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IITRI

IITRI Project No. V6102
(Final Report)

TECHNOLOGY APPLICATIONS TEAM

National Aeronautics and Space Administration
Washington, D. C.

IIT Research Institute

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Final Report

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By

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for

National Aeronautics and Space Administration
Washington, D. C.

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FOREWORD

This study was undertaken for the National Aeronautics and Space Administration to achieve technology transfer of aerospace technology to public sector problems in the areas of crime and law enforcement, mine safety and water pollution. Work was performed under contract NASW-1953 during the period June 15, 1969 to June 14, 1970. The program was under the overall direction of Mr. Gerald B. Bay, Manager of the Technology Utilization Section, and the Team Director was Mr. F. Robert Hand. Other personnel contributing to this study were Mr. William McMahon, Technical Director of the Law Enforcement Science and Technical Center, Dr. Morton Klein, Director of Chemistry, Dr. Madan Singh, Manager of Soil and Rock Mechanics, Dr. Krishna Kamath, Research Engineer, Mr. John Weyer, Research Engineer, Mr. Edward Fochtman, Manager of Water Research Center, and Mr. Serge Uccetta, Assistant Engineer.

Respectfully submitted,
IIT Research Institute

Gerald B. Bay

Gerald B. Bay
Manager
Technology Utilization Section

APPROVED:

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SUMMARY

The National Aeronautics and Space Administration seeks to give the public an additional return on their investment in the space program. To achieve this objective, NASA established a technology transfer program through which aerospace R & D which is useful to other agencies and organizations is identified, evaluated, and made available. A unique component of the transfer program is the Technology Applications Team which couples aerospace technology to users in the public sector via an active problem solving methodology.

The IIT Research Institute, under contract to NASA's Technolology Utilization Division, established a TA Team whose focus is on assisting in the solution of problems in crime and law enforcement, water pollution, and mine safety. This report describes the development of the experimental procedures for accomplishing technology transfer, the results obtained in applying these techniques, and the significant learnings obtained over the twelve month contract period.

The methodology evolved by the TA Team includes:

-- initial contact with senior administrators of public agencies to explain the program and to secure an agreement to cooperate with the team

-- identification, selection, and detailed definition of critical problems in the selected public sector areas which might be amenable to solution through the use of aerospace technology

-- a thorough search for relevant aerospace technology using computer searches of the aerospace literature and direct contact with researchers in NASA's field centers

-- evaluation of possible technical solutions in terms of their validity in the operational context of the problem originator

-- communication of the results of the investigation to the problem originator and assistance to him in implementing any relevant technology identified.

Utilizing this approach, the IITRI TA Team identified and defined 38 technical problems and found aerospace technology applicable to the solution of the seven problems described below:

1. A portable coal dust monitor utilizing an aerosol particle analyzer developed at NASA's Electronics Research Center for the Apollo space craft.

2. A mine explosion detector using a principle worked out at NASA's Langley Research Center which enables the rejection of extraneous signals which otherwise would cause false alarms.

3. A low speed air velocity meter derived from an air speed indicator developed for use in V/STOL aircraft at the Electronics Research Center. Using a fluidics principle, it will assist in controlling the ventilation in mines.

4. An improved methane monitor for coal mines using one of three devices: 1) a miniature mass spectrometer developed for the Voyager mission by Langley Research Center, 2) a W-value detector, developed by a consultant to the Ames Research Center, and 3) a thin film detector developed for the Marshall Space Flight Center.

5. An improved life support system for firemen employs chlorate candles developed for NASA's astronauts as an oxygen source for their extra vehicular activities.

6. A device to recover indented writing from note pads seized in a gambling raid is based on a fiber optics surface gauge developed for the Marshall Space Flight Center.

7. A portable water density meter based on a fluid density instrument designed for the Jet Propulsion Laboratory. This instrument will be used in locating unwanted strata in large reservoirs.

The technology described above represents a potential market of several million dollars. When incorporated into regular use, improvement in the health and safety of coal miners, assistance in the apprehension of criminals, and more effective location of water pollutants will result.

The experimental mode of the IITRI TA Team led to a number of significant learnings including the following:

-- Cooperative agreements with senior administrators in the prime federal agencies involved are needed for the team to be effective but detailed problem definition takes place at lower levels.

-- Detailed problem definition and characterization are critical to the team's success in identifying relevant aerospace technology and in transferring it to the problem originator.

-- Computerized literature searches are especially valuable in identifying individuals working within a field. Personal contact with these individuals identifies more recent work.

-- The time required to progress from a potential transfer to an implemented solution may be lengthy since key steps in the process are dependent upon the decision making and implementation time scales of the federal agencies with which the team is interfacing.

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I. Introduction

Since 1958, The National Aeronautics and Space Administration (NASA) has been collecting and disseminating technical information developed in the space program. In the Space Act, Congress charged NASA with the additional responsibility of ensuring that this knowledge is made available to others outside the aerospace field. As a result, NASA's Technology Utilization (TU) Program brings to industry and to the American public many innovations which become incorporated into our daily routines. The process by which the results of aerospace research are utilized by people outside the aerospace field is called 'technology transfer.'

This report describes one of the several mechanisms by which NASA achieves technology transfer. Called the Technology Applications Team (TA Team), it takes an active role in coupling NASA-developed technology with potential users of that technology in the public sector. The Team acts as a catalyst in every activity necessary to utilize this technology and may be thought of as a tool enabling the NASA store of new technology to be put to work for the public good.

The methods used by the TA Team differ from other mechanisms employed in the Technology Utilization Program. Unlike the aerospace data bank or TU special publications, the TA Team is an active means of locating, guiding and ultimately effecting a specific technology transfer.

In the past year, the IITRI TA Team focused its efforts on the public sector areas of Mine Safety, Law Enforcement, and Water Pollution. The selection of these areas was based on the national significance of the problem, the prospects for technology transfer, and IITRI capabilities in these areas.

The report first describes the organization of the team and the methods it uses. A discussion of achievements, in terms of technology transfer, follows. An analysis of what has been learned about the transfer process and a statistical summary are also included. Finally, the report presents detailed conclusions and recommendations based on the work performed between 1 July 1969 and 30 June 1970.

II. The Technology Applications Team

To attain its objective, the TA Team functions as a link between NASA and those who need aerospace technology. To do this a familiarity with aerospace terminology is needed on the one hand; an understanding of the singular needs and constraints of the potential users of NASA technology on the other. As with the other Technology Utilization mechanisms, communications is thus an essential feature in the process of technology transfer evolved by the TA Team. Engineering capabilities in their broadest sense are no less important. When a problem emerges from discussions with one of the agencies it is usually couched in very general terms. Before a solution can be sought, it has to be analyzed into its component factors and re-defined before the search for a solution can begin in earnest. Subsequently any technology resulting from this search has to be evaluated in terms of its practicality in the potential user's context.

A. Composition of the Team

The IITRI TA Team is so composed as to provide both the communication and engineering function. Although the team functions as a unit on each of the problems it accepts, its personnel are of two general categories. The Applications Group consists of senior IITRI engineers who are experienced in research connected with Mine Safety, Law Enforcement, and Water Pollution. They introduce the team and its capabilities to public agencies, interpret the nuances of problems, explain specialized jargon, evaluate the practicality of technical ideas, and advise on the transfer of an item of aerospace technology.

The Technical Group of the team consists of engineers from various disciplines practiced in analyzing and solving technical problems. They are responsible for the technical definition of problems, the search for aerospace technology, and the technical evaluation of potential solutions.

B. Applications Team Procedures

All of the steps taken by the TA Team are intended to foster the transfer of technology from the aerospace community to the public sector. While some of the specific actions are not always necessary - and though the order may vary from problem to problem - the general outline of activities is as follows.

1. Introduction to Public Agencies

The Technology Applications Team is an innovation in itself and was not familiar to most public agencies. Hence, it was necessary to spend some time introducing the team and explaining its function and capabilities. The aim was to establish continuing relationships with agencies who would look to NASA as a resource of new technology.

To obtain formal recognition NASA representatives and the IITRI team contacted the Director of Research of the Bureau of Mines, and the Administrators of the Law Enforcement Assistance Administration. Through an exchange of letters official cooperation was acknowledged. With the Law Enforcement Community, this step was extended to the state and regional level on a less formal basis, by contacting such organizations as the State Planning Agencies for law enforcement. In the water pollution area, contact was made at the Assistant Secretary level of the Federal Water Quality Administration. A list of agencies contacted during the year is given in Section V.

The next action was to contact operational organizations and agency subgroups who could suggest specific problems for the team's consideration. In each case the chief administrator was contacted first to explain the program and to assert that it was NASA's aim to assist in the utilization of aerospace technology, not to conduct research and development in the fields of mine safety, law enforcement, and water pollution.

The team elicits particular problems of importance to the agency. Often these were expressed in operational terms, e.g., "the crime lab cannot interpret faint samples of indented writing." Several discussions are often necessary before all the important facts relevant to the technical aspects of the problem are distinguished. The most complete operational definitions of problems are obtained, generally, by talking with people at the lower echelons of the organization. But occasionally a senior administrator is sufficiently familiar with details to provide adequate definition.

