# USE OF INFRARED TELEMETRY AS PART OF A NONINTRUSIVE INFLIGHT DATA COLLECTION SYSTEM TO COLLECT HUMAN FACTORS DATA

N94-24193

Angelo Micocci
Lockheed Engineering and Sciences Company

*Research directed by Francis Mount, Flight Crew Support Division, NASA JSC.*

## INTRODUCTION

The objective of this paper is to present a methodology and rationale for development of a Nonintrusive Inflight Data Collection System (NIDCS) to collect Human Factors (HF) data during a space mission. These data will enable the research team to identify and resolve issues.

This paper will present the background and history of the NIDCS, the methodology and techniques employed versus those in current use on Earth, initial results of the effort, including a brief description of the equipment, and, finally, a discussion of the scientific importance and possible future applications of this system elsewhere.

The schema for the NIDCS includes a collection of three types of data, behavioral, physiological, and biomechanical. These will be collected using videotape of crewmembers' activities, bioelectric signal measurement, and measurement of kinematics and kinetics, respectively. This paper will focus on the second type of data, physiological activity as determined by changes in bioelectric potentials as crewmembers perform daily assignments.

## BACKGROUND AND HISTORY

Before proceeding, it is necessary to define nonintrusive data collection. The strictest definition of such a system is one in which the subject is unaware of the recording apparatus, i.e., has no knowledge of the fact that data are being collected, etc. Given training procedures, awareness of video cameras, audio report/debriefing taping on Earth, etc., the crew will be aware that data are being recorded. Therefore, the alternative solution to data collection is to employ a system that will not (or only minimally) disrupt routine, ongoing activities (Callaway, 1975). In any case, nonintrusive data collection should not be confused with "noninvasive" data collection, a method frequently used in collection of biomedical data. While nonintrusive methods are noninvasive, the reverse is not true. This distinction excludes collection of blood or other activities where catheterization or collection of other data which alter crew activities, etc., is necessary. We can now proceed to the history of the development of an NIDCS.

A review of the literature from other projects using nonintrusive data collection methods provides a basis for understanding the reasons for the application of such methods, how other methods were employed, the degree of their success, and what was learned from them. The literature search focused on situations likely to be encountered during space flight.

Literature was reviewed from the SEALAB (Radloff, 1966), TEKTITE (Nowliss, 1972), and SKYLAB (LaFevers, NASA JSC) missions. The schedule for development of an NIDCS precluded review of data from submarines, due in part to time limitations and because most submarine data have been collected and evaluated for other purposes (contamination monitoring/control, etc.) and are not structured for application to HF issues. Because data collected on the referenced missions focused on behavioral rather than physiological data, the detailed findings on these projects will not be discussed here. Researchers found that the most expeditious way to collect (behavioral) data was through simple, passive observation of video and through the use of questionnaires and post-mission debriefings. It is reasonable to expect that passive recording of data to yield results can be applied to physiological and biomechanical data as well.

## *METHODOLOGY AND TECHNIQUES*

As mentioned in the introduction, there are three types of data to be collected using the NIDCS during space missions.

First, there are the behavioral data wherein the primary method used for collection is videotapes. Except for those instances where arrangements were prescheduled, researchers were able to see only portions of activities which might be of interest to their disciplines. Camera angles were based on factors other than those which the researcher might select, duration of taping was not optimum, detailed verbal explanations were not forthcoming, etc. The best to be hoped for was that the crew member(s) could provide sufficient details during debriefings, either in flight or postflight. While satisfactory, it is not optimum for determination and resolution of issues.

One of the objectives of this project is to provide input and direction for the program during the early planning stages to ensure that Human Factors-oriented tasks are part of the mission; to attend training and planning sessions involving crewmembers to ensure that training includes performance of these tasks when required; and to specify video camera locations, angles, etc., to ensure that adequate coverage exists for evaluation. Videotapes will be supplemented by the information obtained during debriefings, through the use of questionnaires, etc.

Secondly, there are the biomechanical data which will provide information concerning kinetics and kinematics during performance of space-oriented tasks. Current planning is that these data will be collected in conjunction with another experiment dealing with human force capacity in space. It is anticipated that some of these data will be collected using video cameras, while most will be obtained with the use of sensors and instruments such as transducers, force plates, accelerometers, strain gauges, etc.

