Quarterly Progress Report No. 1

Covering the Period July 1 through September 30, 1969

ACTIVITIES OF THE NASA-SPONSORED SRI TECHNOLOGY APPLICATIONS TEAM IN TRANSFERRING AEROSPACE TECHNOLOGY TO THE PUBLIC SECTOR

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
TECHNOLOGY UTILIZATION DIVISION
ROOM 402, REPORTERS BUILDING
300 SEVENTH STREET, S.W.
WASHINGTON, D.C. 20546

Attention: MR. ROYAL G. BIVINS, Jr.
CODE UT

CONTRACT NASw-1992

STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025 · U.S.A.

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Objective

The primary objective of this contract is to apply the resources of an interdisciplinary Technology Applications Team (TAT) to plan, coordinate, control, and evaluate a program for optimizing the match between public sector user problems and potential solutions in the overall aerospace data bank. User problems in the fields of air pollution, criminalistics, and transportation are being studied. Emphasis is placed on users west of the Rocky Mountains. This initial Quarterly Progress Report contains information on activities from the contract starting date of July 1 through September 30, 1969.

The technical solution of a problem by use of aerospace-generated technology may not be a practical solution. Therefore, in the case of each Problem Statement with a technical solution, we need an implementation strategy, i.e., we need to document possible constraints imposed on the technical solution by the political, social, psychological, organizational, and economic environment. We can then evaluate the practicality of the solution. The implementation strategy for each problem, for groups of problems, or for an entire agency will be documented in regular reports.

SRI Team Components

Dr. Charles J. Cook, Executive Director, Physical Sciences Division, is Supervisor of the TAT . Dr. Lloyd P. Smith, Senior Scientific Adviser, Office of Research Operations, assists Dr. Cook and the other team members in an advisory capacity. Mr. William C. Thuman, Physical Chemist, is Director of the TAT and project leader for the studies in air pollution. He is assisted in the air pollution studies by Dr. Robert C. Robbins, Senior Physical Chemist. Dr. Aryeh H. Samuel, Program Manager, Criminalistics, is in charge of the work on criminalistics. Mr. Edward C. Wood, Director of Applied Programs, is project leader for the transportation studies, assisted by Leslie R. Parkinson, Engineering Management Specialist.

Visits to User Institutions

Visits were made to eight northern California user agencies to introduce the TAT function and to obtain a preliminary definition of problems that appear possible to solve by applications of aerospace-related technology. Discussions with personnel in user institutions in the fields of criminalistics, transportation, and air pollution are given separately below and are preceded by general background information to aid in evaluating the probability of successfully applying NASA-generated knowledge to the solution of discrete problems in the particular field.

Criminalistics

As a result of meetings held so far, as well as the TAT members' acquaintance with the criminalistics field, a preliminary treatment of the implementation strategy can be given.

First of all, it is necessary to understand the function and structure of criminalistics. Criminalistics is defined as the use of science and technology in the law enforcement process, primarily in the detection of criminal activity and the development of evidence to be used in judicial proceedings. It is practiced in police laboratories, which are staffed by civilians or uniformed personnel and headed by directors who report to the chief of police, sheriff, district attorney, or attorney general (state or federal). The largest laboratory is that of the Federal Bureau of Investigation. Only about one-sixth of the 100 laboratories have as many as 20 workers (including clerical and administrative personnel). There is no administrative link between laboratories.

Under these circumstances the most important aim of every laboratory director is to maintain his position of independence with respect to his superior, who is understandably eager for convictions. The laboratory director therefore emphasizes, to himself and to others, his status as an objective scientist immune to pressures from above. His emotional loyalty tends to be to his profession rather than to his organizational frame. (Of course he does feel great loyalty to his laboratory and his staff.)

It would not therefore be good strategy to try to impose cooperation on the laboratory director by working through his formal superiors. Their pressure could achieve a grudging cooperation at best.

Laboratories face many objective pressures. The most urgent of these is work load. Every year the number of cases demanding laboratory services rises. Some of this is routine (e.g., blood alcohol), some semiroutine (e.g., blood narcotics), and some of the work load consists of important cases requiring many hours of nonroutine work. Low budgets and unavailability of trained personnel make it difficult to meet this demand. Therefore, any laboratory director would welcome innovations that help him accomplish more per man-hour.

In addition, the police laboratory is often asked to do things that are not possible in the present state of the art. A very frequent demand is the analysis of tiny samples; another, the performance of analyses that cannot now be performed; others are of the type "when was this fingerprint (footprint etc.) made?" These demands can easily be refused, yet their existence and the director's professional pride make him look for ways to satisfy them.

In judging proposed technical innovations the laboratory director must decide whether it is justifiable to devote any of his limited resources to testing them. The probable future value must outweigh the certain immediate cost. In this decision he will be guided by:

1. His own scientific judgment about the validity of the method (most important factor). It is therefore imperative that the TAT and the laboratory director who is to try the new concept develop the method together.

2. The probable contribution of the concept (if successful) to the capabilities of the laboratory. The TAT team will ensure a positive judgment on this point by choosing problems suggested by laboratory directors.

