Final Project Report

U.S.-U.S.S.R. Telemedicine Consultation Spacebridge to Armenia and Ufa

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INTRODUCTION

A devastating earthquake occurred on December 7, 1988, in Soviet Armenia. This earthquake caused widespread destruction and loss of life and property. Help, both medical and material, was rushed to the affected area and many countries, including all the Soviet republics, cooperated together to provide initial help to the victims.

Two weeks after this tragic event, a concept of telemedicine consultation was developed by the National Aeronautics and Space Administration (NASA) and proposed to the Soviet Government under the auspices of the existing bilateral Space Agreement between the U.S. and U.S.S.R. Concerning the Exploration and Use of Outer Space for Peaceful Purposes, concluded April 15, 1987, and amended May 31, 1988. This proposal was made through the established U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, and implemented from May 4 through July 28, 1989. The Life Sciences Division, with the support of the Communications and Information Systems Division at NASA Headquarters, was responsible for the U.S. implementation phase of this project; and the NPO Soyuz Medinform and "Space for Health" organization were assigned the responsibility for the Soviet portion of this project.

The goal of this activity was to provide expert medical consultation to the Armenian medical personnel in the areas of plastic and reconstructive surgery, physical and psychological rehabilitation, public health and epidemiology.

The U.S. and U.S.S.R. implementation teams developed new standards for medical information transmittal as well as protocols and schedules on how to conduct medical consultations (See Supporting Materials). The consultations were provided to the Republic Diagnostic Center in Yerevan, U.S.S.R. by four U.S. medical centers: University of Utah/LDS Hospital, University of Texas, Maryland Institute for Emergency Medical Service Systems, and Uniformed Services University of the Health Sciences.

The idea for telemedicine consultations was simple in scope. However, many technical and logistic issues had to be worked out prior to its implementation. It was determined that the two most critical periods where such help is of utmost importance are immediately after the disaster or several months later. In the immediate time frame, telecommunications are important for the purposes of patient triage, planning for long-term care, identification of medical supplies and expertise which might be required at the scene. In the follow-on time frame, telecommunications are primarily required for treatment of chronic problems and rebuilding of medical capabilities in otherwise devastated areas. Technical problems precluded the initiation of this project in the early phase. Some of the technical issues can be summarized as follows:

1. Identification and installation of suitable ground communications links
2. Identification and securing of suitable satellite channels
3. Conformance to the existing international communications policy and procedures
4. Training of participating personnel from different countries and suitable translations
5. Privacy of medical consultations.

In this instance, Intelsat and Comsat donated free access to uplink and satellite transponders and the Soviet Union donated the downlink channels. A ground station for video, voice and facsimile communication was rented from the "Stars" company in Houston, Texas, and deployed in the Republic Diagnostic Center. Ground communication lines were provided by NASA to the U.S. medical facilities, including the use of domestic satellites for retransmission of signals. All communications were encrypted in such a way as to protect the privacy of the patients. The U.S. team visited the Yerevan Republic Diagnostic Center and got acquainted with the facilities, layouts, and capabilities existing in Soviet Armenia. The Soviet team visited the U.S. medical facilities and the NASA Goddard Space Flight Center communication center, and familiarized themselves with the U.S. medical and communications experts, procedures, and capabilities. These preliminary exchanges significantly contributed to the later success of the Spacebridge. Precise protocols and procedures were developed prior to the initiation of the telemedicine consultation network, and were amended at a later time as necessary during the telemedicine sessions. A central communication status room was established at NASA Headquarters which played the role of a "dispatcher" and assured the smooth conduct of the sessions and resolution of "conflicts."

The unfortunate railroad accident happened on June 4, 1989, near the city of Ufa, during the existence of this network. Through the efforts of the Public Service Satellite Consortium (a private U.S. organization), the NPO Soyuz Medinform, and NASA personnel involved in the telemedicine consultation Spacebridge, a satellite station consisting of a Slow Scan Video System, donated by Colorado Video, was deployed at the Ufa Medical Center and became operational 3 weeks later. This station was connected via ground links to the "Star" station in Yerevan and was serviced by both the U.S. and Armenian expert consultants.

Overall, the project was on outstanding success. Over 400 physicians and medical personnel from both countries participated in 51 sessions during the 3 months of existence of the Telemedicine Spacebridge. Experts consulted upon 253 cases representative of the general population affected by disaster. The communication links worked very effectively. In retrospect the language differences between the different medical institutions required working adjustments both from the patient and physician standpoint. Telemedicine has been tried on many different occasions over the last 20 years; however, never before was it deployed and tested on such a large scale.

