

**EHAS  
LOW-COST TELECOMMUNICATION  
SYSTEMS AND INFORMATION  
SERVICES FOR RURAL PRIMARY  
HEALTHCARE IN DEVELOPING  
COUNTRIES**



**ABSTRACT**

More than half of the world population lives in isolated rural areas out of the scope of any terrestrial telecommunication networks. This is particularly true in developing countries, where rural areas very often lack of any access to the public telephone network or even to electricity. Low density and low concentration of population make difficult to afford the installation of permanent infrastructures that would be expensive due to typical restrictions in power service, accessibility, maintainability and security. In EHAS - "Enlace Hispano Americano de Salud", which means in English "Hispano-American Health Link" - we are very concerned about these scenarios, and specifically we are focused on the Health Area. We develop telemedicine low-cost telecommunication systems and information services specially designed for rural primary healthcare personnel from isolated areas in Latin American countries.

The EHAS program researches and develops appropriated information and communication technologies, deploys developed services and systems through pilot projects and evaluates their impact. This paper examines the results of each line of work, with emphasis on some of the pilot schemes deployed in rural areas of both jungle and mountain sites. Some of the conclusions gathered at the end of the paper show that our systems give great benefits such as a drastic reduction in the average evacuation time of critical patients, improvement of diagnostics' reliability, and decrease of travels needed by the staff.

**INTRODUCTION**

A great promise of telemedicine has been to help isolated or scattered populations gain access to health services. In industrialized countries, telemedicine has proven to be a good tool for enabling access to knowledge and allowing information exchange, and showing that it is possible to bring good quality healthcare to isolated communities. Telemedicine can also (and must) be used to deliver healthcare to poor areas in countries with scarce infrastructure and to developing countries. But while information and communication technologies have tremendous potential for improving healthcare, we have to bear in mind that in rural areas of many developing countries, telephone networks and computers are scarce. This is especially true in the health sector. Another barrier to the implementation of telemedicine in rural areas of developing countries is limited access to electricity. Yet another important factor is the deficient transportation infrastructure resulting in a lack of appropriate maintenance and control systems, limited ability to afford expensive telecommunication infrastructure, and poorly trained health personnel. Due to these restrictions, the rural populations of developing countries (already a highly undeserved group) are far from enjoying the advantages of the so-called "Global Information Society." Information and communication technologies and services can improve the work conditions of isolated health staff only if those technologies are selected, developed, adapted, and carefully deployed to suit the population's real needs in their real environment.

These facts highlight important differences between developed and developing countries that condition any telemedicine project. Moreover, there is a technology gap between urban and rural zones within developing countries themselves. While in the main towns of developing countries most modern communication networks are accessible (xDSL; Wi-Fi, etc.), there are many rural areas without even a basic telephone network. Therefore, while the telemedicine experiences of urban areas, mostly inter-hospital projects, are very similar anywhere, rural telemedicine projects seeking to improve the efficiency of primary care result in quite different implementations, depending on whether we are dealing with rural areas of industrialized countries or isolated rural areas of developing countries. The needs and priorities are completely different. Most importantly, the lack of communication infrastructure and financial limitations condition enormously both the appropriate technology and the services required.

The **Enlace Hispano Americano de Salud (EHAS)** initiative is a viable proposal to face this problematic situation through telemedicine systems and services in rural areas of developing countries.

### **ABOUT EHAS**

Under the premises described before, the Telemedicine Group of the Technical University of Madrid (GBT-UPM in Spanish) and the non-governmental organization Engineering Without Frontiers (ISF in Spanish) created the EHAS Program in 1997. Its main aim was to verify if an appropriate design and use of ICT (Information and Communication Technologies) might solve some of the important efficacy and efficiency problems at the rural primary health care level in isolated areas in Latin American countries.

After an initial research period performed in Madrid by GBT-UPM, a first conclusion arose: access to Internet via VHF/HF radio in isolated rural areas in developing countries was viable both technological and economically.

In that time two Peruvian institutions joined the EHAS Program: the Catholic University of Peru (PUCP), acting as a technological counterpart, and the Cayetano Heredia University (UPCH), acting in this case as a medical counterpart. This multidisciplinary team started to work in the development and deployment of two main lines of action: "EHAS technology", and "EHAS services".