2. Selection and Technical Definition of Problems

When problems are specified and defined in operational terms, the team meets to consider them. Each problem is examined in the light of the following criteria:

a. Does the problem originator place high priority on this problem?

b. Is the problem of national or regional importance?

c. Does the problem fit the applications team approach - or would it best be handled by a literature search service or by an engineering design service?

d. Can the problem be solved by discrete technology rather than requiring research into major systems?

e. Is a solution likely within the bounds of current technology rather than requiring a major advance?

f. Is the best solution a technical one or could the problem be solved by a change in operating procedure?

g. If a technical solution is found, will it require such a major change in the user's operations that it will be unpractical and unacceptable?

This preliminary screening causes some problems to be rejected. The possibility of such rejections is carefully explained to the problem originator at the time of the team's introduction. About 60 per cent of the problems posed to the IITRI TA Team during the year survived the screening process. Those that did then passed to the technical definition phase.

3. Technical Definition of Problems

Before seeking new technology to apply to a given problem, its technical requirements must be understood and expressed in aerospace terms. A technical rather than an operational definition is necessary for two reasons. First, because scientists and engineers are trained to think and work in complex technical language, they must be given the physical parameters of the problem and the range of values that are important. Secondly, one of the principal resources used by the team is the Aerospace Data Bank containing over 700,000 scientific reports, which are indexed in aerospace terminology. To retrieve pertinent information, a computer strategy of aerospace key words must be used.

For this re-definition, the TA Team, meeting as a group, submits the problem to a technical analysis. Ideas are exchanged and often the analysis will raise new questions about the problem. The problem originator is contacted as often as is necessary to clarify these points.

Among the questions which must usually be answered before an effective search can be mounted are:

1. Is there any commercial equipment or technique which might meet the need?
2. Have any technical solutions been proposed previously for this problem?

3. Why were they inadequate?

4. Are there any restrictions - such as radiation sensitivity, cost, legal acceptance, etc. - which would make certain solutions unacceptable?

Sometimes, experts other than the problem originator must be consulted. The definition process is time consuming but experience suggests that it is one of the keys to successful solution of a problem.

4. Search For Technology

Several technical approaches can usually be expected to evolve from the problem analysis phase. The search strategy is specifically designed to retrieve technology applicable to each approach. If more than one possible solution is identified, selection is based upon further consideration of costs, ease of deployment, and other constraints set by the problem originator.

The Technology Applications Team has several resources to which it can turn. Among these are:

Aerospace Data Bank - a computerized store of over 700,000 aerospace reports. About 25 per cent of these are NASA documents; 35 per cent are reports from the Department of Defense and other agencies; and about 40 per cent are of foreign origin.

NASA Scientists and Engineers - NASA operates 12 research centers around the U. S. and, together with its contractors, maintains a force of several hundred thousand scientists and engineers.

Open and Commercial Literature - IITRI maintains a library of aerospace literature, a microfilm file of product literature and commercial data, and is associated with the John Crerar Library, one of the nation's largest technical libraries.

Fellow Scientists and Engineers - IITRI researchers and associates at other institutions with whom contact is maintained.

The Aerospace Data Bank is created and maintained by NASA's Scientific and Technical Information Facility (STIF) and the computer tapes are supplied to Regional Dissemination Centers (RDC) established by NASA at universities and research institutes across the country. The RDCs offer a literature searching service using the Aerospace Data Bank as well as the specialized tapes they have developed. In its literature searches, the IITRI team employs the services of the RDCs at Indiana University, Aerospace Research Applications Center (ARAC), and the University of Pittsburgh, Knowledge Availability Systems Center (KASC).

STIF also maintains and operates a remote terminal computer system for the Data Bank called RECON. RECON terminals are located at NASA Headquarters in Washington, STIF's own facility in Maryland and at several of NASA's Research Centers. Access to the computer is obtained using a keyboard at one of these terminals. Information retrieved from the Data Bank is displayed on a cathode ray tube (CRT) at the terminal. Once the necessary keywords are decided upon, the information retrieval operation is quick. The CRT display gives flexibility, as information is evaluated directly and the search strategy modified in the course of the search.

All the methods of searching the literature listed on the previous page are used by the TA Team. One advantage of these literature searches is that the names of individuals working in technical fields related to the problem will be disclosed. Such leads are particularly valuable since direct contact with the individuals identifies their most recent work.

There are several ways in which contact is made with NASA scientists and engineers. From the analysis and re-definition of the problem, a Problem Statement is usually prepared. This is a concise and brief memorandum for circulation among the NASA scientists and engineers. Each research center maintains a Technology Utilization (TU) Office and the TA Team Problem Statements are distributed by the TU Officer (TUO).

Through the Problem Statement, the team reaches those scientists and engineers who can contribute their ideas to the solution of the problem. Thus, the Problem Statement must be attractive and provide motivation for its recipients. Those who are aware of any innovation or technique relating to the problem, normally respond directly to the TA Team or indirectly via the TU Officer.

In the course of the past year the circulation of Problem Statements elicited many responses from the NASA Centers. Some were most useful and led to potential technology transfers.

5. Technology Evaluation

In general the literature searches described in the foregoing paragraphs will have one of three results:

(a) Some aerospace innovation or technique will be revealed which with little or no modification will resolve the problem under consideration.

(b) A device or technique will be disclosed which needs considerable adaptive engineering before it can be considered a satisfactory solution.

(c) No aerospace technology relevant to the problem will be revealed.

Experience over the past year suggests that suitable technology - most of it in category (b) - will be found for 25 per cent of the problems.

For the evaluation of the information disclosed by the search, six criteria evolved:

(a) Does the technology show promise of resolving the problem?

(b) Does it represent a major advance over what is currently being used?

(c) Is it an economic proposition?

(d) Will its introduction imply training too sophisticated to make it practical?

(e) Does it leave significant parts of the problem unsolved?

(f) Is it adaptable to the user's special environment?

If these criteria and any others established by the problem originator are satisfied, a potential solution is in the offing, and details of it are passed on to him. A telephone conversation or a personal visit may reveal additional constraints which were not evident previously and which may enhance or reduce the suitability of the potential solution. Occasionally, more information is needed to demonstrate its feasibility as a solution to the problem under consideration.

Where technology is rejected during the primary search phase, additional searching continues. But if an exhaustive search is completed and no other technology commends itself to the TA Team, work on that particular problem ceases and the problem originator is told that it is inactivated. (Whether this inactivation is permanent is really decided by the nature of the problem. NASA research and development is a continuing process and a seemingly unsolvable problem today may well find a solution among the technology of tomorrow.)

Sometimes it is desirable to test an aerospace innovation or technique to verify its applicability to a non-aerospace environment. The TA Team does not conduct experimental programs on its own accord. But in such circumstances it is possible to arrange for experiments and tests to be performed by the NASA contractors responsible for the original development, or at a NASA Center.

6. Transfer Strategy

When the problem originator agrees that the recommended innovation or technique may resolve his problem, the strategy for converting this 'potential solution' into a hard transfer is worked out. This strategy will depend on a number of factors:

1. The nature of the solution
2. Its state of development
3. The sources of engineering expertise
4. The availability of development funds
5. The administrative structure of the agencies involved
6. The market picture
7. The interest of commercial firms.

In some cases a feasibility study is necessary before a decision is made on the way the recommended innovation should be adapted or the new technique applied. Resolving who will perform this study - NASA, a NASA contractor or an independent contractor - and finding the means to pay for it, is the responsibility of the TA Team. Where aerospace technology is of interest to a public sector agency other than NASA, the cost of a feasibility study and any adaptive engineering which may be necessary is the responsibility of the agency concerned. Sometimes a local agency does not have enough money for such purposes. Usually, however, federal agencies can be found who are willing to support local departments. (For example, the LEAA provided funds for a feasibility study related to a potential transfer with the Chicago Police Department. See page 22.)

To develop the transfer strategy it is often necessary for the NASA innovator to visit the problem originator - or vice versa. Such visits, which are essential if the specific application of the innovation is to be understood in the context of the problem, are usually arranged by the TA Team. So too are the details of field trials, and - where the equipment exists - the preliminary arrangements for the loan of a prototype model for evaluation.

Ultimately, when an agency decides that a recommended solution satisfies their requirements, the users - who in our case are miners, policemen or people concerned with water pollution - must be equipped with the adapted version of the original NASA innovation. Consideration of the potential market for the adapted technology thus becomes necessary, and the TA Team conducts a brief market analysis of the innovation's potential. Such information is not only useful to the potential user and of interest to NASA, it also arouses interest among those who may manufacture the innovation for the users.

In sum, therefore, the work of the TA Team may be regarded as a catalytic function: probing and disclosing problems, seeking solution to them, bringing together problem originators with NASA scientists, locating sources of funds which will enable aerospace technology to be adapted and manufactured and, finally, observing and reporting the trials and evaluations of the equipment in its adapted role. Once the latter is pronounced satisfactory, a technology transfer is accomplished and the TA Team completes its mission on that particular problem.