3. The reputation and record of the organization proposing the innovation. The name of NASA counts for something here; criminalists are not accustomed to help of any sort and will initially accept it gratefully. But it is important for the TAT to acquire, as rapidly as possible, a good reputation as an innovator; this indeed will be the core of the implementation strategy. To do so TAT must choose the right problems; propose feasible solutions only; help with practical testing (e.g., SRI can offer use of facilities and personnel); and publicize successes, especially by papers in the professional literature.

Bureau of Criminal Identification and Investigation (CII), California Department of Justice, 3201 C Street, Sacramento, California 95816

Date of Visit: July 22, 1969

CII representatives: George W. Roche, Head, Criminalistics Groups, members of his staff: W. Jerry Chisum, Harry Johnson, Frances M. Evans, David Q. Burd, and Theodore R. Elzerman. Also present was a visiting Jordanian criminalist, Abdulrahman S. Attiyat.

TAT representatives: C. J. Cook, A. H. Samuel, and W. C. Thuman.

This criminalistics laboratory appears to specialize in firearms identification and arson. It also handles toxicology and other tasks but gets rather few cases of blood alcohol and drug samples. Work load is derived from local authorities and from state agencies such as Highway Patrol. The lab does research, and the TAT was particularly impressed by its work on the gas chromatography of fire residues.

The CII group members were questioned and expressed opinions about potential advances in criminalistics that might reasonably be expected from NASA-developed technology. They were extremely interested in the Technology Utilization Program.

Emphasis throughout the discussion was on the individualization of evidence. This applies to traces of people and of objects. With regard to people, it is very desirable to get individual signatures from bloodstains and other physiological residues. These criminalists attempt to get such signatures by immunoelectrophoresis, which responds essentially to individual medical/immunological history and may eventually give an identification.

Other biomedical techniques that would be helpful are: olfactronics (as applied to breath, drug samples); voiceprint (some work on this is going on); and thermoluminescent analysis (marketed by Optics Technology as "Biosignet").

A major problem of analysis is the introduction into a material of new components (e.g., pyrolytic products in arson samples and metabolic products in blood drug samples) that hinder comparison with reference samples.

Another major problem of criminalistics is the collection, updating, and accessibility of reference sample libraries. This involves not only each product but each batch of a product (e.g., paint), and at present looks very difficult.

TAT was given several instances of collections that are valueless because they have not been kept up to date (tail lights, prescription pills). In other cases (headlights, gun barrels) there are problems due to changes in the manufacturing process.

A highly desirable technique would be one that allows reflectance spectrophotometry of very small specks, such as auto paints and inks.

Very little has been done with electron microscopy, which may offer help in the individualization of biological and product samples.

Another promising area is the use of modern techniques for visual comparison. Mentioned were computerized correlation, Fourier transforms* and holography. The objective is to eliminate using the human eye for comparisons of fingerprints, bullets, toolmarks, signatures, etc. Here also NASA technology should be highly applicable.

There was also considerable discussion of evidential value and the need for theoretical systematization of probability theory as applied to it.

Laboratory of Criminalistics of Santa Clara County, 875 North San Pedro Street, San Jose, California 95110

Date of Visit: July 30, 1969

Agency representative: Lowell W. Bradford, Director

NASA representative: R. G. Bivins, Jr.

TAT representatives: A. H. Samuel and W. C. Thuman

Among the problems discussed that might be helped by NASA technology were the following:

Coatings for ink in questioned documents. In documents it is often important to determine which of two crossed lines was written first. This could be done by microscopy when liquid inks were used, but is impossible with ball point inks that flow less. Scanning electron microscopy

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* See Anal. Chem. 41, 97A (May 1969).

was tried. This did not work but the gold coating applied aided visual microscopic determination of priority. A nonreflective thin coating that will do the same without glare is desired.

Preservative for vaginal swabs. Many such swabs are received from examination of complaints. However, relatively few complaints (20 percent) develop into rape prosecution as complainant normally withdraws complaint. To examine all swabs would therefore be wasteful and costly. It takes a month to tell whether there will be a prosecution. Four days is the current limit. The tests made are visual (spermatozoa) and biochemical (acid phosphates in seminal fluid). Enzyme preservatives interfere with the latter. Freezing is not practical. A preservative is needed that will allow the tests to be made on the relevant samples after one month's storage.

Mass spectrometry. Mr. Bradford wanted to know what is the optimum mass spectrometer system to use in a crime lab for data handling for the gas chromatograph-mass spectrometer (GC-MS) combination. He is currently using a Bendix ballistic-type MS, which requires much time for analysis. This is a general problem and is not restricted to criminalistics. He also wants mass spectra of drugs--no compendium seems to exist. Similar problems will arise when the MS is used for other criminalistic purposes such as pyrolysis.

Blood grouping analysis. It is very important to find a way to determine blood immunological factors (other than the A, B, O, AB classification that can be done) in dried blood and in blood stains. It would also be most important to extend this to other physiological samples, especially hair. At present, practically no individualization of hair is possible.

Another not specifically criminalistic problem is automatic retrieval of infrared (IR) spectra.