The first pilot experience consisted of a voice and data (electronic mail) network to communicate 39 health nodes in the area of Huallaga in Alto Amazonas (Peru). After obtaining impressive results with this first pilot (2001), the EHAS program decided to widen their geographic field to other countries like Colombia and Cuba, besides exploring new locations in Peru. During next years new pilot projects were deployed in all of these countries, thanks to the financing from institutions, among others, like the World Bank, the Council of Madrid, Greenpeace and the European Union.

The hierarchical structure proposed for EHAS Peru (a technological partner and a medical partner) was replicated to the case of Colombia and Cuba. Thus, in Colombia the Department of Telematics and the Department of Social Medicine and Family Health, both from the University of Cauca, became respectively the technological and the medical counterpart. In the case of Cuba, INFOMED and CEDISAP, both institutions belonging to the Health Ministry of Cuba, were respectively the institutions involved.

Simultaneously to these pilot projects, EHAS team kept working on the adaption of new IT solutions adapted to be used in isolated rural areas. This way, some results were achieved, among others: the development of high performance software modems in both VHF and HF bands, the research on Wi-Fi technology for long distance links and high -speed networks, and the use of VoIP technology.

In 2004, due to the important dimension acquired by EHAS, both ISF and UPM created the EHAS Foundation, a non-profit organization with independent legal entity but under the supervision of both institutions.

## **LINES OF ACTION**

In general terms EHAS initiative has six lines of action: 1) Research on the communication and information needs of rural health personnel in developing countries, 2) R&D on voice and data communication systems designed according to conditions of rural areas, 3) R&D on information services systems suited to the needs of health personnel, 4) Deployment of those services and systems through pilot projects, 5) Evaluation of the impact of these telemedicine systems on health services, and 6) Spreading of the knowledge acquired.

All of them apply to all of the EHAS Countries and will be described in depth below.

### **1. Research on the communication and information needs of rural health personnel in developing countries**

It is important to start this section describing, in general terms, the structure of the healthcare system in Latin American countries. Primary care institutions in Latin America can be grouped into two categories: **Health Centres (HC)** and **Health Posts (HP)**. A HP is a point of access to the health care system for a rural population. HP are typically located in towns of no more than 1000 inhabitants that have no telephone line and poor transport. A HC is usually located in a provincial or district capital and has telephone lines installed. HC are always under the direction of a physician and are equipped to make select diagnostic tests. They can also hospitalize some patients.

Several HP depend on a single HC, which together comprise a health 'micronetwork'— a basic primary care unit. The micronetworks are under the direction of the physician responsible for the HC, who coordinates the activities of the HP. Most HP need better ways of communicating with the physician for consultation, conveying epidemiological surveillance reports, ordering medical supplies and relaying information concerning acute epidemic outbreaks, medical emergencies or natural disasters. Communication and the exchange of information require health-care workers to travel from one facility to another, which can take hours or even days.

The use of a communication system seems an obvious solution for the situation described before, but in order to achieve long-term viability, the situation in rural areas of developing countries has to be considered. EHAS has carried out several studies on the information and communication needs of the rural health personnel of Latin America. These studies are used to facilitate developments in technologies and services within the EHAS initiative.

- There is no access to electricity in most rural villages (in rural areas of Alto Amazonas, Peru, only a very few towns have electricity, and those only 4 hours a day).
- Rural areas have limited or no public telecommunication infrastructure and they are not included in the midterm expansion plans of the operator companies.
- Rural health establishments have limited financial resources to fund expensive infrastructure and, more importantly, the operating costs.
- Maintenance costs of any system are very high due to the long distances between establishments. The average time for a technician to travel to his HC is very high (Alto Amazonas, 10 hours and a half)
- There are few well-trained candidates for the management, maintenance, and repair of computer and telecommunication systems.
- The cost of current telecommunication systems on the market is too high to become a systematic solution for all the rural areas of a country (e.g., the Peruvian Ministry of Health has more than 5500 primary health establishments without a telecommunication system).
- No information systems suited to the real needs and capabilities of rural health personnel in Latin America are currently available on the market.

Considering all the previous constraints, EHAS works on the research and development of appropriate telecommunication technologies and services designed to solve the needs of rural health personnel in developing countries.

