EUTELSAT has been developing multimedia digital platforms to provide PC-based Internet and data broadcasting service via satellite. The equipment needed to receive these services consists of a DVB/MPEG-2 card for the PC at the user's premises and a small antenna. On the transmit side, an ordinary modem connected to a telephone line or an ISDN line is all that is needed for real-time interactivity.

Almost 20 transponders are used for one and two-way VSAT networks for applications such as videoconferencing, stock control, telemedicine, distance-learning, newswire distribution etc. EUTELSAT is also setting up a bandwidth-on-demand network for corporate and institutional communications which will be operated on a pay-as-you-use basis. Called EWDS

(EUTELSAT Wideband DAMA Services), it will be able to support applications such as LAN-to-LAN interconnection, high-speed file transfer and support various standard network protocols such as Frame Relay and ISDN.

EUTELSAT also provide EUTELTRACS, the two-way message-exchange and position-reporting service for trucks and fishing vessels operates via EUTELSAT capacity in Europe, North Africa and the Middle East. In November 1998 EUTELSAT started to offer emsat, a mobile telephony service which can provide voice, data, fax, messaging and positioning services connected to the switched network. EMSAT is provided within the framework of an agreement with Telespazio to commercialize the EMS payload embarked on the Italian communications satellite Italsat F2 at 16.4E.

## Terminals

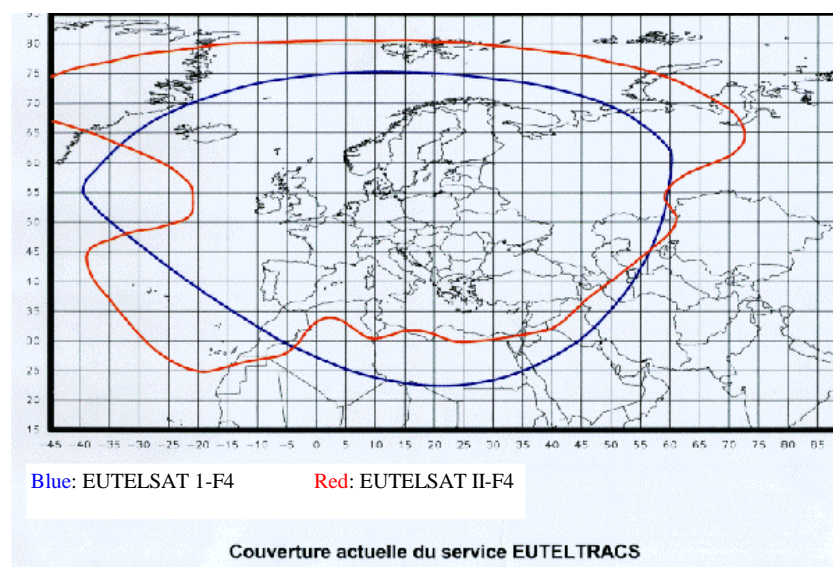
«Business-terminals», advanced professionally equipment are use to communication through EUTELSAT-satellites.

### EUTELTRACS (Italsat F2), Mobile Terminals.

Each terminal consists of a central unit, a handset/screen and an antenna. Four types of antenna are available (mast, marine dome, terrestrial dome and fixed) and any type of vehicle or ship can be equipped. It is also possible to install the system as a temporary or permanent fixed facility. SMS messages of up to 30 characters can be read on-screen. The terminal has one RS 232 port to connect peripherals such as a PC or sensors, and one fax port.

EUTEL Mobile Telephony Service offers five complementary services:

- Voice; digital at 4.8 Kbps, connected to the switched telecommunications network, within a closed user group if required, normal or priority access.
- Fax; Group 3 at 2.4 Kbps
- Data; at 2.4 Kbps to transfer files or send/receive e-mails.
- Messaging (SMS); in packets, up to 44 bits per packet with acknowledgement of receipt.
- Positioning; integrated GPS card, report delivered via the SMS channel All services are accessible from a robust and user-friendly on-board terminal, that can be installed on virtually any form of transport (vehicles, trains, ships, etc) or at a fixed location.



## **5.4 ORBCOMM**

Orbital is a space technology company that designs, manufactures and markets a broad range of space products and satellite-based services. Orbital's experience includes carrying out over 215 satellite rocket and space payload missions during the past 15 years.

### **Ownership**

ORBCOMM is a partnership owned by Orbital Sciences Corporation and Teleglobe Inc. of Canada.

### **Technical parameters**

The ORBCOMM System uses 48 low-Earth orbit satellites, orbiting at 825km, with 8 spares on the ground. It provides worldwide geographic coverage. The ORBCOMM System is the world's first low-Earth orbit satellite system to provide high availability, low-cost, two-way, on-the-move communications over the entire globe.

Receive freq. 148 to 149.9 MHz

Transmit freq. 137 to 138 MHz and 400.05 to 400.15 MHz

Data rate up to 2.4 kbit/s

### **Coverage area**

Worldwide, including the polar area.

### **Services**

Services includes tracking, monitoring, messaging

#### **Tracking**

ORBCOMM's low-cost data communication system is an easy way to keep track of your mobile equipment, vehicles, or vessels - anywhere in the world. By attaching a small ORBCOMM communicator, you can know where it is, if it's moving, or even how long it hasn't been moving.

#### **Monitoring**

ORBCOMM enables you to place a sensor and monitor remotely by ORBCOMM equipment.

#### **Messaging**

With ORBCOMM satellite system you can send and receive e-mail, text messages to and from anywhere in the world.

### **Terminals including costs**

The Magellan GSC 100 allows you to send and receive e-mail, text messages to and from anywhere in the world using ORBCOMM satellite system. The GSC 100 also has a fully-functional GPS receiver to help you navigate and pinpoint your location anywhere in the world.

To activate a GSC 100 unit in the United States or Canada, users pay a one-time activation fee of \$49.95. There is a monthly access charge of \$29.95, which includes 10 messages of up to 500 characters per message and 30 message checks. ORBCOMM service pricing differs from country to country.

Integrated GPS receiver capabilities allow you to identify your position, plot and track your course, store waypoints and communicate this information to anyone, anywhere in the world.



**MAGELLAN handheld receiver.**

## 5.5 AMSC (Regional system, mobile communications)

Founded in 1988 and is the first and only business authorized by the Federal Communications Commission to provide mobile satellite communications services to North America. AMSC's nationwide two-way radio network is a satellite communications service designed for the mobile work force. The service is called Skycell.

### Ownership

Partners are Hughes Communications, AT&T, Singapore Telecom and Ronald Baron.

### Satellite system parameters

The AMSC uses two HS601 satellites. The first, AMSC-1, is operational and is in geostationary orbit at 101 W Longitude. The accompanying earth station is located in Reston, VA. The second is for launching in 2000.

Tx: 1.6265 - 1.6605 GHz    Rx: 1.525GHz - 1.559 GHz    Data to 4800 b/s

### Coverage area

Skycell satellite communications services provide seamless broadcast dispatch, data, fax and voice coverage virtually anywhere in North America, Central America, the Caribbean and hundreds of miles of surrounding waters.



### Services including costs

- Satellite Roaming Service automatically routes customers' calls (voice/fax/data) through the AMSC-1 satellite when the calls are outside the range participating cellular carrier services.
- Fleet Management Services offer Private Voice Network Services and Mobile Data Services via the AMSC-1 satellite. Private Voice Network Services allow fleet managers to communicate with a fleet of vehicles (e.g., trucks, railcars, vessels) simultaneously. The Mobile Data Services offer "Store-and-Forward" text-message communications designed for use in a variety of industries.

## Terminals

Equipment manufactured by vendors such as KVH Industries, Mitsubishi Electronics America, and Westinghouse Wireless Solutions Company, gives mobile communications. Telephones are grouped in:

- Maritime Satellite Telephones
- Land Mobile Satellite Telephones
- Fixed Site Satellite Telephones
- Portable Satellite Telephones

### **KVH K-3 Tracphone™ (Maritime Satellite Telephone)**



Tracphone is designed specifically for the marine environment with a 3-axis stabilized antenna to track the satellite in all sea conditions.

Accessories include: interface adapter; AC/DC converter or DC/DC converter; coaxial cable; handset cradle; junction box, power cable; optional external speaker and hands-free microphone.

#### Technical Specifications:

Voice	Full-duplex digital voice
	Half-duplex digital voice
Fax	Group 3 facsimile at 4800 bps
Data	4800 bps
Price	ca. 1000\$

## 5.6 Iridium

Introduced in November 1998. Serious problems are seen ahead, including major refinancing of the massive debt load. The prices is decreased, in a attempt to get more users.

### Ownership

Shareholders and Strategic Partners:

Motorola, Nippon Iridium Corp., Verbatim GmbH, Sprint, BCD Mobile Communications Inc., STET, DDI, UCOM, SK Telecom Corp., PT Bakrie Communications Corp., Raytheon, Bouygues.

### Technical parameters

The Iridium network comprises of a constellation of 66 satellites in low earth orbit, about 420 nautical miles above the earth's surface.

User frequency: 1.616 to 1.6265 GHz

Feeder uplink freq. 29.1 to 29.3 GHz.

Feeder downlink freq. 19.4 to 19.6 GHz

Intersatellite crosslinks freq. 23.18 to 23.38 GHz.

Voice: 2.4 kbit/s; data 2.4 kbit/s

### Coverage area

Worldwide including polar regions.

### Services including costs

Voice and pager. (Data transmission will be offered later this year.)

#### 1. July prices:

International satellite calls from anywhere in the world to an international fixed-line or mobile phone anywhere in the world will cost A\$2.22 per 30 seconds for Iridium South Pacific customers. Domestic satellite calls made from an Iridium satellite phone to fixed-line or mobile phones within Australia, costing A\$1.30 for 30 seconds. Satellite calls made by Iridium South Pacific customers to another Iridium phone anywhere in the world via the Iridium network will now be priced at a single global rate of A\$1.07 per 30 second.

### Terminals

Small handheld phones. Manufactured by Motorola and Kyocera.

Before the price fall, the phone-cost were about \$3000.



## 5.7 Shinawatra Satellite Public Company Ltd. (Thaicom)

Shinawatra Satellite Public Company Limited was founded in 1991 after it was granted a license from Thailand's Ministry of Transport and Communications permitting it to launch and operate satellites. It was the first company in Thailand to be allowed to do this, and the first privately-owned satellite company in Asia.

### Ownership

Shinawatra Satellite Public Company Ltd. are a wholly-owned subsidiary of Shin Corporations, Thailand's largest telecommunications group.

### Satellite system parameters

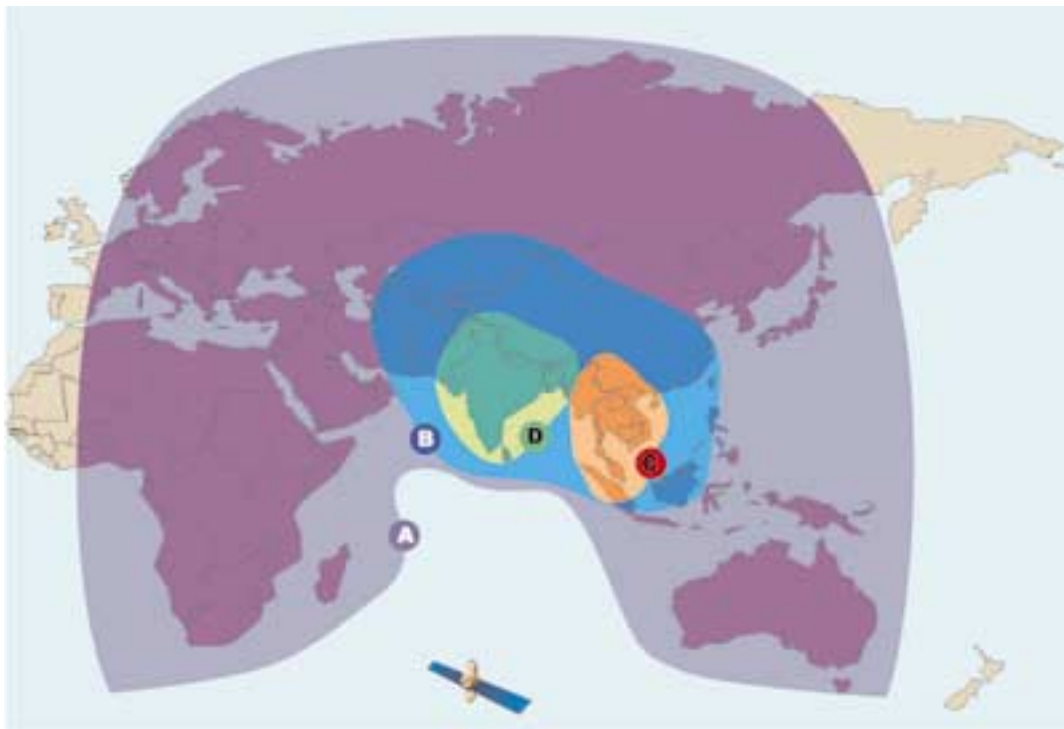
Shinawatra Satellite now has three satellites in geostationary orbit with corresponding Thai-based customer service facilities. These are the Thaicom-1A, Thaicom-2 and Thaicom-3.

- Thaicom-1A&2 are Two identical Hughes HS-376, C-band and Ku-band, 120 degrees East and 78.5 degrees East.
- Thaicom-3 is an Aerospatiale SpaceBus 3000A, C-band, extended C-band and Ku-band, 78.5 degrees East.

The nerve center is the Thaicom Satellite Station just north of Bangkok from where all three satellites are controlled.

### Coverage area

Coverage area is Asia, Australia, Africa, the Middle East and most of Europe.



**Footprint THAICOM-3**

### **Services including costs**

Thaicom provides a wide range of typical satellite transponder leasing business, as well as new and advanced value satellite communication services. These include: Transponder Leasing-SSA generally provides both typical Full time and Occasional transponder capacity for user assigned applications such as: trunking, VSAT, analog TV and digital DTH, SNG, etc. Thaicom also offers the new DAMA (Demand Assigned Multiple Access) Transponder Services for telecom usage.

### **Terminals**

No mobile or fixed terminals available. VSAT-installation is a contingency. Ref INTELSAT terminal, page 16.

## **5.8 OPTUS (MobileSat)**

Since 1992, Cable & Wireless Optus has grown rapidly into one of Australia's largest companies, with over 1.7 million mobile phone users, almost 2 million long distance customers and more than 5,000 employees.

A similar M-SAT satellite system covers Alaska, North America, Hawaii, Bermuda and the Caribbean. Another M-SAT system is planned employing an ItalSat F2 satellite to provide coverage over rural, remote and coastal regions of Europe.

Information-service on the Web is insufficient. Ownership and technical parameters lacks.

### **Satellite system**

Optus operates MobileSat using two geostationary satellites the B1 and B3. MobileSat as its name implies comes in a mobile configuration more suited to vehicle/boat mounting.

### **Coverage area**

Coverage is generally confined to the Australian continent and surroundings. There are exceptions in some SE Asia and the Western Pacific regions if you use a high gain antenna.

### **Services including costs**

MobileSat is an exception because it was especially designed to work happily with an omnidirectional (non-directional) mast antenna. This is the reason MobileSat can work on moving/turning vehicles without the added expense of complex satellite antenna tracking gadgetry. If you require a vehicle mounted sat-phone for use within Australia only, your choice is likely to be MobileSat because the hardware and cost of calls is relatively cheap and the system can handle fax and data. MobileSat can also be used on-the-fly with the standard omni-directional antenna so you don't need to be stationary to make or receive a call. MobileSat can definitely be used to dial/receive calls to/from anywhere in the world. The statement "for use within Australia only" means that the telephone must be physically located within Australia and surrounding waters otherwise it won't work. There are some exceptions to this rule in the SE Asia & the western Pacific region, if you use a high gain antennae. Call charges for MobileSat vary upwards from 98c per minute off-peak, making this system the most economical satellite voice/fax/data mobile telephone in the world.

### **Voice**

MobileSat Voice service enables full dial-up capability into and out of the Public Switched Telephone Network (PSTN). It enables full duplex, high quality voice calls between a MobileSat telephone and any landline telephone (via the PSTN or PABX) another MobileSat telephone a cellular phone.

### **MobileSat Facsimile**

MobileSat Facsimile service utilises a MobileSat Modem that allows a standard fax machine to be used via the MobileSat telephone.

### **MobileSat Data**

MobileSat Data is a service that provides full duplex data channels between a MobileSat telephone with a MobileSat Modem and: head-office computer with dial in capability another PC connected via a modem to a phone.

Detailed prices are available at <http://www.transair.com/msatcall.html>

### **Terminals**

Satellite phones are available in fixed site, transportable and marine configurations. Typical terminal prices varies from \$3000 to about \$6500. Leasing is also offered. NEC and Westinghouse produces Mobile Satellite Telephone System. An illustration is the transportable 3000. It only require an antenna and a 12 volt powersupply to be «on the air».



**Westinghouse Mobile Satellite Telephone System 3000, transportable.**

## 5.9 PanAmSat

PanAmSat Corporation, provider of satellite-based communications services, operates a global network of 19 satellites and seven technical ground facilities enables the company to relay video programming and digital communications customers worldwide.

PanAmSat is scheduled to launch seven additional satellites by late 2000, increasing total capacity to more than 900 usable transponders worldwide.

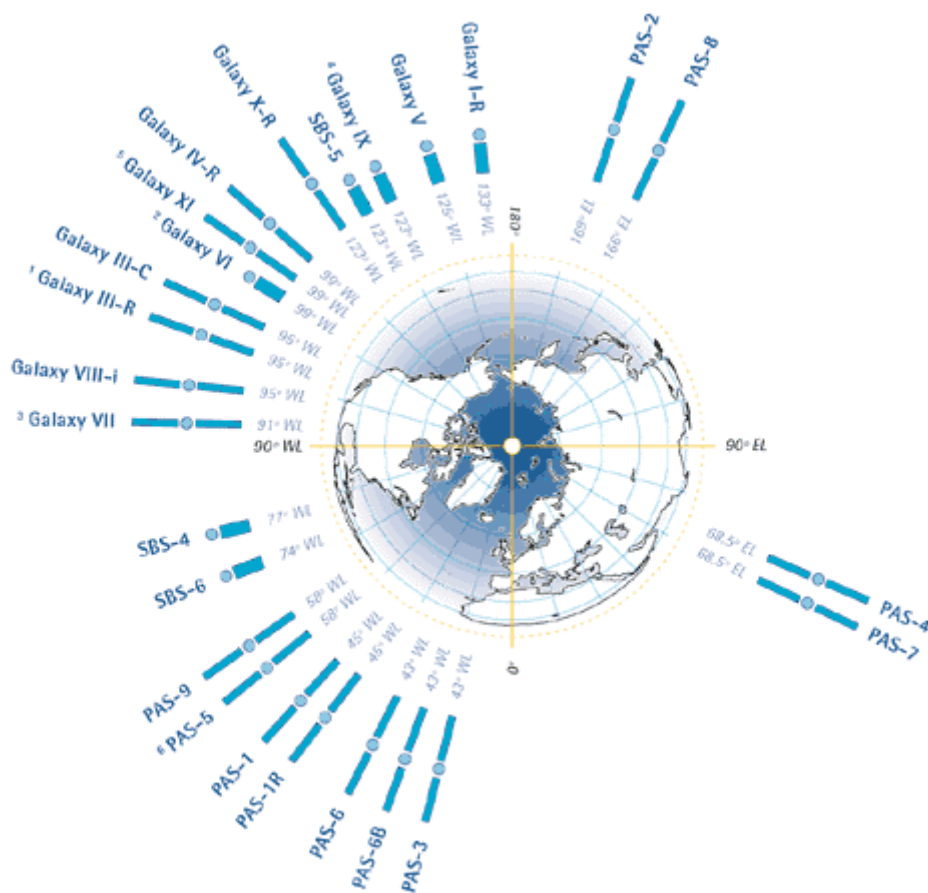
PanAmSat has merged with Hughes Galaxy.