This project demonstrated both the value of such a system and the need to institutionalize this capability nationally and internationally, so that it could be activated on demand. Today, elements of telemedicine exist on a regional or urban basis in the United States and are operating quite successfully. Telemedicine is also an integral part of the manned space program. It is important, however, that serious steps are taken today to plan for the development, maintenance, and associated training on a global scale system of telemedicine with appropriately dedicated communications, medical personnel, and even rapidly deployable, self-sufficient medical care systems. Areas stricken by serious disasters usually lack of all these components which are disrupted in the immediate post-catastrophe periods. To facilitate the dissemination of the experience gained as a result of this project, the U.S. and U.S.S.R. Joint Working Group on Space Biology and Medicine has formed a joint implementation team in telemedicine charged with the specific objectives of:

1. Supporting research to advance telemedicine support for space flight
2. Recommending application of the experience to space medicine and care of sick and injured space crews
3. Recommending applicability of currently available compact and self-sustaining medical care capabilities, such as the ones developed for Mir or International Space Station Freedom, to be included into the

telemedicine system for providing immediate care to victims of natural disasters

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TELEMEDICINE: A HISTORICAL PERSPECTIVE

The word **telemedicine** denotes the practice of medicine at a distance. The origin of this term is difficult to establish, and it has been probably coined as a result of the space age. What really constitutes telemedicine is a point of debate. In the early days of the telephone, telegraph, and radio, medical consultations were obtained between physicians by voice or mail. A critical step which preceded telemedicine was the need for and development of telemetry. Telemetry is a process for sending or receiving measurements, either physical or biological, from remote locations. Undoubtedly, the space age and the introduction of new means for communications, both audio and video, gave a new and expanding role to telemetry, biotelemetry, and later on to telemedicine. In the early 1960's and 1970's, the spinoffs from telemetry, or better biotelemetry, found their way into doctors' offices, hospitals, ambulances, and aviation. Gradually, links between different medical centers were established which serviced not only urban but also rural areas. Implantable devices such as pacemakers and defibrillators were developed which can telemeter the data via telephone and microwave links to physician offices and be individually programmed. Thus, the combination of electronic medical systems and communications, voice or video, became an efficient way of improving patient health care, and, in essence, brought the practice of medicine to the doorstep of where the patient resides. The combined system, referred to as telemedicine, has been effectively used to augment existing health care delivery systems, by providing a direct consultation link between remotely located medical personnel working with the patient and expert consultants at a central location.

The first experiment in telemedicine was conducted in 1971 with an NPSA-launched ATS-1 satellite. Experiments in the use of telemedicine in Alaska began under the auspices of the Indian Health Service (the arm of the U.S. Public Health Service responsible for providing health care to native Alaskans). Faced with the problem of servicing scattered small villages in remote regions and thwarted by the lack of reliable communication channels in the bush, the agency turned to telemedicine in the hope that consultation on a regular basis would improve village health services.

In one of the earliest health applications, 14 villages in the central Alaskan Tanana Service unit, 1 of 7 Alaskan health service units, were chosen to participate in a telemedical consultation experiment in conjunction with a service unit hospital in

Tanana. The experiment was financed by the Lister Hill Center for Biomedical Communication, and involved daily consultation between a local village health aide and a physician at the hospital.

In addition to teleconsultation, the system was used for communications between patients at the service unit hospital and their families in the villages. Because there was no telephone service to the villages, patients had been previously isolated from such interaction. The system was also used for interactive searching of MEDLINE, the National Library of Medicine online computer retrieval system in Bethesda, Maryland, and for transmission of a continuing education course on coronary care offered to nurses by the University of Alaska.

During the year 1974-1975, NASA's ATS-6 satellite added a video component to Alaska's telemedicine experiments.

The success of the ATS experiments is well documented. The number of contacts between doctors and health aides increased by 400 percent during the first year of the experiment. The State of Alaska and the Public Health Service subsequently transferred the health demonstrations to an operational system using commercial satellite services.

Similar medical assistance was given to appropriately equipped merchant ships at sea via the MARISAT system, which routes such requests for diagnostic help to a hospital on Long Island in New York City. In the same time frame, another project was being developed to apply the experience gained as a result of the Apollo/Skylab program to the 10,000 inhabitants scattered over 4,400-square-mile Papago region. A mix of electronic technology, closed circuit color television, and computerized patient data banks was developed for this purpose. Physicians at the Indian Health Service (IHS) Hospital near the center of the region consulted via television with community health medics (paramedics), who visited patients in remote villages on a regular basis in a large van called a Mobile Health Unit (MHU). Anywhere the MHU stopped in the vast region, it had instantaneous two-way contact with the IHS hospital. This project, which was very successful, was named Space Technology Applied to Rural Papago Health Care (STARPAHC).

One piece of equipment adapted for use in the Papago health care system is a suitcase-sized emergency treatment kit that allows communication between trained ambulance attendants at an accident scene and a physician at the IHS hospital. Originally developed for medical monitoring during the Skylab program, it is now marketed commercially. This portable kit is widely used by emergency medical systems throughout the United States to provide voice and telemetry communications of vital signs, electrocardiogram (EKG), and blood pressure from a remotely located patient to a central major medical center. It has permitted paramedical personnel to provide effective stabilization and care to cardiac and trauma patients, with significant improvements in their eventual outcome and survival as a result of improved early therapy. Also included in the kit carried in the ambulance are a battery-powered defibrillator and pacemaker, oxygen supply, aspirator, resuscitator and airways, laryngoscope, prepackaged drugs and supplies, and stethoscope.