## 2. R&D on voice and data communication systems designed according to conditions of rural areas

The needs and problems for developed countries and developing countries are far from being the same, and consequently solutions are different as well. For that reason, in a developing country we can not automatically use a technology originally designed for a developed country. This has been a traditional mistake in many development programs and it raises here the idea of **appropriate technology**. We say that a technology is appropriate if takes into account the needs and interests of the final target users. In other words, it focuses beyond the technology itself and considers human, social and economic factors. In EHAS we have identified several characteristics intrinsic to an appropriate technology for an isolated rural area: robustness, low cost, low-power consumption and easiness of maintenance.

Below we will show the appropriate technologies that EHAS is currently developing and deploying. In order to determine which one fits best in a specific scenario, it is important to understand how these technologies work and what their limitations are, e.g. range, power requirements, etc.

### – VHF/HF Radio Systems

The main aim of a EHAS radio network is to connect an isolated HP to its referential HC and, additionally, with others HP in the network. For short and half-distance coverage without direct visibility (where Wi-Fi networks do not apply) the **VHF/UHF** radio band (30-3000 MHz) is usually the best alternative in terms of voice. In this range of frequencies, it is possible to connect stations in distances up to 50km (depending on the orography) with a good voice quality. The VHF/UHF band shows a high stability, and does not depend on the environmental conditions.

The **HF** band (3-30MHz), on the other hand, allows long and very long distance coverage (depending on the frequency, thousands of kilometers) due to a phenomenon known as ionospheric propagation, which lies in the reflection of the radio signals in the ionosphere. HF's main disadvantage is the low quality transmission, since the transmitted signals are commonly exposed to distortion (atmospheric absorption, high noise, multipath). Moreover, channel conditions are extremely variable, depending on the moment of the day, season, sun spots activity, ionospheric storms, among others factors.

Once satisfied the fundamental need of voice transmission, digital communication appears to be a valuable complement. Thus, client stations are equipped with a computer and an independent router which interfaces the computer and the radio voice transceiver. Data throughput achieved is relatively low, raw speed is set to 9600 bps (bits per second) in VHF and 2500 bps in HF; real user throughput variable depends on channel conditions and data compression, but sufficient for e-mail exchange (a very important service in EHAS networks). In fact, real-time services are often the only technically practicable (many HC have only intermittent and/or very low Internet connections).

Data exchange is made with periodic connections between HP, HC and the main server in each country. Other services like web-browsing and chat are also supported and enabled depending on the network nature. The most common topology in EHAS (both for VHF/UHF and HF networks) is a centralized scheme, where several



Figure 1: Server and battery loader at the HC of Shucushyacu

clients connect to a server which has an Internet gateway. Other complex topologies which allow wider coverage --and where a server is also a client of another network-- are also considered and supported.

This communication infrastructure is completely based upon free software (mainly GNU/Linux), so it has been possible to check and modify the source code. Among other tasks, it has been necessary to implement a more robust codification scheme and some protocol improvements to avoid unnecessary data resending. Free software has served us to achieve a low-cost competitive solution.

Nonetheless, this solution presents some important restrictions like extremely low data speed, relatively high cost of installations, high power consumption of equipments (since solar powered system has important restrictions in the duration of communications), voice communications are half-duplex and licensed bands must be used.

Due to these limitations, in EHAS we have made a special effort to research other possible appropriate technologies. At first glance satellite could be a feasible solution because it is available worldwide. But both installation, operation and maintenance costs are usually unaffordable for the scope we are considering here. Moreover, in rural areas population is very dispersed, and additional systems are needed in order to distribute the connectivity. Thus we conclude that satellite option should be avoided as far as possible.

#### – **Wi-Fi**

Next step was to consider **IEEE 802.11 (Wi-Fi)** technology, and specifically **mesh** architectures, as a candidate solution for distributing voice and data communications in our scenarios. Wi-Fi mesh networks have many interesting properties that are worth to be indicated here:

