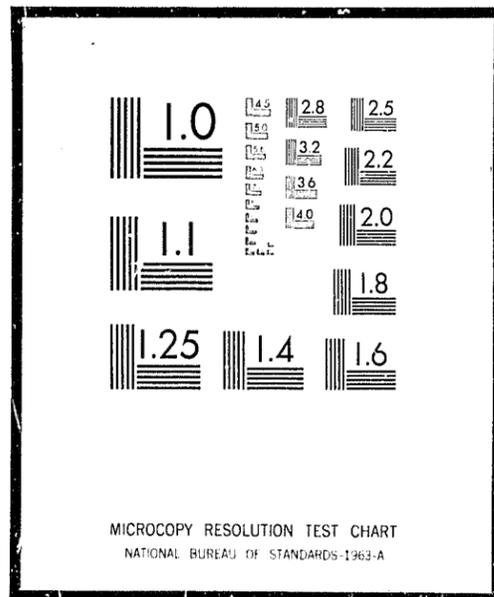


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U.S. DEPARTMENT OF JUSTICE
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
NATIONAL CRIMINAL JUSTICE REFERENCE SERVICE
WASHINGTON, D.C. 20531

Date filmed 9/10/75

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

ANNUAL OPERATING PLAN

FISCAL YEAR 1974

LAW ENFORCEMENT DEVELOPMENT GROUP

JUNE 1973

NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE
Law Enforcement Assistance Administration
U.S. Department of Justice

Prepared by
THE AEROSPACE CORPORATION
El Segundo, California

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(Report No. TOR-0073(3640)-4)

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I. INTRODUCTION AND BACKGROUND

The National Institute of Law Enforcement and Criminal Justice (NILEJC) has been established to encourage research and development to improve and strengthen the nation's law enforcement and criminal justice system. This responsibility has resulted in three major activities. First, the Institute functions as the research arm of the Law Enforcement Assistance Administration. Secondly, the Institute sponsors programs which translate research and analysis work into specific hardware development programs. Finally, the Institute is responsible for technology transfer; that is, for programs which ensure that knowledge acquired through research or project experience is made readily available to the operating law enforcement and criminal justice community. These research, program development, and technology transfer activities are conducted using both government and industrial capabilities.

To achieve a more effective utilization of its resources, the National Institute of Law Enforcement and Criminal Justice established definite priorities and in FY 72 implemented a number of new programs. These programs were aimed at strengthening and expanding various activities of the Institute. One of these programs was the Equipment Systems Improvement Program.

The purpose of the Equipment Systems Improvement Program is to provide an integrated approach to equipment-related research and development. It was recognized that equipment, when appropriately designed and utilized, can contribute to solving law enforcement and criminal justice problems. The security of people and their property in their homes, on the streets, and at work, as well as the effectiveness of police agencies, of court systems, and of correctional institutions will be improved by developments undertaken in this program. The program will also provide performance standards, guidelines, and information about equipment systems and their application both to users and to manufacturers and distributors.

The Equipment Systems Improvement Program is designed to draw upon the experience and expertise of responsible professionals for identifying current problem areas and for evaluating the practicality of proposed solutions. To carry out the technical work of the Improvement Program, the Institute established three functionally specialized groups and contracted for the services of three subsidiary organizations:

Analysis Group	The MITRE Corporation
Development Group	The Aerospace Corporation
Standards Group	The National Bureau of Standards

Each group receives funding support, policy guidance, and direction from the Institute and reports its findings and recommendations for action to the Institute.

This document, the Annual Operating Plan for Fiscal Year 1974 of the Law Enforcement Development Group, describes the projects proposed for support during the second year's development activity under the Equipment Systems Improvement Program. The projects included in the proposed FY 74 Development Program are the result of an extensive effort to identify and rank candidate projects. The initial phase of the effort was performed by the Analysis Group and involved defining problem areas for which development solutions were to be identified.¹ At the Institute's direction, the Equipment Systems Development Program has been oriented toward burglary and stranger-to-stranger crimes. Consequently, the problem areas identified by the Analysis Group are within the context of their relation to murder, rape, aggravated assault, robbery, and burglary.