A device is desired that will trap ethanol from the breath and release it on demand later into the breath analyzer. The device should not require refrigeration or power. Calcium chloride has been tried but gives false positives.

Transportation

We have encountered three general classes of situations in contacting transportation agencies. These are illustrated by the Bay Area Rapid Transit District (BARTD), AC Transit, and California Division of

Highways. The last is by far the simplest case. It is a generously funded agency with continuing, real problems and a history of success in devoting substantial sums to research and development. The agency understands the opportunity presented by the TAT, identifies discrete technological problems readily, and has the money and technical capability to implement good solutions.

The large public bus transit agency, on the other hand, is a deficit operation unable to pay all of its operating costs from the fare box. This is not a critical observation about one agency; the condition is general throughout the United States. The best ones, like AC Transit, are willing--even anxious--to try technological ideas that would improve their operations, but they can do so only for low cost ideas. AC has equipped less than half its vehicles with two-way radio (which is hardly a technological innovation in 1968) and is only beginning to recognize the benefits that two-way radio can provide in control dispatching. Bus location and dispatcher's display systems that would make Dial-a-bus or flexible scheduling possible are far in their future without outside initiation, funding, and sponsorship of the necessary development.

That outside impetus exists and is primarily federal; its main source is the Urban Mass Transportation Administration (UMTA) of the Department of Transportation. It appears that a most effective route for technology transfer to make an impact on urban bus transportation is through the R&D contractors of this agency.

To an important degree, the same is true of the rail transit industry. Operating systems are generally deficit agencies. The R&D support of the rail industry is either private or federally funded. Despite the deficit experience of most operating systems, their importance to the development and renewal of inner cities is so great that new systems will be built. San Francisco's is well known. Washington, D.C., is initiating construction contracts. To these new systems, not yet fully designed or built, there should be many opportunities to transfer technology. The route is more difficult, however. The problem solution, whether construction method or design, is ultimately the responsibility of the private contractors whose bids have been accepted by the agency. The immediate benefit of a solution may be collected by the contractor; the ultimate public benefit may not be realized until the next system is built.

One facet of the construction technique for these systems appears to have special potential for both technology transfer and ultimate public benefit: tunnel excavation. There is substantial federal interest in this topic in the U.S. Bureau of Mines, UMTA, Bureau of Reclamation, and the Office of High Speed Ground Transportation in DOT. Some NASA technology--in remote systems and in bulk cryogenic fluids, particularly--appears applicable to those types of tunnelling where a compressed air heading is now used. If so, a joint federal-local, agency-contractor demonstration would ultimately be needed to develop them. (We hope to explore the interest and opportunity for such demonstrations during the Second Symposium on Rapid Excavation in Sacramento, October 16 and 17, 1969.)

Bay Area Rapid Transit District (BARTD), 814 Mission Street, San Francisco, California 94103

Date of Visit: July 29, 1969

BARTD representatives: E. John Ray, Manager, Operations; Earl A. Tillman, Manager, Engineering; and Paul McCutcheon, Chief of Design

NASA representative: R. G. Bivins, Jr.

TAT representative: E. C. Wood, L. R. Parkinson and W. C. Thuman

Although BARTD is not yet operating, it embodies the only recent experience in design and construction of a mass transportation system in the United States. Many of the problems solved in the course of building the system will serve as models for systems to follow, and the application of NASA technology might have appreciable impact on the cost or efficiency of future systems.

As soon as BARTD considers it appropriate, SRI and BARTD representatives will meet to explore the immediate and future application areas for NASA technology. The discussion will include the identification of discrete, important, definable technological problems.

The TAT will also contact Rohr Corporation, which was recently awarded the contract to manufacture BART cars, and when appropriate will contact Parsons, Brinkerhoff, Tudor, and Bechtel for further identification of discrete problems. This joint venture is the BART engineering contractor.

Although few discrete problems were defined at the preliminary meeting, the following problem areas that might benefit from use of advanced technology were discussed: coating for aluminum surfaces; nondestructive test for deterioration of aluminum coating; improved glass for windshields; derailment detector; automatic derailment control device; advanced, economical tunneling techniques; seismology instrumentation to identify motion in tunnels; in connection with trans-Bay tube construction; underpinning to support buildings adjacent to tunneling; use of strain gages to predict nature of soils and rock masses; information display for visual aid to passengers; and solution of many technological problems associated with extensions of system into the Oakland Airport and later into the San Francisco Airport.

AC Transit District, 508 - 16th Street, Oakland, California 95612

Date of visit: August 12, 1969

AC representative: Mr. E. Sam Davis, Manager, Research and Planning

TAT representative: L. R. Parkinson

The Technology Utilization (TU) Program was explained to Mr. Davis, who was very receptive. We are free to call him any time. AC has some problems that may be of interest. First, there is the bus location problem. All buses have radios, but the bus may not be where the driver says he is. Reported locator systems are not yet available. Second, AC has no way of knowing the "fare mix." A survey is made about once a year, but the cost ($2.00/driver/hr extra) is too much. AC cannot tell whether the 60¢ dropped in the box is for one passenger (long distance) or four school children at 15¢ each. Putting a counter on the step still does not tell. AC has about 40 different kinds of tickets that have to be sorted and counted according to route. What AC needs is a machine that will sense the kind of ticket and record the face value. The interface with BART schedules and tickets is a problem that must be figured out. AC drivers are free to pass busses that are heavily loaded or taking most of the passengers, but they don't. If there were a locator, the dispatcher could issue instructions. Getting passengers on and off the bus at a reasonable rate is another problem; some drivers can hurry passengers along but others can't.