A modified emergency system is now in use in Houston, San Antonio, and Corpus Christi, Texas; Montgomery County, Maryland; Altoona, Pennsylvania; San Francisco, California; and Cleveland, Ohio.

Although the original emergency package was widely used for adult medical transports, the system has been redesigned to transport high-risk, low-birth-rate infants from small community hospitals to a central Newborn Intensive Care Unit. Combined with appropriate thermal and respiratory support, this system was placed in use in 1978 and has transported nearly 500 infants a year in Northern California over distances ranging from 50 to 500 miles.

Reliable physiological monitoring and communications permit a largely dispersed population to benefit from a rather limited supply of highly trained personnel. This allows people in remote villages to receive better treatment and allows better control over the need for patient transport to a regional center when absolutely necessary for definitive care.

In 1985, another satellite developed by NASA, ATS-3, was used to help the victims of the devastating Mexico City earthquakes. Within 24 hours after the disaster, the satellite was on the air and was used extensively by the American Red Cross and the Pan American World Health Organization.

An additional example of telemedicine is the COSPAS/SARSAT communications satellite system, which became operational in the mid 1980's. U.S., Soviet, French, and Canadian satellites maintain a constant space-based watch for distress signals from marine, air, and land operations. Since their operations began, more than 1,000 lives have been saved. Currently, more than 15 nations participate in this activity.

Two other examples include ATS-6 which was positioned over India in 1976 for one year of health, education, agriculture, and cultural experiments; and the Communications Technology Satellite (CTS), a joint NASA/Canadian experimental satellite in the early 1970's (which was the precursor of today's broadcast satellites) used extensively for health care, emergency, and education applications.

NASA's commitment to serving the public continues today using its experimental resources in the United States, the Pacific basin, the Caribbean, and most recently, the Soviet Union.

SPACEBRIDGE TO ARMENIA: BACKGROUND

The earthquake which occurred in Armenia S.S.R. on December 7, 1988, caused over 150,000 casualties as well as widespread destruction. NASA, under the auspices of the U.S./U.S.S.R. Joint Working Group on Space Biology and Medicine, made an official offer on December 12th to the U.S.S.R. Government to provide humanitarian aid in the aftermath of the tragic disaster. The Soviet authorities accepted NASA's proposal for organizing consultative medical aid involving leading U.S. medical institutions and specialists via space telecommunications.

In March 1989, physicians from NASA and four U.S. medical centers as well as communication specialists visited Moscow and Armenia to organize a Spacebridge operation. Likewise, U.S.S.R. officials from the Ministry of Health, Ministry of Post, Telegraph, and Communication, Gostel Radio Agency, and the Republic Diagnostic Center (Yerevan, Armenia) visited the U.S. in early April to finalize the arrangements. As a result of these exchanges, a Protocol and Implementation Plan (See Supporting Materials) were signed by NASA and U.S.S.R. officials agreeing to the Spacebridge which would enable Soviet physicians at the Republic Diagnostic Center in Yerevan to consult via audiovisual network with American medical specialists in four centers.

It was anticipated that Spacebridge would be in operation from May 3rd until the end of June. However, due to another tragedy, the Ufa train accident of June 4th, in which there were over 1,200 casualties, the U.S. immediately offered to extend the Spacebridge for an additional month in order to provide further consultation for these casualties. The Soviet Government immediately accepted the offer thereby permitting Spacebridge to continue until July 28th.

Once communication equipment, which was transported by Aeroflot from the U.S. to Yerevan, was installed and operational, broadcasts were able to commence on May 4th. They continued accordingly until the final day of operations on July 28th, when Spacebridge was officially terminated.

Interest in the use of telecommunications for medical purposes has grown steadily in recent years. Various nations have gained significant experience with transmitting medical information by means of digital, acoustic, facsimile and video equipment along appropriate communication channels. Modern telemedicine has taken the following major forms: medical support of space station crews and other isolated groups; creation or improvement of access to literature in medical libraries; production of single, series and ongoing programs for educational objectives; organization of interactive medical conferences in the form of seminars, scientific discussions, and consultations; solution of administrative and practical problems associated with medical relief measures directed at elimination of the consequences of natural disasters and catastrophes.

Due to NASA's unique expertise in the application of the most advanced satellite technology to problems in public health, and to the readiness of medical personnel of four major U.S. medical centers to share their knowledge and experience, the medical personnel of the affected areas of Armenia had the opportunity to consult with American physicians on issues in a number of medical specialities. Leading specialists from the Uniformed Services University of the Health Sciences (Bethesda, Maryland); the University of Maryland Institute of Emergency Medical Services Systems (Baltimore, Maryland); the University of Texas Health Science Center (Houston, Texas); and the Latter Day Saints Hospital and University of Utah (Salt Lake City, Utah) acted as consultants for Armenian physicians for 3 months.