### Ownership

Private cooperation.

### Satellite system parameters

Total satellites in Operation are 19 geostationary satellites. They use C- and/or Ku-band.



**Existing and planned PanAmSat satellites**

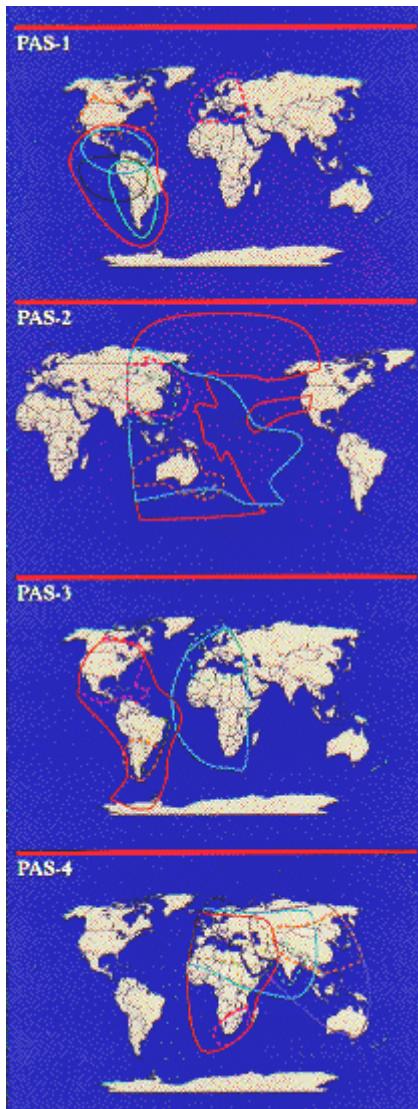
## Services

- Broadcasting
- Telecommunications service providers in the United States, Latin America, Africa, Europe and Asia, which use PanAmSat satellites as their pipelines for communications traffic.
- News organizations which beam news, financial information, sports and special events around the world.
- Internet service providers in more than 50 countries, including Japan, Paraguay, Indonesia, Zambia and New Zealand, which obtain access to the U.S. Internet backbone over PanAmSat's global satellite system.

Satellite capacity and terrestrial facilities are available to offer everything from 10 minute transmissions to 24 hour leases.

## Coverage area

The coverage is worldwide land area. No coverage beyond 81 degrees north/south.



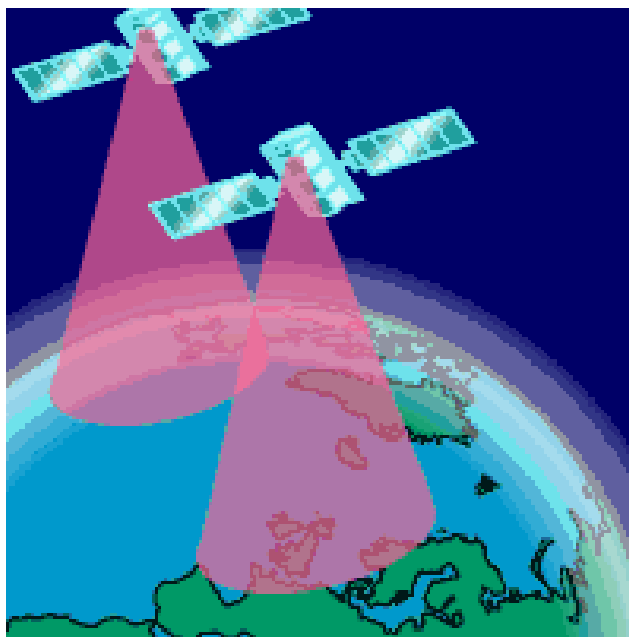
## Terminals

No mobile or fixed terminals available for civil use.  
VSAT-installation is a contingency.  
Ref INTELSAT terminal, page 16.

## 6 Future satellite systems

There are a lot of new satellite communication systems coming up. This research has covered up 26 new systems. This chapter will describe in basis of facts available today the following systems:

- ICO (Narrowband, MEO)
- Globalstar (Narrowband, LEO)
- Ellipso (Narrowband, MEO)
- EuroSkyWay (Broadband, GEO)
- WEST (Broadband, GEO and MEO)
- Astrolink (Broadband, GEO)
- Spaceway (Broadband, GEO)
- Teledesic (Broadband, LEO)
- Skybridge (Broadband, LEO)
- Cyberstar. (Broadband, GEO)



## 6.1 ICO (Narrowband, MEO)

ICO (Intermediate Circular Orbit, another term for Medium Earth Orbit) was originally begun by Inmarsat as Project 21, then Inmarsat-P, before being spun off into a separate company.

### Ownership

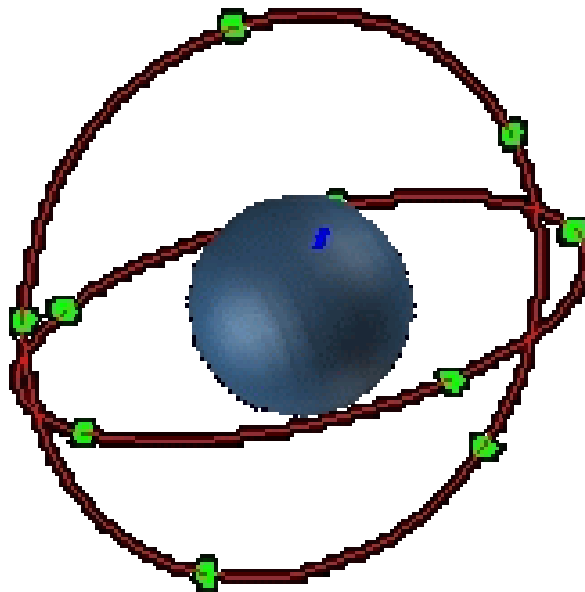
As an international consortium which countries join, Inmarsat has a lot of clout. There are 26 partners and about 60 investors.

### Operational

ICO plans to be operational by 2000.

### Satellite system / Technical parameters

The ICO system will comprise ten operational satellites and two in orbit spares operating in intermediate circular orbit at an altitude of 10,355 km. These are divided between two orthogonal planes, each 45 degrees to the equator. Each satellite will be able to handle 4,500 simultaneous telephone calls. Hughes is building the satellites and will deliver them in orbit, starting in the fourth quarter of this year. They will be controlled from the Satellite Control Centre (SCC) near London in the UK and the Back-up Satellite Control Centre (BCC) in Tokyo.



ISO satellite system

The system will route calls from terrestrial networks through the ICONET - comprising 12 Earth stations or satellite access nodes (SANs) and the terrestrial links between them which will select a satellite through which to deliver the call to a mobile terminal.

ICO's satellite geometry offers several service-quality benefits:

- High average elevation angle from user to satellites, minimizing the probability of blockage by terrain or buildings.
- High probability of the user having more than one satellite at a time in view and thus having an alternative path if the satellite in use goes below the horizon.
- Slow- about 1 degree/min - satellite movement through the user's field of view, minimizing the probability of satellite hand-off and possible call loss. These attributes mean that ICO users will be less likely to have to wait to make a connection and less likely to have their calls interrupted.

### **Coverage area**

Worldwide, including the polar area.

### **Services**

The design of the ICO system integrates mobile satellite communications capability with terrestrial networks. ICO user terminals will include, among others, handheld mobile telephones which, in outdoor environments, will offer services similar to those provided by normal cellular phones.

The ICO system will make it possible to offer service in several different market segments:

- Cellular Existing users of terrestrial cellular and PCS networks who want to extend the service area within which they can roam.
- Carrying dual-mode hand-held terminals, these customers will roam from terrestrial coverage to the ICO network and will be billed for their use of the satellite system: by their terrestrial providers.

### **Terminals**

Most ICO user terminals are expected to be handheld, pocket-sized phones capable of dual-mode (satellite and cellular or PCS) operation and very similar in size, appearance and voice quality to today's handheld cellular/PCS phones. The price of ICO dual-mode phones, on the basis of high volume production, is expected to be competitive with those other comparable satellite systems at service introduction.

The ICO handheld phone is planned to have optional features, including external data ports and internal buffer memory to support data communication, messaging functions, fax and the use of smartcards (SIMs).

Calls will cost between 30 UK pence and £2.20 a minute

## **6.2 Globalstar (Narrowband, LEO)**

A \$3.26 billion project using 48 satellites in low-earth-orbiting.

The project received a setback when 12 satellites were lost with the failure of the Zenith 2 rocket in September 1998. The project has also run into problems with disagreements between the US and Russia about launching from a military base. The service is planned to commence with only 32 satellites, some time before the end of 1999. 33 gateways are planned, with five completed. By the middle of 1999 nine gateways will be operational, in the US, China, Canada, France, Italy, Russia, Argentina, Korea and South Africa. It is hoped that 16 gateways, covering 45% of the world will be operational by the end of 1999.

By June 10, 1999 - Globalstar announced the successful launch of an additional four low-earth-orbiting satellites into space, bringing the total number of Globalstar satellites that have been successfully launched to 24.

Globalstar needs an additional \$565 million before it can commence commercial service.

Globalstar is targeted towards developing countries with none, or poor wireline and cellular services.

### **Ownership**

Partners include Loral Qualcomm, AirTouch Communications, DACOM/Hyundai, France Telecom/Alcatel, Daimler Benz, Vodafone, Alenia Spazio, ElsagBailey, Finmeccania and Space System/Loral.

### **Operational**

Early 2000 is scheduled as the period for full service.

### **Satellite system / Technical parameters**

Globalstar is a low-earth-orbiting satellite-based digital telecommunications system. Calls will be relayed through Globalstar's 48 satellite (plus 8 in orbit spares) constellation, in a 1,414 kilometer orbit above the earth, to a groundstation and then through local terrestrial wireline and wireless systems to their end destinations.

Voice 2400 bit/s Data 9600 bit/s

User Links:

1610-1625.5 MHz (user-to-satellite)

2483.5-2500 MHz (satellite-to-user)

Feeder Links:

5091-5250 MHz (gateway-to-satellite)

6700-7075 MHz (satellite-to-gateway)

## Coverage area

Globalstar will provide wireless telephone service in virtually every populated area of the world where Globalstar service is authorized by the local telecommunications regulatory authorities.

## Services

Globalstar will offer wireless telephone and other telecommunications such as data transmission, short message service, facsimile and position location services to areas currently underserved or not served by existing wireline and cellular telecommunications systems.

Globalstar will sell access to its system via a worldwide network of regional and local telecommunications service providers, including its strategic partners, AirTouch Communications, France Telecom/Alcatel, Vodafone, Elsacom, China Telecom and Loral Space & Communications Ltd. together with franchise partners who have agreed to act as Globalstar service providers in more than 120 countries. Each service provider has the exclusive right to offer Globalstar service in its operating areas and will market and distribute Globalstar service, obtain all necessary regulatory approvals and own and operate the gateways necessary to serve their respective markets.

## Terminals

Globalstar will offer handheld phones, pay phones and fixed phones as showed below. The price of a Globalstar handset will cost less than \$1,000.



The Ericsson dual-mode GSM handset

Globalstar handheld and fixed phones

### **6.3 Ellipso (Narrowband, MEO)**

Ellipso is a \$1.5 billion project which service is expected to be ideal for countries seeking to expand or initiate telecommunications services without investing in cost-prohibitive traditional infrastructure

The Ellipso system is unique in that it divides its global coverage into two zones, each served primarily by its own constellation of satellites. The earth's distribution of land and population by latitude serves as the basis for the overall Ellipso constellation design. One of the most interesting features of the world is the distribution of the landmasses. The Northern Hemisphere contains many times more landmass north of 40°N than the Southern Hemisphere has south of 40°S. Virtually all of Europe is north of 40°N, almost one half of the United States and all of Canada lie north of 40°N, and all the CIS and part of Japan lie north of 40°N. Among these are some of the largest countries on earth.

#### **Ownership**

The partners are Boeing, Harris Corporation, IAI, Spar, L-3 Com and Lockheed Martin.

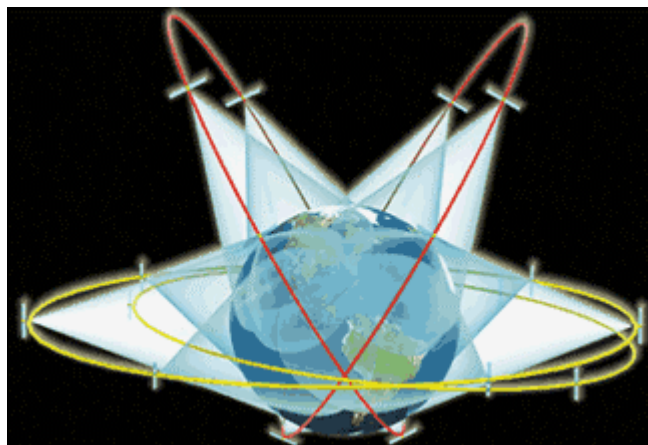
#### **Operational**

Operation is scheduled for early 2002.

#### **Satellite system / Technical parameters**

Ellipso will utilize 14 operational and 3 spare satellites. It will use two inclined elliptical orbits at 633km and 7605km, and a circular orbit at 8050km to bring mobile and fixed voice, data, fax, paging and geolocation services, with data rates up to 9600 bit/s.

The Ellipso system is designed to match its capacity more closely to the populated land masses than would be possible using any constellation of satellites in circular orbits. It does so by using two complementary and coordinated constellations of satellites, Borealis and Concordia.



**Ellipso satellites**

The Ellipso Orbits As shown in the figure, the Borealis constellation primarily serves areas in the northern temperate latitudes, while the Concordia constellation serves areas in the tropical and southern latitudes. The Tropic of Cancer roughly divides the service areas of the two constellations, although there is a wide band of latitude that can be served by either or both constellations. Each constellation has been carefully conceived to complement the other, so as together to offer the most effective and efficient solution to worldwide coverage possible. The Ellipso satellites operate at MEO altitudes. As a consequence, each satellite is capable of seeing a much larger area than low earth orbit satellites can see. This significantly reduces the number of ground entry stations.

## **Coverage area**

Worldwide, including polar area.

## **Services**

Voice telephony will be the primary service Ellipso will support. To support this service, Ellipso will use the Code Division Multiple Access (CDMA) transmission method, using Global System for Mobile Communications (GSM) protocols. Voice rates will be at 2400 bits per second.

Ellipso will also use its basic digital transmission capability to support various kinds of digitally-based services, such as modem data, facsimile, message forwarding, paging, and geolocation information. These services will be available at various data rates from 300 to 9600 bits per second.

## **Terminals**

The Ellipso user terminal is very similar in form and operation to those used for cellular telephony. There are three primary types of Ellipso user terminals:

**Handheld terminals** resemble present cellular pocket phones in size, radiated power, battery life, weight and operation. Illustrated on next page.

**Mobile terminals** are designed for vehicular use.

**Fixed terminals** are designed for public or private installed use.

Both the mobile and handheld terminal types use omnidirectional antennas, fixed terminals use more directive antenna designs for greater efficiency. Ellipso terminals will be dual mode terminals, capable of operating either on the Ellipso system or on the local terrestrial cellular system. Ellipso will also support other more specialized terminal designs. These can include data-only terminals, personal digital assistants, and paging/polling terminals, as well as packages with application and features for specialized markets, such as fisheries or trucking.

Ellipso's system design permits wholesale call pricing that is competitive with terrestrial cellular telephone service, that is, around \$US 0.35 per min Ellipso for mobile prime-time service and \$US 0.08 per minute for fixed service.



**Ellipso handheld terminal**

## **6.4 EuroSkyWay**

Alenia Aerospazio Space Division first introduced the EuroSkyWay concept in 1995 to address the growing demand for broadband services, using its experience in Ka-band and On-Board Processing (OBP) technologies.

### **Ownership**

EuroSkyWay s.r.l., founded in March 1997, is the Finmeccanica company coordinated by Alenia Aerospazio that will design, procure and operate the network.

### **Operational**

The first EuroSkyWay satellite will be launched early in the year 2001 and a second satellite is scheduled one year after that.

### **Satellite System/Technical Parameters**

The EuroSkyWay network will offer an aggregate capacity of 45 Gbps through a cluster of five geostationary satellites. Capacity will be made available on demand and billed on the basis of its utilization. Permanent or long term circuit allocations can be reserved too.

Making use of digital on-board processing (OBP) and inter-satellite links (ISL), EuroSkyWay is well suited to providing full interconnectivity between any pair of spot beams and to handling Packet type traffic, such as the one generated by Internet. The latency "problem", defined as the main critical issue for the use of the Internet protocol TCP/IP for geo satellites, will be overcome by using a proprietary system based on the use of the Asynchronous Transfer Mode protocol. The on-demand bandwidth will be from 16 Kbit/s up to 32,768 Mbit/s.

### **Coverage area**

This first network will cover Europe and the Mediterranean Basin. Another three satellites will be launched to extend the coverage to Africa, Eastern Europe and Asia.

### **Services**

EuroSkyWay will offer "bandwidth on demand" to Service Providers, such as Telecom Operators, TV Broadcasters and Internet Access Providers, who can expand their network infrastructure and reach new customers. EuroSkyWay combines the advantages of wide area coverage with those of the speed and quality of the communication links. Data, voice and video can be transmitted over the same digital stream and with full compatibility with the ISDN, ATM, IP, DVB/MPEG standards.

EuroSkyWay will also bring broadband services to mobile users by offering communication links at a speed up to 200 times higher than traditional cellular phones.