California Highway Patrol, 2611 - 26th Street, Sacramento, California

Date of visit: August 25, 1969

CHP representative: Inspector J. D. Lowe, Commander-Safety Services Division

TAT representative: L. R. Parkinson

The NASA-TU Program was explained and Inspector Lowe will meet with his various section heads to determine how they want to participate.

CHP has several problems, among which is that of locating highway patrol cars. The patrol cars check in at intervals but the in-between operations are unknown. CHP needs a display in each section office showing the location of each CHP car at all times. The large number of passenger cars in California has precluded regular safety checks. The CHP has to rely on spot checks and has little or no control of cars between checks. The CHP has an exhaust sniffer for emission checks but not much sophisticated equipment.

Division of Highways, Materials and Research Department, 5900 Folsom Blvd., Sacramento, California 95819

Date of visit: September 16, 1969

Agency representatives: John L. Beaton, Department Head; George Sherman, Assistant; and Wallace H. Ames, Assistant Materials and Research Engineer

TAT representative: L. R. Parkinson

Mr. Beaton assembled his section heads and the NASA-TU Program was explained. They already had a list of many problem areas, but decided it would be more helpful if they would subsequently give more detailed information, specifically: background, nature of the problem, and restraints and requirements.

The M and R Department has a number of very interesting requirements such as determining pavement thickness without coring, coating steel bridge structure, crash barricades, etc.

Mr. Parkinson made a detailed tour of the laboratories, which appear to be doing a good research and development job with modern equipment. For example, these labs developed the adhesive used for securing the highway lane divider reflectors to the highway surface.

As a result of this meeting, the Division of Highways has submitted 38 discrete problem areas for the TAT's consideration.

Air Pollution

The pollution of our environment has created a wide variety of technoeconomic problems for industry and government, and public pressure is increasingly being applied to improve and conserve our resources while permitting technological progress. Air pollution is a particularly active field for NASA participation in solving problems of concern to public sector agencies. State Departments of Public Health and the larger air pollution control districts, such as those of the San Francisco Bay Area and Los Angeles County, have a number of discrete and pressing problems relating to monitoring and abatement of emissions, atmospheric reactions of pollutants, development of instruments and facilities for studies of atmospheric reactions, meteorological aspects of air pollution, and studies of the effects of pollutants on biological systems and materials. These agencies--there are several hundred of them in the United States--have limited budgets for research and development and must look to other public agencies, such as the National Air Pollution Control Association (NAPCA), for solutions to many of their problems.

In addition, their budgets for monitoring and research instrumentation are severely limited, while their needs for such instruments are critical. They therefore tend to be very cooperative when help is offered on a basis such as that of the TU Program, and there is a high level of probability that new, practical approaches to solving air pollution problems can be developed through use of the NASA technological resources.

Bay Area Air Pollution Control District (BAAPCD), 939 Ellis Street, San Francisco, California 94109

Date of visit: July 29, 1969

BAAPCD representative: Dr. Milton Feldstein, Director, Technical Services

NASA representative: R. G. Bivins, Jr.

TAT representatives: R. C. Robbins and W. C. Thuman

Dr. Feldstein has been with BAAPCD for many years and is highly qualified to evaluate public sector needs in the field of air pollution control, particularly the needs of BAAPCD. This large (about 4,000 square miles), pioneering district presently includes the counties of Alameda, Contra Costa, Marin, San Francisco, San Mateo, and Santa Clara. Although its jurisdiction is limited to the control of stationary sources, BAAPCD works closely with the State of California Motor Vehicle Control Board.

Mr. Bivins provided a briefing on the NASA-TU Program, including details on a cooperative effort between the NASA Technology Applications Team located at the Research Triangle Institute, North Carolina, and the National Air Pollution Control Association to solve air problems by using aerospace technology.

Dr. Feldstein showed a high level of interest in the TU Program. The following critical problem areas were discussed and were subsequently ranked in respect to relative importance to the District. In summary, large numbers of sensitive, rugged monitoring instruments are needed. The cost must be low: less than $1,000 each.

- Measurement of stack effluent has the highest priority and must be accomplished at low cost. The development of a sensitive, objective method to measure plume opacity for subsequent control of submicron particles is of particular importance. The "Ringlemann" scale is employed in the present, standard surveillance method. It is relatively insensitive and is a subjective measurement because it is based on the observation of a plume compared to a standard. The number of sources is increasing at a rate that will soon require all plumes to measure no more than about 1 on the Ringlemann scale: an indication of a very "light" plume principally containing particles in the submicron range. This range is particularly difficult to measure by the present method.