Medical interaction and coordination of work in the U.S.S.R. was organized by the "Soyuzmedinform" Scientific Production Agency of the U.S.S.R. Ministry of Health, which is the lead organization for the "Space For Health" program. The general director of this organization, Professor A.A. Kiselev, acted as project director for the Soviet side. The "Diagnostika" Scientific Production Organization of the Armenian S.S.R. Ministry of Health was selected as the base organization for the preparation and conduct of the teleconferences. The director of this organization, H. Nicogossian, acted as medical coordinator of the project in Armenia.

After the train crash in the Bashkir Autonomous S.S.R. in June 1989, it was decided to establish a temporary teleconferencing studio in the city of Ufa, where numerous burn cases were being treated, and to connect this studio to the Yerevan-U.S. teleconferencing network, which had already been operating for 2 months.

Thus, the "Armenia-U.S.A." medical telebridge with the "Ufa-Armenia-U.S.A." hook-up became the first example in history of the use of a system of satellite communications in support of systematic, long-term, multidisciplinary collaboration among the medical personnel of two nations.

COMMUNICATIONS AND NETWORK

The NASA Communications Division of the Goddard Space Flight Center (GSFC), which has NASA-wide responsibility for design, implementation, operations and maintenance of the operational communications network, the Nascom Network, was given the assignment to meet the communications requirements of the Medical Spacebridge.

The communications links supporting the Medical Spacebridge between various U.S. medical centers and Yerevan, Armenia was accomplished utilizing a combination of domestic and international satellite and terrestrial networks, communications facilities and services.

The major components of the service were: a transportable C-band earth station; two INTELSAT C-band transponders; two earth stations at Roaring Creek Pa. - one for international service and one for domestic service; an AT&T domestic satellite transponder; and AT&T terrestrial private voice lines.

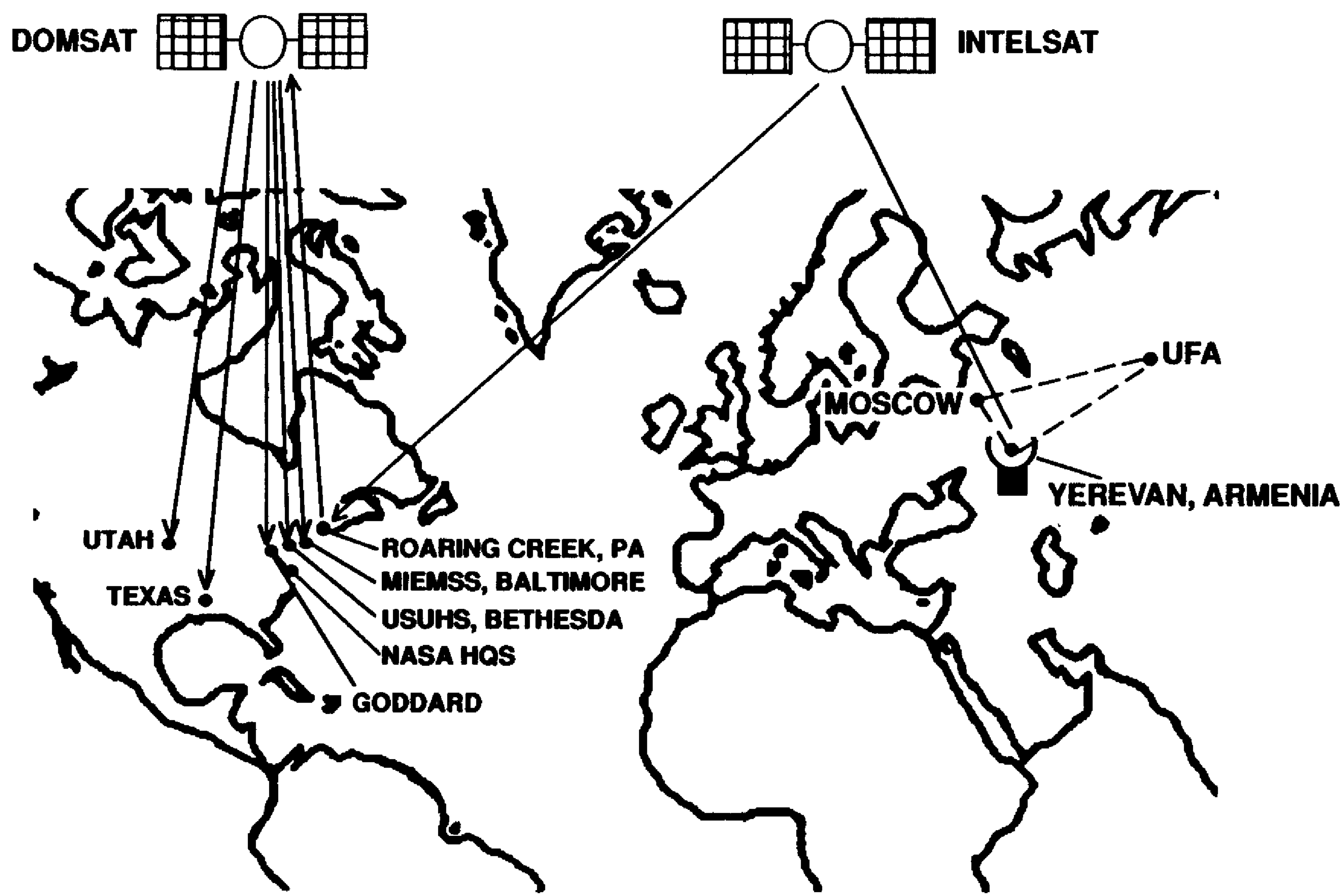
To accomplish the end-to-end service required coordination and cooperation of several different organizations. Primary organizations were: Satellite Transmission and Reception Specialists (STARS) of Houston, TX; the International Telecommunications Satellite Organization (INTELSAT); the Communications Satellite Corporation, (COMSAT); and the American Telephone & Telegraph Company (AT&T).

