IMPACT OF BIOINSTRUMENTATION RESEARCH AT AMES RESEARCH CENTER

The scale, precision, and interpretability of experimental research results are strongly limited unless continuing efforts are made to improve the accuracy of instrumentation, eliminate unwanted sensitivity to environmental factors, and minimize the effect of the instrument on the experiment. A research organization which is attacking new and unique problems must remove the old obstacles limiting research by continual improvement of its measurement technology. The extent to which that measurement technology develops is in a very real way a measure of the viability of the research programs. The extent to which that technology is used by other ogranizations is a measure of the relatedness of the research programs to the problems of the outside world.

To provide the new technology in the measurement sciences required to support its research programs in astronautics, aeronautics, and the life sciences, Ames Research Center has continuously maintained a centralized instrument development effort. Approximately 50 members of Ames' staff have been concerned with research programs directed toward development of new measurement technology. Together with a supporting staff (approximately 150 people), this group occupies office and laboratory facilities representing an investment of approximately $4.5 million. The group is interdisciplinary -- with expertise in chemistry, physics, optics, mechanics, electronics, radio propagations, and communication -- and has made extensive contributions to the state-of-the-art in instrumentation. A qualitative evaluation of Ames' success in meeting NASA's instrumentation needs can be obtained from a May 26, 1970 memorandum from the Chief of the NASA Headquarters group concerned with Instrumentation and Data Processing to the Chief of the Electronic Techniques and Components group. The enclosure to the memorandum listed new technology (developed by seven NASA Centers) that had been applied to NASA problems and listed separately new technology available for application. In the first category, six of the seven items listed were from Ames' Instrumentation Division. In the second category, six of the nine items listed were from Ames' Instrumentation Division. This disproportionate contribution from Ames to NASA technology suggests that the objectives of Ames' programs were both carefully selected and frequently met.

These contributions to new technology have been made available to NASA as a direct result of the need to overcome measurement problems impeding research at Ames. By the same process, new technology became available which offered the solution of problems in other government agencies, in universities, in industry (see attached table), and in medical research laboratories. The following examples are typical of the applications of Ames' instrumentation technology to biomedical problems.

A small device for precisely measuring angles of wind tunnel models at Ames was used to solve unique measurement problems:

- related to providing more precise control of pen position in recorders made by Hewlett Packard and used to record data in the scientific laboratory and to monitor the health of patients in the medical clinic.

Miniature telemetry devices developed for biomedical research at Ames have been used:

- to detect impairment of breathing in tracheostomized children at the Children's Hospital of the East Bay in Oakland, California, at Rancho Los Amigos Hospital in Downey, California, and at other hospitals in California and Oregon.
- to screen schizophrenic patients at entry to California's Agnews State Hospital and determine the most effective method of treatment.

Unique force and acceleration transducers developed to meet Ames research needs have been used:

- in research by Dr. Ursala Abbott of the University of California at Davis to improve poultry yield.
- in research programs by Dr. Kohen-Raz of Israel and Stanford Medical School which show promise of allowing screening of pre-school children to identify those who require special preparation to improve their learning potential.
- in research programs by Dr. Robert Taylor and others of the University of California Dental School directed toward developing techniques for characterizing and correcting improper "bite dynamics" leading to diseases of the bones and joints of the jaw.

Optical technology developed in support of Ames research requirements

- has allowed Dr. Donald Harrison of the Stanford University Medical School to measure the beating

of cells taken from the heart muscle and placed in a chemical solution, and to measure the effects of different chemical solutions on the health of those heart cells.

- has allowed Dr. Sydney Leverett of the Air Force School of Aviation Medicine, San Antonio, Texas, and Drs. Paul Bailey and Kenneth C. Swan of the University of Oregon's Medical School to conduct important research on vascular diseases.
- provides a technology background currently being drawn on by the National Air Pollution Control Agency, by General Motors, and Ford Motor Company as a possible solution to the problem of measuring carbon monoxide in the atmosphere and in the exhaust of automobiles, in closed environments -- and will potentially lead to real time monitoring of CO as a monitor of pulmonary diffusion and a detector of hemolytic incidents; and as a combinational gas analyzer for use in "anesthesology".

Pressure transducers developed to meet the unique requirements of aeronautical and biomedical research at Ames

- have been used to explore diseased hearts by Dr. Donald Harrison at Stanford Medical School.
- are being evaluated by the National Institute of Health for general clinical use involving heart catherterization.
- have allowed Prof. E. B. Christiansen of the University of Utah to do new and fundamental research on the properties of elastic liquids.

Electronic network and component technology developed in support of Ames Research needs

- have been described by Prof. Robert W. Newcomb of the University of Maryland (a leading expert in the field) as significantly reducing the "sensitivity barrier" which prevented reduction of modern network developments to integrated circuit form -- and prevented realizing the reduced cost, and higher reliability characteristic of the integrated electronics. These network techniques are currently being used by Burr Brown of Arizona, by Western Microwave, Kinetics Technology of California, and by Western Electric to provide improved filters.
- have produced new transistor designs which show promise of providing more complex electronic devices at lower cost.

- have provided special conductive elastomeric connectors to be evaluated by doctors at the Texas Rehabilitation Institute as substitutes for metal electrodes currently being used to provide controlled electrical nerve stimulation for alleviating the common "drop-foot phenomena" experienced by post-stroke patients. The metal electrodes, placed opposite the knee frequently abrade the leg or change position due to the rigid structure.