- A method is needed for continuous identification and measurement of the size distribution of airborne particulates to correlate with visibility reduction caused by photochemical smog and nonreactive particulates. Although these particulates--again in the submicron range--arise primarily from autos, the District must determine what fraction of the particulates arises from stationary sources. The device must therefore determine the chemical composition of the cloud as well as the concentration and size distribution of particulates. An array of these instruments is necessary to obtain statistically meaningful data. The instrument should be lightweight and portable, and should be designed so that data can be transmitted continuously to a central station.

- Improved instruments are needed for monitoring gaseous pollutants--particularly reactive "hydrocarbons" and nitrogen oxides. Reactive hydrocarbons are those hydrocarbons important in photochemical air pollution reactions and include aldehydes, olefins, and substituted hydrocarbons. Again, the need is based on the District's requirement to monitor and control effluents from stationary sources, and an array of the instruments will be required to obtain statistically significant results. In addition to being rugged, portable, and remote sensing, the instruments must be sensitive in the fraction of a part-per-million range.

- The continuous determination of temperature, wind speed, and wind direction within the first two kilometers of the atmosphere is essential for improved forecasting of air pollution conditions. No reasonably inexpensive method is presently available for this structure analysis, and the size and heterogeneity of the District's atmosphere is such that at least ten instruments would be required to obtain reasonable forecasting data. The instruments must be designed for continuous transmittal of data to a central station.

- A method is needed to implement the qualitative and quantitative analysis of odors. At the present time only a few odors can be satisfactorily characterized.

- Parallel to the need to measure "light" stack plume's opacity accurately is the need for methods to remove submicron particles from stack effluent. This is a very difficult problem, but one which must be solved.

Air and Industrial Hygiene Laboratory, California Department of Public Health, 2151 Berkeley Way, Berkeley, California 94704

Date of visit: July 30, 1969

Agency representative: Dr. Peter Mueller, Director

TAT representative: Dr. Robert C. Robbins

Dr. Mueller was very interested in this mission. He hoped that the NASA Technology Utilization Division might even help the A.I.H. Lab with its need for newer, faster methods of data reduction.

He outlined six problems in air pollution and four in the biomedical air pollution area on which he feels work should be initiated or pressed further. The problems in air pollution are: a continuous measurement system for airborne particulate on a mass basis; methods for identifying particulate sources; methods for identifying carbon sources in collected particulate sample, i.e., inorganic carbon, carbon from photochemical smog aerosol, carbon from rubber aerosol, etc.; methods for identifying biological particles in air (pollen, bacteria, etc.); methods for measuring trace gases in closed circulation chamber atmospheres; and methods for the utilization of luminescent bacteria in air pollution studies.

The biomedical problems associated with air pollution are: methods for preclinical indication of intoxication from air pollutants; methods of measuring oxygen delivery rates to the tissues; information on lung metabolic processes; and information on mechanism of histamine release in the body.

Dr. Mueller felt that it would be a great help if he and his counterparts in the other public agencies were to receive instruction in the art of problem stating in the proper form for their optimum utilization of the NASA information bank.

Problem Statements

Nineteen problem statements were prepared on the basis of these meetings. They are given on the following pages. References are not given because a computerized literature search of NASA's aerospace information bank has not yet been performed.

SRI/C-1
September 1969

PROBLEM STATEMENT

"Measuring Reflection Spectra of Very Small Samples"

What Is Needed

A means to measure reflection spectra of very small samples.

Background

A frequent problem in criminalistics is to identify an automobile from a small amount of paint left by it on an object it has scraped. This applies primarily to the investigation of hit-and-run cases, but such scrapings also occur when a getaway is made by a car from a terrain with which the driver is not familiar. Sometimes several square centimetres are left; sometimes only about a square millimetre. The paint can serve to characterize the make of car and sometimes year and model. At present only visual characterization is possible.

Obtaining a complete reflection spectrogram, at least in the visible and possibly also on either side of it, would help this characterization because many more points of resemblance with and difference from authentic samples could be determined.

Constraints and Specifications

Cost will be a factor. Ideally, an attachment to an existing spectrophotometer that costs not more than $1,000 is desirable.

Technical problems may include reflections from the base material beneath the paint.

Since some paint scratches are on immovable objects, portability of the test instrument would be desirable. (However, it is usually possible to cut away a sample.)

The museum of comparison samples or spectra does not yet exist, but could be assembled rather quickly if the method proved practical.

Note: Please respond with nonspectral or even nonoptical methods of characterization if you can think of any.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

A possible solution would be a spectrophotometer that could take reflection spectra of very small samples. For example, this could contain an intense white source, a black velvet chamber to hold the sample, a wide-angle lens to collect all reflected light, and a system of lenses to feed this light into the monochromator as a parallel beam.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

SRI/C-2
September 1969

PROBLEM STATEMENT

"Determining Immunological Properties in Physiological Materials"

What Is Needed

Materials are needed for determining immunological properties (in addition to simple blood groupings) in physiological materials, particularly in dried blood and blood stains.