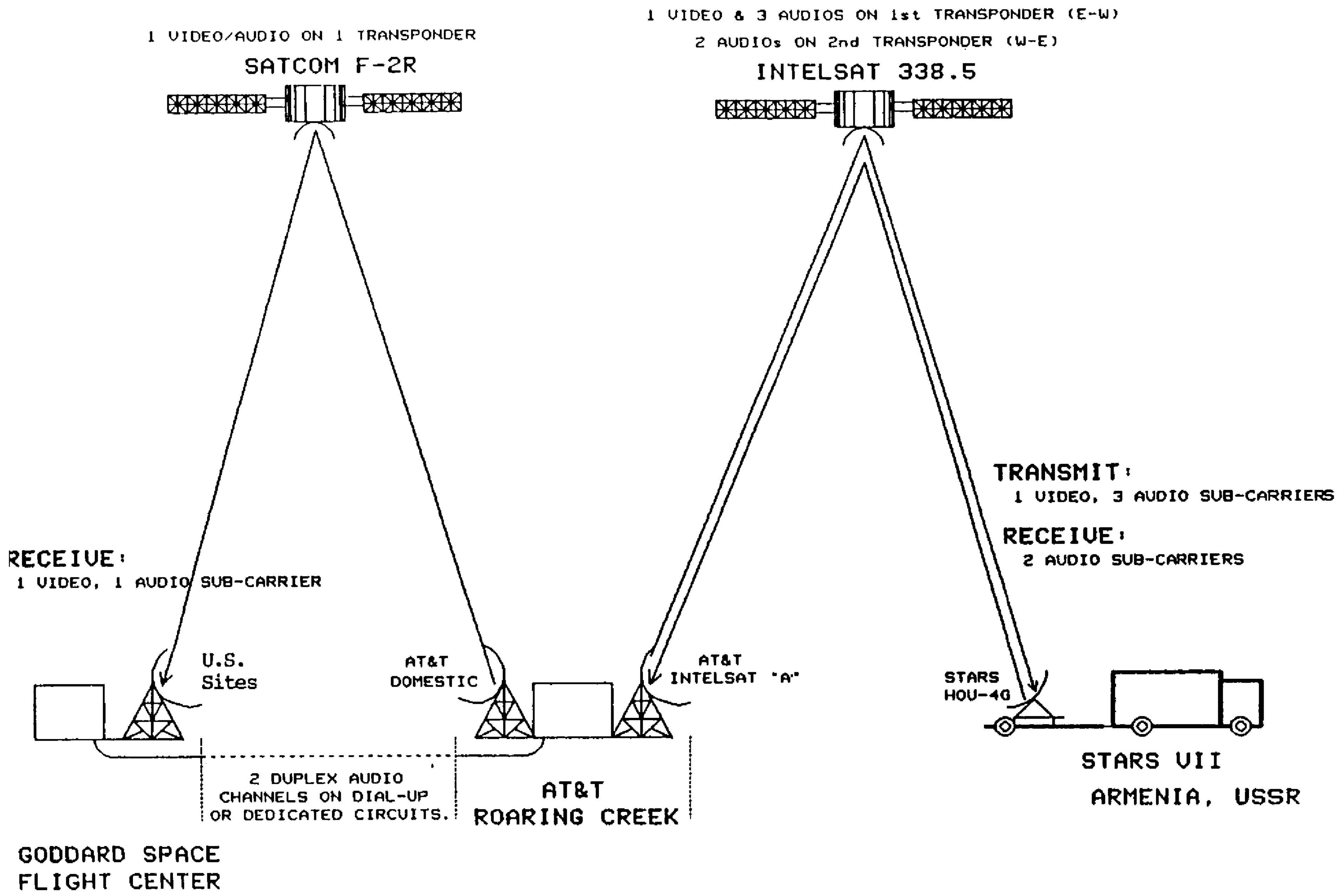
The U.S.S.R. Ministry of Post, Telegraph, and Communications and Gostel Radio Agency ensured that the frequencies utilized were available and free of interference. Furthermore, they provided free of charge down link capability and arranged communication links between Moscow and Yerevan.