Finally, there are the physiological data. Much of modern research has focused on clinical applications, diagnostic purposes to develop prosthetic devices, etc. Various studies have been performed to measure muscle fatigue, per se. Only recently (in the past 25-30 years) has research been done toward interpretation of these data as indicators of human performance (sports medicine, etc.) and/or operator alertness.

Some work has been done in manufacturing facilities, some in academic laboratories (Evoked Potentials Response-ERP) and some by HF engineers involved with the Space Program. These studies have been conducted to measure operator stress and alertness during the performance of assigned tasks. With regard to space, studies have focused on measuring electromyograms (EMGs) collected from subjects operating under both shirtsleeve and pressure suited conditions while performing simulated space vehicle control tasks. Some studies have been performed using electrocardiograms (ECGs) or electro-oculograms (EOGs) as measures of stress and performance, etc.

This research has been performed in settings where the subject is connected to the recording device(s) through a system of cables or "hard wires." In a simulated space vehicle control environment, the subject might exert forces against some controller device, track a target, etc. This approach is suitable and works well for Earthbound experiments; however, it presents problems during a space mission. On Earth, gravity acts on the interconnecting cables and keeps them in a cohesive bundle. This minimizes interference with task performance. In most Earth testing situations, cables dangling from the subject present no problems. Such is not the case during space flight. Feedback from videotapes, postflight debriefings, and other sources indicate that the interconnecting cables tend to float and interfere with task performance. This is true of audio system cables as well as cables interconnecting experiments, crewmembers,

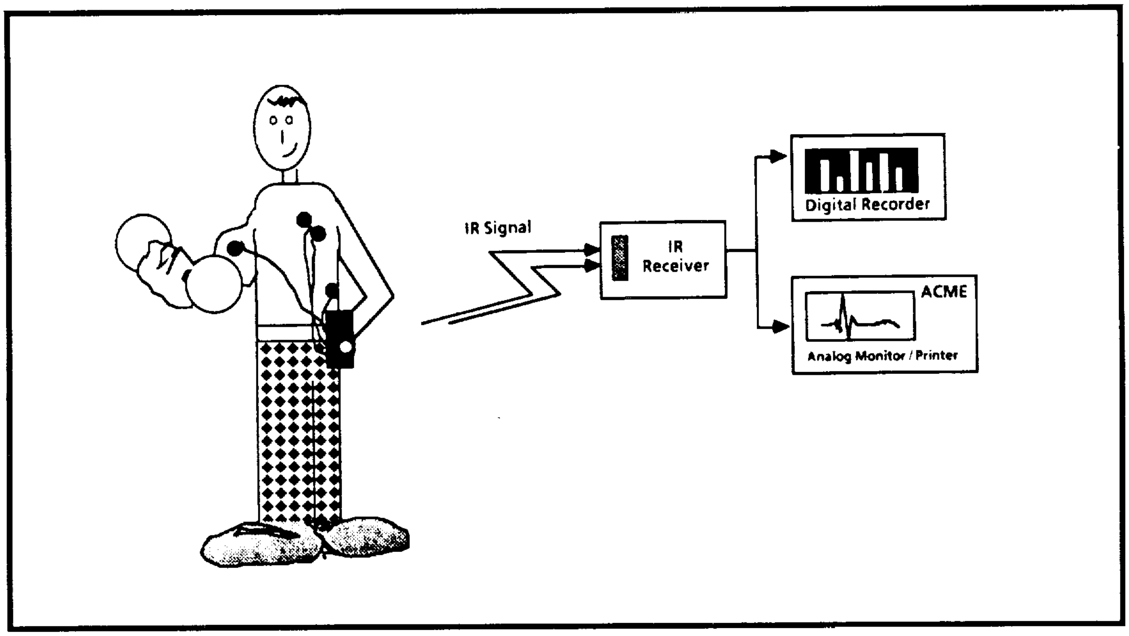


**Figure 1.** Paradigm of Telemetry System

etc. Much time is spent sweeping these cables out of the way. Shortening of cables provides an unsatisfactory solution, since this restricts crewmembers' mobility and range. These types of problems, concomitant with the HF experimenter's desire to collect data under normal conditions, make the use of hardwiring undesirable for data collection during space missions. With these considerations in mind, the NIDCS was devised.

### *EQUIPMENT*

Meetings were held to discuss the viability and feasibility for developing a "noninterference" (telemetry) system for transmission of physiological signals. Infrared was selected as the signal carrier because the RF channels are assigned for flight data or other critical inflight parameters. There are few channels available for other uses. Also, IR tends to reflect off certain surfaces and increases the probability of detection.