Background

Blood stains and dried blood are among the most common items of physical evidence left behind by criminals. Many types of immunological classification (in addition to the simple A-B-AB-O blood grouping) are known for liquid blood. If these classification methods could be applied to blood stains and dried blood, detection and conviction of criminals would be aided.

At present, blood groupings can be determined. However, even the rarest of the four classes still has millions of members in the United States alone. Thus, while this analysis can furnish important negative evidence (a suspect's blood belongs to a different class than that left behind and he is therefore innocent--assuming that there was only one criminal and the blood stain is definitely associated with him), it is of very little value for finding and for convicting the guilty. By adding a number of other classification types, the size of the class of possible donors can be greatly reduced. This will greatly strengthen both the negative and the positive evidential value of the blood residue or stain.

In addition, it would be helpful to be able to determine similar groupings in other physiological materials, primarily in semen.

Constraints and Specifications

Any test must have high reliability. The presence of other organic material (textiles, etc.) must not interfere. The cost of apparatus and the required amount of labor will be important factors.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

A method for taking up dried blood into a liquid medium in such a way that immunological tests can be run by conventional methods; a modification of immunological tests so that they can be applied to dried blood in situ, and indication analogous to agglutination that can be observed in the dried blood; and an immunoelectrophoretic approach.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

PROBLEM STATEMENT

"Enhancing of Contrast on Questioned Documents"

What Is Needed

A nonreflective thin coating is needed to enhance contrast on questioned documents.

Background

In the study of disputed documents the question frequently arises which of two crossing lines was written first. When liquid inks were in common use, the flow of ink from the later line into channels made by the passage of the earlier nib could determine the answer. Since the much more viscuous ball point inks have come into use, this method no longer works. An attempt was made to determine priority by examination with a scanning electron microscope. This did not work, but it was found fortuitously that the thin gold coating that was applied in this process made a visual (microscopic) determination of priority possible. The mechanism is not fully understood, but possibly the gold coating accentuates minute ridges (less than 1 micron in height) on the edges of the ink trace; the unbroken ridge is the later one. A drawback of using gold is that its specular reflection makes microscopic examination very difficult; an optically dull substitute is desired. An acceptable solution to this problem would provide a new standard method for document examination.

Constraints and Specifications

Particle size of the covering must be well under 1 micron--probably less than 500 angstroms. This applies both to settling particles and to agglutinations of atoms or molecules from vapor. On the other hand, some agglutination is required so that the surface is not shiny.

Cost is a factor. Although vacuum evaporation in a bell jar is perfectly feasible for larger criminalistics laboratories, a method not requiring vacuum would be accepted more readily by smaller laboratories.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

Vacuum evaporation of a nonmetal or metal that does not give a shiny surface. Possibilities: carbon, silicon, arsenic, iron.

Deposition of a precipitate from a gas + gas - solid reaction. Possibilities: NH_3 + HCl - NH_4Cl - H_2S + oxidized - S.

Deposition of a precipitate from an aerosol spray.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

SRI/C-4
September 1969

PROBLEM STATEMENT

"Preserving Vaginal Swabs"

What Is Needed

A preservative that will not interfere with tests for semen is needed for vaginal swabs.

Background

Whenever a complaint is made that involves a possible prosecution for rape, a vaginal swab of the victim is secured. Experience shows that only a small fraction of the complaints develop into rape prosecutions. It would therefore be wasteful and prohibitively expensive to examine all these samples immediately. The time needed to determine whether the sample should be examined is about one month. It would be desirable to preserve the samples so that they can be examined when indictment is being considered.

The tests made are visual (microscopic examination for spermatozoa) and biochemical (test for acid phosphatase activity).

Freezing the samples has been suggested but is not an optimal solution.

A preservative is desired that would allow the samples to be maintained at room temperature and the tests to be performed at the end of the period (upper limit probably around four months).

Constraints and Specifications

It should be remembered that other materials may also be present: cotton gauze or equivalent, vaginal secretions, possibly blood, possibly petroleum jelly.

The method should be easy to apply and should certainly require much less labor than the examination, as otherwise it would be simpler just to examine samples as they come in.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

A chemical or biological preservative that will interfere neither with the visual nor the biochemical examination.

A new test for semen that does not require preservation of the sample.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

SRI/C-5
September 1969

PROBLEM STATEMENT

"Characterizing and Individualizing Hair"

What Is Needed

Methods are needed to characterize and individualize hair.

Background

Among the most frequently found items of physical evidence are samples of hair. In many cases it can be proved or shown to be likely that the hair was left by the criminal. At present, it is not possible to establish positive identification on the basis of hair. Its color, diameter, shape of cross section, curvature, and surface characteristics (scale pattern) can be observed, but these yield only a broad (in part racial) classification. This permits negative conclusions (e.g., a given suspect is dark-haired and could not have left a blond hair) but is not very helpful either in finding the criminal or in positively identifying a suspect. It would be very helpful to have more specific methods of relating hair samples to individuals. The easier problem is to establish that his hair is the same as the sample hair, but that the points of resemblance are such as to exclude or practically exclude the possibility that another person's hair would also match the sample. The harder problem is to describe the individual or certain aspects of the individual (e.g., his medical history) on the basis of the analysis of the hair so as to help identify and find him.