The second phase of the development projects selection process for FY 74 was performed by the Development Group. This involved the screening of all available sources for candidate development programs as solutions to the problem areas identified in the initial phase. Based upon

¹MITRE Technical Report No. 6538, Analysis of Criminal Justice Problems (19 March 1973).

the planning guidance provided by the Analysis Group and adjusted to reflect Institute comments and recommendations, numerous candidate solutions were identified and considered by the Development Group. A total of 78 candidate projects were identified and a report identifying and assessing these projects was prepared.²

In reviewing the candidate list, a criteria rating and ranking system was developed as the basis for selecting the specific projects to be included in the proposed FY 74 Development Program. Various factors covering technical considerations, application and economic factors, as well as civil factors, were considered. Five separate evaluation criteria were identified, and an evaluation number composed of an individual score for each criterion was generated for all proposed projects. The five criteria upon which the rankings were based are:

1. The Problem Area Priority established by the Analysis Group.
2. Technical Factors which influence the desirability of a specific solution to an identified problem area.
3. Application and Economic Factors which assess the potential acceptability of a specific problem solution.
4. The expected level of required Research and Development Funding.
5. Civil Factors which consider the social, political, and legislative acceptability of the developed hardware.

All 78 candidate projects described in Reference 2, were ranked against these criteria and further screened by the National Institute of Law Enforcement and Criminal Justice. As a result of this screening the list of candidate projects was reduced to approximately 25. In addition to rank order selection, candidate projects were eliminated if other government agencies had already been assigned the responsibility for the problem area or had already initiated an activity on the problem (the drug-related projects were eliminated for this

²The Aerospace Corporation Report No. TOR-0073(3640)-3, Equipment Systems Improvement Program--Development, Candidate Equipment Projects FY 74 (30 March 1973).

reason). In other cases, the problem definition inputs by the Analysis Group were not yet complete and the selection of a potential solution was premature.

The reduced list of project candidates is given in Table I. The Development Group was directed by the National Institute of Law Enforcement and Criminal Justice to base the FY 74 program primarily upon the priority ranking indicated in this table. Those projects for which there was FY 73 effort are listed as the first seven items and are given a high priority since hardware delivery is expected on most of these programs in FY 74. The remaining items on the list are tabulated in essentially the same relative priority ranking in which they appeared in the Aerospace candidate project report.

The specific projects proposed by the Development Group for FY 74 support were selected from Table I. An Institute review of the proposed FY 74 program in late April resulted in approving 13 of the projects listed in Table I. Further review and redirection was provided in late May and the final list of projects was reduced to eight. The approved program is summarized in Section II and detailed project descriptions are given in Section III.

Table I. Institute-Recommended Project List

Rank	Project	Selected for Inclusion in FY 74 AOP
1	Cost-Effective Security Alarm System	X
2	Citizens Alarm System	X
3	Lightweight Body Armor	X
4	Communications Helmet	
5	Improved Airborne Policing	
6	Speaker Identification	X
7	Truck Anti-hijacking System	X
*8	Study of Latent Fingerprint Research	X
9	Improved Hardened Doors and Windows	
10	Residence/Business Lock Systems	
**	Police Emergency Call Warning System	
11	Officer and Inmate Security System	
12	Blood and Bloodstain Analysis	X
13	Improved Institutional Locking System	
14	Active Metal-Weapon Detection System	
15	Perimeter Security	
16	900 MHz Technology	
17	Explosives Detection and Identification	X
18	Detection of Gunshot Residue	
19	Frequency Management Study	
20	Robber Tagging	
21	Thermoluminescent Techniques	
22	Undercover Agent Communications	
**	New Mass Spectrometry Methods	
23	Concealed Recording System	

* Institute-recommended project

** Conditionally approved

II. PROGRAM SUMMARY

The following eight projects from Table I have been selected for inclusion in the Annual Operating Plan for Fiscal Year 1974 Equipment Systems Development Program.

Continuing FY 73 Programs

- Cost-Effective Security Alarm
- Citizens Alarm System
- Lightweight Body Armor
- Speaker Identification
- Truck Anti-hijacking System

New Programs

- Study of Latent Fingerprint Research
- Blood and Bloodstain Analysis
- Explosives Detection and Identification

A summary overview of these projects organized into the general outline of the Institute's overall program plan is given in Table II. Short statements summarizing the purpose of each project and describing the effort to be undertaken in FY 74 are also included in this table.

The planned accomplishments for FY 74 are summarized in Table III. The accomplishments are highlighted by delivery of hardware; reporting on studies and analysis; and completion of documentation and proposal review prior to letting subcontracts.

The projects generally fall into one of the following four phases of development.

- Technology Development
- Concept Development
- Hardware Development
- Field Test/Standardization Support

The Technology Development phase involves the acquisition and assessment of the technical information needed to develop and establish appropriate technology for problem solution. This effort is a prerequisite to identifying or selecting a specific approach(es) for solving an identified problem. It should be noted that not all candidate development projects must include this phase. In some cases, sufficient technology is already available and the project can then be initiated with the second phase.