III. Progress Towards Technology Transfer

During the first year of operation a good deal of emphasis was placed on experimenting with the methods and adding data to the understanding of the process of technology transfer. Nevertheless, technology transfer - the object of the program and the goal against which the success of the TA Team's operations will ultimately be measured - was constantly kept in view. A great deal was learned about the procedures for effecting transfers and steps were taken towards the transfer of specific items of technology. Those items, and their present status in the context of the problems to which they are applied, are discussed in this Section.

A. Aerospace Technology Applications

1. Title: Portable Coal Dust Monitor

Problem Originator: Dr. Robert Van Dolah, Director
Mine Safety Research
U.S. Bureau of Mines
Pittsburgh

The Problem: Coal dust is a hazard in mines. Under certain conditions it will initiate or propagate explosions; like silicious dusts it is also a cause of pneuomoconiosis. Recent federal and state legislation tightened the standards of the industry, pushing permissible coal dust concentrations in mine atmospheres to lower levels. As a consequence the new standards require a monitoring capability beyond that which now exists.

What is needed, therefore, is a portable, rugged, continuous reading instrument which can measure particle sizes from 0.2μ to 10μ in mass concentrations on the order of $2 mg/m^3$. The instrument must operate under its own power for at least eight hours and conform to the usual regulations controlling its use in explosive atmospheres.

The Solution: An Aerosol Particle Analyzer was developed at NASA's Electronics Research Center to monitor the atmosphere in the Apollo space craft cabin. This instrument is entirely self contained, weighs 5.5 pounds, and sorts particle counts into five size ranges from 0.5μ to 10μ. The analyzer uses the forward scattering of light by a dust particle to register a pulse in a photomultiplier tube. The amplitude of the pulse is proportional to particle size.

Status: The instrument was first demonstrated to the Bureau of Mines in December 1969, by Mr. Lavery, of ERC. In February 1970, a series of tests were performed at the Bureau of Mines lab in Pittsburgh. There the instrument was subjected to the dust concentrations typical of coal mine atmospheres. The performance of the instrument showed high correlation with dust standards used by the Bureau.

For the NASA instrument to be used in mine atmospheres some adaptive engineering is necessary. Most of this is concerned with redesigning and repackaging the circuitry to ensure its safe operation in a mine atmosphere. Adaptive engineering is estimated at $15,000. The Bureau of Mines will itself provide funds for the work if a decision is made to proceed.

Impact: Although the NASA instrument cannot be used as a standard for certification of a mine against federal standards, it will provide the Bureau of Mines inspector with a portable tool with which he can make on-the-spot measurements of the quality of a mine atmosphere. Should these measurements show the mine to be unsafe, the mine operator will be compelled to take remedial action.

A projected 200-300 instruments will be required by mine inspectors in the next few years to effectively control the dust levels in U. S. coal mines. It is estimated that a mine-permissible instrument may cost in the range of $5,000. Thus, the particle analyzer represents a potential market of more than $1,000,000.

2. Title: Mine Explosion Detector

Problem Originator: Dr. Robert Van Dolah, Director
Mine Safety Research
U.S. Bureau of Mines
Pittsburgh

The Problem: When an explosion occurs in a coal mine - as happened at Mannington, W. Virginia, in 1968 - it often results in a disaster which claims many lives. One method of preventing the spread of an explosion is to discharge a quenching agent in its path. The discharge of the agent would be triggered by the explosion itself.

What is needed is a rapid response detector which will trigger this quenching action within less than 50 milliseconds of the ignition of the explosion. At the same time, the detector must discriminate between extraneous "noise" signals present in the mine, such as those emanating from cap lamp beams, cosmic rays, air hammer noise, and electric trolley sparks.

The Solution: Mr. R. Trimpi, of NASA's Langley Research Center responded to our Problem Statement with a conceptual suggestion for a twin channel detector. The ignition of methane and air mixture is the cause of most mine explosions, and the presence and concentration of methane may be detected by its ultra-violet radiation. In Mr. Trimpi's detector concept the two channels would be focused on different sections of the UV spectrum, unique to the presence of methane. The detector would respond to the ratio of signals from both spectral regions. In this way it would respond to the ignition of methane gas but not to extraneous signals.

Status: Experimental measurements using a collection of laboratory instruments were made at Langley Research Center. The results indicate that the concept is valid, and that extraneous signals are indeed discriminated against. Since no prototype model of the detector exists, a development project must be initiated to engineer the concept to the mine application. The Bureau of Mines already has its own version of a detector, without the capability to discriminate. Incorporation of the NASA concept into this device would involve an engineering effort of approximately one man year. The Bureau of Mines has not yet evaluated the concept and so the item remains in the Potential Solution status.

Impact: Virtually every coal mine explosion begins with the ignition of methane gas, which diffuses into open areas of the mine from the coal itself. A detector which responds only to methane ignition could be placed at each working face of a mine. A properly operating quencher would prevent spread of an ignition to other parts of a mine, and save the lives of all but perhaps those immediately at the coal face.

3. Title: Low Speed Air Velocity Meter

Problem Originator: Dr. Robert Van Dolah, Director
Mine Safety Research
U. S. Bureau of Mines
Pittsburgh

The Problem: To prevent the accumulation of methane in coal mines, and to provide fresh air for the miners, the mines are forced-air ventilated. A minimum flow is directed to unworked areas of the mine, and the velocities in these areas are often as low as 10 feet per minute. A simple, rugged instrument is needed to measure the air flow and this must cover a range from 10 to 2000 feet per second. Conventional instruments in current use such as vane and hot wire anemometers, smoke tubes, etc. are either too delicate or too insensitive.

The Solution: NASA has employed several methods to measure low velocity wind currents. Of those considered, a device developed for the Electronics Research Center to be used in V/STOL aircraft appears to be the most practical. Based on a fluidics principle, the device has no moving parts and is capable of resolving air velocities of about 6 feet per minute. It can be made into a portable hand held meter which gives a continuous reading and which will cost approximatedly $100.

Status: The adoption of this device to coal mine ventilation was suggested by Mr. R. Miner of NASA/ERC. It was first demonstrated to the Bureau of Mines in January 1970, and a report containing a description of the technology was submitted to the Bureau. So much interest was generated that the fluidics device will be included in a study of existing technology which is being conducted by the Bureau before it embarks on a development program.

Impact: Virtually every mine explosion begins with the ignition of methane gas. An instrument which will measure very low air velocities will ensure that adequate ventilation is provided to idle areas of the mine while the requisite air flow is being maintained at the face. It is estimated that 2000 such instruments will be needed by the mining industry, representing a potential market of $200,000.

4. Title: Improved Methane Monitor

Problem Originator: Dr. Robert Van Dolah, Director
Mine Safety Research
U.S. Bureau of Mines
Pittsburgh

The Problem: Since almost all explosions in coal mines start with the ignition of methane, the presence of methane at concentrations between 5 and 15 per cent, constitutes a major hazard. The most common method of monitoring methane concentration uses the catalytic decomposition of methane (CH_4) to change the electrical resistance of a platinum sensor in a Wheatstone bridge circuit. A flame methanometer, which relates an increase in height of an open flame to the concentration of methane, is sometimes used. The prime drawback to the former is its susceptibility to fouling of the platinum sensor, and therefore its frequent replacement. The flame methanometer is not sufficiently accurate under various mining conditions. Thus, the need is for an instrument which will give accurate and reliable data on the concentration of methane in the mine atmosphere.

The Solution: Several possible solutions from aerospace technology were suggested. Dr. J. E. Lovelock, a NASA consultant, developed an ionization gage type instrument which identifies several gases and vapors - including methane - by a characteristic property known as the W value. The W value is the energy absorbed by a gas from an ionizing particle during the production of an ion pair. A small quantity of tritium supplies the ionizing radiation and the resulting ion current is collected by an electrode. Selection of methane is done by adjusting the ionizing potential and the electrode spacing.

Another NASA-developed instrument suitable for monitoring methane in coal mines is a lightweight, mass spectrometer designed for gas monitoring by the "Voyager" satellite. According to Mr. P. Yeager of the Langley Research Center this spectrometer can be simplified to meet the requirements of a methane monitor by eliminating the scanning mechanism and focusing only on the methane mass number.

An indium sesquioxide semiconductor thin film detector developed for NASA by the General Electric Company was also suggested (by Mr. C. E. Decker of Research Triangle Institute) as a means of solving this problem. On paper this detector offers distinct advantages over current methods - primarily because it measures the ambient methane concentration directly and no catalytic combustion of the gas is necessary.

Status: The three suggested solutions were evaluated, and each has desirable properties for the problem under consideration. The Voyager spectrometer will be more expensive than the other two instruments but it is very likely more accurate. Details of all three devices are being reported to the Bureau of Mines with a recommendation that the information should be incorporated in the Bureau's current research.

Impact: As was said earlier, mine explosions are started by methane ignition, and all possible approaches should be taken to maintain the methane concentration below the danger level. A methane monitor would form part of an overall protection system which measures gas concentration, controls ventilation, and suppresses explosives. Creation of a complete system can be expected to save dozens of lives each year.