## Terminals

The user terminals consist of a satellite dish and a special computer card to be inserted in the user's PC. They will be able to receive up to 32 Mbps of data information.

User terminals will be offered in different configurations to address different market needs. EuroSkyWay will support mobile, portable and fixed subscriber terminals with different throughput and availability characteristics. Three categories of terminals are foreseen:

- small (lap top size) with 160 Kbps upstream speed
- standard (PC-size) with 512 Kbps upstream speed
- high capacity (PC-size) with 2 Mbps upstream speed.

The selected system allows the use of components derived from commercial DVB receivers, making the subscriber terminal smaller, lighter and easier to use. This commercial approach allows the service to be performed with compact and lightweight terminals equipped also with a detachable antenna.

## **6.5 WEST**

WEST is a Matra Marconi Space initiative to develop a satellite-based infrastructure to satisfy multimedia services.

### **Ownership**

Matra Marconi Space and several unknown partner.

### **Operational**

Presumable within about 5 years. Unknown scheduling.

### **Satellite System/Technical Parameters**

WEST is a broadband interactive communications network which will initially comprise geostationary Ka-band satellites. The system will be complemented by a constellation of a limited number of Ka-band satellites in Medium Earth Orbit (MEO) to provide additional services and to extend the coverage.

### **Coverage area**

After the first construction stage the coverage area will be Europe and adjacent regions. After the expansion of MEO-satellites, the coverage area will in all likelihood be worldwide including the polar area.

### **Services**

The WEST system is sad to satisfy multimedia services. Details are not available.

### **Terminals**

No details are available about terminals.

## **6.6 Astrolink (Broadband, GEO)**

Astrolink's system idea is to meet the demands of customers operating in tomorrow's global marketplace by providing high-speed, quality, flexible, global bandwidth-on-demand services. Astrolink intend to deliver a robust and reliable portfolio of services at a significantly lower cost. This is a \$4 billion project.

### **Ownership**

Astrolink is owned by Lockheed Martin Global Telecommunications, TRW and Telespazio.

### **Operational**

Expected to be in operation by 2000.

### **Satellite system / Technical parameters**

Uses nine A2100 geostationary satellites in five orbital slots.

- 97° W - Americas
- 130° E - East Asia and Australia
- 21.5° W - Atlantic
- 2° E - Europe, Africa and West Asia
- 175° E - Oceania

Uplink frequency is 28.35 - 28.6 and 29.25 - 30 GHz and downlink at 19.7 - 20.2 GHz.

Data rates between 16kbps - 20Mbps.

Transmission is by Asynchronous Transfer Mode (ATM).

### **Coverage area**

Worldwide except the polar area.

### **Services**

Astrolink's two-way connectivity capabilities will let you do that through applications such as e-commerce, distance learning, remote manufacturing, sales support, telemedicine and corporate training. Astrolink offers encryption.

**Bandwidth-on-Demand** That means you pay for actual speed and volume of data transmitted.

## **6.7 Spaceway (Broadband, GEO)**

A \$3.2 billion project putting on the high-speed broadband marked.

### **Ownership**

Owned by Hughes Communications Inc.

### **Operational**

Expected into service in 2002.

### **Satellite system / Technical parameters**

Using nine HS702 geostationary satellites, operating in the Ka-band spectrum

#### **North America Slots Assigned**

- 101°W
- 99°W

#### **International Slots Assigned**

- 49°W
- 25°E
- 54°E
- 101°E
- 11°E
- 164°E

An optional broadband uplink terminal will support applications requiring up to 6 megabits per second.

### **Coverage area**

Worldwide except the polar area.

### **Services**

Spaceway will provide high-speed bandwidth-on-demand satellite communications. Using a globally deployed system of satellites in conjunction with a ground-based infrastructure, users will transmit and receive video, audio, multimedia and other digital data at uplink rates between 16Kbps to 6Mbps.

Spaceway will incorporate complete digital electronics that can interface with a wide variety of end-user equipment such as telephone, facsimile, personal computer and video. The system is fully compatible with a wide range of terrestrial transmission standards such as ATM, ISDN, Frame Relay and X.25.

### **Terminals**

Access to the system is through a family of low-cost, easily installed 26-inch (66cm) terminals.

## **6.8 Teledesic (Broadband, LEO)**

Teledesic is a private company based in Kirkland, Washington. The company was founded in 1990. Teledesic is building global, broadband Internet-in-the-Sky. Design, production and deployment of the Teledesic system are estimated to cost about \$9 billion.

### **Ownership**

Teledesic's primary investors are McCaw, Bill Gates, Motorola, Saudi Prince Alwaleed Bin Talal and Boeing.

### **Operational**

Operational from 2003.

### **Coverage area**

Worldwide, including polar area.

### **Satellite system / Technical parameters**

288 Satellites + spares in 1375km circular low earth orbit. Broadband data and voice services. Teledesic will operate in the high-frequency Ka-band of the radio spectrum (28.6 - 29.1 GHz uplink and 18.8 - 19.3 GHz downlink).

Data rate: from 16kbit/s to 2 Mbit/s uplink

Data rate: from 16kbit/s to 64 Mbit/s downlink

### **Service**

Teledesic will develop alliances with service partners in countries worldwide, enabling service providers to extend their networks, both in terms of geographic scope and in the kinds of services they can offer. Most users will have two-way connections that provide up to 64 Mbps on the downlink and up to 2 Mbps on the uplink. Higher-speed terminals will offer 64 Mbps or greater of two-way capacity. This represents access speeds more than 2,000 times faster than today's standard analog modems.

### **Terminals**

The Teledesic system's low orbit eliminates the long signal delay normally experienced in satellite communications and enables the use of small, low-power terminals and antennas. The compact terminals will mount on a rooftop and connect inside to a computer network or PC.

## **6.9 Skybridge (Broadband, LEO)**

A broadband satellite project led by Alcatel Alsthom.

Space segment cost: B\$4.2. Ground segment cost: B\$1.9

Has contracts with China, US, Proton & Arianespace to launch satellites.

Will be marketed together with Cyberstar.

### **Ownership**

Owned by Alcatel Espace, Loral Space and Communications, Mitsubishi, Sharp, Spar Aerospace (Canada), Aerospatial (France) , SRIW (Belgium), Toshiba, and Com Dev (Canada).

### **Operational**

Expected to enter service in 2001, with full operation by 2002.

### **Satellite system / Technical parameters**

Using 80 LEO satellites (up from 64) orbiting at 1,469 km, in Ku Band. This low earth orbit allows the short signal propagation time - 30 milliseconds - needed for the provision of real-time interactive services. Data rates from 16kbit/s to 2Mbit/s uplink, and 16kbit/s to 20 Mbit/s downlink. (Professional users can achieve 100Mbit/s downlink.)

### **Coverage area**

Worldwide including the polar area.

### **Services**

SkyBridge is designed to provide end users with:

- high speed connection to the Internet and the global backbone
- immediate access to local service providers and content
- connection to the public telephony network

SkyBridge will try to be attractive to operators by:

- Letting the local operator "own" the customer relationship
- Unlike some other systems, SkyBridge will not "bypass" the terrestrial network, either technically or commercially
- The local operator will define products and pricing in its market
- Standard interfaces and technologies, such as ATM and IP, will make SkyBridge easy to integrate with existing terrestrial networks
- SkyBridge will conform to local regulatory and governmental conditions in the delivery of its service.

### **Terminals**

Users - either business or private will be equipped with low cost terminals (\$700 for a residential terminal).

## **6.10 CyberStar (Broadband, GEO)**

Introduced as a service in 1998, using Telstar Ku-band satellites.

Loral and Alcatel will market the Cyberstar and Skybridge together, and plans to bring Internet Access, broadband interconnection, VOD and data services.

The project is estimated at \$1.6 billion.

### **Ownership**

Cyberstar is a joint venture of Loral Space and Communications and Alcatel Espace.

### **Operational**

Expected to launch dedicated satellites in 2000 and be fully operational in 2001.

### **Satellite system / Technical parameters**

Utilizes three geostationary satellites in the Ka band.

Very little technical details are available.

### **Coverage area**

The coverage area will be North America, Asia and Europe.

### **Services**

By adhering to current standards, CyberStar's services will support industry standards such as Internet Protocol (IP), MPEG, and HTML.

CyberStar claim to offer six distinct services:

**eCinema** - CyberStar's service is a satellite-based system that enables studios to distribute movies to theaters within hours of the final edit.

**Enhanced Business Television** - CyberStar provides global business television services for sales, corporate, and educational communications - building networks, producing and delivering special events and daily programming.

**Digital Delivery Services** - Some software can be downloaded from the Internet easily and quickly, while other software, due to its size, is better suited for CD distribution; however, both solutions are costly. With CyberStar Digital Delivery Services, distributing even the largest applications and the latest commercial and marketing literature can be sent to five or 5,000 offices, simultaneously, overnight.

**Narrowcast TV** - Through in-store marketing techniques, retail stores can offer customers videos and mini-commercials on monitors or kiosks displayed in store walkways. Each store's kiosk can be updated with one multicast. The individual store receives the data through its satellite dish and stores it on computers for immediate or later use.

**Distance Training and Learning** - Instructors can use CyberStar's satellite-based communications capabilities to enhance their training offerings. CyberStar can disseminate course materials and courses to students; high-speed browsing will provide on-line research for key course work; and streaming will give students additional curriculum by sending vast amounts of text, video, and graphics directly to the students.

**High-Speed Internet Browsing** - Users can browse the Internet and the World Wide Web using satellite technology with significant performance improvements.

Compliance with industry standards.

### **Terminals**

No details are available about terminals.

## 7 Future satellite systems, overview

Chapter 4 described carefully these future systems:

ICO, Globalstar, Ellipso, Astrolink, Spaceway, Teledesic, Skybridge and Cyberstar.

This research has covered up 24 new systems and the remaining 16 future systems are given a roughly overview in this chapter.

This systems are introduced in alphabetic order:

- ACeS
- Africom
- APMT Asia Pacific Mobile Telecom
- ASC (Agrani) Afro-Asian Satellite Communications
- E-Sat
- EAST Euro African Satellite Telecommunications
- ECCO (Constellation)
- Expressway
- FAISAT
- Gemnet
- GE\*Star
- KaStar
- Leo One
- M2A
- Satphone
- Thuraya



## **7.1 ACeS**

A \$900 million fully financed project that uses two A2100AX geo satellites manufactured by Lockheed Martin. The launch is now 1999, with service commencing in 1999.

The services are voice, data, fax and paging. ACeS stands for Asia Cellular Satellite System. It will cover South East Asia, India, China and Australia.

The Network Control Centre and the three gateways for Indonesia, Philippines and Thailand will begin receiving equipment for site installation late 1997, and all systems will be installed by late 1998.

Partners in the project are Pasifik Satelit Nusantara (PSN) of Indonesia, Philippine Long Distance Company, Jasmine International PLC, of Thailand. Lockheed Martin is likely to take a 25-32% stake in ACeS. Service provider agreements in India, Pakistan and Bangladesh. Ericsson will provide dual-mode handsets.

## **7.2 Africom**

A partnership between Africom and Lockheed Martin that expects to have a geo satellite (cost \$650 million) operational by 1999. The project was created to address the business market, perceived to be starved of terrestrial capacity. The service offered was to be mobile telephony using handheld sets. Few details are available.

## **7.3 APMT Asia Pacific Mobile Telecom**

Two HS702 geostationary satellites, one spare, built by Hughes. Offering hand-held mobile services.

Was expected to launch in 1998 at a cost of \$650 million, but in July 1998 the export license for Hughes, to export the APMT satellite to China, was suspended by the US Government. Hughes and APMT are searching for alternatives. Plans called for launch by end of 1999, and service in 2000.

Venture by China Satellite Launch & Tracking Control General, China United Telecommunications Satellite Co. Ltd., China Telecommunications Broadcast Satellite, China Overseas Space Development & Investment Co., Singapore Technologies, Singapore Telecom.

It is in direct competition to ACeS Garuda, targeting China, Philippines, Vietnam and South East Asia, with mobile and fixed voice, fax and data. Recent announcements claim service charges less than one third of competitors at around \$1 per minute.

## **7.4 ASC (Agrani) Afro-Asian Satellite Communications**

Launch date slipping and reported to be looking for another satellite, until ASC can be launched. Cost is estimated at around \$710 million, with just over \$200 million achieved to date.

ASC uses two satellites, covering 54 countries from Turkey to Singapore, and Sri Lanka up to Russia. The first satellite will concentrate on India. Costs of hand held phones reported to be \$700 - 1000 and the cost per call \$2 per minute.

The partners are Essar Telecom and Essel Group, VSNL. Originally the system used Hughes satellites, but now has signed with Lockheed Martin.

## **7.5 E-Sat**

The FCC awarded a license in March 1998. This \$50 million project from Echostar Communications and DBS Industries focuses on remote reading and monitoring in North America, particularly for gas and electricity utilities.

Plans to use six LEO satellites orbiting at 1260Km. Launch slipped to 2000.

Shareholders & Strategic Partners:

- Echostar Communications, DBS Industries. Matra Marconi Space designs the satellites and SAIT systems the ground terminals.
- DBSI is currently seeking an equity investment from Matra and SAIT, and negotiate a definitive agreement.

Services Offered

- Store and forward messaging.
- Low cost, two-way data messaging services for fixed users in rural areas in US and Europe.

Geographic Coverage

- Focused mainly on North America.

Market Strategy

- It is particularly targeting the gas and electricity utility industries in North America for remote monitoring of equipment for faults.

## **7.6 EAST Euro African Satellite Telecommunications**

The satellite is expected to be launched in late 2001 for 2002 operation. Announcements expected later in 1999.

Uses a Eurostar 3000 geostationary satellite to cover Africa, Middle East and parts of Europe, focusing on rural voice, with some data, with Internet access at 57.6, 115.2 and 384kb/s. Plans to provide low cost services to extend the terrestrial networks.

Partners are Matra Marconi Space, Digimed, Matra Hautes Technologies (France), Nera (Norway), Aon Space (space insurance). Estimated costs are \$800 million for satellites, and \$350 million for gateways. \$250 million is reported to have been obtained from MMS, Cyprus Telecommunications Authority, and NERA and a further \$150 million is needed to proceed further.)

## **7.7 ECCO (Constellation)**

A \$450 million project from a consortium consisting of Constellation Communication Services, Telebras, Bell Atlantic, CTA Launch Services Inc, E-Systems.

CCI International's initial Constellation space and ground network will consist of 12 Orbital-built satellites ringing the Earth's equator in low-altitude orbits, ground-based gateway switching stations strategically located throughout the world, a central satellite control and communications management facility and various types of subscriber telephones, including mobile handsets and fixed-site units. Later, in a phased deployment of additional satellites, the Constellation system will be expanded to provide continuous global coverage with similar satellite, ground systems and telephone technologies.

Beginning in 2001, CCI International's affordable satellite telephony services will be available to subscribers in the world's equatorial regions, comprising over 75 countries. With a combined population of more than 1.8 billion people, these countries include Brazil, Mexico, Venezuela, India, Indonesia, Malaysia, Philippines, Australia and dozens more in Asia, South and Central America, Africa and the Middle East.

One of the basic characteristics of the system is to establish mobile services for the Earth's intertropical. Through commercial/operational agreements with other LEO/MEO systems, it will be possible to use ECCO to cover latitudes beyond 30 degrees. With dual cellular/satellite handheld terminals, the coverage may also include areas where mobile cellular services are available, by means of roaming agreements with cellular operators.

The ECCO System is designed to offer the usual telecommunications services such as telephony (on-board communications for the mobile segment, private telephones in rural properties, public payphones, operating with both prepaid and credit cards, installed at remote convergence points); data communications; fac-simile; paging; radio

location for vehicles as trucks, trains, boats and buses; telemetry for remote data collection (meteorological applications: pluviometry, temperature and humidity, hydrology: dam and river levels, environmental control: pollution, and forest fires); telecommands; and telesensors.

Terminaltype:           Portable + Dual Cellular/Satellite  
Unit Cost:               US\$ 1,000 to 1,500

## **7.8 Expressway**

In July 1997 GM Hughes filed an application with the FCC for a \$3.9 billion project using 14 geostationary satellites on V and Ku band frequencies for global provision of high speed data services.

## **7.9 FAISAT**

A \$250 million project from Final Analysis and Polyot Enterprises, planned for 2002, using 32 LEO satellites in 6 orbit planes, plus 6 in-orbit spares. The FCC awarded a license in 1998, and is expected to be operational by 2002.

The system is designed for two-way messaging, asset tracking, monitoring and control, and file transfer. The geographical area is worldwide.

## **7.10 Gemnet**

A \$160 million project from Orbital Sciences (CTA Inc) for 38 LEO satellites in 1000km circular orbit for tracking & monitoring, email and paging. Low data niche markets. Was expected to begin in 1999.

## **7.11 GE\*Star**

GE Americom has filed with the FCC for five KA band slots in a \$4 billion project using nine geostationary satellites from Alcatel.

Frequency Uplink: 28.35 - 28.6 and 29.25 - 30  
GHZ and data speeds from 384kbits to 40Mbit/s.

Harris was selected as the prime contractor for the GE\*Star Satellite System, which will utilize the Ka-Band frequency spectrum to provide global broadband multimedia services that handle internet traffic, video broadcasting, satellite news gathering, telemedicine and other applications. Beginning operations in 2002, the GE\*Star Satellite System will complement the existing fleet of C-band and Ku-Band satellites operated by GE Americom.

## 7.12 KaStar

A \$520 million project for two geostationary satellites from Lockheed Martin, expected to be operational in 2001 for broadband ATM data, digital video and voice, targeted at the US, Mexico and Caribbean.

Uplink freq: 19.2 to 20.0 GHz  
Downlink freq. 29.0 to 30.0GHz  
Data rates >1.544 Mbit/s

KaSTAR Satellite Corporation will use Arianspace to launch the satellites with Ariane V launchers. Space Systems/Loral have signed a \$300 million agreement to construct the two Ka-band spot beam satellites.

KaSTAR plans to augment terrestrial and satellite networks with ubiquitous, 2-way, broadband service directly from space to the home.

## 7.13 Leo One

The FCC awarded a license in Feb of 1998. Leo One plans to be operational some time in 2000.

A \$250 million project from dBX Corp for 48 LEO satellites arranged in 8 orbital planes at an altitude of 950 Km. Each satellite weighs about 165 kilograms (364 pounds) and has an orbital period of approximately 104 minutes.

The useful life of the satellites is five to seven years. They are designed for easy deployment, singly or in groups, from a variety of available launch vehicles

Downlink freq. 137 to 138 MHz  
Uplink freq. 148 to 150.05 MHz  
Data rate (uplink) 2.4 to 9.6 kbit/s  
Data rate (downlink) 24 kbit/s

Aimed at the low cost vehicle tracking, status monitoring, paging, and emergency alerting niches. The constellation will serve business, industry, and consumers worldwide.