The second phase of a development project is Concept Development. This activity involves identification and development of feasible concepts and solutions to the problem being considered. The activities include design analyses and tradeoff studies and may also involve breadboard hardware testing.

Hardware Development is the phase under which the actual design and development of hardware for specific systems identified as feasible and useful are supported. The effort is performed under subcontract by the Development Group and may also include the procurement of hardware and exploratory field testing.

The final phase of a development project involves support for field testing of a prototype system by the Analysis Group to evaluate its operational performance. If the field tests are successful, then support is provided to the Standards Group to facilitate the transfer to both industry and the consumer of appropriate knowledge and skills in design, manufacturing, and use which have been acquired in the preceding phases.

The current development phase for each of the FY 74 projects is indicated in Table II. Additional detailed description and discussion of the background and scope of each project are contained in Section III.

Table II. Proposed FY 74 Development Projects

PROGRAM AREA	OBJECTIVE	DESCRIPTION OF FY 74 EFFORT	PHASE				PRO-GRAM	
			Technology Development	Concept Development	Hardware Development	Field Test/Standards	Continuing	New
I. <u>Reduce Causes of Crime</u> A. <u>Alleviate Crime Conditions</u> (none at present) B. <u>Intervention in Criminal Careers</u> (none at present) II. <u>Control Incidence of Crime</u> A. <u>Reduce Opportunities for Crime</u> 1. <u>Target Vulnerability</u> Cost-Effective Security Alarm System Lightweight Body Armor 2. <u>Community Support</u> (none at present) B. <u>Increase Risk of Committing Crime</u> 1. <u>Detection and Reporting Systems</u> Citizens Alarm System	Obtain the development of low-cost, reliable security alarm systems for residences and small businesses. Develop a family of lightweight protective garments for use by key public officials and law enforcement personnel. Provide a covert alarm system for individuals in high crime areas. FY 73-funded effort directed at alarm for use inside of buildings; FY 74 effort will address an "open-space" alarm system.	Continuation of on-going program to lower costs and reduce false alarms. Activities include study of external alarm concepts (power line, CCTV, telephone alternatives) and development of integrated alarm locks, more effective installation materials and methods, and improved sensors. Continuation of on-going program on outer garments for key public figures. Effort on inner and outer garments to meet law enforcement needs will be initiated and field evaluation begun. Continuation of on-going program to modify or adapt ultrasonic or electromagnetic signalling devices for "in-building" alarm use and hardware development for field test demonstration. Feasibility demonstration contract for external alarm system.			X		X	
					X		X	
					X			X
					X			X

Table II. Proposed FY 74 Development Projects (Continued)

PROGRAM AREA	OBJECTIVE	DESCRIPTION OF FY 74 EFFORT	PHASE				PRO-GRAM	
			Technology Development	Concept Development	Hardware Development	Field Test/Standards	Continuing	New
Explosives Detection and Identification	Development of reliable nonintrusive instrumentation for detection of characteristic vapors of concealed explosives. Improve detection methods of tagged, concealed explosives and post-detonation determination of origin of explosives.	Define explosive effluents and effects of barrier materials and aging. Establish specifications for prototype system. Assess tagging and initiate industry studies of applicable explosives tagging techniques; review practical procedures for tagging explosives during manufacture.	X					X
2. <u>Identification Techniques</u>								
Blood and Bloodstain Analysis	Facilitate use of modern techniques for blood individualization by developing reliable and easy-to-use blood analysis equipment for police laboratories.	Develop methods of blood individualization for use by police laboratories. Data files for blood similar to fingerprint files will be developed.		X				X
Speaker Identification	Provide reliable suspect identification by analysis of voice recordings.	Continuation of on-going program to validate speaker identification using voiceprints and to develop a computer-aided speaker identification system. Initiate programs to determine optimum voice features for identification purposes and to develop a voice classification system to facilitate search of large voice sample file.		X			X	
Study of Latent Fingerprint Research	Investigate new technology applicable to latent fingerprint classification, and to automatic coding, file searching, and matching.	Examine new concepts of fingerprint classification. Survey the fields of analog and digital coding and matching technologies for advanced concepts applicable to latent fingerprint identification. Assess feasibility of fully automated fingerprint identification systems using advanced technology.	X					X
Truck Anti-hijacking System	Develop low-cost system for detecting and locating a hijacked truck.	Continuation of on-going program. Initiate prototype development of location system. Initiate development of hijack detection and alarm devices and demonstrate design feasibility.		X			X	
4. <u>Adjudication Systems</u> (none at present)								