5. Title: Fireman's Life Support System

Problem Originator: Commissioner James Kelley
Boston Fire Department
Btn. Chief James Neville
Chicago Fire Department

The Problem: The atmospheres in which firemen usually operate can, and often do, contain such potentially harmful gases as carbon dioxide, carbon monoxide, ammonia, hydrogen cyanide, hydrogen sulfide, and sulfur dioxide; all of these are lethal. Many fire fighters feel that present devices impair their efficiency and effectiveness as fire fighters. They believe that with improved harness configurations, and lighter, less bulky and simpler systems it would be easier for a fireman to do his job while wearing a protective mask. It is agreed that what is needed to reduce the toll of casualties is an improved, more widely accepted and more efficient protective respiratory device.

The Solution: Under contract to NASA, the AiResearch Manufacturing Company developed for astronaut use, an improved "chlorate candle" which generates oxygen by the chemical decomposition of sodium chlorate. Chlorate candles have existed for some time but the work of the AiResearch Manufacturing Company brought high reliability, reduction of contaminants, improved igniter systems and better production methods. These improvements will enable chlorate candles to be used in portable breathing apparatus saving size and weight. The solid-state oxygen storage such candles provide also enables long shelf life without periodic recharging.

Status: As applied to a fireman's life support system the chlorate candle technology was reported to both the fire service and to industry. Because of the uncertainty of the market picture, no industrial firm has attempted to develop a prototype. Some fire departments (Chicago and New York, for example) expressed an interest in evaluating the chlorate candle concept but they have no funds to support development. At present the technology is awaiting funds for applications engineering which will enable a prototype system to be designed and built for the firemen to test under operating conditions. For this work an estimated engineering effort of $50,000 is required.

Impact: A study conducted by the International Association of Fire Chiefs showed that smoke inhalation is the direct cause of 2 out of every 10 injuries to fire fighters. During the study period, the total number of firemen injured per year was 2700 and of this number, 40 were killed in the line of duty - 20 of these deaths being directly attributed to smoke poisoning. If a breathing apparatus could be made which firemen could use comfortably and which would not hinder his activity, an equivalent number of lives may be expected to be saved each year.

6. Title: Detection of Indented Writing

Problem Originator: Captain David Pertell
Miss Maureen Casey
Documents Laboratory
Chicago Police Department

The Problem: One of the most important pieces of evidence confiscated during a gambling raid may be a writing pad which was used to record betting information. Even if the page bearing the writing is destroyed, the pages underneath often still carry an indented impression of what was recorded. What is needed therefore is a device which will recover the writing.

The Solution: A fiber optics profilometer developed for NASA by Metro Physics, Inc. is capable of measuring minute imperfections in a surface. It was developed originally for inspecting the mating surface of flared tubing used with the Saturn rocket. A crude experiment by Metro Physics, Inc. indicated that the profilometer is capable of measuring grooves in a paper surface, and it is believed that a scanning arrangement could be incorporated in which the indentations would be plotted on a chart recorder. Alternatively the indentations could be viewed directly by means of a fiber optic bundle.

Status: The concept was studied and appears feasible. But before proceding on a large scale development project, an experimental probe will be built to try to show conclusively that the device works on a paper surface. According to Metro Physics, this experiment will cost $2980. The firm itself is not prepared to commit such funds to the experiment, but arrangements were made with the Law Enforcement Assistance Administration to transfer funds to NASA, who will then contract with Metro Physics for the work involved. This experiment will be performed early in the next program year.

Impact: If successful, an instrument based on the fiber optics principle will enable the document examiner to read samples of indented writing which are invisible under normal circumstances. Such an instrument could be made fully automatic, yielding a graphic or photographic print of the evidence, and saving as much as 20 per cent of an examiner's time. The device will be useful not only to all major police departments but also to the FBI and the armed forces.

7. Title: Water Density Measurement

Problem Originator: Mr. Lowell Leach
Federal Water Quality Administration
Ada, Oklahoma

The Problem: Within large reservoirs, water movement is relatively slow and varied in direction. Water, containing certain impurities or deficient in oxygen, often tends to stratify into layers of differing density.

These layers move about and by the time a laboratory analysis of samples drawn from the reservoir is completed, the conditions may change. What is needed is a portable instrument which can measure on-site the density of water in a reservoir.

The Solution: A "fluid density analyzer" developed by TRW for the Jet Propulsion Laboratory (NASA/Pasadena Office), measures density of a gas in vacuum. Using Archimedes' Principle, it measures the buoyant force of a specifc volume of displace fluid to determine the gas density. The device is capable of measurements to six significant figures.

Status: Calculations by TRW show the device to be feasible for the water density application. The problem originator agrees that it represents a practical solution to his problem. TRW's Mr. Owen Fiet was placed in contact with Mr. Leach and will prepare a proposal to FWQA for the development of a prototype instrument.

Impact: The ability to track layers of impotable water in a reservoir will facilitate corrective action, or permit the level at which water is withdrawn from a reservoir to be adjusted. Not only the FWQA, but the TVA, Army Corps of Engineers and others concerned with reservoir management will find such an instrument to be valuable. The ultimate benefit, however, will be the people who depend on the reservoir for their drinking water.

B. Non-Aerospace Technology Applications

While searching for new technology with which to resolve the problems put to the TA Team, commercial products are examined to ensure that nothing already exists which will provide a solution. Occasionally, some device or instrument, of which the problem originator may be unaware, is disclosed. Although the work involved does not directly relate to the transfer of aerospace technology, it does represent a valuable service to the problem originator. Thus, it can be counted a secondary benefit of the NASA-sponsored program. Some problems which were solved with commercial devices are listed below.

1. Title: Accident Investigation Using Photographic Information

   Problem Originator: Sgt. Joseph Cea
   Accident Investigation Squad
   New York Police Department

   The Problem: The team which investigates an automobile accident often overlooks some measurement which, at a subsequent court hearing, is found to be critical. Thus there is a need for a permanent photographic record of the accident scene from which dimensional data may subsequently be retrieved.

   The Solution: A stereo camera apparatus and a mechanical plotter is manufactured by Wild-Heerbrugg in Switzerland. For many years, this device was used by police in Europe expressly for the purpose of investigating auto accidents.

   Status: The information is being forwarded to Sgt. Cea, NYPD, and the manufacturer's representative was told of the application. To date no U. S. police department has adopted this device, although its potential application is undoubtedly wide-spread throughout the country.

Impact: The use of such a technique as stereo photogrammetry should reduce the "on-the-scene" work required of the investigating team. As a result the scene can be cleared to permit traffic flow much quicker than at present. Furthermore, a permanent photographic record can be maintained to meet any court requests for information.

2. Title: Water Current Sensor

Problem Originator: Mr. Lowell Leach
Federal Water Quality Administration
Ada, Oklahoma

The Problem: Water in large reservoirs and lakes moves relatively slowly. Information about currents in such bodies of water helps locate the source of pollutants and predict their dissemination. Vane propeller type meters are in use at present, but they are not sensitive enough to measure the low velocities commonly found in these waters. What is needed is a portable instrument capable of three-component current measurement at speeds as low as 1 ft/min.

The Solution: An instrument made by the Intergalactic Corporation, Salt Lake City, and which was marketed comparatively recently, appears to fulfill the requirements of the problem. An electromagnetic technique is used and a range of instruments selling from $100 to $3000 is available.

Status: The problem originator was informed of the existence of these instruments and because of his interest, more detailed information was requested from the manufacturer.

Impact: Solution of this problem will enable pollution control authorities to track water pollutants to their source. It will also permit the prediction of water flow in these lakes through more accurate mapping of the currents. The effects of weather changes on the currents can be studied. All these factors will result in more effective usage and better control on the quality of water available to the public.

IV. Significant Learnings

When the IITRI TA Team was first formed an operating mode had to be established. In Section II the procedures developed in the course of the year were described. With twelve months hindsight a survey of these procedures confirms that they are sound. Nevertheless some aspects deserve attention if the effectiveness of the transfer process is to be improved. In the following paragraphs the team's learnings over the past year are presented and particular approaches which might be pursued to advantage during the forthcoming year are reviewed.

1. Public Agency Contacts

Before problems can be solicited, contacts invariably must be made with administrators in the area of concern. Such contacts are intended to gain:

(a) Recognition and acceptance of the TU Program
(b) An awareness of the need for innovation and where
(c) An understanding of the organization through which technical progress will be achieved.

In our experience these requirements can only be settled by an approach at three different levels. Recognition and acceptance of the TU program in general, and the role of the TA Team in particular is accomplished through introduction to senior, federal administrators. These introductory meetings paved the way for discussions at intermediate organizational levels.

At these levels, the awareness of the need for innovation and an understanding of the means by which new technology will be received have usually started to become apparent. From here the next contacts were with the potential problem originators and it is with this class of individuals we are most concerned. In presenting the TU program to them, stress is laid on the fact that NASA wishes to function as an additional resource to agencies seeking new technology; that NASA does not embark on mission-oriented research in any of the fields it seeks to assist, and that it is trying to make available aerospace innovations and hardware which may assist in solution of significant national problems.

