A Study on a Nationwide Ambulance Communication System via HEOs to Support Telemedicine

Isao Nakajima, Hiroshi Juzoji, Muhammad Athar Muhammad,
Toshihiko Kitano, Naokazu Hamamoto*
Tokai University School of Medicine
National Institute of Information and Communications Technology*

Abstract

The Government of Japan is investigating the ability of HEOs(Highly-inclined Elliptical Orbits) to cover nationwide without blocking and shadowing, especially application of mobile communications during disaster and emergency situations. We have studied on a nationwide emergency medical communication system via these satellites to support telemedicine during the transportation.

1. Purpose

The Emergency Medicine has the requirement to transmit real-time video from a moving ambulance to an Emergency Medical Facility (Triage Center) to enhance efficiency. Real-time video reception will allow EMS staff to assess patient condition, perform triage, make preparations, and provide critical guidance to ambulance personnel while the patient is en route. Tokai University and JAXA have developed a state-of-art satellite tracking and transmitting system on Ku, or Ka-band with real-time MPEG-2 and MPEG-4 video up to 6 Mbps for HEOs system. The outline of the HEOs system(3 satellites constellation, 8 hours for each) shown on the Figure 1 and on Figure 2.

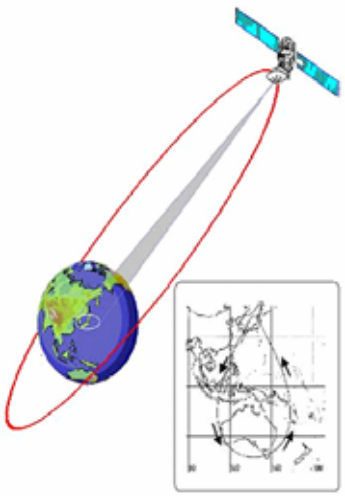

Fig. 1 HEOs system

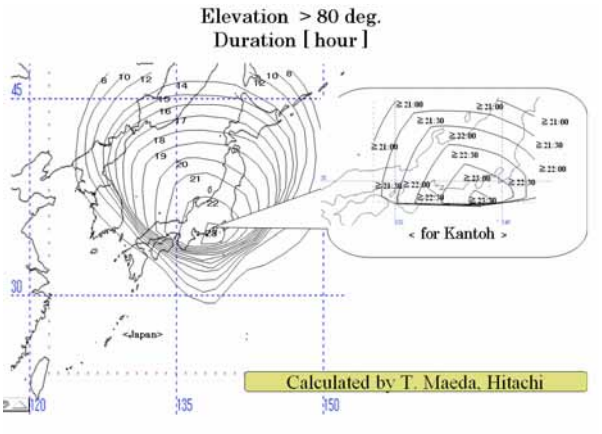

Fig. 2 Total duration with elevation angle over 80 degree

2. Back ground

ITU-D SG-2 Q14/2 "Telemedicine" has been study to telecommunication application for medical field, "Telemedicine Lessons Learned" and "Telemedicine Directory" (Documentation 2/195) were submitted by Q14/2 to SG-2 in September 2001 and 2005 respectively, and are now available on the Web. These activities supported by Prof. Leonid Androuchko; Rapporteur, Isao Nakajima; Vice-Rapporteur of Q14/2, and they have described how to establish a commercially successful telemedical service on the ITU publication. Based on these activities, Tokai University School of Medicine; the first sector member of ITU-D from medical field, NICT, and JAXA have been studied on “Mobile eHealth”; next generation ambulance communication system to support telemedicine in Japan.

Interpretation of Article 20 of the Medical Law

As of December 24, 1997, the Director of Health Policy Bureau sent to all municipal governors nationwide a notification (Health Policy Bureau No.1075) identifying the principle of face-to-face diagnosis in Article 20 of Medical Law and the basic ideas of remote medicine. This notification comprised ten items. The major items can be summarized into the five points, as follows in

Table 1. Of particular importance, we can note that the first medical diagnosis performed through a communications channel has been permitted, and we presume that it includes the diagnosis of a patient in an ambulance through high-quality communications channels. Most healthcare controls have been implemented on the basis of such notifications in Japan. Legal experts thus believe that the remote medicine employing image data transmission from ambulances has a solid legal foundation.

1. Remote medicine using information communications tools does not violate Article 20 of the Medical Law.
2. Remote medicine is to be regarded as a tool supplemental to face-to-face diagnoses, and its application is to be limited to patients in stable condition – for example, patients returning for a second or subsequent visit for the diagnosis of a chronic disease.
3. Remote medicine is to be performed at the request of the patient and must be beneficial to the patient.
4. Remote medicine may be used in the cases where there is difficulty gaining access to in-person medical examinations such as patients in remote areas and bedridden senior citizens (in this case, primary diagnosis by remote medicine is permitted).
5. The accountability of doctors and the responsibility of patients are clearly stipulated.

Table 1. Summary of the official notification on remote medicine in Japan

Ambulance communication in Japan

In 1983, the current emergency radio system was increased to 42 frequencies (21 opposing) by the Ministry of Posts and Telecommunications Radio Frequencies Administration Head. Mobile phones are used alongside this system to relay patient information, but they suffer the following problems:

. Small service area
. Limited number of frequency channels.
. Interference from adjacent areas
. "Shadowing" effect of buildings and trees.
. Insufficient bandwidth for image transmission.

3. Study

3.1 Necessity channels

Year after year, the total number of transported patient have been increased all over Japan. Statistics from the Tokyo Fire Defense Agency were the only large-scale data available for our study in Japan. Thus, Tokyo was unable to coordinate medical control for ambulance.