Most of these examples of the application of Ames Research Center's measurement technology to problems of medical importance are taken from the recent past or the present. They have been possible because of a solid technological base which is the result of continuous development of group expertise in the measurement sciences since the second world war. That expertise is only partly responsible, however. The numerous applications of Ames technology to problems of the "outside world" are also the result of a continued sensitivity of the Ames staff to the importance of selecting research activities relevant to social needs, and encouraging the application of the results of those activities to important non-NASA problems. Their concern for society's problems is evidenced by the fact that members of the Ames Instrumentation Division

- have been asked to serve on a National Academy of Engineering group to help develop a statement of problems and technological potential for delivery of improved Delivery of Health Care to the citizen.
- have been asked to arrange a program for an interdisciplinary scientific conference (July '71) to be attended by approximately one hundred of the nation's leading instrumentation experts. The program is to challenge those experts to provide solutions to measurement problems of importance to pollution monitoring, traffic control, battlefield operations, crime detection and control, and health analysis and monitoring.
- have initiated and arranged a first symposium (November '70) between NIH and NASA to extend the interchange of technology between the two agencies.
- have initiated and are planning a national technical meeting on the problems related to detection of pollutants in the air, water, and earth (tentatively set for November 1971 in San Francisco) to be co-sponsored by NASA and one or two other government agencies concerned with environmental

problems and by three technical societies -- the American Institute of Aeronautics and Astronautics, the Instrument Society of America, and the American Chemical Society.

There are many factors, then which suggest significant technical achievement and concern for social problems -- and many specific examples which suggest that technology developed by Ames and for Ames'research programs has been usefully applied to problems of society. Clearly, the impact on society of developing methods to identify pre-school children who need special preparation to allow achievement in the classroom -- that impact is difficult to measure. It is difficult, too, to evaluate the impact of new techniques for identifying appropriate methods of treatment of schizophrenic patients, or of providing parents of long-term tracheostomized infants with a means of returning their youngster to their home without risking its suffocation -- and without imposing the staggering financial burden incurred as a result of the need for continual, vigilant surveillance to prevent suffocation.

The impact of such applications is difficult to measure. Some qualitative assessment can be derived, however, from the fact that material based on applications of Ames technology has been published in the Government Executive of July 1969; has been read into the Congressional Record of March 19, 1969 (page 3, Attachment A) by Congressman Louis Frey, Jr. of Florida, and by Congressman Ken Hechler of West Virginia (August 5, 1969, page 4, Attachment B); were mentioned three times in the body of House Report No. 91-1446, September 14, 1970 (pages 10, 12, and 13) and were mentioned again in statements by Representatives Louis Frey, Jr. and Bertram L. Podell of New York in Appendix B (pages 31 and 46, 47 respectively) of that report; and was the subject of a letter of commendation (March 11, 1970) from President Nixon to the Ames initiators. Also, scientifically oriented companies have written articles including descriptions of Ames technology for their popular magazines (such as the article "Ames - Wonderland of the Life Sciences" in the Brush Recorder, Vol. 9, No. 1), and in their pamphlets (such as "The Family of Man - Prospects for Progress" issued by General Electric at their Disneyland display).

Ames' contributions to instrumentation has also created a significant respect in the scientific community -- such as that voiced by Professor Enoch Durbin of Princeton who said to the July 1968 Research Conference on Instrumentation Science,

"(Ames Research Center has developed) what is very probably the best instrumentation research capability in the nation, and very possibly the best in the world".

This viewpoint was expressed again by a subcommittee of the National Academy of Science meeting in Santa Cruz, California in July 1969 when they stated (Space Biology, page 24, available from Space Science Board), "Major contributions to biology can be made by applying advances in instrumentation, computer technology, telemetering, miniaturization, and vibration control. We believe it important that NASA continue and increase its efforts to make its expertise and facilities available to the biological community". Among the possibilities for implementing this suggestion, they listed first "extending the use of the Ames Research Center to accomodate visiting investigators".

The viewpoint was repeated with respect to general technology in March 11, 1970, when NASA Headquarters responded to a question from the Subcommittee on Advanced Research and Technology of the U. S. House of Representatives Committee on Science and Astronautics (Part 4, page 415) with the statement -- "An unusual situation exists at the Ames Instrumentation Division where a particularly innovative group of researchers have generated thirty-eight spin-offs coordinated through our Technology Utilization Office over the last five years. Inquiries resulting from the publication of the spin-off information totalled 2820 from the public, industry, and government agencies. In many cases, assistance was rendered to the inquirer". To this number of spin-offs one must add a significant number of technology transfers accomplished through less formal channels.

The several qualitative evaluations explicitly or implicitly given above suggest that the combination of a developed competence in the measurement sciences, and a concern for the application of the technology to the solution of socially relevant problems has provided the technical community with a valuable, if not a unique, national capability in instrumentation.

It is likely instrumentation research and development efforts at Ames will continue to influence favorably the productivity of an important center for research in aeronautics, astronautics and biology. It is equally likely that the impact they have so evidently had on research

outside of Ames will continue and perhaps may grow. In view of the pressing need for technical support by the biomedical community, however, special effort should be made to encourage continued transfer of the aero-space developed technology to the medical research laboratory and to the clinic.