That this remains the motive of the program sometimes proves difficult to convey, and there are those who assume that the TA Team seeks research contracts. In most instances, this erroneous idea is dispelled comparatively quickly. Yet the suspicion lingers, and IITRI's view is that it will only be dissipated after a number of transfers are accomplished.

The misunderstanding, if it exists, rarely permeates to the working level and in general all contacts - i.e., with those individuals most directly concerned with these current problems - are cordial and fruitful. Moreover, it is our experience that the more informal these contacts are, the more likely are practical, well-specified problems to emerge. Informality is the keynote which enables us to overcome doubts about the intent of the TA Team, and makes possible the continuing and cordial relationships which now exist.

2. Problem Definition

Experience with the first of the problems posed to the TA Team soon showed that one of the key steps in the technology transfer process was a clear definition of the problem. Thus the TA Team consistently spends about 25 per cent of its time on this phase of its work.

Before all its subtleties are exposed several discussions may be necessary with those directly concerned with a given problem. Protracted discussions by the TA Team may then be necessary before the technical aspects of the problem are resolved and before a clear understanding of its scientific components is achieved. Failure to elicit a full description of every facet of the problem invariably prolongs this definition phase.

One characteristic of the public sector problems which turns up more often than expected is the requirement for instrumentation. Almost half of the problems represented a need for some type of instrument. Possibly this is due to the mission of most of the agencies with which the IITRI TA Team is concerned, i.e., the role of monitoring and enforcement of regulations; hence, the need to measure. But on occasions it could also be due to the relative ease of specifying the characteristics of a measurement problem, and the fact that such problems come to mind faster. Yet within NASA there is a great deal of technology beyond instrumentation available. Additional attention to this broader class of problems will be given in the future.

3. Problem Statements

One of the first accomplishments of IITRI's TA Team was the development of a format for a written statement of public sector problems. Much of the thinking that went into this format was incorporated into a set of Guidelines for Problem Statement Preparation, compiled by Dr. William H. Clingman, (W. H. Clingman & Assoc.), under a separate study sponsored by NASA/TUD. These guidelines, which include the contributions of other Applications Teams as well as Dr. Clingman's own thoughts, have come to be used by all teams in a standardized Problem Statement style and format. A sample problem statement which follows this style is reproduced at page 30.

4. Literature Searches

Searching the aerospace literature represents another major portion of the TA Team's effort. In experimenting with the three methods of searching the data bank, (Regional Dissemination Centers, the Scientific and Technical Information Facility, and RECON), the IITRI TA Team found each method to

IITRI/LE-2

TECHNOLOGY APPLICATIONS TEAM

DETECTION AND RECOVERY OF INDENTED WRITING

A problem in Law Enforcement undertaken by the IIT Research Institute team sponsored by NASA's Technology Utilization Division

This Problem Statement calls to your attention significant technological needs in an important area of concern in the public sector. We hope to bring to bear on this problem the information and expertise that resides in NASA. If you feel you can contribute, please relate your ideas to the Technology Utilization Officer at your installation, or to the team representative named in the statement.

STATEMENT OF THE PROBLEM

The police need a method to examine various types of paper to detect the presence of indented writing, and to reconstruct and record the information it contains.

BACKGROUND INFORMATION

Indented writing is the image of a written message which has been transferred from the original as an impression in the surface of a succeeding layer of material. Very often loose pieces of paper such as note paper, typing paper or other stationery are used as backing sheets for previously written messages. Of course, this is nearly always true for all except the top sheet of a pad of paper. Each time a piece of paper is used as a backing sheet, a portion of the message is transferred to it from the original in the form of indented writing. The police often encounter this type of evidence, for example, in gambling raids where the original copy of telephone numbers and betting amounts has been destroyed but the information is preserved on succeeding pages of a notebook. Depending upon the backing beneath the second sheet, the quality of the papers, the shape of the writing instument, and the pressure applied by the writer, the indented writing in the second sheet is sometimes visible to the unaided eye. But more often than not, the sample of indented writing is too faint to be legible.

In general, an improved technique is most needed to examine a document which contains one or more superimposed messages. While detection of the presence of indented writing in these cases may not be difficult, recovery of the information by techniques presently in use is often impossible.

Techniques presently in general use include various schemes of side-lighted shadow-casting, thermo-setting plastics and several photographic approaches such as the use of high contrast film. These methods are unable to resolve indentations below a certain threshold. The "Hollywood Detective" technique of shading with a pencil is virtually never used in actual practice as it is more likely to destroy the information than aid in retrieving it.

CHARACTERISTICS OF INDENTED WRITING

The mechanism of indented writing has not been totally characterized, but it is primarily a displacement of the paper fibers rather than a compression process, such as is the case with watermarks. As with any forming process, the shape of the indentation is dependent on the shape of the writing instrument.

Rough measurements made on ball pen indentations indicate that when the depth of the furrow is of the order of 2 mils (50 microns) the information can be recovered using shadow lighting. At depths less than 0.6 mil (15 microns) the presence of indented writing can be visually detected but usually not read. These are approximate values and are given only to indicate orders of magnitude. It is not known at what minimum depth the indentations can be visually discerned.

POSSIBLE APPROACHES

Techniques employed to analyze surface imperfections might be adaptable to this problem. Some approaches are:

1. Mechanical measurement of depth of grooves.
2. Holography.
3. Optical reflection from surfaces.
4. Thin-film thickness measurement techniques.

The method employed should be adaptable to scanning an entire page of copy. A visual display of the recovered information is most desirable.

LITERATURE SEARCH

A computerized search of the aerospace literature has been initiated. A number of pertinent references have already been identified and are listed below. However, some relevant technology might not be identified by this means and any additional references you suggest would be appreciated.

1. Surface Irregularities Detected by Flare Inspection Instrument (Fiber Optics), NASA Tech Brief 69-10152.

2. Surface Profilometer for Examining Grain-Boundary Grooves, AEC-NASA Tech Brief 69-10345.

FOR FURTHER INFORMATION

If you need more details about this problem, or if you wish to discuss your ideas with a team representative, please contact:

F. R. Hand, Director
NASA Technology Applications Team
IIT Research Institute
10 West 35 Street
Chicago, Illinois 60616

Telephone: (312) 225-9630
Extension 5281

Reference: LE-2

have certain advantages and limitations. RECON generally brings quick results and retrieves a large amount of information relevant to a specific problem. This is because the individual most familiar with the problem, the TA Team member, is conducting the search and the results are printed out while he is at the console. When time permits however, the RDCs and STIF usually obtain a broader selection of documents; this is due to the familarity of their operators with the indexing system.

The main difficulty with the searching procedure is that aerospace documents are indexed in a subject-oriented indexing system which does not lend itself efficiently to a problem-oriented search strategy. The difficulties encountered are similar to those encountered in a public library. If the title, or author, or subject matter of a book, is known, the book will usually be forthcoming. But an individual entering the library with only an idea and wanting all books related to that idea will face considerable difficulties. Thus, to maximize the absolute number of relevant documents, a strategy must be created which will be broad in scope and which will sometimes retrieve several thousand references, with a 2-5 per cent relevancy factor. Sifting through these documents to find the few which relate directly to the problem is time consuming.

The literature searches were most valuable in providing leads to NASA scientists and engineers who work in technical areas related to the problem. The chlorate candle technology for the Fireman's Life Support System, for example, was located in this way.

What often happens is that although a document describes no specific hardware, a call to one of the authors will begin a chain of contacts with people who work in the particular technical area. Each will have ideas or will know someone else who might contribute. Sometimes the chain ends with a solution to the problem.

5. Contacts with NASA Researchers

During the year the TA Team relied heavily on the written Problem Statement as a stimulant for contacts between the team and scientists at NASA centers. Problem Statements are mailed to the Technology Utilization Office at the various NASA research centers, where they are distributed to selected NASA scientists and engineers. These scientists and engineers are instructed to communicate any ideas which may contribute towards a solution to the problem directly to the TA Team, or indirectly via the TU Officer.

This procedure was moderately effective in eliciting responses. In twelve months, over 70 responses were received. But because of foreseeable but uncontrollable delays in handling the Problem Statements, two months usually elapsed between the time the statement was mailed to the receipt of the first response.

Because of this the TA Team started to experiment with methods of shortening the time of response, and of increasing the number and significance of the responses. The use of the literature search to provide names of NASA researchers was mentioned in paragraph 4. Direct contact by telephone, even a chain of contacts, will take only a few days to complete, and recent experience indicates that the results may be almost as fruitful as that which may be expected from the broad distribution of Problem Statements. Over the course of the next few months these procedures will be examined in more detail.

Contacts with NASA personnel have usually been constructive. Invariably those concerned are cordial and interested in the problems that are put to them. Any means which can be taken to increase the interaction between the TA Team and NASA seems likely to facilitate further the process of technology transfer.

6. Utilizing the Solution

Although several innovations gained a Potential Transfer status during the contractual year, none are yet being utilized by the problem originator. The process of converting aerospace technology to a secondary purpose takes time, and it is apparent that the activities and people involved in each and every transfer will vary.