- Wi-Fi is a very well-known technology and extremely cheap.
- Although Wi-Fi is a technology originally designed for indoor and short distance environments, it is possible to adapt it to long distances. In the last years our group has put a lot of effort into how to adapt Wi-Fi for long distance with good performance. As a result of that we have been able to successfully establish stable permanent Wi-Fi links up to 87km. An important requirement of Wi-Fi links is that they need line of sight between both sides.
- Wi-Fi systems can work in ad-hoc mode, which makes this technology be appropriated for mesh networks. Mesh networks are a feasible option for us since they do not need any communication infrastructure, this is, nodes connect to neighbors as they discover them, and can communicate with non-contiguous nodes or with other networks using other nodes as routers. This reduces even more the price of communication infrastructures because user terminals permit themselves to extend the network scope.
- Wi-Fi hardware needs much less power consumption than VHF-HF equipment. Using Wi-Fi hardware and optimizing its power consumption by several means, it is possible to produce compact autonomous nodes that incorporate a solar power subsystem, thus eliminating any restrictions regarding power sources.

As consequence of our research in this technology we have obtained a first prototype of solar wireless mesh node based on x86 boards, running our own linux distribution. This first version has been used for deploying a mesh network in Cuzco (Peru). Wireless point to point links go up to 42Km in that network and the longest links are permitting a throughput of 3.5Mbps working in 802.11g at 6Mbps speed. We have also verified experimentally that we can get up to 1.2Mbps in a 84Km long link in the jungle working at 2Mbps speed in 802.11b mode.

#### – **VoIP and Software phonepatch**

According to different studies voice communication is the most important service in EHAS networks. Unlike VHF-HF systems, Wi-Fi networks are in essence data IP



networks that were not devised to provide voice service. **Voice over IP (VoIP)** turns up as a technological solution to provide voice connectivity in Wi-Fi networks. In EHAS we have selected an open-source software PBX (Private Branch eXchange) named **Asterisk** that supports VoIP-to-PSTN (Public Switch Telephone Network) switching.



*Figure 2: VoIP tests in Lima laboratory (CUSCO)*

Some of the VoIP services provided to final users are: free voice communication, voice mail, conference and communication to/from PSTN with prepaid cards. All

VoIP terminals in our network use SIP (Session Initiation Protocol) to communicate each other, whereas Asterisk PBX communicates with peers using the proprietary IAX2 (Inter-Asterisk eXchange protocol).

Related to VHF-HF networks the traditional way to connect radio networks to the Public Switched Telephone Network (PSTN) has been the employment of the so-called phonepatch devices. Nevertheless, this solution is excessively rigid, specially nowadays when VoIP has become widely used. For this reason, we have developed a **software phonepatch** that works with Asterisk. The EHAS Asterisk-phonepatch is highly configurable and compatible with HF and VHF/UHF transceivers. Radio users operate a DTMF microphone to interact remotely with the phonepatch so they can receive and make calls to the entire EHAS VoIP network (with no cost) and the PSTN (prepaid card are used for outgoing calls).

### **3. R&D on information services systems suited to the needs of health personnel**

Next step leads us to the design of the services to be offered over the telecommunications system. According to needs studies mentioned before, EHAS medical partners started to work in the development of the following information access and exchange services:

- **Distance training.** Based on an education constructivist model, and taking into account the principal training deficiencies of health personnel, several courses are built by the medical partner. These courses are centered on prevalent diseases of rural areas: childhood and maternal health, diarrhea, infectious diseases, nutrition, etc. Courses, sent through email, allow off-line interaction with the trainees. They also have a system for self-examination and remote assessment. Other complementary training units are also provided, such as “the question of the day”: a clinically focused question whose answer is provided the following day.
- **Epidemiological surveillance.** There are many difficulties associated with the collection, transmission, processing, visualization and feedback of epidemiological information. Frequently, epidemiological information does not get transmitted, arrives late or with erroneous data, which, in many cases, makes it very difficult or impossible to make informed decisions or mobilize rapid interventions. Due to that our team developed a centralized information system for the distribution of forms (based on the Extensible Markup Language, XML) through the EHAS network. These forms are sent to HC so health care personnel are able to fill them out in order to satisfy the requirements of the national epidemiological surveillance system as well as the vertical programs (maternal-child health, tuberculosis, hypertension, etc.). The electronically collected data is transmitted through the wireless links to the hospitals, where automatic processing and visualization of the

information is performed. The information is fed back to the rural HC in monthly bulletins.