The mobile satellite system design developed by Leo One represents attainment of wireless services: a two-way, seamless, wireless network that is both affordable and worldwide in its coverage. The Leo One system complements and extends the existing national networks of local, long distance, public, private, and terrestrial wireless services.

## **7.14 M<sup>2</sup>A**

A single GEO satellite for Pasifik Satelit Nusantara (PSN) aimed at the Asia Pacific Region, primarily Indonesia. Cost estimated at \$350 million.

Launch and operational service was planned for 1999. Work was reported as suspended in 1998. Future projections mean satellite will not be operational until 2000+ One FS-1300 GEO satellite was manufactured by Loral Space and Communications. Alcatel received a \$115 million contract in 1997 for ground segment.

## **7.15 Satphone**

A \$1.7 billion project from Lockheed Martin Telecommunications, Advanced Technology Fund inc., M.O.Al Amoudi Corp to bring mobile and fixed voice to the Middle East, Northern Africa and the Mediterranean.

## **7.16 Thuraya**

A \$850 million project from Etilsat, Arabsat and Bahrain Telecommunications to launch two GEO satellites to cover the Middle East, Eastern Europe, Central and Southern Asia. Target launch 2000.

## 8 Telemedicine via Satellite Systems

This chapter describes a few examples of satellite based telemedicine projects. The examples are chosen in order to demonstrate the variety of satellite based telemedicine projects. The telemedicine projects within the ESA Tender AO/1-3392/98/NL/DS Tele-Education / Tele-Medicine Pilot Operations, is not mentioned in this short summary.

The telemedicine projects are described in the following order:

- US Army, portable satellite telemedicine
- Hector, Göteborg
- MERMAID - Medical Emergency Aid through Telematics
- WETS, Worldwide Emergency Telemedicine Services
- TeleHelth, Keeweenaw Lakes

## **8.1 US Army, portable satellite telemedicine**

The US army's first portable telemedicine unit was built in 1993 and comprised a videoconferencing unit linked through a modem to an Inmarsat A terminal. The unit was initially used in the United Nations' operations in Macedonia in February 1994 and subsequently in support of the Mobile Army Surgical Hospitals in Haiti, but its dimensions and weight (151 kg) made it suitable only for locations where a move at short notice was unlikely. The second portable telemedicine unit comprised a PC linked to an Inmarsat B earth station through a modem. The unit allowed videoconferencing at 64 kbit/s, weighted 53 kg and was called 'The flyaway unit'.

### **The flyaway unit**

The flyaway unit is easily portable. It could be set up anywhere in the world within 15 min, with the exception of some areas in the polar regions. It has been successfully used by US army's medical personnel in Bosnia, Macedonia, Saudi Arabia, Thailand, Panama and Belize.

The unit was provided with a PC, a dual-purpose video/still-image camera and a full set of clinical scopes. The addition of a router and email software allowed high-speed data transmission (store-and-forward) also at 64 Kbit/s (assuming that the server at the receiving end was similarly equipped). A 1 MByte file could be transmitted in less than 1 min. Telemedicine by store-and-forward technique is possible by attaching clinical images to email messages. Clinical pictures, electrocardiograms, radiographs and computerized tomography scans can all be transmitted in this way. Radiographs were routinely transmitted from Bosnia and Saudi Arabia using a film digitizer.

### **Portable telemedicine**

Since the beginning of 1997, reliable, portable, satellite-based telemedicine has become a reality. Trained personnel with technically reliable systems will continue to expand both the role of telemedicine and its utility in providing good quality health care to US forces in the field. The flyaway unit is a major enhancement to deployed forces and others needing to provide good medicine in bad places, anywhere in the world.

Reference: Portable satellite telemedicine in practice by Navein, Fisher, Geiling,  
Richards, Roller and Hagmann  
Journal of medicine and care, Volume 4, Supplement 1

## 8.2 Hector, Göteborg

HECTOR, Health Emergency Care Through Telematic Operational Resources, is a Maritime Medical Consulting System. The purpose of the Hector project in Göteborg is to design and implement a prototype system that promotes safe and qualified medical care at sea. In case of medical emergency on board, a direct contact can be established with the emergency department of a designated hospital. The system transfers video images, sound, medical data and provides direct video-conferencing between the ship and the hospital. Provided with detailed first-hand information about the patient's condition the consulting physician is in a better position to decide upon and guide the ship's personnel in the treatment of the patient.

On-board the ship a PC-based video-conference system and a telemedicine terminal (Mobimed® PWS-1000) is placed. The telemedicine terminal registers and transmits, simultaneously with video and speech, 12-lead ECG and pulsoxymetri (SpO<sub>2</sub>) data. Blood pressure values, forms and text can also be transmitted. An image-stabilized video camera can be used either on a fixed mounting or moved to focus on any part of the body. The system communicates via satellite and ISDN. At the emergency department in the hospital a corresponding video-conference system and a Mobimed® HWS terminal displays medical data and color video images sent from the ship.

The system is in use on a large passenger ferry, M/S Stena Germanica, between Göteborg and Kiel (Germany) as part of the project.



PHOTO CAME AAR EPOTAGE

**M/S Stena Germanica**

Reference:

[http://www.ortivus.se/projects/eu\\_gb.html](http://www.ortivus.se/projects/eu_gb.html)

### 8.3 MERMAID - Medical Emergency Aid through Telematics

MERMAID is setting up an integrated 24-hour multilingual, telematic, around-the-world, medical emergency service that will transfer medical expertise via satellite and ground based ISDN networks to marine (ships, offshore oil rigs etc) points of care taking into account that

- a) voice medical teleconsultation is obsolete,
- b) video-telephony permits "face-to-face" medical teleconsultation and remote visual inspection and
- c) telemedical interventions (which are critically dependent on local paramedic skills), can be aided by locally resident multimedia support. MERMAID is developing:
  1. A locally resident multimedia medical guide for ships to serve both as a training aid and as reference.
  2. INMARSAT links for transferring images, sounds, text (patient anamnesis) and signals which will be feeding into a private ISDN network that links together the MERMAID health care providers.
  3. The telematic means for medical teleconsultants to remotely interact with the locally resident multimedia medical guide, so that they can efficiently demonstrate health care procedures to local paramedics

Requests for help, broadcast over INMARSAT, will be routed to one or more MERMAID specialist teleconsultants depending on the type of help needed, language(s) required for efficient communication, proximity to the site of emergency etc. Thus MERMAID, by relying on telepresence and by combining locally stored multimedia reference material with remote medical consultation, proposes a viable solution to the problem of missing medical expertise for isolated points of care. It is significant that the MERMAID pilot users represent 1% of the world merchant marine, a size that guarantees the validity of its outcome and is a good start for disseminating the MERMAID results.

Reference:

<http://www2.echo.lu/telematics/health/mermaid.html>

## 8.4 WETS, Worldwide Emergency Telemedicine Services

The objective of WETS is to demonstrate the feasibility and effectiveness of a common infrastructure able to give support to any mobile unit in case of medical emergency on land, sea and air.

It will be achieved through:

- use of different communication links (i.e. GSM, Satellite, Radio, ISDN);
- use of positioning system (i.e. GPS);
- transmission of vital signs and images;
- access to relevant clinical information;
- use of on-board decision support tools (i.e. Multimedia Medical Guide);
- access to remote medical expertise (i.e. healthcare referring centres).

WETS will heavily rely on the European HECTOR and MERMAID projects. In fact, it will start its activities on the basis of the user needs analysis and functional specifications definitions as produced in the corresponding HECTOR and MERMAID activities and deliverables.

WETS will develop three "extended" pilot sites (in Italy, Greece and Spain), integrating the pilot sites functionality's of the two aforementioned projects.

The main activity will be focused on their validation on a large scale, involving a quite broad range of user-groups, both at the end-user level (seamen, air passengers, fishermen, citizens) and the professional level (medical doctors, ship-owners, airlines).

The consortium include all the appropriate actors (University-hospitals as healthcare referring centers, front-end support centers, industries, etc) many of them being already experienced in the management and development of large healthcare telematics R&D projects.

Reference:

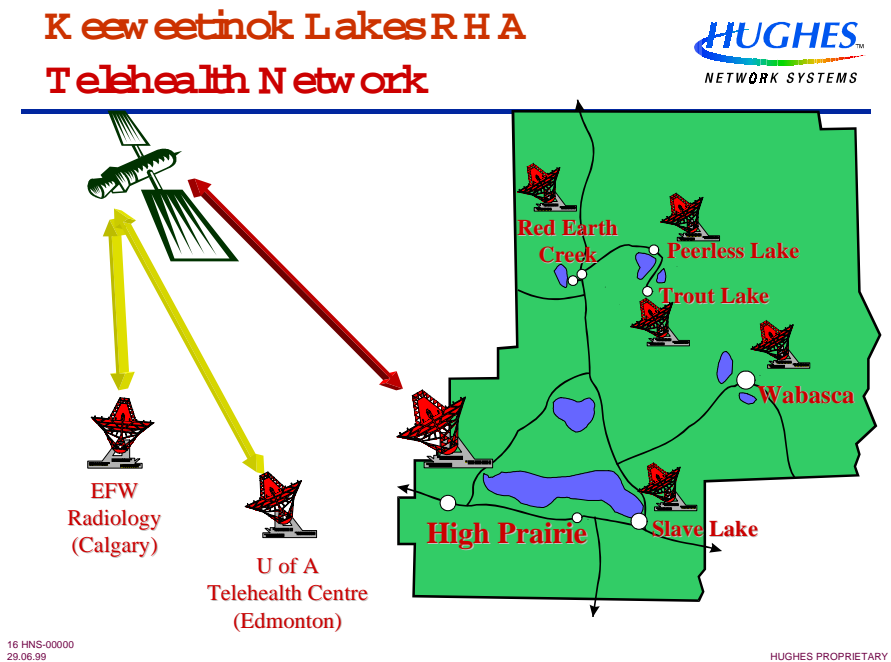
<http://www.dist.unige.it/wets/main.html>

## 8.5 TeleHealth, Keeweenok Lakes Canada

The project TeleHealth, a satellite-assisted, televised health care service that "transports" doctors to remotely located patients for real-time consultation and treatment. Hughes Network Systems (HNS) is providing very small aperture terminal (VSAT) equipment for TeleHealth, which consists of a series of communications links connecting health-care providers with remote residents of the Keeweenok Lakes Health Region No. 15 in Alberta, Canada. The system employs the HNS inTELEconference system, which provides videoconference links via satellite for point-to-point or multipoint conferencing in a full-mesh network architecture. HNS is working in conjunction with Raytheon Systems Canada (formerly Hughes Aircraft of Canada, Ltd.), Raytheon Training Inc. (formerly Hughes Training, Inc.), and Telesat Canada.

In 1994, the Alberta government restructured its province into 17 Regional Health Authorities (RHAs). Keeweenok Lakes RHA No. 15, an area of approximately 19,000 sq. miles (50,000 sq. kilometers), contains a population of 25,000 people, widely dispersed over great expanses of land. For this reason, remote areas have difficulty retaining physicians, and doctors are discouraged from setting up local practices. For patients, travel to and from doctors and health care facilities is often problematic. Using the inTELEconference network, Raytheon Training LINKcare® TeleHealth systems will provide services such as direct assessments, doctor-patient interaction ranging from consultation to endoscopic and dentistry applications and continuing education for healthcare practitioners.

Executing this type of service terrestrially or through point-to-point satellite was either too expensive or impractical. Instead, through inTELEconference, six Alberta communities are linked for TeleHealth applications and are also connected with Edmonton, Calgary and other centers through Canada so they can directly communicate with each other.



## 9 References, existing and future satellite systems

<http://www.intelsat.int/>

<http://www2.eutelsat.de/home.html>

<http://www.alespazio.it/italsat.htm>

<http://www.orbcomm.com/>

<http://www.magellangps.com/>

<http://www.iridium.com/>

<http://www.thaicom.net/>

<http://www.optus.net/>

<http://www.teledesic.com>

<http://www.cyberstar.com>

<http://www.astrolink.com/index.html>

<http://www.spaceway.com>

<http://www.skybridgesatellite.com/>

<http://www.globalstar.com>

<http://www.stratos.ca/services/pss/m4/map.htm>

<http://www.ico.com>



Telemedicine via Satellite Services – Work-Package 2

**Project:** Telemedicine via Satellite Services

**Contract:** 13489/99/NL/S

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This report is the second out of three on the project *Telemedicine via Satellite Services*. The aim of work-package 2 is to:

1. Perform a practical demonstration of telemedicine via satellite communication at already established sites.
2. Investigate quality, efficiency and cost of telemedicine services at sites using satellite communication, ISDN and a combination. The sites in question will be selected from current and planned international telemedicine projects in progress.
3. Report findings.

## 10 Preface

## Work Package 2

This work-package report is the second out of three on the project *Telemedicine via Satellite Services*.

The project is funded by European Space Agency (ESA).

The main aim of the project is competence building in the field of satellite-based telemedicine. As a result, the National Centre of Telemedicine, University Hospital of Tromsø, will gain experiences in order to develop telemedicine services to other parts of the world by means of global satellite services.

This report is written by project manager Ms. Eli Larsen at the National Centre of Telemedicine, Tromsø University Hospital and senior advisor Mr. Erik Otto Evenstad at Telenor Research and Development. The report is based on practical testing on satellite equipment.

The work has mainly taken place from August to the end of October 1999.

The report consists of four chapters:

- Introduction
- Testing of equipment and services
- Telemedicine scenarios
- Conclusion

We would like to give our acknowledgments to:

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University Hospital of Tromsø, the 31<sup>st</sup> of October 1999

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Eli Larsen

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Erik Otto Evenstad

## **11 Introduction            Work Package 2**

Satellite communications has undergone many stages since the introduction of Early Bird in 1965. Today communication via satellite is evolving in many countries.

The introduction of digital TV has resulted in a huge number of channels coming down to receivers in industrialized countries. Moreover, VSAT systems are increasing. Development in technology has now opened up for terminals with smaller size and increased capacity. Access to mobile terminals and services are necessary in order to meet the Fixed Mobile Convergence trend.

Internet via satellite is a fast growing sector within satellite communication. Several of the new satellite systems coming up, stakes a lot on this market. The potential is huge, extending from big companies to small office/home office (SOHO). It is possible to obtain broadband communication to Internet via a simple installation to a personal computer. Skybridge and Teledesic are two representative future systems in this sector.

Telemedicine and health telematics have proved to cause several socio-economic benefits. It can generate new sources of revenues for service providers and equipment suppliers and can optimize the use of available human and capital resources in many countries. There cannot be high-technology hospitals everywhere, and with telemedicine links there is no need to be either.

In this project we have evaluated several available satellite communications services with special focus on telemedicine and existing applications.

Two kinds of services, terminals and equipment have been evaluated.

For the mobile case – activity 1, the new multimedia service from Inmarsat has been investigated. This is the so-called M4-service which was introduced by Inmarsat during this fall. There has been accomplished several tests on a WorldCommunicator delivered by the Norwegian company Nera. The M4-service offers ISDN from “anywhere” in the world covered by the spot beams from the Inmarsat satellites. This terminal can therefore be used for telemedicine purpose where mobility is a key element.

In activity 2 we have focused on multimedia services in a point-to-multipoint configuration. The advantage of satellite communications have clearly been demonstrated by uplinking large information files from a satellite station to be received by ordinary TV receivers and directly fed into a PC for presentation and evaluation. The project group has participated in a practical demonstration of both software and equipment provided as sales product at Telenor Satellite Services. Based on this demonstration and further studies on all available documentation we are able to draw some conclusions regarding this product in this product's context.

Description of the activities, services, equipment, test set up and results is found in chapter 2.

In chapter 3 we have described some scenarios where the above activities are put into a telemedicine perspective.

## 12 Testing of equipment and services

### 12.1 Activity 1 – satellite based telemedicine "on the move"

To a certain extent, telemedicine applications are already used in ambulance today. Information like ECG (Electrical Cardio Gram) can be transferred via mobile telephone systems to the regional hospitals in order to access medical experts for immediate assistance during emergency situations. To some extent, the same information could also be transferred via the Norwegian health radio network.

However, there are several locations outside the coverage area of this radio-network, e.g. mountainous regions and ships.

Access to terrestrial telecommunication networks may be impossible and may therefore isolate users from the surrounding world.

One may overcome this "isolation" by using satellite networks to access health networks and provide health-related information. For three years, mobile units within the Inmarsat system like terminals in the Mini-M service have been available. These terminals are not bigger than the size of a lap-top PC, but offer a limited data speed of 4,8 Kb/s. There are currently some 45.000 Inmarsat Mini-M terminals in use worldwide.<sup>2</sup>

Therefore, in this part of the project, WP-2, it is interesting to look for mobile systems allowing higher data rates than the existing Mini-M. During the fall of 1999, a new service for mobile users has been offered from satellite service suppliers like Telenor. The name of the service is Inmarsat M4 (Multi Media Mini-M) or Mobile ISDN. It has been a natural choice for us to evaluate this service and terminal equipment in a telemedical context.

#### Mobile ISDN – now via satellite

The new service is a Global Area Network (GAN) satellite service, the world's first global communication system for mobile multimedia applications. Within this service, it is possible to link a local or wide area network with a global one.

A Global Area Network user can access up to 64 Kb/s of data capacity from a laptop-size multimedia terminal from anywhere in the world. Comparable in speed to a fixed ISDN connection, GAN dramatically boosts both the data transfer capabilities and the mobility of remote communication.

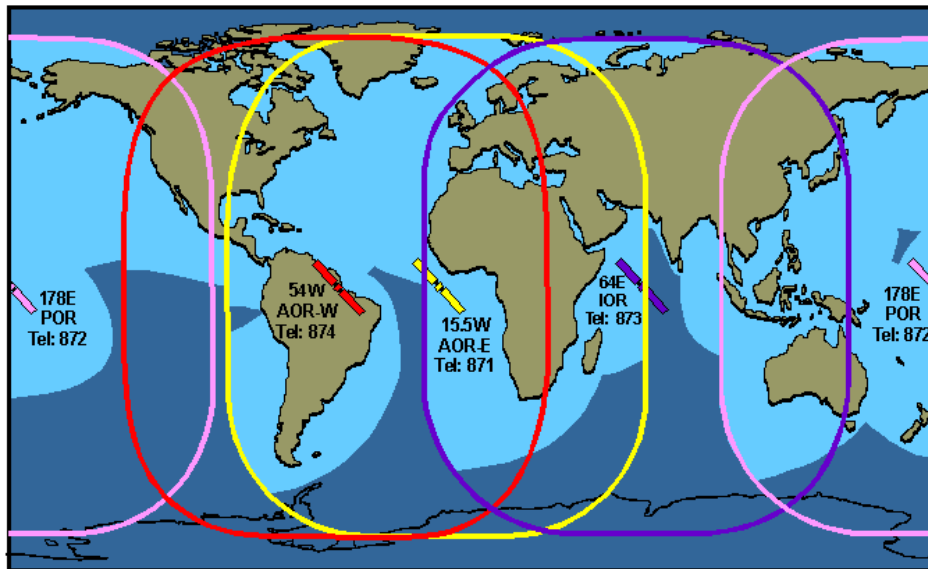
Several satellite equipment companies are offering terminals for GAN including Nera, Thrane & Thrane and STN Atlas Elektronik.