The most likely solution to a public sector problem which may be found in the aerospace technology is a device or instrument. But this solution must be adapted to its new application, because it is not in a form which can be easily visualized by the problem originator, it is sometimes difficult to demonstrate that it is, in fact, a solution. Consequently a feasibility experiment may be necessary (as with the indented writing device) or an initial design study completed (as with the chlorate candle) before the solution is accepted.

The adaptive engineering presents a special difficulty. Some agencies are not equipped to perform application engineering and the onus of finding expertise for this task must necessarily fall on the TA Team. Moreover, there may be no source of funds with which to pay for the work, e.g., as happened in the case of the chlorate candle technology for the proposed FLSS. In such a case it is incumbent on the TA Team to approach other agencies who may be induced to support the program.

Convincing a commercial firm to convert an adapted innovation into a useful product for the public sector application also presents difficulties. If the technology was originally developed for NASA by one of its contractors, that company may be so aerospace-oriented that it is chary of entering a market place where risks are uncertain. Secondly, a company which already caters for a specialized market - say, the police - may be the ideal marketing organization for the new innovation but it might well be reluctant to venture into a new technical area. Additionally, many firms prefer to develop their own products and to retain the exclusive rights to them

Thus, it is clear that for every potential solution to enter the technology transfer field an individual transfer strategy must be devised. This strategy will need to be prepared when the problem originator agrees on the solution, and clearly the strategy may have to be modified as new experience is gained. Nevertheless, some form of guideline is necessary if the transfer process is to be carried out effectively. The IITRI TA Team has begun to do this, and strategies for the indented writing and fireman's life support system problems were recently generated.

V. Statistical Summary

The following pages depict charts which represent statistically the progress made during this past year.

Table I is a listing of the public sector agencies and organizations which the team has contacted. The number of contacts made in each area of concern and the total number of contacts are plotted cumulatively in Figures 1 and 2. Because the third area, Water Pollution, was not designated until December, the team began its work in that field in January. Contacts shown for the Fireman's Life Support System (FLSS), starting in January, represent the beginning of follow-up work after the problem report was issued.

In the field of Mine Safety, the total number of contacts necessary to identify our target number of 15 problems is somewhat fewer than for Law Enforcement. This is so because the Bureau of Mines, with its long history of mining research, has its technical needs well defined and only a few meetings were necessary to arrive at a selection for the team to study.

Figure 3 illustrates the progress in accepting new problems. By the close of the project year, 38 problems were actively pursued by the team.

Figure 4 shows the cumulative total of technical responses from NASA Research Centers to our problem statements. The average response time, from the mailing of the problem statement to the receipt of the first response was two months.

Figure 5 represents the progress of the team in locating potentially transferable technology. The month during which the item was judged to be a potential solution to a given problem.

As technology was identified for application to specific problems, the information was fed back to the problem originator and other interested parties. The increase in public sector contacts during the latter months shown in Figure 1 of the program represent, for the most part, this feed-back activity.

TABLE I

CONTACTS WITH PUBLIC SECTOR AGENCIES

(i) Mine Safety

Federal	-	U.S. Bureau of Mines, Washington
		U.S. Bureau of Mines Research Laboratories, Pittsburgh, Denver
		National Academy of Engineering
Industrial	-	Bituminous Coal Operators Association
		Peabody Coal Company
Labor	-	United Mine Workers of America

(ii) Law Enforcement

Federal	-	Law Enforcement Assistance Administration
		U.S. Post Office Department
State	-	Illinois Law Enforcement Commission
		Illinois State Police
		Maryland Gov. Commission on Law Enforcement and Criminal Justice
		Maryland State Police
		New York State Office of Crime Control Planning
		New York State Police
		New York State Investigation and Intelligence System
Local	-	Chicago Police Department
		Los Angeles Police Department
		New York Police Department
		Chicago Fire Department
		Los Angeles Fire Department

(iii) Water Pollution

Federal	-	Assistant Secretary of the Interior
		Federal Water Quality Administration
		FWQA Research Laboratories Cincinnati, Ohio Ada, Oklahoma

Corvallis, Oregon
Athens, Georgia

<u>Local</u> - City of Dallas Sanitation Administration

<u>Industrial</u> - American Iron and Steel Institute
U.S. Soap and Detergent Association
American Petroleum Institute

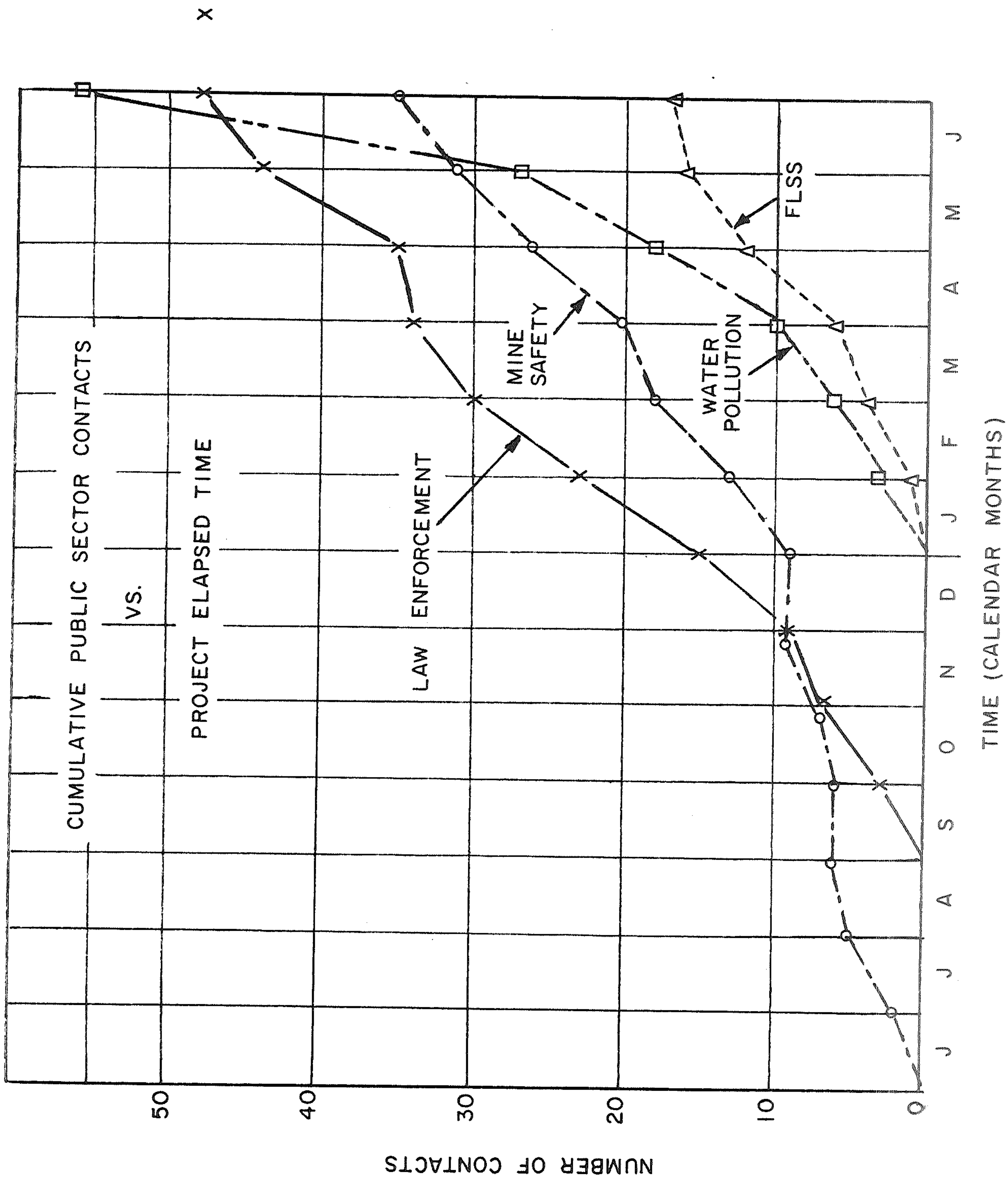
CUMULATIVE PUBLIC SECTOR CONTACTS
VS.
PROJECT ELAPSED TIME
LAW ENFORCEMENT
MINE SAFETY
WATER POLLUTION
FLSS
NUMBER OF CONTACTS
0
10
20
30
40
50
J J A S O N D J F M A M J
TIME (CALENDAR MONTHS)

FIGURE 1.