STARS was the primary communications carrier involved in this service which consisted of a one way video channel from Yerevan to the U.S. and two duplex voice grade channels, one intended for the medical conference and one for communications coordination. Either voice grade channel could be used to support the Medical Spacebridge, but not simultaneously. The voice terminating equipment was equipped with a switch which would allow use either in the voice or facsimile mode. STARS

TELEMEDICINE SPACEBRIDGE

COMMUNICATIONS NETWORK





1 VIDEO/AUDIO ON 1 TRANSPONDER
SATCOM F-2R
1 VIDEO & 3 AUDIOS ON 1st TRANSPONDER (E-W)
2 AUDIOs ON 2nd TRANSPONDER (W-E)
INTELSAT 338.5
TRANSMIT:
1 VIDEO, 3 AUDIO SUB-CARRIERS
RECEIVE:
2 AUDIO SUB-CARRIERS
RECEIVE:
1 VIDEO, 1 AUDIO SUB-CARRIER
U.S. Sites
AT&T DOMESTIC
AT&T INTELSAT 'A'
STARS HOU-4G
2 DUPLEX AUDIO CHANNELS ON DIAL-UP OR DEDICATED CIRCUITS.
AT&T ROARING CREEK
STARS VII
ARMENIA, USSR
GODDARD SPACE FLIGHT CENTER

provided a transportable Earth Station and technicians in Yerevan. These technicians also assisted in the initial installation and training of hospital personnel in Yerevan in the use of the video, voice and facsimile equipment, in addition to the operations and maintenance of their facility. STARS was also the responsible party for obtaining all authorizations for the use of the INTELSAT transponders. On the international portion of this service, two transponders were used, one transponder was used for the video of and the accompanying audio channel while the other transponder was used for the two voice channels.

STARS also obtained the use of an AT&T earth station at Roaring Creek, PA to be used in conjunction with the STARS Yerevan earth station. Distribution of the Yerevan signal to the U.S. medical locations was planned to use a NASA obtained transponder on GE American Communications, Inc. domestic satellite, F2R. When the AT&T transmission from Roaring Creek to F2R caused interference to an adjacent satellite service, AT&T made available to STARS (and the Medical Spacebridge) a transponder on an AT&T COMSTAR satellite. The video signal with audio was downlinked to the U.S. medical locations. STARS was also responsible for the acquisition and installation of the receive only antenna and associated equipment at several locations. This arrangement provided near broadcast quality, (limited in quality by the camera's used) full motion video for the four hours, five days per week for approximately three months. At the request of the Soviet Union, the signal was also scrambled for the U.S. domestic broadcast, the scramblers and descramblers were provided by STARS.

From Roaring Creek, two private line voice grade services were installed to the Goddard Space Flight Center (GSFC). One service terminated there and was used as a coordination channel. The other was interconnected to a multipoint private line with terminations at all of the U.S. medical centers and NASA Headquarters. Simultaneous transmission of facsimile and voice could not be accomplished.

Along with the video equipment, cameras, monitors and VCRs, NASA provided the voice terminating equipment and the facsimile machine.

Daily coordination and monitoring of the Bridge was accomplished by the Bendix Field Engineering Corporation who has the operations and maintenance responsibilities for the Nascom Network.

The Soviet Government accepted additional communications links as a result of the Ufa gas explosion. NASA extended the Spacebridge to include black and white slow scan video and voice communications between Ufa and Yerevan for retransmission through the Spacebridge to the United States. This equipment was used because of the need to quickly establish simple to operate links using existing Soviet terrestrial voice circuits and infrastructure not capable of accommodating full motion video. It permitted adequate quality photo images of the burn victims, taken by Soviet physicians, to be transmitted every 20-40 seconds as well as audio teleconferencing.

This quick response was made possible by an intensive coordinated effort by the Soviet Ministry of Health and the Ministry of Post and Telecommunications. The slow scan video transceivers were donated by Colorado Video of Boulder, Colorado at the request of the Public Service Satellite Consortium (PSSC). PSSC provided telecommunications consultation in support of NASA and the USSR Ministry of Health.

The Soviet Union provided transportation of the STARS terminal. NASA provided equipment, and the STARS technicians to and from Yerevan as well as food and loading for the technicians while in Yerevan.

From a NASA Communications Network point of view the service quality was very good and most of the daily programming was accomplished with few impacts caused by communications problems.

Voice Communications

The major mode of communications used by the participants in the telebridge was voice communications. The high quality of the acoustics served to prevent difficulties in speech intelligibility.