Constraints and Specifications

The method must be applicable in a rather modest laboratory with time, money, and staff qualification constraints.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

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Considerable work has been done on nuclear activation analysis (NAA) of hair. This is expensive and inconvenient; more importantly, there is not as yet a large enough study of NAA characteristics of the general population, so that it is not known how distinctive an NAA spectrum is. Information on NAA characteristics of hair (i.e., variation of trace element content) would be valuable.

Electron spin resonance (ESR) spectrometry of hair, with or without prior X-ray irradiation, has been suggested but not used. Information on individual variation of hair ESR spectra is solicited.

Probably more promising than either of the first two approaches would be a biochemical or immunological approach. Any data on immunological characteristics of hair are solicited (e.g., can the blood group be determined); also information on individual variation of amino acid content and other constituents.

New concepts are evidently needed.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

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PROBLEM STATEMENT

"Using Electron Microscopy in Individualizing Biological Samples"

What Is Needed

Techniques employing electron microscopy should be developed as an aid in individualizing biological samples.

Background

In many criminal investigations, part of the physical evidence left at the scene of the crime is biological in nature. Roughly in decreasirg order of frequency one finds blood (often dried and/or absorbed), hair, skin, semen, saliva, etc. This evidence provides a direct link to the criminal, and it would be most desirable to utilize it to establish his identity: (1) to use this evidence to confirm the criminal's identity once he is caught, i.e. to establish that it and authentic sample come from the same person, and (2) to infer from the sample characteristics of the criminal that will aid in his apprehension. The last is most difficult. Each stop requires that the sample be characterized uniquely so as to differentiate it from equivalent samples derived from any other person. Chemical and microscopic methods are generally insufficient to accomplish this (rare exceptions: very unusual pathological conditions evident in the samples). This leaves immunology (considered in another problem statement), electron microscopy, and perhaps other techniques.

In this problem statement we seek observations of the above biological materials, made by any kind of electron microscopy, that have determined variations between samples from different donors, but samples from the same donor show consistent similarity. Each such variation that is discovered divides mankind into two or more classes. A sufficient number of identifiable characteristics (at least 30) would permit unambiguous identification of individuals to accomplish the first aim. Correlation of the characteristics with external observable characteristics would allow description of the donor and thus accomplish the second objective.

Constraints and Specifications

To have criminalistic value, any variation must be individualized, and all samples from an individual must show this variation.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

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PROBLEM STATEMENT

"Automatic Comparison of Objects and Photographs"

What Is Needed

Techniques should be developed for the automatic comparison of objects and photographs, with special application to fingerprints, bullets, tool marks, signatures, etc.

Background

A very typical activity of the criminalist is the comparison of a standard and an unknown object to confirm their identity or lack thereof. The examination may be made on the object itself (e.g., bullets in a comparison microscopy) or on a photograph, which is often magnified. A sufficient number of correspondences is sought to prove identity; alternatively, deviations will show nonidentity. For further detail, see J. W. Osterburg's "The Crime Laboratory: Case Studies of Scientific Criminal Investigations" (Indiana University Press, Bloomington, Ind., 1968; available in paperback), which is largely devoted to visual comparisons and has outstanding photographs and examples.

Visual comparison is extremely tedious and time-consuming and it would be most desirable to perform it automatically. With the development of optical character readers and other types of scanning equipment, this appears within the bounds of possibility.

Part of the problem is that an overall identity ("gestalt") rather than identity of detail needs to be established. For example, fingerprints may vary in the area of the fingertip that is covered, as well as in angle of presentation, scale (due to variations in pressure), intensity, etc. Bullets fired from the same gun may retain whatever points of difference they had before firing. Handwriting samples from the same hand show variations as well as similarities. It is desired to pick out those points that are important in determining identity (e.g., topology of fingerprint pattern) and to ignore those that are accidental or incidental. On the other hand, the instrument need not make a final decision. It will be sufficient if it is capable of screening out the majority of comparison samples that are definitely not identical to the unknown sample, leaving a small number for final determination by the expert.

Constraints and Specifications

In addition to the inherent problems of comparison that have already been mentioned, there are expected to be mechanical and optical problems as well as reliability problems. Cost will be a factor but should not be considered initially.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

One approach that appears promising because it deals with the overall characteristics of an image is that of the Fourier transform. A hologram is in effect a Fourier transform of an image, and digital representations of such transforms might be compared automatically.

Other possibilities include analog methods, such as superimposition of a positive of the unknown and a negative of the standard and adjusting to minimize the transmission of light. In all cases, the method must permit translation and rotation of the images with respect to each other and, in some instances, change of scale.

For further information or discussion contact

Dr. A. H. Samuel, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3594

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PROBLEM STATEMENT

"Determining the 'Fare Mix' on Buses"

What Is Needed

A method is needed for determining the "fare mix" on buses.

