Engineering Notes

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An Integrated Medical System for Long-Duration Space Missions

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Introduction

DURING preparation for NASA's first manned space flight many questions were raised about human responses to the unfamiliar environment of space. Such disabling responses as nausea, dizziness, and even hallucinations were considered possible; predictions concerning other responses such as fluid retention and fluid loss were contradictory.[1] Consequently, bioinstrumentation systems were developed to monitor physiological status and to provide for physiological experiments in flight. By use of these biomedical systems during Project Mercury, the Gemini Program, and the Apollo Program, many questions have been answered.

The Skylab Program should provide the medical scientist with the data necessary to assess the effect of the space flight environment on several of man's physiological systems for periods of up to 56 days. In the Skylab workshop, a limited inflight diagnostic and treatment capability will be provided for routine and emergency medical care. The medical equipment on these flights will measure physiological parameters that previously have been measured only in ground-based laboratories; e.g., cardiovascular response to exposure to lower body negative pressure (LBNP); respiratory, cardiovascular, and metabolic response to a programed workload on the bicycle ergometer; and vestibular response to rotation and attitude changes in a rotating litter chair.

To answer all significant physiological questions about extended-duration space missions, comprehensive capabilities for medical research and clinical medicine are required. Onboard laboratory facilities will be required to measure lung volume, lung diffusion capacity, urine and blood ion content, red blood cell fragility, and sensory perception.

NASA is developing the Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) for onboard medical support of the crew and for medical research. The medical support system will permit diagnosis and treatment of injuries and illnesses. The medical research system will allow life scientists to conduct a comprehensive series of physiological and clinical measurements in flight. By the use of a flexible design approach, the IMBLMS will be suitable for use in early extended space flights.

Developmental Approach

NASA has conducted a series of baseline studies. The first study indicated that NASA should develop a single biomedical support system to integrate medical and data management facilities. This comprehensive system should replace the individual items of biomedical equipment used on previous missions, and it should be an onboard biomedical laboratory. The second study further defined medical measurement system requirements, equipment requirements, and candidate techniques for zero g.

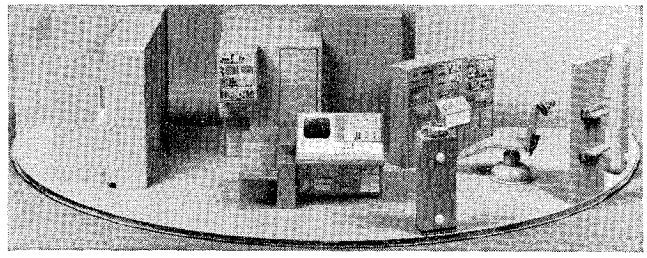

Fig. 1 One flight design concept for the IMBLMS on board a space station.

NASA has elected to design, build, and test functional breadboards (FBB's) to demonstrate flight applicable techniques and gain information needed to develop requirements for flight hardware and software. In addition, FBB'S were essential to validate many measurement techniques identified in the initial studies and to verify further the concept of performing multiple measurements with an integrated system. Two FBB's were built, and the information collected during the testing of the FBB's was applied to the preliminary flight design (Fig. 1).

The FBB systems were installed at the NASA Manned Spacecraft Center (MSC) in Feb. 1970. Both have undergone extensive MSC testing and analysis to assess their adequacy for performing required measurements. In both breadboard designs, data from the subject were conditioned and routed to the data management system for computations and display. Breadboard 1 (Fig. 2) included the capability for automatic control and sequencing of such equipment as the LBNP device; the data mangement system also formatted all FBB data in the Apollo Program format, as if obtained on board the spacecraft. Figure 3 shows (left to right) a vision tester, a behavioral task panel, a laboratory analysis section, and a control and display section. Experimental data are presented to the operator on an alphanumeric screen, and parameters are updated at periodic, pre-selected intervals. Breadboard 2 (Figs. 2 and 4)‡ included a fairly complete laboratory capability with a television microscope.

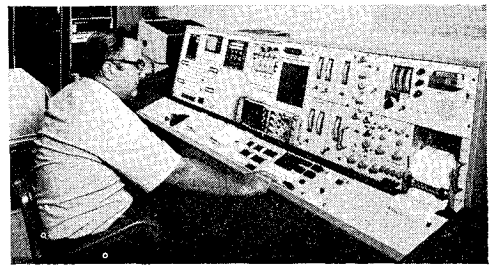

Fig. 2 The IMBLMS breadboard 1.

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‡ Figure 2 shows (left to right) a behavioral task panel, a television microscope and diplay, a control and display area, respiratory flowmeter integrator, and a two-channel strip chart recorder.