In this project we have used equipment from Nera. This will be further described in the next chapter.

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<sup>2</sup>[http://www.telenor.com/display.cfm?m=3&s1=2&s2=1&file=products\\_services/satellite/news220999.html](http://www.telenor.com/display.cfm?m=3&s1=2&s2=1&file=products_services/satellite/news220999.html)

The M4 service allows a user to hook up ISDN terminal equipment to the M4 terminal that has an Euro-ISDN interface. These special feature opens up for ISDN equipment in general to be used anywhere within the coverage area of the service, which is shown below.



**Figure 1 M4 coverage area - light blue**

Only one of the B-channels are available over the satellite giving a net service capacity of 64 Kb/s compared to 128 Kb/s (2\*B-channels) for terrestrial ISDN.

Another limitation for this kind of service is the necessity of free sight or no obstacles towards the operational space segment.

Typical terminal cost for Nera terminals are \$ 10 000 and the price per minute is approximately \$ 10.

Inmarsat's Global Area Network Service (M4) has been introduced to meet the increasing demand for mobile data capacity. It enables users to bring their ISDN environment, or other applications requiring bandwidth, from their offices to anywhere on earth.

The combinations of the Nera WorldCommunicator and the Global Area Network service is the perfect solution where clear and dependable communication is vital. It provides 64 Kb/s "high speed data" low cost voice in a format and in a way, which is as easy to use as an ordinary phone.



**Figure 2 Nera WorldCommunicator**

### **Key Features for Nera WorldCommunicator**

- 64 Kb/s data
- 4.8 Kb/s compressed voice
- ISDN compatibility
- USB (Universal Serial Bus) interface (In later version)
- Self explanatory man machine interface
- Built in Lithium -Ion battery
- Handy cordura bag supplied with the terminal
- Built in DECT base station

### **Value added service options**

- Supplied with each terminal there is a CD ROM which provides easy access to manual, applications, user guidance and other useful information
- Pole mounted antenna available for more permanent installations
- Secure voice STU III (In later version)

### **System specifications**

- Tx frequency: 1626.5 - 1660.5 MHz
- Rx frequency: 1525 - 1559 MHz
- Channel spacing: 5/40 KHz
- EIRP: 25 dBW
- G/T: -7 dB/K
- DECT: 1880 - 1900 MHz

## Size and weight

- Dimensions collapsed: H=68mm W=275mm D=355mm
- Antenna folded out: H=340mm W=774mm D=12mm
- Weight (including battery): 3.9kg (3.4kg without battery)

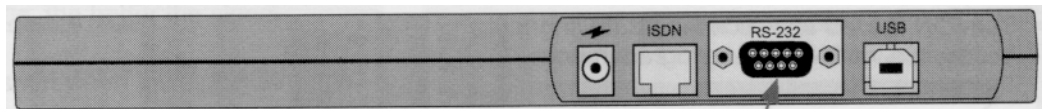
## Environmental conditions

Operational: Antenna: -25 - +55 C, Modem -25 - +55 C  
The battery efficiency is degraded under low temperatures

## Electromagnetic compatibility

- EN 300 339
- TBR 44

## Interfaces



- 19 VDC input
- ISDN (RJ45-50)
- RS-232 (9-pin DSUB)
- USB port (In later version)

## External options

- Line adapter for analogue devices such as group 3 faxes
- DC/DC converter: Input range 10-32 VDC

## Power consumption

Standby time: >50 hours  
Transmit: 40 W maximum  
Charging: 40 W maximum

## Telemedicine applications

In medicine there is a constant development of applications that is possible to apply to telemedicine. The applications can mainly be divided into two technical groups depending on the need for real time service or not (store and forward solutions).

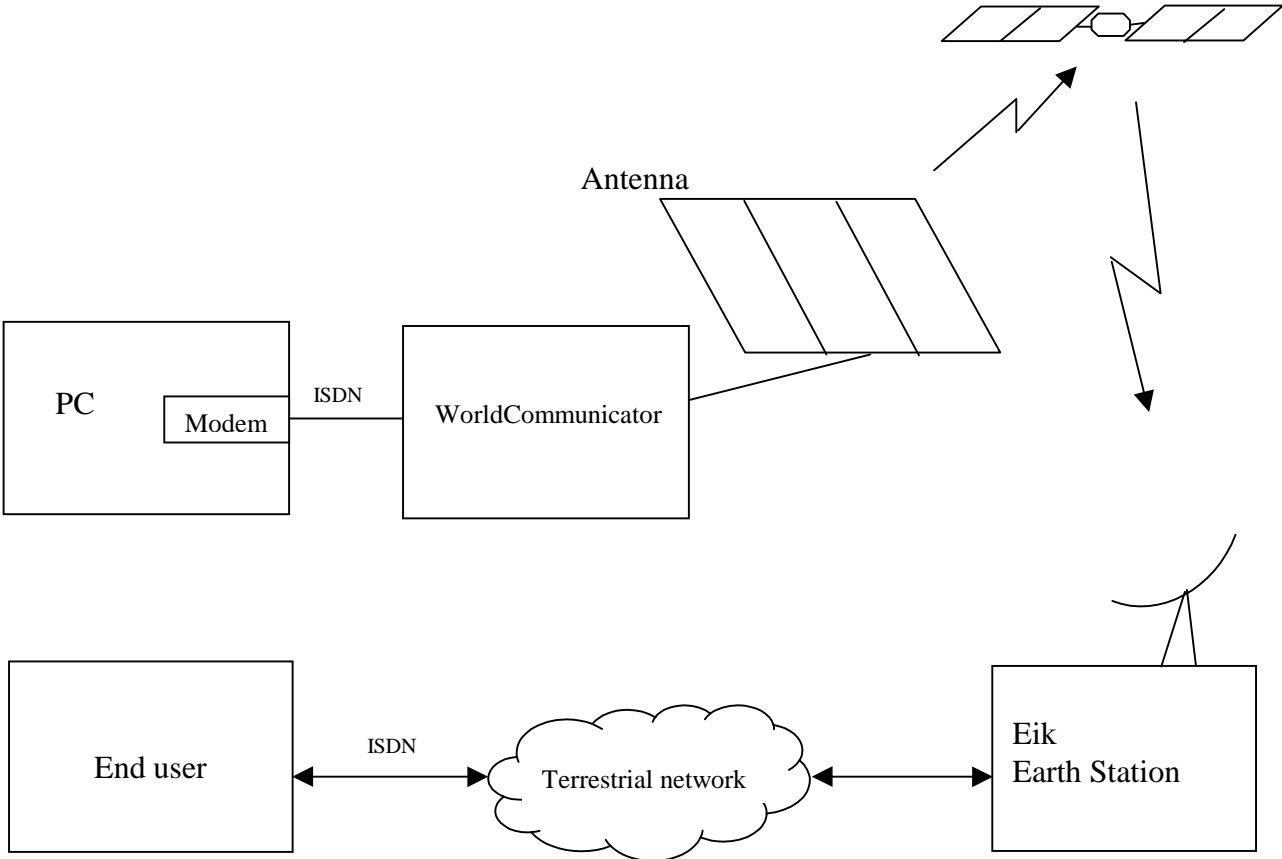
1. High quality real time video. Used for conference, training and surgery. The communication lines need to be broadband in order to satisfy the users.
2. File transfer. Store and forward solutions can be used for still images, sound, ECG and text files. Types of images vary from pictures of sores taken by a digital camera, via pictures from endoscopi and ultrasound to X-rays. Files containing images are characterized by a large amount of data. Sound, ECG and text files are just a fraction as big as the high resolution image files. Requirements of the communication lines depend on how fast the data must be transferred from one place to another.

In project activity 1, we have tested:

- Real time video/videoconference using 64Kb/s bandwidth. This is an absolute minimum limit for videoconferences. In small mobile units the quality requirements can be lower than in an “indoor hospital environment”. The videoconferences equipment used has an ISDN interface and can be plugged right into the WorldCommunicator.
- Transferring ECG-files. Special mobile ECG-equipment is connected to the PC, which records and stores the ECG-recordings. The ECG’s are viewed in a range of format and is possible to send via ISDN-modem to the WorldCommunicator and further to a host at a hospital for example. A typical ECG-file is about 10 – 30 Kbyte.
- Transferring DORIS-files and using the “in conference” application. DORIS, **D**iagnostics **O**rders and **R**eports **I**nformation **S**ystem, is a multimedia telemedicine system. DORIS-files may consist of still images from endoscopi and digital camera together with explaining text. A typical DORIS-file is about the size of 1 Mbyte.

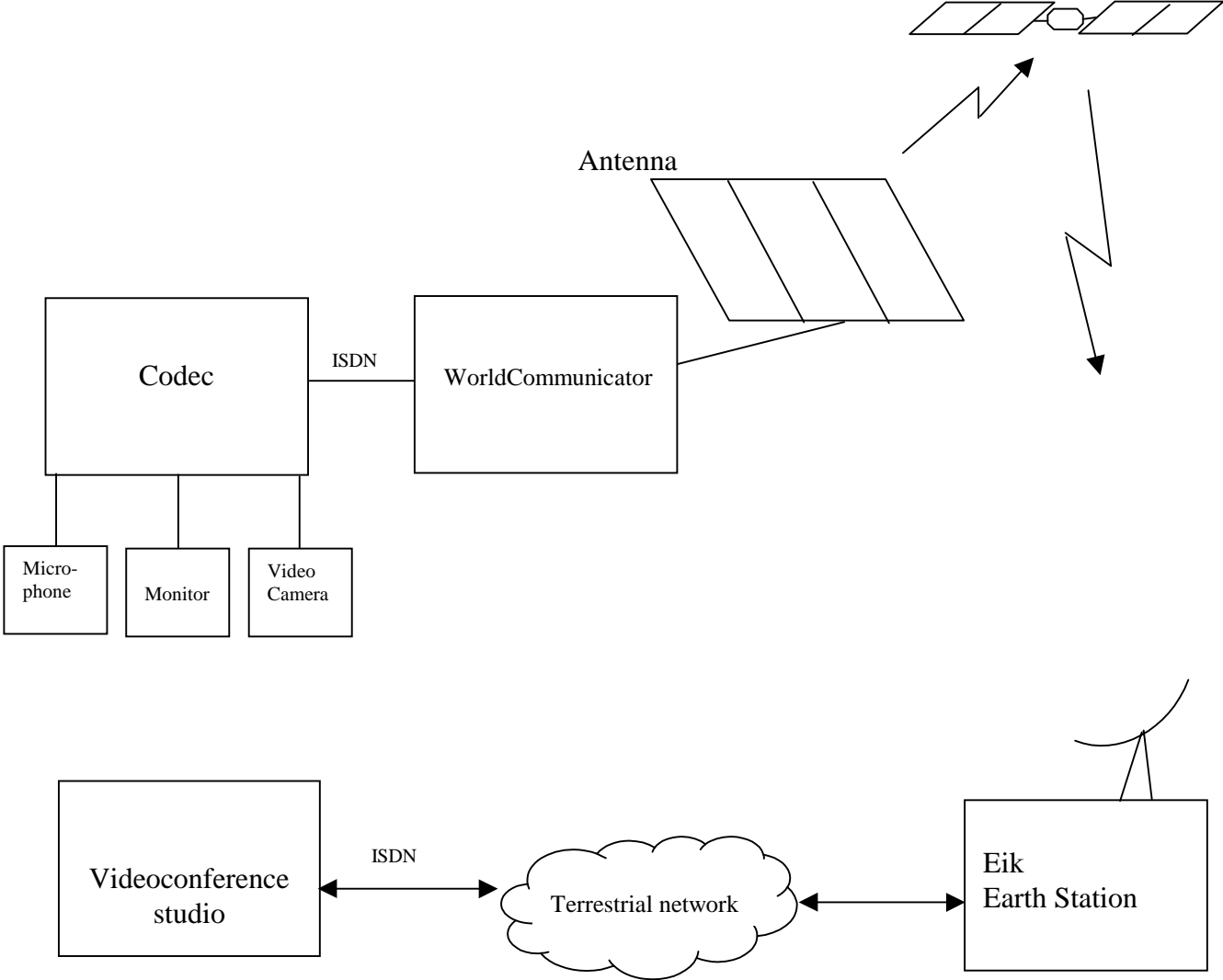
**Test set up via satellite**

The illustration describes the set-ups which were used for transferring DORIS and ECG files. The set-up was hooked up at Eik Earth Station and in Tromsoe. It is possible to make a connection like this anywhere within the M4 service coverage area.



**Figure 3 Set-up for transferring DORIS and ECG files via satellite**

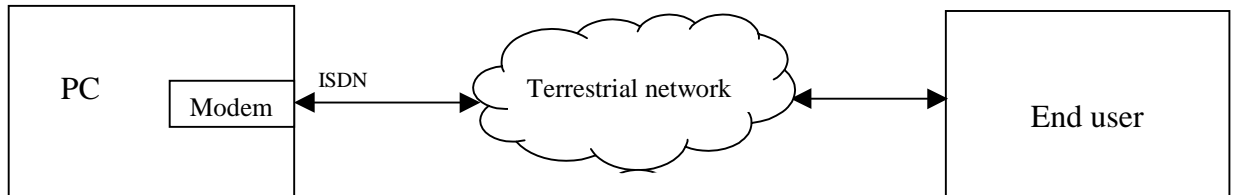
The illustration describes the set-ups which were used for testing videoconference. The set-up was hooked up in Tromsøe. It is possible to make a connection like this anywhere within the M4 service coverage area.



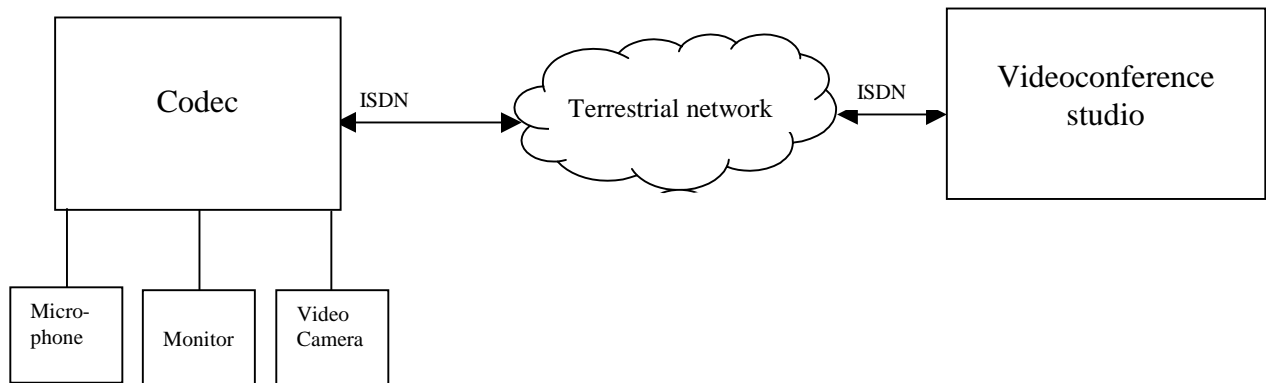
**Figure 4 Set-up for videoconference via satellite**

### Test set up via terrestrial ISDN

The illustrations describe the set-ups, which were used for transferring DORIS and ECG files and videoconference via terrestrial ISDN. The set-up was hooked up at Eik Earth Station and in Tromsø. It is possible to make a connection like this wherever ISDN is available.



**Figure 5 Set-up for transferring DORIS and ECG files on terrestrial network**



**Figure 6 Set-up for videoconference via terrestrial ISDN.**

## Evaluation of test results – activity 1

The WorldCommunicator has been tested for these applications:

- Internet connection (Via ISDN)
  - DORIS application - communication by e-mail and using “in conference” application
  - ECG application - communication by e-mail
- Videoconference 64 Kb/s
- Speech 4,8 Kb/s

Parameters for speech and videoconference quality is not measured in a technical point of view. Quality has been evaluated from a practical and a uses point of view. We have compared quality for the two applications with and without use of a satellite link.

Internet connection for e-mail sending and receiving gives us the possibility to measure data through put. We have further tried to verify if this kind of communication introduces errors to the transmitted medical files.

Additionally, we have evaluated the need of skills to install the equipment and the availability of a satellite connection.

## Results

The results are as follows.

- Internet connection. Once the equipment was installed Internet could be used similar to other more familiar connections. The WorldCommunicator made no difference from terrestrial ISDN. Medical information where sent and received without errors. The files where recognizable and identical to the original files. Using DORIS in the “in conference” application is depending on an additional phone connection between the two parties. This necessary additional telephone communication is not included in the DORIS application. DORIS used in a mobile situation will require such additional telephone.
  - The speed was measured to approximately 59 Kb/s when sending e-mail via satellite. Corresponding data speed in terrestrial ISDN was measured to approximately 61,5 Kb/s, introducing only a slight difference of 4 %. (Consult the Appendix B for details. We are referring to “Average..... sent bits/efficient time”.)
  - The speed was measured to approximately 47,7 Kb/s when receiving e-mail via satellite. Corresponding data speed in terrestrial ISDN was measured to approximately 62,4 Kb/s. The satellite communication is 24 % slower than the terrestrial network in receive mode. The measured difference between sending and receiving speed has no obvious explanation from the tests carried out in this project. This might be caused by different transponder through put receptively sending and receiving. Further studies

will have to be carried out in order to give a conclusive answer. (Consult the Appendix B for details. We are referring to “Average.....received bits/efficient time”.)

- Speech 4,8 Kb/s. The quality is good enough to recognize a known voice. The delay is of course the most unwanted effect. However this can be coped with by training of the users.
- Videoconference. Delay caused by satellite is the only noticeable difference between conference by satellite and conference by terrestrial network. Picture quality seems to be identical between these two media. Videoconference codec technology is based on transferring only changes in the pictures within a timeframe. This means that fast moving elements in the video pictures will be received in a poor video quality. This effect is similar in the two tested communication set-ups. Further this means that still pictures will be transmitted in both set-ups with high quality.
- Terminal set-up. It is very easy to locate the right satellite for communication. Directing the antenna approximately to the south will easily show signal strength and satellite identification in WorldCommunicator display. Using these indicators makes it easy to locate the wanted satellite and tune into maximum signal. The user's guide states the recommended signal power for 4,8Kb/s speech or 64 Kb/s data. After entering PIN-code, the terminal is ready to use.

