

Medical Care Delivery in the U.S. Space Program

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The stated goal of this meeting is to examine the use of telemedicine in disaster management, public health, and remote health care. NASA, for obvious reasons, has a vested interest in providing health care to crews in remote environments. NASA has unique requirements for telemedicine support, in that our flight crews conduct their job in the most remote of all work environments. Compounding the degree of remoteness are other environmental concerns, including confinement, lack of atmosphere, spaceflight physiological deconditioning, and radiation exposure, to name a few.

In-flight medical care is a key component in the overall medical support for missions, which also includes extensive medical screening during selection, preventive medical programs for the astronauts, and in-flight medical monitoring and consultation. This latter element constitutes the telemedicine aspect of crew health care. Due to the extreme resource constraints present in spacecraft (defined here as crew time, weight, volume, and power), all medical support systems must be rigorously justified and directly related to the perceived risk of a given mission.

The level of in-flight resources dedicated to medical care is determined by the perceived risk of a given mission, which in turn is related to mission duration, planned crew activities, and length of time required for return to definitive medical care facilities. In the Mercury Program, although the perceived risk of medical problems was very high, the medical kit was very small and rudimentary, containing only four medications. This was in keeping with the extreme volume constraints, and the ability to effect a rapid return to Earth. In-flight medical care capability was subsequently expanded during the Gemini and Apollo Programs in response to longer mission duration and the prospect of conducting operations away from the relative safety of low Earth orbit. For the Apollo Program, medical kits were included in both the command module and the lunar module. While there were no major medical problems during the approximately 7500 hours of flight time that accumulated during Apollo, the initial cases of space motion sickness (SMS) were observed, potentially serious cardiac arrhythmias were observed during Apollo 15, and near-catastrophe was averted during the Apollo 13 mission, when flight control teams managed to nurse the crippled spacecraft back to Earth. This latter mission highlighted the fact that life support system failures or compromise can threaten crew health. The spectrum of medical illness or injury that might result from life support degradation or failure should therefore be considered in the

design of in-flight medical care systems. It follows logically that real-time analysis of atmospheric contaminants in a spacecraft will be necessary to diagnose the potential medical consequences.

Since 1981, there have been four Space Shuttle missions lasting from 8-10 days, each mission carrying 4-7 crewmembers. Although some astronauts have had minor illness in flight, there have been no major medical incidents. Perhaps the most vexing problem that we have had to cope with is space motion sickness, which causes nausea and vomiting, usually during the first 72 hours of flight, after which there is complete remission.

In spite of our good record in space, we have an active medical program to ensure care should it become necessary in flight. The major facets of the program include the Health Stabilization Program (HSP), crew medical training, the Shuttle Orbiter Medical System Kit (SOMS), Contaminant Cleanup Kit (CCK), the Bends Treatment Apparatus (BTA), and routine private medical conferences on a daily basis.

The medical conferences occur on a routine, scheduled basis, allowing the crew surgeon to communicate with the crew medical officer (CMO). Should an urgent medical concern arise, the CMO can request a medical conference at any time. The flight surgeon in turn has a host of medical specialists available if needed for specialty consultation. In-flight health care delivery capability is limited by the contents of the medical kit and the skills of the CMO. Since approximately 10 percent of the U.S. astronauts are physicians, medical care capability, in terms of the CMO, can vary substantially.

The HSP requires that all astronauts, beginning 1 week prior to flight, have limited contact with other individuals in order to reduce the risk of exposure to any communicable disease. The HSP was first initiated during Apollo and has been credited with significantly reducing pre-flight and in-flight illness. In addition, two members of the crew (who may or may not be physicians) are designated CMOs. They receive extensive pre-flight training in basic medical diagnostics and therapeutics, including suturing and IV techniques, medical procedures, and CPR. The other crewmembers also receive some training in medical procedures as well as CPR in order to back up the CMOs.

The medical instruments, supplies, and medications are carried in the SOMS Kit and CCK. These kits weigh approximately 20 pounds and easily fit into one Shuttle middeck locker. They contain basic medications including topicals, injectables, and an IV fluid administration set. There are also bandages and dressings as well as patient restraints, rescuer restraints, and a resuscitator. The CCK contains gloves, goggles, and masks to be used in the event of toxic spills.

Because EVA is sometimes necessary during Shuttle missions, an Operational Bioinstrumentation System (OBS) is provided so that physicians on the ground can monitor the ECG, heart rate, respiration, and temperature of the EVA crewmember. In the event of bends, a

BTA can be attached to the pressure suit, allowing an increase of pressure of 8 psi. Fortunately, there have been no bends incidents reported in flight during the U.S. Space Program.

In summary, the paucity of significant medical incidents on Shuttle flights has placed few demands on the SOMS/CCK system. However, should there be a need, we believe trained CMOs, utilizing the SOMS kit and CCK, could provide reasonable comprehensive medical care allowing temporization of any major medical problems until the Shuttle could deorbit and land.

NASA's involvement in telemedicine began as an outgrowth of the need for biomedical monitoring of flight crews. From this beginning in the 1960s, several terrestrial applications evolved as testbeds for NASA technology. The first of these applications involved use of a NASA ATS-1 satellite to provide medical consultation to remote Alaskan villages. Between 1973 and 1977, a telemedicine demonstration program known as STARPAHC (Space Technology Applied to Rural Papago Advanced Health Care) was conducted on the Papago Indian Reservation in Arizona. This activity, sponsored by NASA and the Indian Health Service, was the most comprehensive application of space technology to remote health care delivery of that era. This system was designed to improve the quality of health care to remote areas by utilizing a mobile health clinic with advanced health care equipment. The Mobile Health Unit (MHU) was staffed with a physician's assistant and a laboratory technician. The physician's assistant would administer health care to patients under the direct supervision of physicians, who were located at the Health Services Support Control Center (HSSCC) in the city of Sells. If specialty consultation was required, a dedicated console at the Indian Health Hospital in Phoenix allowed access to specialist physicians.

The level of clinical care allowed by mobile health units was comparable to that of a fixed clinic. Access to computerized medical records by means of telemetry allowed the physician's assistant access to pertinent clinical information as needed. Clinical chemistry, urine analysis, and X-rays could be accomplished and transmitted to the monitoring physician. In addition to two-way audio, color TV cameras transmitted live images to the physician consoles, allowing the physician to remotely control the TV cameras. If necessary, visualization of a body orifice, such as the throat, could be accomplished by means of a patient viewing microscope. Transmission of X-ray films was done by means of slow-scan video.