Background

Bus line companies can determine the revenue from each line by segregating the fare boxes, but they would also like to know the makeup of the fares. Is it one passenger on a 60¢ ride, or four school children at 15¢ each? One person paying for two or more (such as a woman with children) precludes a coin box that will record the amount of each fare. For instance, on AC Transit more than 40 different kinds of tickets are used although all are the same physical size. About half the number of tickets are in monetary denominations, and the others are special for school children, etc. Transfers and tokens are also used. Although a step counter can indicate the number of people getting on the bus, there is no way of knowing the intensity and type of passenger by zone, a requirement for intelligent bus allocation and routing. Once a year a survey is made but the expense is high. Further, the driver/surveyor method may not be too good so that all surveys are relative if not precise.

The problem will be further complicated with the BART (Bay Area Rapid Transit) interchange because AC has no way to handle the BART magnetic tickets.

Constraints and Specifications

Any change of system requires years to effect. Tokens come in forever and complicate subsequent fare change (increase) structures. Other limitations (real or imaginary) may arise as the study proceeds in depth.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

The obvious solution would be to revise the fare collection system and eliminate tickets. However, with an exact fare system, tickets and tokens are a hedge for a passenger who might not have the correct change and no way to get it.

Tickets can be magnetically coded (in the ink) and sorted, as are letters in the Post Offices. The BART magnetic ticket costs 3¢. AC cannot afford this so the identification must be inexpensive. The approach on this might be a study to compare present cost of tickets, plus the sorting and accounting costs, plus the annual passenger survey with the cost of the new ticket, plus the automated sorting, plus the benefits that accrue from a continual knowledge of the operations. It might be that the ticket printing costs are relatively unimportant.

A receipt printer operated by the driver could include zone area and type of passenger, but this is time consuming.

A passenger type count might be integrated with a bus locator system.

Ingenuity is required in order to know what to look for in the NASA-TU data bank.

For further information or discussion contact

L. R. Parkinson, Stanford Research Institute
Area Code 415, 326-6200, Ext. 4478

or

E. C. Wood, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3652

PROBLEM STATEMENT

"Producing a Bus Locator"

What Is Needed

A method is needed for locating buses along the route.

Background

Although this locating problem applies to trains, it is more urgent for buses because the dispatching can be varied to meet unforeseen peak passenger loads. Some transit system operators have no knowledge of bus location or conditions being encountered along the routes; other operators that have radio-equipped buses know only what the driver reports. It is reported that the bus is not always where the driver says it is. Also, there is no way of knowing how precisely the schedule is maintained. If the dispatcher knew the relative positions of each bus, he could reroute or accelerate the system (by rescheduling stops or having a close following bus take the lead). Driver initiative in this type of action is not uniform.

Constraints and Specifications

The radio companies (Motorola, etc.,) that are working on locators may soon develop a system. In any case they should be aware of NASA technology and not require SRI assistance.

The expense of a locator system might be too high although it may be that the transit people do not know the real worth of knowing bus location and condition. A study should be made to determine how much they can afford to pay.

Possible Solution

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

Several systems (sensors in the road, on poles, etc.) are in various stages of development, but it is reported that none are practical as yet. The ideal system is one that would indicate not only bus location but also passenger loading.

A coded signal could indicate bus location, and a compact TV camera in the bus could give the dispatcher a visual picture of the bus-loading condition. It might also be a security aid.

Some mass detection technique might indicate passenger volume.

A differential counter (people on minus people off) might be converted into a signal and combined with the bus locator system.

For further information or discussion contact

L. R. Parkinson, Stanford Research Institute
Area Code 415, 326-6200, Ext. 4478

or

E. C. Wood, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3652

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PROBLEM STATEMENT

"Developing a Derailment Detector"

What Is Needed

A device is needed to detect derailment of high speed cars.

Background

The need is for a device that will detect derailment at the moment of occurrence and will shut off the power to prevent continued propulsion of the derailed car by the remainder of the train. Derailment is likely to occur if a wheel flange breaks or if the track surface is impaired as at a switch or crossover. A second factor is an obstacle on the track. The latter is more remote, although still possible, by fencing the ground level right-of-way.

Constraint and Specifications

Snow or ice may prove to be a problem for some devices. The chief limitation seems to be the lack of an ingenious method.

Possible Solutions

(Note: This section is illustrative only and is not intended to bias other solutions or avenues of approach.)

A frangible device of some sort has been tried but apparently it was not satisfactory.

A track follower on each truck could indicate when the truck deviated from the rails and then shut off all propulsion power.

A device that would be actuated by hitting the rail when the wheels dropped to roadbed level.

For the obstacle on the track, a laser beam system is possible. The RCA system is reported to cost $500,000 per mile. Possibly one that is carried on the truck is possible except that it would be no good on curves or switching areas.

<u>For further information or discussion contact</u>

L. R. Parkinson, Stanford Research Institute
Area Code 415, 326-6200, Ext. 4478

or

E. C. Wood, Stanford Research Institute
Area Code 415, 326-6200, Ext. 3652

William C. Thuman, Director
Technology Applications Team

Approved:

C. J. Cook, Executive Director
Physical Sciences Division