- **Patient referral and counter-referral.** The remission of patients from rural health centers to hospitals in the capital city is always somewhat complicated for the physician as well as the patient. The introduction of a referral system for patients with appointments (obtained by e-mail), and the prior mailing of a summary of their clinical histories, would facilitate the effectiveness of care by specialists. Patient follow-up would improve markedly with counter-referral support, that is, if the rural physician received by e-mail the specialists' reports of lab tests, procedures, therapies, recommendations, etc.
- **Consultations.** The possibility of obtaining an informed opinion from a specialist in cases difficult to diagnose or manage helps to reduce the number of elective and emergency referrals, as well as costs and inconveniences to patients and their families. In the case of emergency referrals, the availability of voice communication systems (VHF radio or VoIP in Wi-Fi links) connecting the health care establishments at different levels, allows for a more rapid and efficient use of available transportation in rural areas, reducing considerably the delay time for patient transfer.
- **Access to health information.** This kind of service allows a mediated access to remote data bases and magazines related to health. Magazines and publications are edited by the medical partner and include relevant news and events. This can help to reduce the feeling of isolation experienced by the rural health professionals.

#### **4. Deployment of those technologies and services through pilot projects**

Once appropriate technologies and services have been designed and tested in the laboratory, next step consists of the deployment of a pilot project in an isolated rural area. Besides the installation itself, there are some important aspects that need to be taken into account. To obviate some of them could unequivocally make the project fail.

- **Selection criteria.** Several factors fall into the selection of the health sites to be part of a EHAS network: degree of necessity, isolation, accessibility, etc. Normally the provincial Hospital has a significant participation on the selection of the HC and HP involved as well as on the design of the hierarchical features of the communication network.
- **Appropriation.** To encourage local appropriation, or a feeling of ownership, many institutions (province government, local authorities and the recipients communities) are involved in the project through active contributions on some deployment activities, such as transportation of experts, equipment, and materials, construction of the tower foundations, etc.
- **Training.** Once installations have been completed, users will be trained on preventive maintenance, operation of the communication system, and use of the computer (hardware and software). An adult training method consists initially of two 50-hour courses per user. Further courses can be taken in order to strengthen the knowledge acquired. Additionally during the project several local technicians can be trained in network maintenance. Finally the province Hospital receives support on how to develop a maintenance system: procedures, equipment replacement, and economic provisions.
- **Adapting to new procedures.** Managers of each department at the province Hospital received support on how to change their traditional procedures to new ones in order to better benefit from the new communication system. In order to make the technology useful for the organizations, we have to adapt the organization to the technology, and also adapt the technology to the organization. The actions we take on the social level (local participation, users and technician training, maintenance procedures and organizational change) give those results,

better matching the technology and organization in both directions: from technology to organization, and from organization to technology.

Taking into account these aspects in EHAS we have carried out several pilot projects in the last years. The first pilot experience took place in the health network of Huallaga in Alto Amazonas, Peru. 39 EHAS telecommunication systems were deployed. It consisted of 7 email servers and 32 client systems. The network came into operation in September 2001.



Figure 3: Wi-Fi installation in Cusco (Peru)

Following the initial results of the impact evaluation of Alto Amazonas, EHAS considered other pilot projects: two new areas in Peru: Marañón network in the Loreto region (22 systems) and Quispicanchi-Acomayo health network in the Cusco region (13 systems); two in Colombia: a radio network in the jungle of Pacific Coast (12 systems) and the Municipalities of Silvia, Jambaló in the department of Cauca (22 systems); and one in Cuba, in the province of Guantánamo (28 systems).

## 5. Evaluation of the impact of these telemedicine systems on health services

Up to now three impact evaluations have been programmed in EHAS; two related to the first EHAS pilot project in Huallaga and one related to European project @LIS. These studies are centered on measuring the effectiveness, usability, economic, institutional and technological sustainability, and impact on health service, health attention process, accessibility and economic aspects.

These studies used both quantitative and qualitative data collection techniques: documental review, questionnaire, interview to key informants, direct observation and group dynamics based on Participatory Rural Appraisal (PRA).

Here we will present the main results of the Alto Amazonas, Pacific Coast of Cauca, Cuzco and Guantánamo pilot projects and will go with the conclusions in a further section.

### – Usability of the system

Users are **very satisfied with the system**: 71,6% in Cauca's Pacific Coast, 59,1% in Guantánamo and 68,2% in Cuzco. In Alto Amazonas, 100% of users say the system allows better coordination, 93% say the system allows them to improve their work and 80% say the task load has decreased.