Initially it was planned to use a single microphone to "cover" the entire conference room, with a second microphone available to the interpreter. However, it soon became necessary to eliminate the background microphone, since it was a source of interference when a large number of participants was present. In the second arrangement, two microphones with lower amplification were made available to teleconference participants, and a third was given to the interpreter. The microphones of the physicians, who spoke Armenian and Russian, served a purely psychological support; the physicians felt more at ease when a microphone transmitted their words, even though what they said was not comprehensible to the listeners. Of course, hearing the intonations and emotional overtones of the speaker's voice was also useful, creating a situation that was closer to normal human communication.

The second microphone, which was left on in the majority of cases, was a continuing source of interference, since the person holding it and the people in his vicinity frequently forgot that their voices, along with that of the speaker, were being picked up. For this reason, for the final version it was decided to have only two microphones in the hall, one for the participants and the second for the interpreter.

A second acoustic channel, used mainly by the conference coordinator, was also important. First, it provided a link with the Goddard Flight Control Center, which constantly monitored communications and maintained the telebridge configuration; second, it was the "back-up" channel in case of interference or malfunction of the primary television acoustic channel.

Virtually the sole problem associated with voice communications was the frequent occurrence of feedback or echo (or, in the parlance of Soviet communications specialists, "snarl"). The source of this echo was a "hot" (switched on) microphone near the speaker. The transmitted voice was picked up by the microphone and transmitted with a delay along the voice channel, amplified for each transmission-reception cycle. The phenomenon occurred with variable frequency during many conferences, at times seriously disrupting the proceedings. The "echo" was more likely to occur when there were more medical centers participating in the conference. One means for eliminating this phenomenon would have been a push-button switch for the microphones ensuring that they were only on while pressure was maintained on the button.

Video Communications

The Armenia-U.S. video channel made it possible to hold full medical teleconsultations. As the project was being planned and developed, it was thought that it might be necessary to include a special digitizing device for transmitting x-rays and other medical images along the acoustic channels in the telebridge configuration, as it was feared that the quality of the images transmitted along the video channel would not be sufficiently high. However, this fear turned out to have been unjustified: the telebridge video channel satisfied all requirements.

The video channel served three major functions in the teleconferences:

1. *Visual access to the patient.* The attending physician conducted a physical examination which was observed by the consulting specialists. Throughout the period that the telebridge was operational there was not a single instance where the quality of the transmitted image was considered unsatisfactory. The color of the patient's skin, the condition of his mucous membranes, wounds, scars, and other changes observed during the examination were clearly visible in the U.S. medical centers. The high quality of the video transmission of movement is especially worthy of note. Observation of patient limb movements and gait is often critical to the evaluation of orthopedic cases. In neurological pathologies it was necessary to demonstrate tendon and other reflexes, disruption of motor coordination, etc. In consultations on patients with psychiatric problems, much attention was devoted to body language, facial expression, and appropriateness and other properties of movement. In addition, the video channel was used to transmit video records of such dynamic diagnostic procedures as fluoroscopy, endoscopy, ultrasound, and other diagnostic and therapeutic manipulations, as demonstrated in a video transmission from the University of Utah on June 28.

2. *Video presentation of medical images, curves, diagrams, charts, etc.* The transmission of medical images constituted a significant portion of the video transmissions for the telebridge. Many of these were images on a transparent x-ray film: x-rays, angiograms, computer tomography. These images were shown on a light box so that ambient illumination did

not have to be turned off. Images on nontransparent media (paper) — sonograms, curves, photographs, etc. — were visible under conditions of normal illumination. The majority of images were depicted in shades of grey — ranging from white to black. During the trial video-communication session, "grey scale" test images typically used for the adjustment of medical monitoring apparatus were transmitted. The receiving centers confirmed that all the gradations of grey on the test pattern could be distinguished. Thus, in combination with adequate accuracy (good resolution) and the good brightness-resolving capacity when the monitors were properly adjusted made it possible for the x-rays and other medical images to be transmitted virtually without loss of information. Some participants expressed the opinion that in many cases the transmitted image was superior to the original, due to the presence of a "zoom lens" that made it possible to magnify portions of the image, and also to automate brightness regulation. Thus, in the unanimous opinion of the Armenian participants in the Armenia-U.S. telebridge, there was no need for special equipment to transmit x-rays and other medical images. This was demonstrated by the level of detail with which the images were interpreted by the consulting specialists.

3. *To show the audience.* In the intervals between showing the patients and diagnostic images, the camera was directed at the physicians participating in the conference. It would be redundant to again emphasize the psychological value of this procedure above and beyond the medical information transmitted.

When the patient could not be present in the conference hall because of the severity of his condition, danger to others, medical contraindications, or great distance, visual observation of the patient was enabled by transmission of a video tape of a previous examination in the hospital ward. During the period the telebridge was in operation, consultations on more than 15 patients were conducted in this way. Such conferences included those focusing on infections in children, and were resorted to in the majority of the conferences on spinal pathology and neurosurgery. The playing of the video tape was accompanied by commentary from the conference hall. After the tape had been played, x-rays and other medical images were shown.