Table III. Summary of FY 74 Planned Accomplishments

	FY 74											
	J	A	S	O	N	D	I	F	M	A	M	J
<u>Cost Effective Security Alarm Systems</u>												
Sylvania Alarm Transmission Hardware		X										
Powerline Study Report		X										
Candidate Concept Selection Report					X							
Subcontract Procurement						X		X				
<u>Citizens Alarm System</u>												
In-Building Alarm System Hardware									X			
System Design and Test Planning Report (In Building)									X			
Feasibility Assessment Report (In Building)										X		
Concept Definition Report (External)					X							
Subcontract Procurement						X			X			X
<u>Lightweight Body Armor</u>												
Prototype Hardware	X											
Soft Body Armor Model										X		
Edgewood/LWL Final Report		X										
Body Damage Criteria Report											X	
Garment Procurement Specifications											X	
Subcontract Procurement		X									X	
<u>Speaker Identification</u>												
Computer Aided Voice ID System Hardware										X		
Concept Development Plan	X										X	
Interim Validation Test Report												X
Subcontract Procurement			X			X						
<u>Truck Anti-hijacking System</u>												
Concept Definition Reports				X								
Concept Development Reports	X									X		
Subcontract Procurement				X		X						X
<u>Latent Fingerprint Research</u>												
Technology Summary Report								X				
<u>Blood and Bloodstain Analysis</u>												
Technical Assessment Report								X				
Equipment Evaluation Report												X
Subcontract Procurement					X		X		X			
<u>Explosives Detection and Identification</u>												
Optoacoustic Vapor Detection Report												X
Explosive Tagging for Detection Report												X
Vapor Characteristics Study Report												X
Subcontract Procurement			X		X							

III. PROJECT DESCRIPTIONS

The projects considered for FY 74 cover a variety of developments which, if successful, should lead to the demonstration of useful equipment and systems for use by individual citizens and operating law enforcement and criminal justice agencies. Special emphasis has been placed on those projects which will reduce the type of crime that now frightens the citizens of this country; e.g., burglary and stranger-to-stranger crime. Longer term projects to upgrade both the technology and the equipment available to law enforcement agencies in order to assist in the improved operation of these agencies as well as in deterring crime are also included.

All projects are planned to build on the technology base presently available in industry and in laboratories and agencies throughout the nation and will be directed toward encouraging industry to provide equipment which makes full use of recent advances in technology.

The descriptions of the eight projects contained in this section are organized into programs initiated in FY 73 which are continuing and new programs to be initiated in FY 74. For convenience in assessing the distribution of these programs according to development phase as well as the area they support within the Institute's overall program plan, the following summary table is provided.

	Technology Development	Concept Development	Hardware Development	Field Test/Standards	Total
Intervention in Criminal Careers					
Reduce Opportunities for Crime			2		2
Detection and Reporting Systems	1		1		2
Identification Techniques	1	2			3
Apprehension Systems		1			1
Adjudication Systems					
Total Projects	2	3	3		8

The format used in describing each proposed FY 74 project consists of seven sections:

- Problem Area
- Program Objective
- Background
- Scope
- FY 74 Accomplishments
- Schedule
- Activity Flow Diagram

The Problem Area and Program Objective sections contain brief statements summarizing the main goals of the project. The Background section provides an introductory and background discussion from which the proposed project activity can be assessed. The Scope section treats the proposed FY 74 effort and describes the specific tasks, goals and objectives, and anticipated accomplishments. If appropriate, the Scope also includes a broad overview of the total program. The planned FY 74 Accomplishments are summarized and highlighted in the next section.

Consistent with the Scope and FY 74 Accomplishment sections, the Schedule chart presents detailed information for FY 74 as well as an overview of the total program through 1975. Similarly, in order to place the proposed FY 74 effort in perspective, the Activity Flow Diagram also treats the entire program and includes the coordination and inputs required from the Analysis and Standards Groups.

Some of the activity described in the Scope section will be performed both in-house by the Development Group and by means of subcontracts to industry. The initial role of the Development Group on any specific project will generally involve the preliminary planning and evaluation tasks which lead to the definition and scheduling of the subsequent effort. Most of the subsequent development effort discussed in the program descriptions will be performed by industry under subcontract to the Development Group and will be awarded by means of competition between qualified bidders. All subcontracted development effort will be under the technical direction of the Development Group.