The **level of use is from “moderate high” to “high”**. The use of each system is as follows:

1. for voice (radio or VoIP), 100% in Alto Amazonas, 41,7% in Cauca's Pacific Coast, 60% in Guantánamo and 85% in Cuzco;
2. for PC (mainly office tools), 86,7% in Alto Amazonas, 38,5% in Cauca's Pacific Coast, 70,6% in Guantánamo and 73,7% in Cuzco;
3. and for Internet (mail and Web access), 77% in Alto Amazonas, 9,1% in Cauca's Pacific Coast, 12,5% in Guantánamo and 61,1% in Cuzco.

**System has a good usability.** Users declare that the system is “easy” or “very easy” to use, as follows:

1. for voice system (radio or VoIP), 100% users in Alto Amazonas, 100% in Cauca's Pacific Coast, 71,4% in Guantánamo and 94,7% in Cuzco;
2. for PC, 77% in Alto Amazonas, 41,7% in Cauca's Pacific Coast, 83,3% in Guantánamo and 94,1% in Cuzco;



3. for Internet, 93% in Alto Amazonas 33,3% in Cauca's Pacific Coast, 45,5% in Guantánamo and 83,3% in Cuzco.

Health workers spontaneously tend to apply the system to the following processes:

- Emergency management and coordination: use of voice systems to receive distance support to diagnosis or treatment, and coordination for patient transportation.
- Coordination of patient referral and counter-referral: exchange of referral forms through email or voice system.
- Support to distance training: access to on-line courses or documents.
- Consultations of clinic doubts (second opinion) through voice or email.
- Management, process and exchange of statistical information: epidemiological, administrative, etc.
- Personal communication with relatives and friends through chat, email or VoIP.
- Monitoring from hospitals of counter-referred patients.
- Use by people not directly related to healthcare: local government, education workers, and other public workers.

#### **- Impact on healthcare**

**Improvement in emergency management.** Thanks to the use of the system, patient evacuation is better coordinated (between 88% and 100% of the cases voice system is used for this use) what implies: sharing of scarce vehicles (up to 64% of cases), less time for referral (up to 60% of reduction), better readiness of resources (specially blood) in the hospital and a higher number of scheduled appointments (this increased from hardly zero to near 70% in most of the projects). Finally, healthcare staff believe EHAS system helped to save lives (mainly in pregnant women cases).

**Improvement in diagnosis and treatment capacity.** First thanks to EHAS systems healthcare staff has a second opinion (very important for staff living in isolated areas). In all of the projects, EHAS systems are associated with the increase of consultations. In Guantánamo we found an increase of monthly clinic consultations from 2,8 to 24,1 (more than eight times more), while in Cuzco the increase was from 1,3 to 3.

The number of administrative consultations also increased: in Guantánamo, from 1,4 to 1,8 and in Cuzco from 1,3 to 4,2. Once more workers prefer voice systems to do consultations. Satisfaction with EHAS system for distance consultations is 44,4% in Guantánamo and 77,8% in Cuzco. The EHAS system has been useful for distance training; 5 courses have been imparted (malaria, dengue, tuberculosis, breast breeding, and first aid) and the participants evaluated them with a score of 16.95/20. 95.2% of interviewed people declared that the EHAS system was appropriate for training rural health personnel.

**Improvement in epidemiological surveillance.** The EHAS system has proved to be effective in improving the epidemiological surveillance system in Balsapuerto (one of the most isolated areas in Alto Amazonas), by reducing to a quarter the number of trips made to send reports. Twice the number of health establishments are now reporting weekly, compared to the time before EHAS system was installed. In 60% of the cases the PC has been useful in filling in reports, allowing a reduction in the monthly time devoted to preparing reports from 20 hours to 13 hours (35% reduction). Malaria detection time was reduced by half.