A system was developed by modifying existing equipment. This modified system contained both a transmitter and a receiver unit with an "end-to-end" response of 6 kHz. It was felt that this bandwidth would allow the systems to handle 3 channels of physiological data. This portion of the NIDCS is referred to as the IPDL (Infrared Physiological Data Link).

Further modifications were performed on the unit to increase wearing comfort, to adapt the unit to physiological data handling, etc. A "breadboard" model was developed and tested. Testing was accomplished through the use of commercially available electrodes attached to a subject and to specifically developed signal conditioners through a (body-worn) cable which then attached to the IPDL transmitter (Figure 1). The subject then walked, flexed muscles, and simulated task performance. Data were recorded on a 4-channel strip chart recorder where one channel was used as the event marker. None of the data collected during testing were analyzed since they had not been collected using strict scientific standards or practices. They were used only to indicate the presence of bioelectric potentials. System reliability was determined through recording signals on the strip chart, both through the IPDL system and hardwiring the subject to the recorder. Wave forms were then compared for distortion or any other changes which might have occurred and could be attributed to the IPDL.

The system operated satisfactorily except for interference (crosstalk) between the center channel and both end channels. As a result, plans were revised from development of a channel unit to a 2-channel system. Using the same approach as described above, a 2-channel prototype unit was developed, tested, and found to be satisfactory.

Experiments were designed, and a pilot study was run. Data were collected through the use of an instrument-quality tape recorder. Signals were then played into a personal computer for data storage and waveform and statistical analyses. The results of that study are being presented separately (by F. E. Mount, NASA JSC, under whose auspices this project was funded and directed) and will not be reported herein.

## *FUTURE APPLICATIONS*

The importance of this effort is that a means has been developed which allows data collection while reducing, if not eliminating, certain types of experimental bias, such as the guinea pig effect, role selection, response sets, and measurement as an independent variable. Further, experimental error created by the investigator (subject induced bias due to sex, race, etc.) can be eliminated, data collection can occur under everyday settings rather than a laboratory (which may affect some data), errors due to changes in procedures or instructions are eliminated, etc. Finally, data can be collected that might not be collected in any other way.

Future applications for this approach are seen in the fields of medicine where restriction of a patient's movement is undesirable and in other similar situations. This technique could be utilized to make patients with certain disorders more independent by allowing them to be away from a laboratory or medical environment while still allowing for monitoring of homeostatic functions on a continuous basis.

Other research areas which need to be addressed are development of better, more natural and more comfortable electrodes, digitizing signals at the transmitting unit to compress data for storage, etc. This is only a short, and by no means exhaustive, list of areas for future research.

## *REFERENCES*

Due to space limitations, the following is an abbreviated list of references.

1. Basmajian, J. V. *Muscles Alive* (Williams and Wilkins Co., 1974).

2. Callaway, E. *Brain Electrical Potentials and Individual Psychological Differences*. (Grune and Stratton, 1975).

3. Gale, A. *Some EEG Correlates of Sustained Attention.* Vigilance (Plenum Press, 1977).

4. Gould, J. D. Eye Movements During Visual Search. IBM Research Report RC 2680 (Yorktown Heights, NY, 1969).

5. Kubis, J. F., et al. Time and Work on Skylab Missions 2, 3 and 4. Biomedical Results From Skylab. NASA SP-377 (1977).

6. LaFevers, E. A., and Hursta, W. Final Report: Lower Spectral Density Analysis of the SkyLab 3 Data. NASA Report (JSC).

7. LeVeau, B. *Biomechanics of Human Motion* (W. B. Saunders, 1977).

8. McKay, R. S. *Biomedical Telemetry* (John Wiley, 1965).

9. NASA Workshop on Advances in NASA-Relevant, Minimally Invasive Instrumentation. (Pacific Grove, CA, April 1984).

10. Nowliss, D. P., Wortz, E.C., and Waters, H. TEKTITE II, Habitability Research Program. Airsearch Mfg. Co. Report. 7-6192-1 (January 1972).

11. Radloff, R., and Helmrich, R. *Groups Under Stress: Psychological Research in SEALAB II* (Appleton-Century-Crofts, 1968).

12. Weaver, C. S. Wearable Blood Pressure and ECG Recording System. Stanford Research Institute Interim Report (February 1976).