As of 1999, Tokyo had a population of 12,059,237, served by 201 ambulances. The ambulances were operated a total of 537,416 times, with 504,675 people transported(Fig. 3). The average transport time was 1,002 seconds and victims who were seemingly dead or victims in critical or serious condition accounted for 8.4% of all those transported. We thought that this 8.4% of victims would be the target of the patient data transmission system. With Erlang's B-formula(Figure 4), the minimum number of channels required was calculated as six (for daily operations in Tokyo) for a call loss probability <0.02. So, 6 channels for Tokyo, then total 64 channels should be needed nationwide with 4800 ambulances.

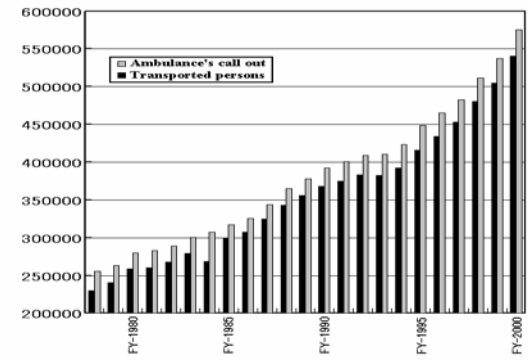

Fig.3 Emergency transportation by ambulance in Tokyo

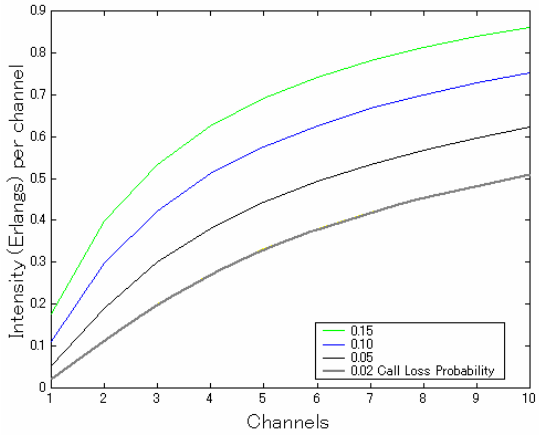

Fig. 4 Results of Call loss probability; Erlang's B-formula

3.2 Proposed new service

We have designed and made a prototype of an emergency ambulances mounted satellite tracking system and a IP-based wireless radio system to support telemedicine. The roof top drive system features a compact, simple design, and mechanically controls a dish antenna 40 cm in diameter(Fig 3). With GPS continuous kinematic positioning, a fiber-optic 3D-gyro, and a quadrant detector, DC motor systems for azimuth and elevation control are installed, and the reduction gears have a harmonic drive mechanism with non-backlash gears aligned on a single input/output line.

With this system we can send up to 2.0-6.0 Mbps (MPEG-2, MPEG-4) motion picture from ambulance via HEO satellites, and/or wireless radio on S band on the ground. Telemedicine, especially triage for emergency transportation must encompass a wide range of patients, from children to the elderly, not only developed country, but also developing countries. The transmitted data should

be IP-based multimedia data that provides diverse information such as 12-lead ECG, SaO_2, and digital video of cardio-echogram of myocardial infarction and the affected area of trauma victim during disaster.

Fig. 5 Prototype super ambulance
Two diversity antenna mounted on the roof

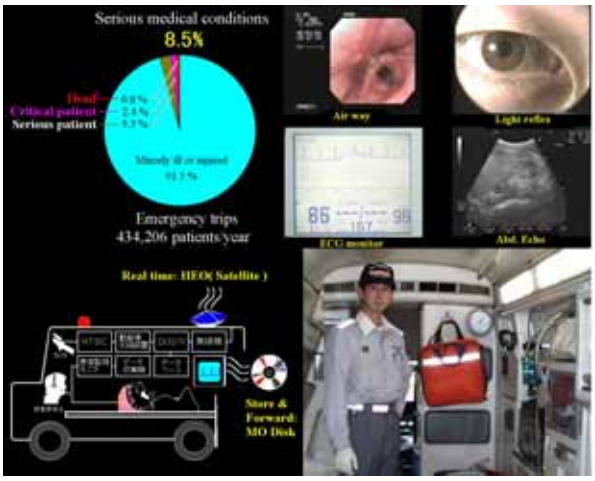

Fig.6 Medical data for transmission; Light reflex, Vocal cord, Echogram

Fig. 7 Tracking test in urban area Japan

4. Considerations

Tele-education and telemedicine are regarded as one of the triggers to spread ICT. However, is it appropriate to follow the same extension policy as the other ICT application? Preparation for communication infrastructure such as PSTN, mobile communications, satellite communications, and optical fiber communication networks differs according to each user's circumstance. Furthermore unlike other needs whose markets change on the principle of free competition, medical service is provided by the managed economy and administered based on a government's powerful support policy in each nation. Therefore, it is indispensable to implement not only hardware but also software suitable to each communications environment.

In case of Acute Myocardial Infarction, thrombolytic agents are reportedly effective when injected into vein within one hour after the attack. The patients who are lucky enough to be transported to a CCU (coronary care unit) in emergency centers are in most cases given thrombolytic agents while undergoing PTC (Percutaneous Transluminal Coronary) operations to remove the coronary thrombus. Thrombolytic agents are reportedly effective even when injected into a vein, if injected in the early stages . In fact, some trials of doses in ambulances have been initiated. We estimated that over 50% of patients will benefit from this satellite system. One solution for curbing medical expenses in Japan, which is currently growing 5% annually, is improving pre-hospital care. The high-speed data channels will enable doctors to assess the conditions of the patient in an ambulance regardless of the distance.

5. Acknowledgement

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