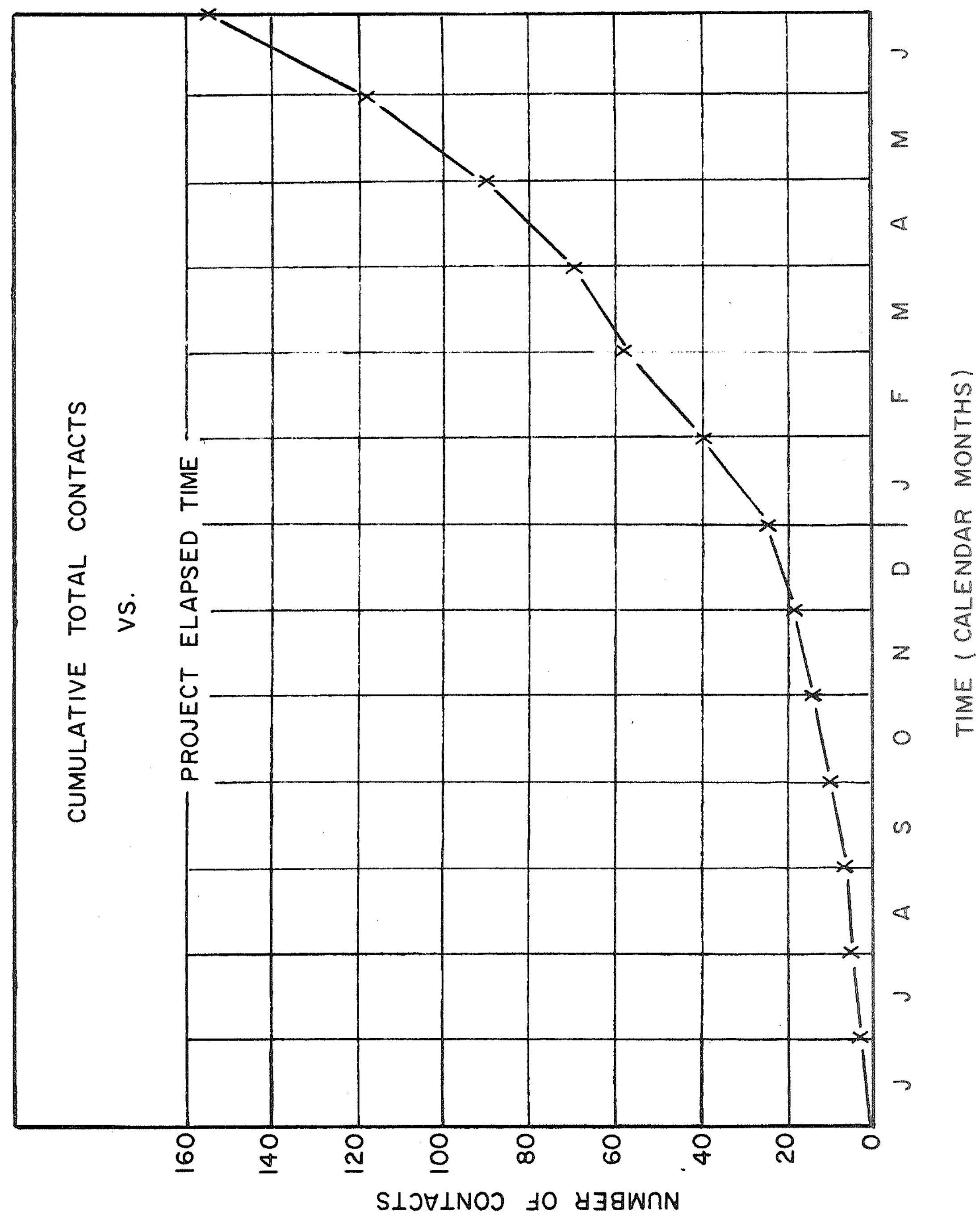
CUMULATIVE TOTAL CONTACTS
VS.
PROJECT ELAPSED TIME
NUMBER OF CONTACTS
0
20
40
60
80
100
120
140
160
J J A S O N D J F M A M J
TIME (CALENDAR MONTHS)

FIGURE 2

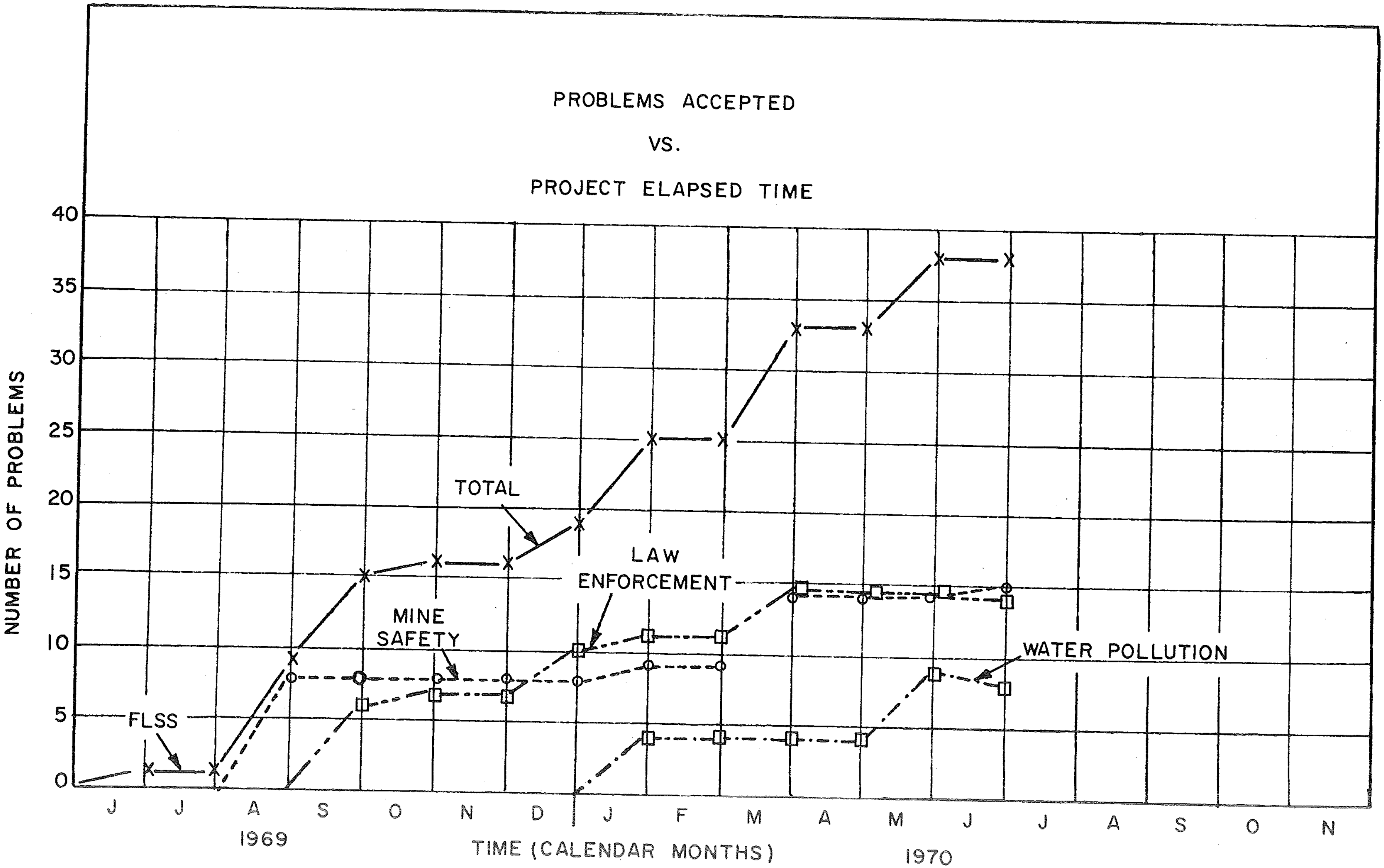
PROBLEMS ACCEPTED
VS.
PROJECT ELAPSED TIME
NUMBER OF PROBLEMS
0
5
10
15
20
25
30
35
40
TOTAL
LAW
ENFORCEMENT
MINE
SAFETY
WATER POLLUTION
FLSS
J J A S O N D J F M A M J J A S O N
1969
1970
TIME (CALENDAR MONTHS)