Aside from showing the patient himself, this use of the video channel made it possible to display the conditions under which the patients were being treated and to create the impression that the consulting physicians were present at and participating in the examination and treatment of the patients. The preliminary preparation of the videotape offered an important advantage in that it could be done without rushing, in the less frenetic environment of the hospital ward. The major shortcomings of this technique were that it precluded direct contact (conversation) between the consulting physicians and the patient, and precluded video transmission of additional symptoms not photographed when the film was prepared.

In the Ufa component of the telebridge, the output signal of the slow-scan transceiver was transmitted along the video channel. When the system (Colorado Video, model 250) was used, each static black-and-white image required 80 seconds to be transmitted along an ordinary narrow band telephone channel between the cities of Ufa and Yerevan. However, since discussion during the conference required a great deal of time, such slow transmission of the images did not disrupt the normal course of the conference. No complaints were made about the quality of the images. The only palpable shortcoming of the slow-scan video was the absence of color and movement. Sometimes there were differences of opinion among the participants concerning the suitability of slow-scan video for telemedical consultation. Professor John Siegel (Shock and Trauma Center, Baltimore), for example, expressed the opinion that the absence of color in the images could increase the chance of physician error. For consultation on burn patients, on the other hand, the consultants in Texas and Utah pronounced the slow-scan video "completely satisfactory." Overall, slow-scan video was deemed suitable for consultations on the majority of pathological conditions, and completely adequate for transmission of x-rays and other black-and-white medical images. Moreover, when x-rays are transmitted this technique permits preliminary processing to enhance essential details, which is an advantage of slow-scan video over ordinary television for transmitting x-rays.

The majority of participants in the telebridge regretted the absence of two-way video communications. This question must be posed as follows: do the advantages of two-way video justify the required expenditure of time and resources? A 2-hour experiment with the physicians at Utah showed that the advantages of transmitting video signals from the consulting centers to Armenia include extensive opportunities for teaching, the possibility for illustrating what the consultants are saying, and the major positive psychological effect on the participating patients and physicians. Thus the answer to the question depends on the purpose and type of teleconference. In the "Armenia-U.S." telebridge, in which the conferences mainly involved teleconsultation, two-way video would be desirable, but would be unlikely to yield significantly new or major results.

Facsimile Communications

Facsimile communications, along with voice and video communications, were an enormous factor in the success of the "Armenia-U.S." telebridge. The facsimile communication line was used to transmit the following information from Armenia to the consulting centers:

- Medical data prepared according to an agreed format for the patient consultations
- Lists of participants in the conferences
- Lists of specific questions of the Armenian physicians
- Lists of literature requested by the Armenian physicians
- Corrected agendas for upcoming conferences
- Miscellaneous communications, requests, etc.

The following information was sent from the U.S. consulting centers to Armenia:

- Written consulting recommendations
- Literature on past or upcoming conferences
- Written answers to questions
- Lists of participants in the conferences

- Miscellaneous communications, etc.

Although the quality of the photographs, x-rays, etc. in the literature was considerably degraded in transmission, the overwhelming majority of the materials remained intelligible and useful. More than 1000 pages of medical information were transmitted while the telebridge was functioning.

Unfortunately, for technical reasons, facsimiles could not be transmitted during the conferences, so special communication sessions were devoted to facsimile transmission. During these sessions, all the technical personnel and communications apparatus were devoted to the facsimiles. Aside from saving time and resources, simultaneous facsimile transmission could have facilitated more efficient exchange of information during the conference.

In addition, since most of the information originating from Armenia was transmitted to more than one participant, the capability for transmission to two or more recipients would have been desirable. Another relative disadvantage of facsimile communication was the uneven rate of transmission. In most cases, transmission from Armenia to the U.S. proceeded at a rate of 9600 baud, while transmission in the other direction was almost always twice as slow, at 4800 baud. Nevertheless, both the quality and the content of the facsimile material received satisfied the majority of telebridge participants.

It is difficult to draw conclusions of the relative importance of one or another mode of communication in the functioning of the telebridge. To illustrate the utilization of all three modes of communication for consultations on a specific patient, we may cite one of the most interesting consultations, both from a medical and an technical point of view. This consultation involved a 9-year-old girl with cerebral paralysis and subluxation of both coxofemoral joints. Because of the unavailability of the appropriate consultant, the entire video presentation of the patient was recorded on video tape with detailed commentary. Detailed medical data were sent via the facsimile channel. A video cassette was then sent to a specialist in this specific area, who after studying all the data used a new technology of computer analysis of x-rays to plan orthopedic intervention. Along with the minutes of the consultation and the sources in the literature, a blueprint for the operation printed by the computer program for planning orthopedic operations was sent on the facsimile channel. In this example, all three forms of communication were necessary to maximize the value of the consultation.