## **Problems**

The tests were completed without problems worth mentioning except the following:

- Connecting the videoconference equipment caused us some trouble. The conference equipment must have its own telephone number programmed. However when using the WorldCommunicator as ISDN provider, we experienced that this number should be the local number of the WorldCommunicator. This local number and its use was not easily found in the manuals. After this number (MSN 60) was programmed correctly, the conference equipment indicated an OK ISDN line and it was possible to make a connection to another videostudio. To get the WorldCommunicator to make a call, the dialed number must be followed by a #. Nera told us about trouble getting a # from some videoconference equipment. We experienced that we had to put # # after the dialed number in order to obtain a connection to another videostudio.
- Connecting to Internet led to several problems, but all the problems were related to the PC and not to the WorldCommunicator. The problems experienced were all related to the PC used and Internet Service Provider settings. This is important to have in mind if an inexperienced user is to install and operate the terminal for Intranet/Internet communication.

## **Overall impression of Nera WorldCommunicator**

Impressions regarding use of the M4 terminal can be summarized as follows:

- Our impressions of the Nera WorldCommunicator are overall positive. Terminal set-up for satellite communication is easy.
- Making a call, presuppose an ISDN or a DECT telephone. Registration at a Net Service Provider is of course needed. In this context it was easy to connect and operate an ISDN telephone. No problems occurred.
- Videoconference via WorldCommunicator appears to be easy once you know the few tricks.
- Connection to Internet is easy and reliable once you have a correct PC set-up.
- The terminal has an excellent mechanical construction, which should be practical for mobile units. With the use of minor rain protective means, the terminal should survive even in very wet conditions. This is a highly important aspect if equipment like this is to be used in medical rescue operations outdoor.

Remember that if using any equipment with more than one knob; Try the equipment at home before taking it on the move!

## 12.2 Activity 2 – distribution of telemedicine information

Several operators in Europe have started or will soon initialize services allowing for receiving of large amounts of data via TV distribution satellites. By means of modern access techniques including conditional access, information can be transmitted to individual or groups of users.

The need for having low cost receiving terminals for this kind of update information is fundamental in order to increase the number of receiving sites and hence increase the number of users receiving the information. Since the distribution cost is fixed for a certain size of information, an increasing number of users implements a reduced cost per user.

### Distribution of multimedia via satellite

In Norway, for example, Telenor is now doing some beta tests on a service called SkyCast. This service is for point-to-multipoint information distribution.

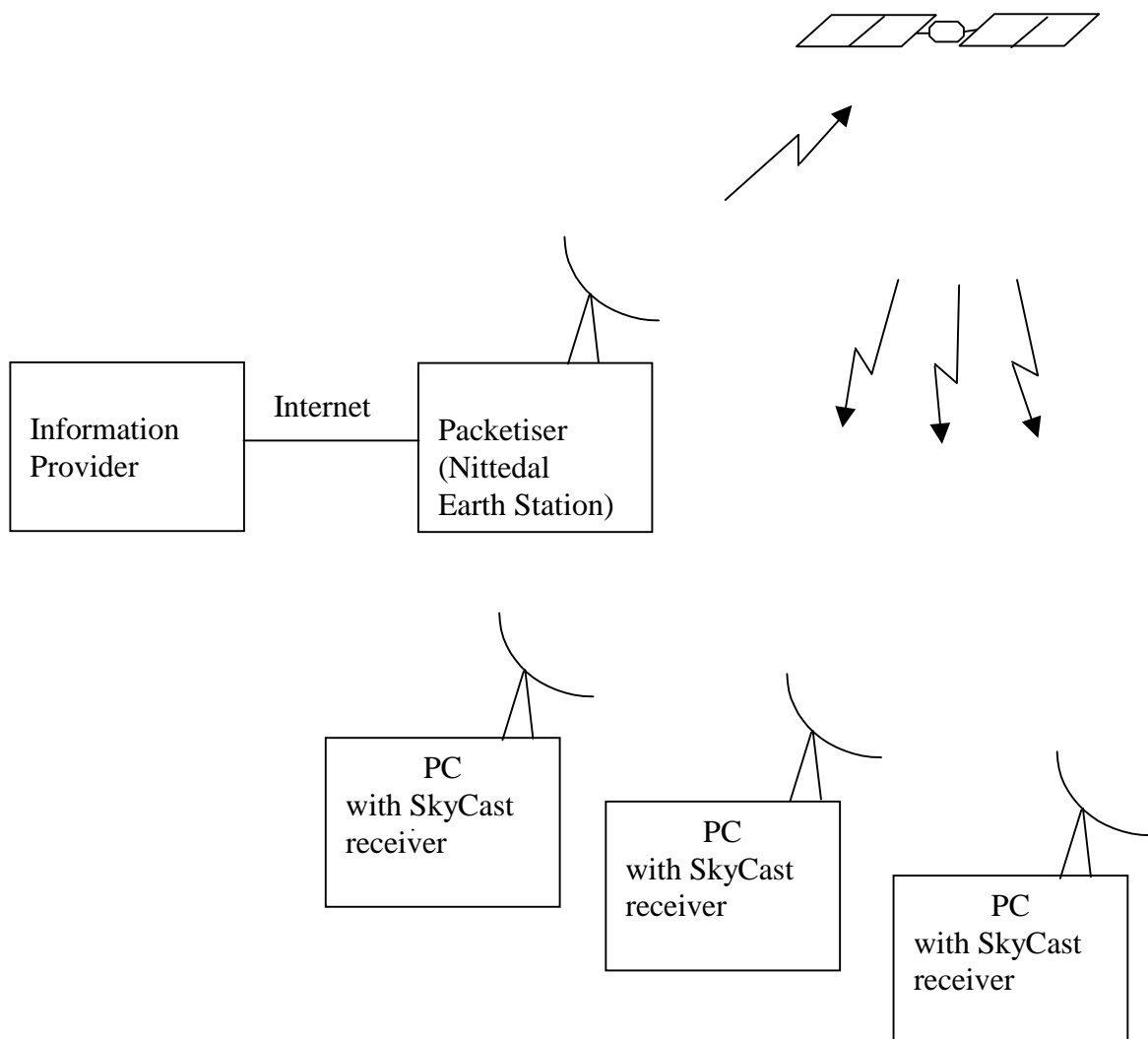


Figure 7 SkyCast infrastructure

## **Description of SkyCast service**

The SkyCast is a fully integrated solution for easy management of data broadcasting via satellite. The administrator of this program, the Information Provider, can easily transmit data to dedicated receiver groups worldwide. Broadcasted information can be any kind of digitalized data. The Information Provider controls the information to be transmitted, including the receivers. From the user's point of view, the receivers can be addressed by their names, only – without having to deal with technical options.

- The Information Provider prepares data to be transmitted and sent to the Packetiser (Nittedal Earth Station for Norwegian Information Providers) by using File Transfer Protocol (FTP) on the Internet.
- The Packetiser receives automatically data and prepare transmission(s) according to the scheduling specifications given by the Information Provider.
- Satellite transmission reaches users wherever they might be – in the office next door or the other side of the globe.
- All receivers specified by the Information Provider will automatically receive the data.

Briefly, SkyCast is a mass file transfer system that virtually does not require any cabled network in order to operate. All data will be transferred compressed. The file compression is based on the commercial program Winzip. File and encryption program is scheduled being implemented later.

When you are using the Information Provider software, is it possible to set up the system with several clients. Each client can administrate its own transmission schedule both regarding information and receiving groups.

### **What a transfer consists of**

A transfer to a Packetiser consists of the following.

- Files to be transmitted. You may transfer as many files as you like, and there are no file size limits.
- Scheduling information per file tells when and how the transmission of each file is supposed to be performed.
- Information about the channel being used.

All the information above will be compressed prior to the transfer. When the transferred file is received in the Packetiser it will be processed through a parser to check that parameters and instructions are correct. If it does not pass, it will be placed in an error directory. Using an Internet browser to manually search the transferred file in the error file on the server computer can check this directory. The SkyCast Information Provider has a transfer log which stores the history about the files that are transferred to the Packetiser, whether the transfer succeeded and what kind of scheduling options were used.

## Receivers

SkyCast is a system for broadcasting data files via satellite. It utilizes the broadcasting capabilities of satellite systems, using IP multicast to address receivers. The key features of the SkyCast system are its ability to offer high bandwidth data distribution to many receivers simultaneously.

It is not required that the PC is connected to the Internet or any other network, as the SkyCast receiver application operates in a “passive” manner. This means that it always listens for files being sent via satellite and receives the proper file according to the current set-up. A download can be set up with a filename filter, to indicate the names of the files you wish to receive. All file receptions is logged in a separate file. The log can be viewed at any time from within the SkyCast receiver application.

Installing SkyCast receiver hardware and software require a normal desktop PC running Windows 95 or 98. Additionally the PC must have TCP/IP protocol installed. When your satellite dish with a standard LNB is connected to SkyCast receiver board in your computer, the SkyCast antenna positioning tool makes it easy to position the antenna towards the 1 grad west position which is the satellite position used for *this* satellite service.

## Evaluation of SkyCast service

The project team has evaluated the SkyCast service, and will especially emphasize on the following features:

- Access to the service is possible using TV-RO satellite stations with plug-in hardware and software. The terminal cost is approximately 1500 EURO and hence allowing for a large number of users.
- There are two options for the pricing. One possibility is to subscribe to a certain amount of Mbyte per month. The other possibility is to pay per Mbyte, which is 1.5 – 2.5 EURO per Mbyte.
- An increasing number of users imply a reduced cost per user as the price per user is decreasing with an increasing number of users.
- Putting terminals to fit in services like for example SkyCast at the roof-top of e.g. hospitals, primary health care units, premises of community doctors, etc., closed group information as well as public information may be received in a smooth and cost-effective way. Whenever the number of receivers is very large, the health community could distribute information also by means of business TV operation.
- The service is excellent for distribution of a large amount of data to a large number of sites.

## 13 Telemedicine scenarios

The benefits of telemedicine are several, especially for people living in remote and rural areas of developing countries. In order to explain why there has been increasing focus on telemedicine and telemedicine applications, we will list some of the advantages of telemedicine before we proceed to the two scenarios:

- Fewer patients need to be referred to urban hospitals, which saves time and money spent on travel and which reduces the stress when family members are separated.
- Health care professionals in rural areas can consult specialists in urban hospitals.
- Health care professionals can keep up to date through access to the latest information in their fields contained in medical data bases.
- Remote clinics and rural hospitals can order drugs and other medical supplies when they are needed.
- Reliable communications can help hospitals and health care agencies to improve public health management and supervision of epidemics as well as the delivery of health care to remote regions.
- Rescue workers are better able to coordinate their response to disasters and emergencies and thereby mitigate the effects.

Now we will continue with looking at the practical telemedicine use of the services and equipment described in chapter 2.

### 13.1 Mobile telemedicine

The mobile ISDN terminal would allow us to:

- Broadcasting news reports from a war zone.
- Holding a video conference with a research colleague in the rainforest.
- Accessing your company's intranet and your e-mail from anywhere.
- Directing a surgical procedure in a remote village from an Italian hospital.
- Diagnosing equipment problems in a Caspian ocean oil field from Oslo.

If the ISDN terminal was bundled with telemedicine applications and promoted as a “mobile ISDN suitcase”, what kind of users would be interested? Who would be in need of a suitcase at the size of a small bag, a lap-top PC included?

Some users could be people who normally operate in areas where local telecommunication infrastructure is destroyed or temporarily absent. Examples of such groups are:

- Medicines Sans Frontieres (Doctors Without Borders)
- The Internal Red Cross
- Catastrophe teams
- Fishermen on fishing vessels, all sizes.

In the further description, we will concentrate on the latter.

## **Fisherman scenario**

A fisherman is normally working in a quite “rough” environment on board the fishing boat. Outside areas with terrestrial infrastructure he has to trust the satellite as the prime communication channel.

At the end of 1996 there were approximately 84 000 vessels<sup>3</sup> in the international marine vessel fleet. Several of these are equipped with Inmarsat equipment for satellite communications. Approximately 25 000 of these are fishing boats.

One could imagine that the reason for many of these fishing boats not having Inmarsat A or B because of the size of the boat being too small for stabilized Inmarsat terminals. In these cases the presence of a “mobile ISDN suitcase” could bring social safety to the crew on board in terms of

- having the possibility to get in touch with doctors at a remote site in case of health emergency among the crew members
- videoconference with the family

If for example an image of a crewmember being sick or hurt is sent to the hospital of Bergen, the doctors could assist directly and immediately in cases like

- cut accidents
- fall accidents
- infection
- fracture

The “mobile ISDN suitcase” could be a cheap life insurance for the crew. In addition the suitcase could be used in trouble shooting during vessel engine maintenance.

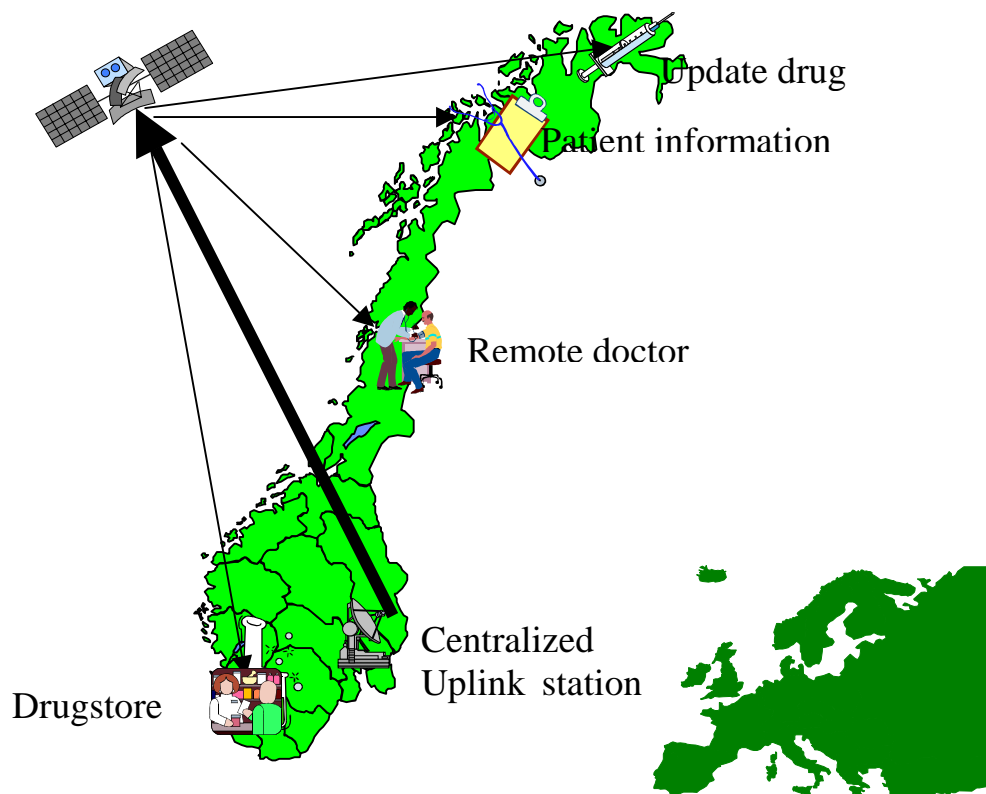
## **13.2 Telemedicine via multimedia satellite services**

When Television started back in the 50’s, nobody could imagine how big the industry would be. When Internet started in the early 60’s, nobody could imagine that at the end of the century the network could link people all over the world. Today, content – as well as service providers are coming up with solutions for multimedia applications allowing users to transmit or receive large amounts of information to people or organizations. Thanks to the geostationary satellites surrounding the earth, a user can be reached anywhere within a certain region. In the future this region would be larger and the possible information size would be larger as well. This will be the case when services like Astrolink, Spaceway and others see the beginning of the day early in the next century. Until then we have the ability to use existing satellites doing in principle the same job, however with a smaller amount of data.

Services like Turbo Internet, SkyCast and similar solutions allowing for collection and distribution respectively of information could give the health community an option for better information flow via mobile units or via fixed sites.

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<sup>3</sup> Lloyds: World Fleet Statistics 1996, Lloyds register of Shipping



**Figure 8 Distribution of health information to the health community**

Using SkyCast, it is possible to imagine the following scenario:

The example is given for Norway, but it could in principle be any country in Europe.

The sites all have a TV-RO system and a PC-card and an application dependant software. The cost per site is estimated to 1500 EURO.

In Norway, there are approximately 2000 primary health care units and 60 hospitals.

The nice thing about this kind of information distribution is the low cost per receiving site. Assuming 100 stations to receive 650 Mbyte per week, the total operational cost per site per month would be 50 EURO. Assuming 2000 stations to receive 2000 Mbyte per week, the total operational cost per site per month would be 7 EURO.

Today information to several users in the health community is done via e.g. via postal distribution. One could imagine information uplinked from the centralized site and via satellite be received at remote sites via a traditional TV-RO station. What kind of information are we talking about and who are the users?

Well, the users and the corresponding information could be

- Primary health care units
- Hospitals
- Drug stores

The information could be

- Public health information
- Dedicated information for the health community

## 14 Conclusion Work Package 2

In activity 1, the project team has evaluated a mobile ISDN satellite terminal with the following features

- May be used within coverage area which is almost world wide
- Can be used together with terminal equipment with EURO-ISDN interface protocol
- Weight less than 4 kg

**With this terminal the following trials have been carried out in the project:**

1. Set up via satellite to test the through put of two telemedicine applications including medical images and ECG.
2. In addition, a test has been done with a videoconference set up with 64 kbit/s from the satellite terminal.

The experience from 64 Kb/s communication via satellite has been compared with terrestrial ISDN.

Outlook Express has been used as mail system for file transfer. Through put for satellite and terrestrial set up is given below:

<b>Link</b>	<b>Through put Mail Transmit</b>	<b>Through put Mail Receive</b>
Satellite ISDN (Tx/rx bytes)	59,1 Kb/s	47,7 Kb/s
Terrestrial ISDN (Tx/rx bytes)	61,5 Kb/s	62,4 Kb/s

As can be observed, the through put for the satellite solution is approximately the same as for terrestrial ISDN. The numbers given is an approximately average of the medicine disciplines considered in this test – dermatology, pathology, EarNoseThroat. The numbers given are for calculating the through put as the transferred number of information bytes divided by the transmission time. Some difference with respect to through put for sent mail and receive mail was experienced. This may be caused by different set up at the server site of Telenor Nextel, the Internet Service Provider used in the test.