#### **- Cost-benefit study**

Taking the project in Alto Amazonas as example, infrastructure and installation costs per establishment came to US\$4195, and the estimated cost of the telephone bill (seven telephone lines shared by the 39 establishments) plus the system



*Figure 4: Infirmarian technician using the VHF system for voice and data (email) communication*

maintenance and repair was US\$704/month for the entire communication system. The total cost of the system will be recovered by the savings generated in 2.5 years. In this forecast, we are only considering the savings on travel (US\$1718 monthly) and on patient evacuation (US\$4230 monthly). However, if we also consider the indirect benefits, total amortization will be reached in 13 months. Indirect benefits include the increase of the productivity of health staff due to reduction in travel and office tasks, and the increase of the productivity of patients and relatives due to the reduction in patient evacuations.

## 6. Spreading

From the beginning, EHAS philosophy has been to make our “Know How” and experiences be common knowledge. Our projects are focused on isolated rural areas in American developing countries, but we firmly believe that the knowledge acquired in EHAS can be directly transferred to isolated rural areas in developing countries belonging to other continents, like Africa or Asia. In order to share our “Know How” we carry out several initiatives:

- **EHAS Web Site.** This Web Site allows us to share information that can be consulted worldwide: software used in our designs, hardware descriptions, presentations, articles, update status of our projects and upcoming ones.
- **Publications.** Yearly several articles and papers are presented to technological magazines and Congresses, most of them with international scope.
- **TV Documentary** made with own resources. In 2006 Spanish and South American TV channels were showing a documentary about the EHAS experience. It can be viewed on line at our Web Site.

## RESULTS AND CONCLUSIONS

This project has clearly demonstrated that the use of appropriate technologies to the available local resources (easy to use, robust, and with low operating costs) solves some of the important efficacy and efficiency problems at the rural primary healthcare level. It does so by improving the speed of resolution and diagnostic capacity of the health sites, by speeding up the patient evacuation system, by enhancing the efficiency of epidemiological surveillance mechanisms, by facilitating pharmaceutical deliveries, and by reducing the widespread sense of isolation, both professional and personal, felt by the rural health personnel.

The feasibility and sustainability of the VHF/HF/Wi-Fi/VoIP communication solutions provided to implement rural telemedicine systems in developing countries has also been proved, this being a conclusion that has not been demonstrated with other satellite-based solutions. The working methodology used in the project has also confirmed the hypothesis that only with participative implementation programs, using solutions derived from the needs and constraints of the target communities, and not technology driven, is it possible to achieve the global acceptance of all users involved: administrators, health professionals, and patients, as well as the integration of a rural telemedicine system within the local health institutions. Results obtained are intended to demonstrate to the Health Ministries of the region that the solution proposed, and its systems and services, is within the reach of most health rural centers. There are more powerful alternative technologies, but they do not respond to the priorities of the rural sector demands and, more critically, they can never provide sustainable solutions, taking into account the limitations of the developing countries' health systems. Companies, Public Administrations, and R+D centers have to understand that the massive implantation of telemedicine and telecommunications in isolated rural areas requires a “two-way” approach. In one way, the technology has to be adequate to the user context: local economic resources, human factors and knowledge, cultural considerations, and energy considerations. In the other way, a natural interface must be provided between technology and the institutions: adequate training of the users and of maintenance personnel, and appropriate levels of motivation and tools so the administrative bodies may successfully achieve the organizational changes required. The EHAS experience demonstrates to health program funding bodies that it is possible to improve the efficiency of the isolated

rural systems by means of systems and services such as those we propose here, based on low complexity and low cost technology, as well as appropriate methodologies to support the technological transfer.

Another important result of EHAS program that is worth to be mentioned here is the significant North-South and South-South collaboration in the telecommunications and health sectors between universities, research centers, and a nongovernmental organization with the aim of developing solutions for rural health systems.

EHAS Foundation has become a Latin American reference in both Rural Telemedicine and communication wireless networks in isolated rural areas with a complicated orography. In recognition of this outstanding trajectory EHAS has been awarded four awards, two of them with international scope.

### **PERSPECTIVE**

Currently EHAS is leading several international initiatives, among others: an Ibero-American project focused on Rural Telemedicine funded by Latin American Program for Science and Technology for Development (CYTED), a project funded by the Inter-American Development Bank (IDB) aimed to design a communication infrastructure for more than 200 points in the Peruvian jungle, and is also involved in a Project against Malaria with the participation of Regional Andean Health Organism (ORAS) and financed by the Global Fund.