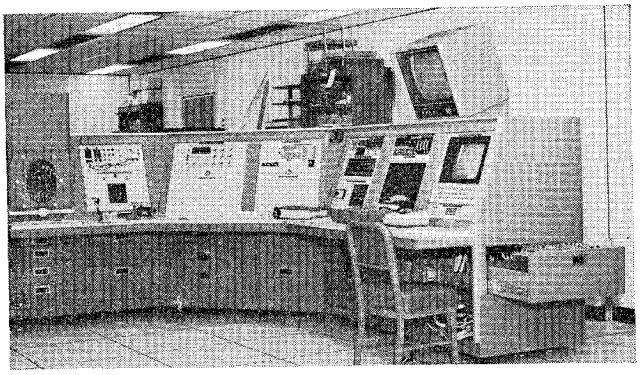

Fig. 3 Breadboard 2 physiological, behavioral, and data management station.

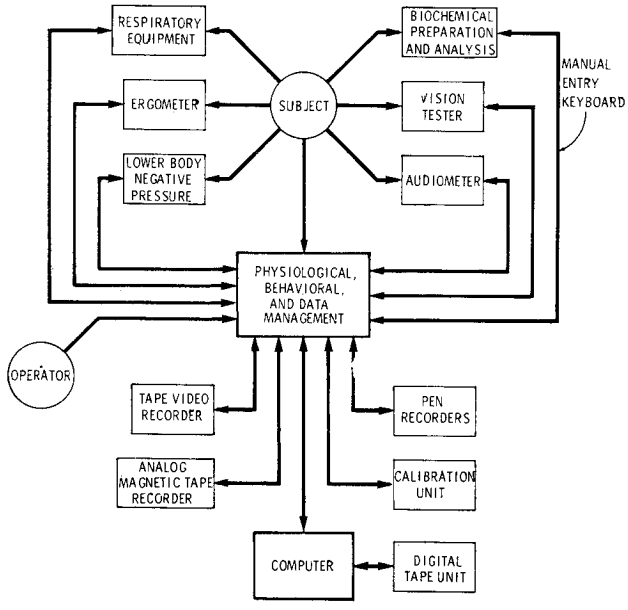

Fig. 4 The IMBLMS breadboard 2 block diagram.

Potential Applications

Although the primary purpose of the IMBLMS development is a flight system, the program may have other potential applications, such as to provide for some relief of the remote health services problems that exist in the United States today. Although the application of this technology obviously could not cure all the problems, it could be adapted for use on Earth as a health services access system with the following features: 1) the use of an integrated medical, communications, and data management facility manned by physicians' assistants to provide points of entry into the health care establishment for people in medically deprived areas; 2) the provision for outpatient services on a local level, coupled with the use of communications technology to provide the consultation support and supervision of the physicians' assistant; 3) the use of appropriate combinations of fixed and mobile facilities to meet the varying needs dictated by different sites; and 4) the use of information processing to relieve personnel of burdensome recordkeeping and administrative functions and to enhance the availability of statistics for more effective planning, features which permit efficient use of the physicians' time and are essential for support and supervision of the physicians' assistants.

Conceptually, a national network of health services units could be developed, although initially a demonstration program would be a cost-effective method to establish the feasibility of the basic approach.[2] The exact configuration of the demonstration program units would depend on the site or sites selected, but the system may be described basically as follows. Remotely located field units would be supported by a control center located adjacent to a large hospital emergency facility. The control center would be in constant communication (voice, data, television) with the remotely located elements of the system. The local center, which would be a fixed facility typically located in a town without a medical clinic or hospital, would offer outpatient and emergency health services, and would serve as a relay point for communications with other more remotely located facilities. The mobile facility, which would be a scaled-down version of the local center, would be capable of offering health services to fewer people and would have the advantage of being transportable over major roads, on a scheduled basis, to cover a wider area. Ambulances and hand-carried equipment would further extend the system so that isolated areas would be offered some regular health services coverage.

Conclusions

The IMBLMS is being developed as a medical system that integrates medical and data management facilities for space application. The modular design of the system will provide the technological tools for onboard medical support to perform projected medical experiments and to permit changes in measurement capability both during and between missions. Thus, the IMBLMS will not only be suitable for use during early extended space flights but also will be able to accommodate measurement and diagnostic apparatus as well as treatment and surgical facilities developed for later missions. Major elements of the IMBLMS also could be adapted for use on earth as a health services unit.

References

[1] Berry, C. A., et al., "Man's Response to Long-Duration Flight in the Gemini Spacecraft," *Gemini Midprogram Conference Including Experiment Results*, NASA SP-121, pp. 235–261.

[2] Johnston, R. S., et al., "A Concept for an Expanded Health Services System," Seventh Autumn Meeting of the National Academy of Engineering, Washington, D.C., Nov. 1–2, 1971.

Electrophilic Property of Uranium Hexafluoride

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Introduction

In recent years a sizable effort has been in progress to develop reactors employing nuclear fission fuels in the gaseous state. This effort has been motivated by the much higher temperatures (12,000—50,000°K) permissible in this new type of reactor, known as the gas core or cavity reactor, than in the present reactors employing solid fuel elements. There are two major applications for which the gas core reactor promises

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