FIGURE 3

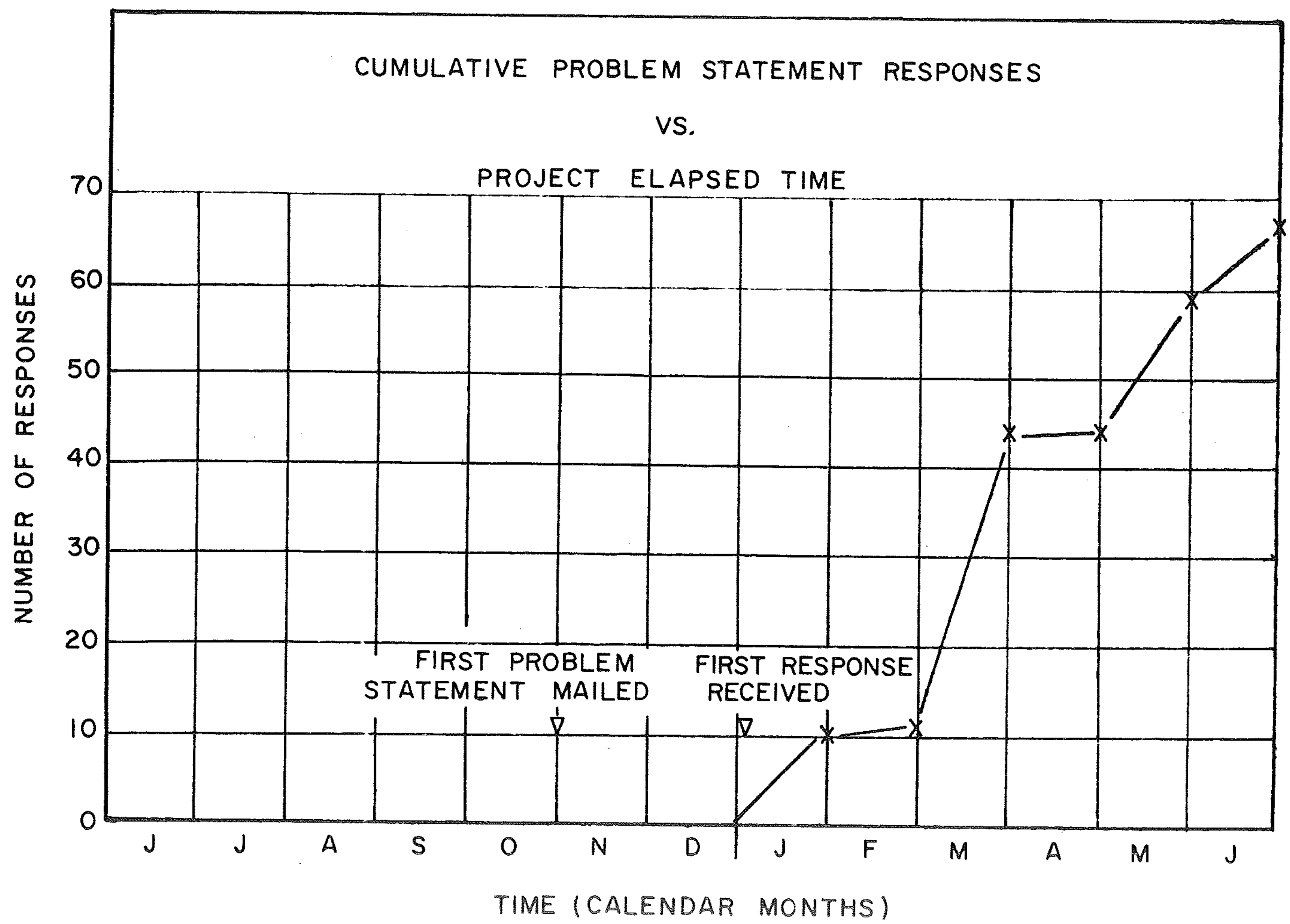
CUMULATIVE PROBLEM STATEMENT RESPONSES
VS.
PROJECT ELAPSED TIME
NUMBER OF RESPONSES
70
60
50
40
30
20
10
0
FIRST PROBLEM STATEMENT MAILED
FIRST RESPONSE RECEIVED
J
J
A
S
O
N
D
J
F
M
A
M
J
TIME (CALENDAR MONTHS)

FIGURE 4

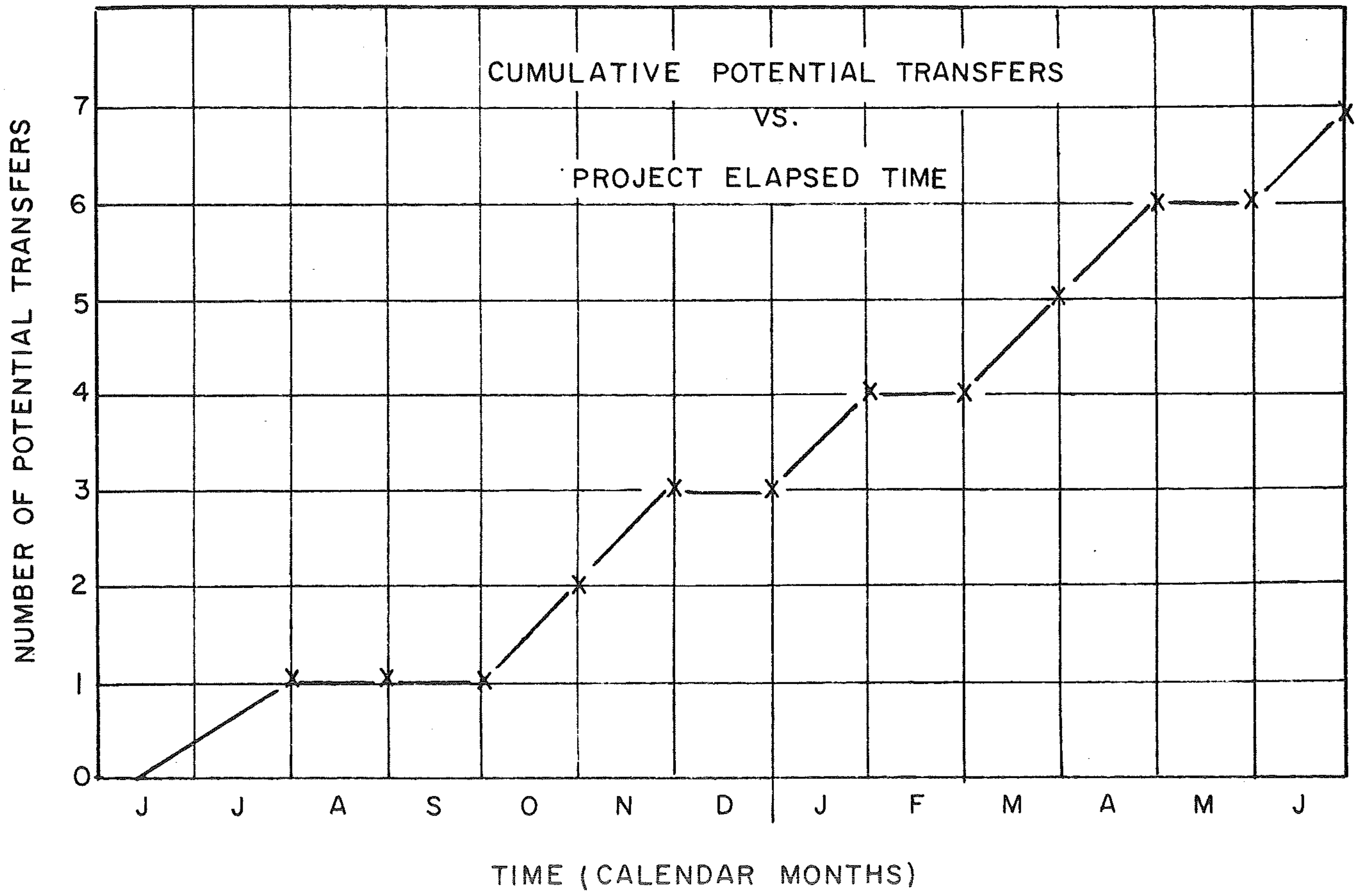
CUMULATIVE POTENTIAL TRANSFERS
VS.
PROJECT ELAPSED TIME
NUMBER OF POTENTIAL TRANSFERS
0
1
2
3
4
5
6
7
J J A S O N D J F M A M J
TIME (CALENDAR MONTHS)

FIGURE 5

VI. Conclusions

In the course of the year our work in pursuit of technology transfer proved to be a challenging but complex undertaking. No one can deny the vast technical resources of the aerospace community, and there is certainly no lack of problems to which these resources can be applied. But to do so effectively requires a great deal of imagination and perseverance. Based on the discussions in previous sections of this report, the following conclusions can be drawn:

On the TA Team Methods

1. The methods developed by the IITRI TA Team comprise an effective way of transferring aerospace technology to non-aerospace spheres of application.
2. To be effective, the TA Team needs to understand the special needs and constraints of the problem originator, and be familiar with aerospace terminology and the variety of resources available to the aerospace community.
3. Accurate and complete problem definition is critical to the success of the transfer process.
4. Problem acceptance criteria are essential for the efficient operation of the team.
5. While literature searching is useful in locating sources of technology, personal contact with the scientist or engineer responsible for the innovation is always necessary for the adequate communication of ideas.
6. For successful technology transfer, the technology must represent a practical solution to the problem concerned; and evaluation of this solution will be based on criteria which include environmental constraints, operating requirements, and cost.

7. Each item of technology representing a potential solution to a public sector problem will require its own unique transfer strategy.

8. There needs to be further experimentation with the specific steps in the transfer process if they are to be understood and their effectiveness raised.

On the Technical Accomplishments

1. The need for new technology in Mine Safety, Law Enforcement, and Water Pollution applications continues to be pressing.

2. In about 25 per cent of the problems accepted by the team, a solution was found from the aerospace technology.

3. The type of problem most amenable to a solution from aerospace technology involved some form of instrumentation.

4. The transfer of technology other than instrumentation might involve problems at the cause level - the cause of pollution, the cause of health hazards in mines - rather than the effect. The latter implies a monitoring function which demands instrumentation.

5. By the end of the contractual year, technical solutions were found for seven problems. These are in the early stages of transfer. Two other problems were solved using commercial devices, and aerospace technology is being evaluated for application to two additional problems.

6. The technical items identified as potential transfers in this report represent a potential market value of several million dollars. They will also effect an improvement in the health and safety of many miners and firemen, or assist in the apprehension of criminals and the location of sources of pollution.