These new projects will make use of the new tools developed in EHAS laboratories, such as a low powered Wi-Fi router for long distances, a VoIP phonepatch, or a rural telemedicine system using Wi-Fi for carrying medical data (teleconsultation).

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## AUTHORS

### **Andrés Martínez Fernández {andresmf@ehas.org}**

A. Martínez was born in 1970. He received the Telecomm. Eng. and the Ph.D. degrees from the Universidad Politécnica, Madrid, Spain, in 1994 and 2003, respectively. He is currently an Associate Professor in the Department of Theory of Signals and Communications, Universidad Rey Juan Carlos, Madrid. He is Director of the EHAS Foundation. His current interests are telemedicine and low-cost telecommunication systems for less developed regions.



### **Francisco Javier Simó Reigadas {jsimo@ehas.org}**

Born in 1970, he got his degree in telecommunication engineering in 1996. After 8 years of professional experience in the sector of NGO's for development (4 of them living in Africa), he has been researching in the EHAS Foundation on topics related to the use of ICT's in developing countries, finally getting his Ph.D in February 2007. He is currently an associate professor in the King Juan Carlos University in Spain and EHAS' technical director. His current interests are the application of IEEE 802.11 over long distances, ad-hoc networks and wide area broadband wireless communications.



### **Joaquín Seoane {joaquin@ehas.org}**

Born in 1953, is currently an associate professor in the Telecommunication Engineering School of the Polytechnic University of Madrid (UPM), teaching several computer science courses. He got his telecommunication engineering degree in 1976 and a PhD in 1989, and worked in real time control and supervision companies, but the main professional activity was devoted to the University since 1978. His current interests are distributed systems administration, internationalization, XML based teaching tools, free software, and low cost telematic systems for less developed regions. Since 2000 works in the technical direction of EHAS Foundation.



### **Arnau Sánchez Sala {arnau@ehas.org}**

Born in 1978, he received the telecommunication engineering degree in 2001 from the Polytechnic University of Catalunya (UPC). He is currently working in the EHAS foundation as technical researcher, developing low cost telematics system. His research interests are in radio communications, VHF/HF data transmission and free software in general.



### **Sandra Salmerón {makevuy@ehas.org}**

Born in 1981, she got her telecommunication engineering degree in 2005 at the Polytechnic University of Cartagena. She is currently working in the EHAS Foundation, mainly involved in VoIP systems and the adaption of QoS (DiffServ, 802.11e) in Wi-Fi long distance links. Other technological interests include Telemedicine (Teleconsultation) and Wi-Fi/Wimax simulation.



### **Silvia Lafuente Sanz {slafuente@ehas.org}**

Born in 1978, she received the telecommunication engineering degree in 2003 from the Polytechnic University of Madrid (UPM). He is currently working in the EHAS Foundation as technical researcher, developing a low cost Wi-Fi router. Her research interests are radio communications, Wi-Fi/Wimax data transmission and free software in general.



**Valentín Villarroel Ortega {valentin.villarroel@isf.es}**

Born in 1968, he got his telecommunication engineering degree from the Polytechnic University of Madrid (UPM). He works in ICT for Human Development from 1997. His current interests are technology transfer to organisations, organisational factors in ICT projects, participatory approaches, and evaluation studies. From 2000 he is ICT program officer at Engineering Without Frontiers (ISF), where he was former project officer of EHAS projects.



**Pablo Osuna García {posuna@ehas.org}**

Born in 1980, he got his telecommunication engineering degree in 2006 from the Polytechnic University of Madrid (UPM). In 2003 he started to work for Telefonica I+D. In 2004 he moved to Ireland and worked for Digiweb, an innovative Irish Wireless ISP, mainly involved in wireless setups (Wi-Fi and preWimax equipment). In 2005 he started to work for the EHAS Foundation as Wi-Fi consultant, mainly involved in the development of a low-cost Wi-Fi router. His current technical interests are Mesh networks, long distance Wi-Fi links, Wimax technology and its adaption to developing countries.



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E.T.S.I de Telecomunicación Despacho C.203-1 Ciudad Universitaria, s/n 28040 Madrid - España	Tel. +34 91 549 57 00 - ext 8010 Fax +34 91 336 68 28 Web Site: <a href="http://www.ehas.org/">http://www.ehas.org/</a> Mail: <a href="mailto:info@ehas.org">info@ehas.org</a>
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