In a cost/benefit analysis, satellite communication is not comparable with terrestrial solutions. However, the main user environment for the mobile satellite ISDN terminal normally is assumed to be sites where terrestrial telecommunication infrastructure is partly damaged or absent. Only line switched mode is available for transmission in the M4 service today. In near future, service providers will offer a packed switched service called IPDS (Inmarsat Packet Data System) allowing for billing of actual data transfer file size – not transmission time.

For videoconference, the video image quality as experienced by the project team is sufficient for the case to give an overall picture overview of a site taking into account that only 64 kbit/s of user data is provided via satellite. The difference in quality during comparison with terrestrial ISDN was negligible. For the user terminal equipment, no problems occurred with respect to videoconference by means of satellite ISDN compared to terrestrial ISDN. Our impression of the mobile ISDN terminal is mainly positive.

The introduction of a mobile satellite multimedia terminal as the one evaluated in this project could be very positive for the health community and for mobile users without access to local

telecommunication infrastructure. The large coverage area in which the mobile satellite terminal can be used, represents a good opportunity for this kind of ISDN mobile equipment as seen from a telemedical point of view. For future projects, a large scale emergency trial could be very interesting to carry out in close co-operation with medical personnel.

In addition, the project team in activity 2 has evaluated and demonstrated a system, SkyCast, for multimedia information distribution via satellite. The use of the system as seen from a telemedicine point of view has also been described for the two activities. Example of user scenarios are:

Mobile satellite ISDN terminal may be used for medical assistance on board e.g. fishing boats, catastrophe teams, remote field hospitals, etc.

Multimedia distribution of information via satellite can be used for receiving information at hospitals, primary health care units, universities for education purposes, etc.

# DORIS

## A 10 minute guide

**Diagnostic Order and Report Information System**



**Copyright © 1996-1999 National Center of Telemedicine, University Hospital of Tromsøe**

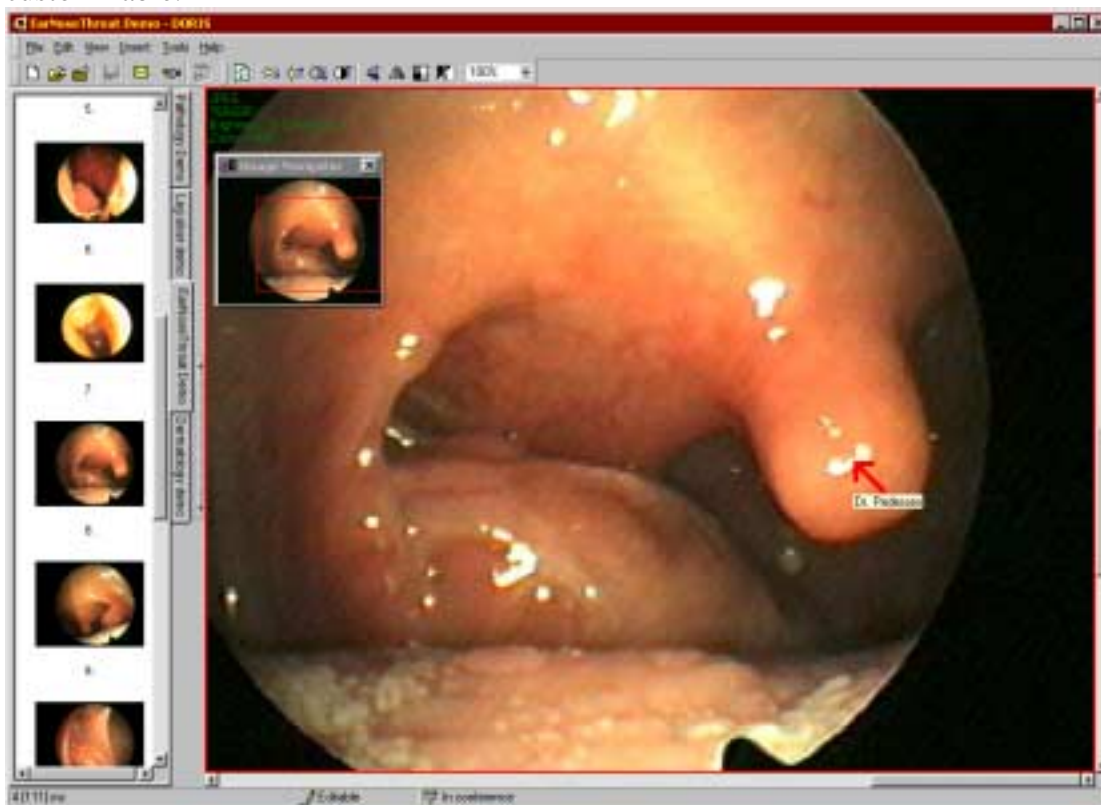


## DORIS

- is a *collaboration* tool for general practitioners and specialists which enables them to exchange requests, reports, second-opinions, research- and teaching files using a standard PC
- handles *medical multimedia* documents where text, audio and images may be freely combined
- is a *multidisciplinary* tool usable in many medical disciplines, ie. dermatology, pathology, otorhinolaryngology, ophthalmology etc. It can also be used as a general tool for teaching and research purposes.
- supports both *offline* (store-and-forward) and *online* modes of communication
- can act both as a *standalone* tool and as an *integrated* part of the electronic patient record system.
- is a 32-bit Windows application with a *familiar* look-and-feel for any Windows user.
- is an acronym for **D**iagnostics **O**rders and **R**eports **I**nformation **S**ystem

## User Interface

The main user interface has a standard menu- and toolbar section. These are fully end user customizable.



**The DORIS main window**

The left side of the main screen displays the contents of a multimedia document as individual thumbnails. Opened documents are displayed in separate page tabs.

The right side displays the proper content of the items contained in the multimedia document. This area may be divided into  $n \times m$  display areas for easy comparison of different items.

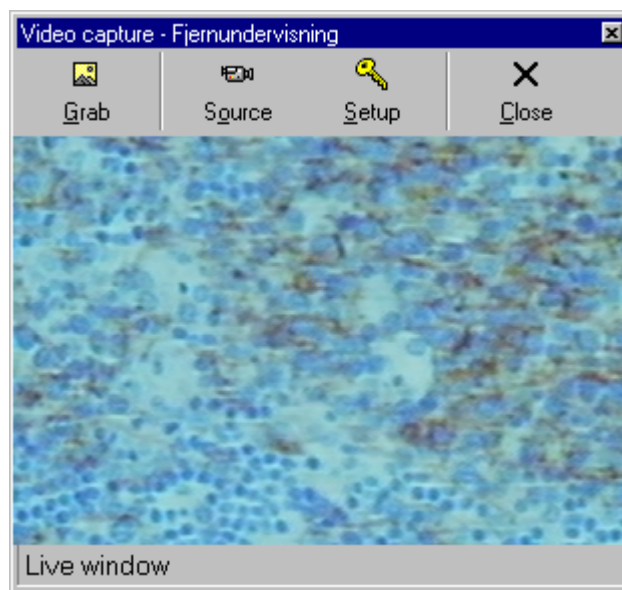
## Image Acquisition

A DORIS user can very easily import images from a number of sources:

- **Frame Grabbing.** Using any frame grabber card having support for Video for Windows or MCI Overlay one can capture images from any video source, such as video cameras, scopes and ultrasound equipment.
- **Document Scanning and Digital Cameras.** DORIS is able to import images from TWAIN devices which means that one can import images from most high-quality digital cameras and scanners.
- **File import.** DORIS can import single graphics files (BMP, JPEG, TIFF, PNG etc) or recursively import all graphics files stored in a directory. This latter option is particularly useful when importing images from PCMCIA cards exchanged between a digital camera and the PC.
- **Screen Capture and Windows Clipboard.** With DORIS you can easily capture parts of your screen or paste the contents of the Windows clipboard into a multimedia document.



All image acquisition commands are available from the **Insert** menu. Selecting the **Video** command or clicking its button will display the video window. From this window the user may grab images and automatically add them to a multimedia document.



**The DORIS video (frame grabbing) window**

## Offline Transmission

A DORIS document may be transmitted to other parties using a number of standard protocols; Internet Mail (SMTP/POP), Internet File Transfer (FTP) or any email system having a MAPI driver (this includes Microsoft Mail, Microsoft Exchange, cc:Mail, Lotus Notes etc). It is also possible to publish a DORIS document to a Web-server in standard HTML format and just send a reference (URL) to the other parties. Information may optionally be encrypted before sending to the other parties.



A user should press the **Send** button in order to send the document to one or more recipients.

## Online Conferencing

DORIS has an integrated online conferencing function (shared whiteboard) enabling two or more users to view text and images synchronized and at the same time display a telepointer. For desktop audio and video conferencing DORIS could be used in combination with any PC based conferencing tool such as Microsoft NetMeeting.

- A user should press the **Connect** button to join a conference. In order to display his or hers telepointer, the user should press the **Show Telepointer** button.

## Hardware requirements

Minimum hardware requirements are a PC with an Intel 486 processor with 8Mb RAM and 500Mb disk. 2Mb true-color (minimum 15-bits per pixel) display card with minimum resolution of 800x600.

A framegrabber card with a Video for Windows driver is recommended for grabbing still images from a video source. A standard audio card is necessary for recording audio from digital stethoscopes.

DORIS runs on Windows 95, 98 and NT 4.0. Recommended platform is Windows NT.

## Appendix B; Data speed (WP2)

Mail sent by satellite	(Signal strength = 535)			
	Dermatology	Pathology	EarNoseTroat	ECG
Seconds (from pushing "send" to finish).	345	125	210	20
Seconds to send to outbox	35	3	3	1
Efficient Send-time (second)	310	122	207	19
Mail-size (byte)	2 025 000	785 000	1 346 000	85 000
Received bytes at start time	1 110	248	974 952	2 411 151
Sent bytes at start time	2457	1889	945 228	242 603
Received bytes at stop time	211052	81679	1 113 214	2 420 496
Sent bytes at stop time	2309160	894528	2 476 236	336 879
Sent bytes	2306703	892639	1531008	94276
Received bytes	209942	81431	138262	9345
Through put byte/sek	7441	7317	7396	4962
Addition to mail-size, Protocol dependent, Mail-size=100%	1,14	1,14	1,14	1,11
<b>Through put bit/sek Received bits/efficient time</b>	<b>59528</b>	<b>58534</b>	<b>59169</b>	<b>39695</b>
<b>Through put bit/sek Mail-size/efficient time</b>	<b>52258</b>	<b>51475</b>	<b>52019</b>	<b>35789</b>

<b>Average for the 3 biggest files</b>	
<b>Through put bit/sek Received bits/efficient time</b>	<b>59077</b>

Mail sent by terrestrial network				
	Dermatology	Pathology	EarNoseThroat	ECG
Seconds (from pushing "send" to finish).	335	125	210	16
Seconds to send to outbox	35	7	14	1
Efficient Send-time (second)	300	118	196	15
Mail-size (byte)	2 025 000	785 000	1 346 000	85 000
Received bytes at start time	681	229	980 086	229
Sent bytes at start time	2 376	1 887	944 299	1 887
Received bytes at stop time	216 850	83 901	1 122 381	9 967
Sent bytes at stop time	2 310 940	894 327	2 473 313	96 163
Sent bytes	2308564	892440	1529014	94276
Received bytes	216169	83672	142295	9738
Through put byte/sek	7695	7563	7801	6285
Addition to mail-size, Protocol dependent, Mail-size=100%	1,14	1,14	1,14	1,11
<b>Through put bit/sek Sent bits/efficient time</b>	<b>61562</b>	<b>60504</b>	<b>62409</b>	<b>50281</b>
<b>Through put bit/sek Mail-size/efficient time</b>	<b>54000</b>	<b>53220</b>	<b>54939</b>	<b>45333</b>

<b>Average for the 3 biggest files</b>	
<b>Through put bit/sek Received bits/efficient time</b>	<b>61492</b>

Mail received by satellite	(Signal strength = 535)			
	Dermatology	Pathology	EarNoseThroat	ECG
Efficient read-time (second)	535	135	220	32
Mail-size (byte)	2 026 000	785 000	1 346 000	83 000
Received bytes at start time	206 947	81 679	1 113 214	2 631 954
Sent bytes at start time	2 304 963	894 528	2 476 236	540 645
Received bytes at stop time	2 516 587	974 952	2 643 297	2 727 646
Sent bytes at stop time	2 539 803	945 228	2 562 776	547 217
Sent bytes	234 840	50 700	86540	6572
Received bytes	2 309 640	893 273	1530083	95692
Through put byte/sek	4317	6617	6955	2990
Addition to mail-size, Protocol dependent, Mail-size=100%	1,14	1,14	1,14	1,15
<b>Through put bit/sek Received bits/efficient time</b>	<b>34537</b>	<b>52935</b>	<b>55639</b>	<b>23923</b>
<b>Through put bit/sek Mail-size/efficient time</b>	<b>30295</b>	<b>46519</b>	<b>48945</b>	<b>20750</b>

<b>Average for the 3 biggest files</b>	
<b>Through put bit/sek Received bits/efficient time</b>	<b>47704</b>

Mail received by terrestrial network				
	Dermatology	Pathology	EarNoseThroat	ECG
Efficient read-time (second)	298	115	195	16
Mail-size (byte)	2 026 000	785 000	1 346 000	83 000
Received bytes at start time	324 663	83 901	1 122 381	9 967
Sent bytes at start time	2 404 359	894 327	2 473 313	96 163
Received bytes at stop time	2 632 990	980 086	2 655 687	111 421
Sent bytes at stop time	2 534 374	944 299	2 558 229	102 799
Sent bytes	130 015	49 972	84 916	6 636
Received bytes	2 308 327	896 185	1533306	101454
Through put byte/sek	7746,06	7792,91	7863,11	6340,88
Addition to mail-size, Protocol dependent, Mail-size=100%	1,14	1,14	1,14	1,22
<b>Through put bit/sek Received bits/efficient time</b>	<b>61969</b>	<b>62343</b>	<b>62905</b>	<b>50727</b>
<b>Through put bit/sek Mail-size/efficient time</b>	<b>54389</b>	<b>54609</b>	<b>55221</b>	<b>41500</b>

Average for the 3 biggest files	
<b>Through put bit/sek Received bits/efficient time</b>	<b>62406</b>

## Appendix C; Equipment and software used for test (WP2)

Equipment used for the test.

Function	Type
Satellite terminal	Nera WorldCommunicator Beta Version
PC	Toshiba 440CDT Laptop
Videoconference	Polycom ViewStation 512MP
Modem	Eicon Diva Mobile V.90
Telephone ISDN	Alcatel 2824
ECG-recorder	Cardio Control

Software used for test

Function	Type
Satellite terminal set up	Nera vtLite
Operating system	Windows 95
Driver for modem	Eicon Diva
ECG	Cardio Perfect for Windows 1.1
Diagnostic system	Doris 2
Multimedia distribution	SkyCast



Telemedicine via Satellite Services – Work-Package 3

**Project:** Telemedicine via Satellite Services

This report is the third out of three on the project *Telemedicine via Satellite Services*.

The aim of work-package 3 is to:

**Contract:** 13489/99/NL/S

1. From the experienced gained in this project, describe a satellite-based telemedicine project. This project should take place in a real setting.

**Authors:** Eli Larsen  
Erik O. Evenstad

2. Consider partners for further projects and activities.

**Recipient:** ESA

**Status:** Document

**Date:** 00-02-29

**Rep. no.:** 03

**Priority:** Normal

**Distribution:** Open

## Preface

This work-package report is the third out of three on the project *Telemedicine via Satellite Services*.

The project is funded by European Space Agency (ESA).

The main aim of the project is competence building in the field of satellite-based telemedicine. As a result, the National Centre of Telemedicine, University Hospital of Tromsø, will gain experiences in order to develop telemedicine services to other parts of the world by means of global satellite services.

This report is written by project manager Ms. Eli Larsen at the National Centre of Telemedicine, Tromsø University Hospital and senior advisor Mr. Erik Otto Evenstad at Telenor Research and Development.

This report contains mainly a project description. List of partners for collaboration is included. 2 scenarios also introduce the report. These scenarios are written as realistic as possible.

The work has mainly taken place from November 1999 to the end of February 2000.

We would like to give our acknowledgments to Per Hasvold and Tove Soerensen, National Centre of Telemedicine, for reading through and commenting on the document. They have also translated part of the document to english.

University Hospital of Tromsø, the 29<sup>th</sup> of February 2000

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Eli Larsen

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Erik Otto Evenstad

Norway is one of the leading nations in developing and providing telemedicine services.<sup>4</sup> The region's major referral centre, the University Hospital of Tromsø (UHT), has been involved in a large range of telemedicine activities since the 1980's. Traditionally, telemedicine has been conducted by videoconferencing-systems, which means two-way live image and sound. However, due to constraints in the organization of services, e.g. that doctors and patients need to be present at the same time, as well as insufficient bandwidth, new ways of providing telemedicine services are emerging. Keywords are mobility, store-and-forward systems and web-based protocols. In line with the technical development in equipment as well as telecommunication means, the need for *mobile telemedicine units* is becoming more urgent every day. Requests for easy functioning mobile telemedicine units come from the shipping industry, the army and emergency care units. Their needs for mobile telemedicine services are the same: How to provide contact with qualified health care professionals for fishermen and cruise-passengers; for rescuers in times of disasters, wars or other situations of crisis where normal telecommunication infrastructures are missing or destroyed?

In such situations, satellite-systems are the only communication means available. Satellite systems used to be fixed and needing huge establishment costs. Today there are satellite terminals available which are small, light and robust. In addition the new terminals provide an adaptable interface with PCs and are therefore easy to set up and use. These are extremely important qualities for devices targeting non-technical user-groups as health care personnel, fishermen and soldiers.

A mobile telemedicine unit is not only an answer to user-needs, it is also generating a whole range of areas to investigate and take care of. Reliable technical and organisational communication systems and 24 hours medical care services are the most important tasks to be solved.

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<sup>4</sup>Telemedicine can be defined as 'medicine at a distance', or: '*Telemedicine is the investigation, monitoring and management of patients and the education of patients and staff using systems which allow ready access to expert advice and patient information no matter where the patient or relevant information is located.*' (Advanced Informatics in Medicine 1991)

## 16 Scenarios

In order to imagine the utility of a telemedicine mobile unit, two scenarios put us into the atmosphere. The medical essence is trustworthy.

### 16.1 Cruise Scenario

The scenario takes place aboard the cruise ship “SS Sunset”. The dinner is about to be served in the dining hall. Mr Smith is your average cruise passenger; retired, 50 years old and wealthy.

This evening the life of Mr Smith is about to change. A sudden pain in the chest and the left arm interrupts the dinner preparations. An officer calls for the ship’s General Practitioner (GP). The symptoms are very similar to those observed on patients with a cardiac infarction. Mr Smith is hasted into the medical examination room for further tests and diagnosis.

The GP has equipment and training for giving a trombolitic injection but needs to have the diagnosis confirmed by a specialist. Luckily, SS Sunset subscribes to the “Global Virtual Doc Service” and a specialist can be called within minutes. To Mr. Smith this will enhance his chances for a good recovery from the probable infarction. To ensure the best possible recovery trombolitic treatment should be provided within what is referred to as the “Golden Hour”.

To confirm the diagnosis an ECG needs to be recorded and examined by the specialist. ECG probes are connected to Mr Smith and the ECG is recorded by the GP using a mobile telemedicine workstation with an ECG recorder.

To Mr Smith the last 15 minutes has seemed as hours. The GP prepares the request, including the recorded ECG, and sends it by email to the specialist at the “Global Virtual Doc Service”. As soon as the GP hits the send button the workstation (PC) connects to a satellite communication device and the request is transferred within a minute. The GP begins preparing the injection in case the diagnosis is confirmed to be an infarction.

10 minutes later a reply is received from the specialist confirming the suggested diagnosis and recommending a trombolitic injection as soon as possible.

The injection is given and Mr Smith is cared for. The presence of telemedicine equipment and service has ensured that Mr Smith’s recovery and quality of life after the infarction is much better than what would have been the case without the early response and treatment. It is not only Mr Smith’s next of kind who are happy that they chose SS Sunset, but even his employer and the society appreciates the fact that Mr Smith did not become an invalid but was able to return to work after a few weeks of rest and recovery because of the treatment provided aboard the SS Sunset.

## 16.2 Field Hospital Scenario

This scenario takes place in a country torn to pieces by war and destruction. People and property are brutally battered by the fighting and suffering. Rebuilding the society is going to take a long time and there are many wounds, physical and psychological, that need to be healed.

One of the Red Cross' many field hospitals has established an Institute for Mentally Handicapped and Psychiatric Patients. Today, a small team from the Institute are visiting a small village, about a days travel from the Institute. The purpose of the visit is to provide care for a number of families traumatised by the war.

The driver has some local knowledge of the area, but the village is remote and so modern navigation equipment is used to make sure they find the way without getting too close to areas not yet cleared for mines. Before they leave they check and pack the navigation and communication equipment. The equipment consists of a PC acting as a mobile telemedicine workstation and navigation tool when connected to a GPS and a satellite communication unit. The size of the equipment is approximately as two portable PCs and allows the team to provide some medical services through the use of experts in other Red Cross field hospitals.

The GPS unit is connected to the PC and the local map is brought up on the screen. The moving map function makes sure the vehicle is plotted in the map on the screen. As the team arrive at the village people start gathering around them. A villager asks if the equipment can be connected to the Internet. He wants to leave his name and whereabouts in a reunitation database run by the Red Cross because he and his brother got separated in the war. The team set up their equipment and can provide the service.

While visiting a local family they are asked to come and look at a small child with a rash. The child is crying and obviously in pain. The parents are very worried. Could this be an allergic reaction? Could chemicals spilled after a bomb was dropped on a local storage of chemicals and paints have caused the rash?

A Red Cross colleague at one of the other field hospitals who is a dermatologist is contacted and is asked to take a look at the skin problem. Several images are collected and a request containing the images is sent to the dermatologist by email. The dermatologist can access the computer network from a similar set up with a computer and a portable satellite communication unit.

After having looked at the images and read the description included in the request the dermatologist is reasonable sure about the diagnosis: A virus infection that will pass within a couple of weeks. The parents are informed about what complications to be aware of and how to treat the child with the means available locally.

Before the team heads back to the Institute the person who had lost his brother visits the team. He searches the database and is happy to find his brother in a nearby village. Through the database service he is able to get the local authorities informed and a message is sent to his brother.

The next time they visit the village, two happy brothers are there to greet them.

## 17 Main aim

The overall aim of the project is to demonstrate how telemedicine services can be provided to people wherever they are and independent of terrestrial telecommunication structure.

The aim is to develop a standard integrated mobile telemedicine unit for transferring medical information. The standard unit shall be easily restructured and further developed in order to provide a maritime Telemedicine Unit (TMU), a military hospital TMU, an emergency care TMU and so on.

The target groups would typically be health care personnel (medical doctors, nurses and nursing assistants) but also non-medical user-groups like shipping officers, fishermen, ambulance drivers should be addressed. In general, the target group is not likely to be technical skilled, hence the unit must offer an easy user interface and set up.

The unit will be developed for the three situations:

1. At sea
2. For field hospitals
3. For situations of disasters

A prototype shall be demonstrated at the end of the project. Based on the given evaluation criteria the model shall be evaluated. In order to get the mobile telemedicine unit industrialised the project shall present the prototype for a number of industrial partners.

### 17.1 Limitations

It is not a goal in this project to design a complete system meeting commercial standards. There will not be built an industrialised unit, but all necessary information and knowledge shall be gathered within the project.

There will be carried out a practical demonstration of a selected setting within one of the three areas. Long time testing and performance is not a part of the project. Customer satisfaction studies are not a part of the project. Such studies will be a natural part of a prototype unit evaluation.

## 18 Technical requirements

As an objective in the development process of the autonomous telemedicine mobile unit, the following requirements should be fulfilled:

- The integrated mobile telemedicine unit shall have an easy user interface. Users should be able to operate the unit with a minimum of technical skills and practical training.
- The unit should be easily restructured to meet specific requests from cruise ships, field hospitals, fishermen boats, organisations like the international Red Cross, emergency care units, etc.
- The unit shall be constructed in order to resist harsh climate conditions and rough transport. Components with military specifications will be preferred.

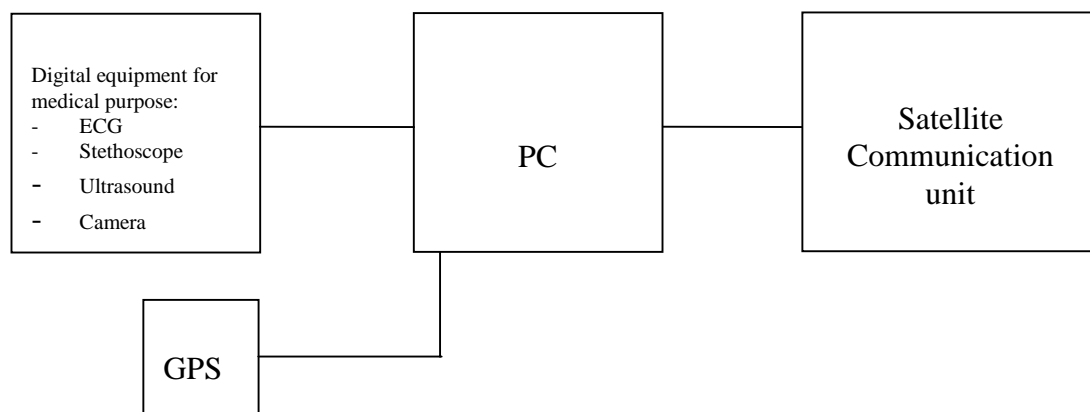
- The unit shall be modular.
- Transferring a typical medical file with still-images should not take more than 10 minutes. The file-size is typically 1-2 Megabyte.
- Technical medical equipment, which is part of the unit, must be able to easy transfer data to the communication unit.
- The unit shall also be used for navigation purposes. The unit shall be able to handle electronic maps (vectorized or scanned).
- The units shall be able to run autonomous with it's own power pack. It must also be able to run from various available powersources, such as car battery, solar panels, mains power supply, etc.

## 19 Method

The following methods will be used throughout the project:

- Needs assessment study: Interviewing key personnel in the three areas of interest, shipping industry, field hospitals and rescuers in order to outmap the particular requirements for a telemedicine mobile unit. Outmapping the requirements for communication, medical equipment and navigation purposes. In addition, the communication structures within the field will be discussed during the interviews.
- Literature and WEB surveys within medical mobile equipment, satellite communication units and electronic maps. Literature & market survey in order to investigate already existing mobile telemedicine units,
- Practical testing of commercial available equipment and systems for the mobile telemedicine unit.

## 20 Block diagram, Mobile Telemedicine Unit.



**Figure 1 Block diagram**

## 21 Activities

The following activities shall be carried out:

1. Specification of users' requirements
2. Market survey for equipment and software
3. Testing relevant equipment and software
4. Development, testing and demonstration of prototype

### 21.1 Work Package 1 (WP1). Specification of users' requirements

Relevant data are to be gathered for use in field hospital, disaster areas and maritime rescue. The following activities shall be completed:

- Specify what kind of information that should be exchanged (transmitted/received). In order to decide what kind of medical instrumentation that should be incorporated in the unit, all data shall be categorised according to the three areas of use.
- Investigate the communication structure and responsibilities for medical requests from the three areas. Describe how the medical requests are organised.
- Specify communication needs for each user-group. Describe communication patterns regarding transmitting/receiving data, online and offline connection. The description shall be based on today's needs and equipment available in the market.
- Describe the need for electronic navigation and how this is met today. This study shall evaluate to what extent navigational data should be integrated with medical data. The findings will form the basis for whether a navigation system should be a 'stand alone' system or if positioning data can be extracted and made useful covering other needs.

Working period for WP1 is estimated to three months. The project will present a report by the end of WP1. This report will provide the basis and give directions for the next phases of the project. The findings and conclusions of WP1 may also influence the evaluation criteria given in Chapter 22 Evaluation.

### 21.2 Work Package 2 (WP2). Market survey for equipment and software.

In WP there will be conducted a on equipment and software which can meet the earlier specified requirements for the mobile unit. A selection of equipment and software shall be made based on the findings from WP1. The survey shall cover the following:

- Medical equipment and software to be integrated in a mobile unit. It is a firm criteria that all medical equipment shall have an interface that can be connected to a standard PC unit.
- Communication systems covering the three areas of interest. The communication systems must have an interface for PC.
- Available global map systems. The study of WP2 shall investigate whether or not there is available software on the marked plotting navigation data into electronic maps scanned from paper maps. WP2 shall also give an estimate on how large areas of the globe that are covered by electronic maps and at which scale.

Working period for WP2 is estimated to three months. The project shall make a report by the end of WP2 describing pros and cons regarding the equipment found and evaluated in the survey. The report shall conclude on each item of equipment whether or not it can be recommended for the mobile telemedicine unit.

### **21.3 Work Package 3 (WP3). Testing relevant equipment and software.**

This work package shall perform realistic testing of the equipment recommended in WP2 to the extent that such equipment are available, thus giving answers to the feasibility of building a mobile unit meeting the demands stated in this project, ref.: Chapter 22 Evaluation Equipment and software testing shall be based on loan or leasing, purchase shall be kept at a minimum for these purposes.

The working period for WP3 is estimated to five months. The project shall make a report at the end of WP3 describing pros and cons regarding the equipment tested. The report shall conclude on each item of equipment whether or not it can be recommended for further use in the project.

### **21.4 Work Package 4 (WP4). Developing, testing and demonstrating a prototype.**

#### **System development.**

Work-package 4 shall develop userfriendly software in order to smoothen the practical operations on the mobile telemedicine unit. The software shall be the interface between the operator, the machines and different systems, and thus contributing to a low threshold of initial use of the system. It is the goal of WP4 that the software developed shall visualise the possibilities of future commercial produced software.

In WP4 a prototype shall be constructed to be demonstrated in one of the three areas of interest. The prototype shall be based on equipment and software recommended in the previous work packages.

#### **Testing and demonstration.**

The aim of testing and demonstration is to:

- Verify to which extent the aims and goals are met according to the evaluation criteria
- Provide user-groups an idea of how a mobile telemedicine unit can meet their expectations. The unit shall additionally show users the potential (future areas) of a mobile telemedicine unit.

Working period for WP4 is estimated to seven months. The project shall make a report by the end of WP4 giving:

- A detailed description of the prototype. All major design choises shall be described.
- A description of the ability of the prototype to meet the design criterias based on evaluation by developers and users.
- An evaluation of the entire project.

## 22 Evaluation

The project shall be evaluated throughout the project periode on the following aspects:

- Functionality
- User friendliness
- Cost/performance ratio
- Feasibility

The ruling documents of the project shall underline the criteria above.  
 All work-packages will be accomplished following the evaluation criteria.

## 23 Project Master Schedule

Provided kick-off at T0 and a total duration of 18 months. The project plan is as described in Table 1.

Number of Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Work Package																		
WP1																		
WP2																		
WP3																		
WP4																		

**Table 1 Project time plan**

## 24 Cost Summary

Technical equipment will mainly be lent or leased. Table 2 shows the total costs of the project.

### 1.1 Cost Summary

Description	NOK/h	h	NOK
Personnel NCT	750	1500	1.125.000
Personnel Kongsberg Spacetec	750	1000	750.000
Personnel Telenor Research and Development	750	300	225.000
Technical equipment, software and others			150.000
Travel costs			250.000
<b>TOTAL cost</b>			<b>2.500.000</b>

Table 2: Price summary table

## 25 Partners

A project group will be established with participants from the following three institutions / companies:

### **National Centre of Telemedicine (NCT)**

The National Centre of Telemedicine is a part of Regional Hospital in Tromsø. The NCT's main task is research and development. New telemedical solutions for the public health service are central. This involves the development of technology, the assurance that new services meet medical quality requirements, and the introduction of new solutions. Research is also conducted on the various effects of telemedical solutions. Another important job is the dissemination of knowledge about telemedicine. In addition, the Department of Telemedicine has a number of operating responsibilities within computer networks.

NCT will be the overall project manager. NCT will be in charge of the integration of the telemedicine equipment, doing a survey on available and feasible medical equipment and evaluating it for this particular purpose.

### **Telenor R&D**

Telenor Research & Development (R&D) is the Group's centre of expertise within information and communication technology and their applications. Following the spin-off and establishment of the separate company 4tel in 1998, which specialises in the development of IT solutions for the telecommunications industry, Telenor R&D is now focusing on long-term research.

Telenor R&D will be in charge of the satellite communication. In addition Teller R&D will be responsible for outmoding user needs in this aspect.

<http://telenor.com/display.cfm?m=4&file=about/business/RandD.html>

### **Kongsberg Spacetec**

Kongsberg Spacetec AS is one of the leading companies within ground station systems for Earth observation satellites. Main business focus is on the delivery of turnkey ground station systems, consultancy services, feasibility studies, systems engineering, training and support.

Kongsberg Spacetec will be responsible for the integration of electronic maps. In case of necessity, Kongsberg Spacetec will develop software in order to improve user-friendliness of the unit.

<http://www.spacetec.no/>

### **Reference group**

To ensure the quality of the project, a reference group from the three sectors will be established. Each group will consist of a user representative, a health care sector member, a telemedicine specialist and a specialist on satellite communication.

## 26 Project Management Plan

### 26.1 The Project Team

The project team will consist of:

- 2 staff members from the National Centre of Telemedicine
- 1 staff member from Kongsberg Spacetec
- 1 staff member from Telenor R&D.

The National Centre of Telemedicine will be responsible for project management.

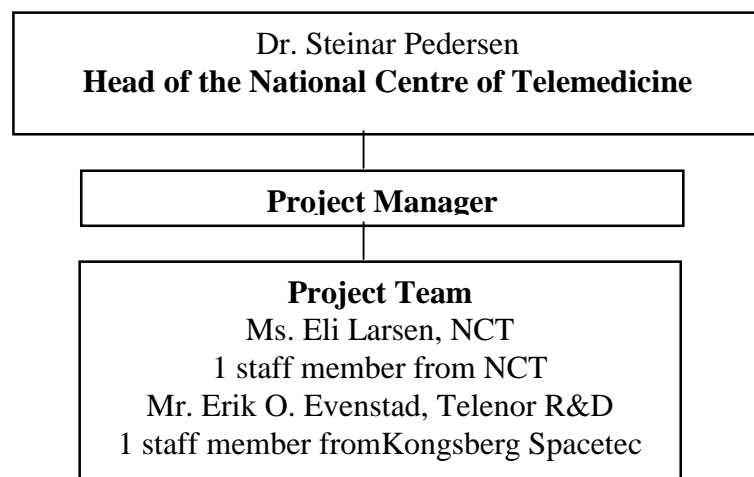
### 26.2 Key Personnel

The project will be organised by the National Centre of Telemedicine. The project manager reports directly to the head of the National Centre of Telemedicine. The team members report to the project manager.

Key Personnel will be Mr. Steinar Pedersen, MD, Director NCT, Ms. Eli Larsen, Project Manager, NCT and Mr. Erik O. Evenstad, Senior Advisor, Telenor R&D. Additionally one key personnel will be staff member of Kongsberg Spacetec.

The project team will fit in as an independent part of the organisation, as shown in Figure 1.

**Figure 1: Project organisation.**



In the case of disagreement within the project organisation, the project manager has the responsibility of reaching consensus.

## 27 Concluding Remarks Final Report

Project activities have been performed in the following order:

1. Existing global satellite services have been investigated regarding availability, speed, costs etc.
2. Future global satellite services have been investigated regarding availability, speed, costs etc.
3. Information on telemedicine services and pilot projects based on satellite communication has been sought.
4. A practical demonstration of telemedicine via satellite communication has been accomplished.
5. A satellite-based telemedicine project has been described. Partners for a mobile telemedicine project have been considered.

In this project, *Telemedicine via Satellite Services*, several available satellite communication services have been evaluated focusing on existing telemedicine applications. Two main types of services, terminals and equipment have been evaluated: For the mobile case, the new multimedia service from Inmarsat has been investigated, the M4-service. For the practical test, a mobile ISDN satellite terminal the so called World Communicator delivered by NERA, was used. The M4-service offers ISDN from 'anywhere' in the world covered by the spot beams from the Inmarsat satellites. The terminal can therefore be used for telemedicine purposes where mobility is a key element.

Based on the experiences from WP1 and WP2 it became clear that the requests for a mobile telemedicine unit was to be further described in WP3. The mobile telemedicine unit should be able to meet requirements from the maritime sector, from emergency health care personnel, from the army as well as other areas where distances and inadequate terrestrial telecommunication lines is preventing easy access to expert medical services.

The end result of the project was to produce knowledge on how telemedicine applications designed for ISDN can be adjusted to satellite communication technologies. From investigations made in the project, National Centre of Telemedicine is now able to provide technical descriptions for the systems in use.

Finally, one must conclude that the study project has contributed positive to competence building at the National Centre of Telemedicine. In addition network-building and improved overall knowledge in the area have been important to the project group.