CONTINUING PROGRAMS

- Cost-Effective Security Alarm System
- Citizen's Alarm System
- Lightweight Body Armor
- Speaker Identification
- Truck Anti-hijacking System

COST-EFFECTIVE SECURITY ALARM SYSTEM

PROBLEM STATEMENT

The use of burglar alarms in the country is seriously limited by the relatively high cost and high false alarm rate of currently available systems.

OBJECTIVE

The objective of this program is to develop and demonstrate security alarm systems for residences and small businesses which are low in cost, reliable, and have a low false alarm rate.

BACKGROUND

Adequate hardware presently exists to satisfy some of the requirements for an effective security alarm system. There are, however, two main problem areas which require additional development efforts for expanded use of burglar alarm systems. These involve the high cost of installed burglar systems (which in many cases is in excess of \$1000) and the high false alarm rates.

The high cost of these systems is primarily due to the cost of hardware installation in the home and possible telephone line costs for tying in to an alarm company. Installation costs may be reduced by the use of existing power wiring to transmit information within structures and by the development of more efficient means of hardware installations. A FY 73 development project is underway to investigate the feasibility of using internal electrical power lines. Also demonstrated will be a single, inexpensive alarm sensing concept using power line impedance characteristics.

There is also a requirement to decrease the cost of alarm signal transmission from businesses and residences to the response agency. Presently used commercial telephone lines from each location are expensive on a yearly rental basis (\$30 to \$50 per month for full alarm service). Systems using existing one-way coaxial TV cables or external power lines or those adding special carriers to telephone lines require development.

MITRE analysis suggests that unless the occurrence of false alarms can be significantly reduced, the widespread use of security alarm systems is unlikely. A significant cause of a false alarm is the user-equipment interface problem; that is, people trigger their own alarms due to careless operating procedures. Therefore, development is also required of equipment which has a built-in decision-making capability, such as a logic circuit and a clock, to determine if two or more sensors are triggered and if the time is appropriate for normal user access. A hardened integrated door and alarm lock could also be used so that normal user entry or exit would automatically arm or disarm the system.

SCOPE

The FY 73 program addressed itself to system installation cost reductions by lowering internal transmission costs. The FY 74 program will emphasize additional cost reductions, false alarm reduction, and rapid security force response. Two general security alarm applications will be addressed; namely, small business alarms and residential alarms. Small business alarms are directed at dealing with both robbery and burglary; multi-sensor arrays, foot-actuated alarms as well as other holdup-indicating alarms are of interest. Residential alarms, on the other hand, are limited to burglary only and holdup-indicating devices are generally not of interest.

The following task areas are proposed for the FY 74 effort:

1. Improved sensor configurations with emphasis on ease of installation and high reliability.
2. Timing clock and fail-safe logic development.
3. Tooling and aesthetically acceptable hookup hardware for efficient and low-cost installation.
4. Definition of alarm interfaces for the various transmission media available and a test demonstration of each method.
5. External alarm transmission and response study.

The prime sensor configurations to be developed and investigated include the space intrusion types (electrostatic); however, some effort will be devoted to positive action types (door, window, and vibration).

The aesthetic problems associated with retrofit hardwire alarm installations and high installation costs will be attacked to simplify these designs and provide better installation tooling.

Various transmission media (alternative telephone uses, power lines, two-way CATV) will be investigated and demonstrated, and interface requirements will be defined to make these systems compatible with current alarm configurations.

Direct alarm tie-in to police departments and alarm companies will include intrusion confirmation schemes and methods for verifying the acceptability of the various transmission media in an effort to reduce transmission costs.

In-house effort in FY 74 will include an assessment of related industry capability and the status of commercially available equipment, preparation of detailed task plans, and the preparation of work statements and RFP's for release to industry. Industry support via subcontract for hardware development and design assessment will also be initiated.

During FY 75, it is anticipated that large scale test scenarios will be developed to verify the results of the limited scale tests and to demonstrate that the approaches taken can be successfully applied on a wider scale. The tests will be conducted utilizing the resources of response agencies (alarm company and/or police) with support from the Underwriters Laboratory and various police and civic organizations. The object of this support will be to directly involve the alarm industry, police and civic agencies, and consumer groups in the tests for public acceptance. The tests will further demonstrate the market and prove out the large scale integration devices and installation hardware for low-cost alarm systems for use by the alarm industry.

FY 74 PLANNED ACCOMPLISHMENTS

The following hardware will be delivered during FY 74:

Sylvania Alarm Transmission hardware consisting of four (4) alarm transmitters and a master control panel - August 1973

The following reports will be submitted to the Institute during FY 74:

1. Report recommending candidates selected under Concept Definition submitted for approval - November 1973
2. Sylvania power line study report - August 1973

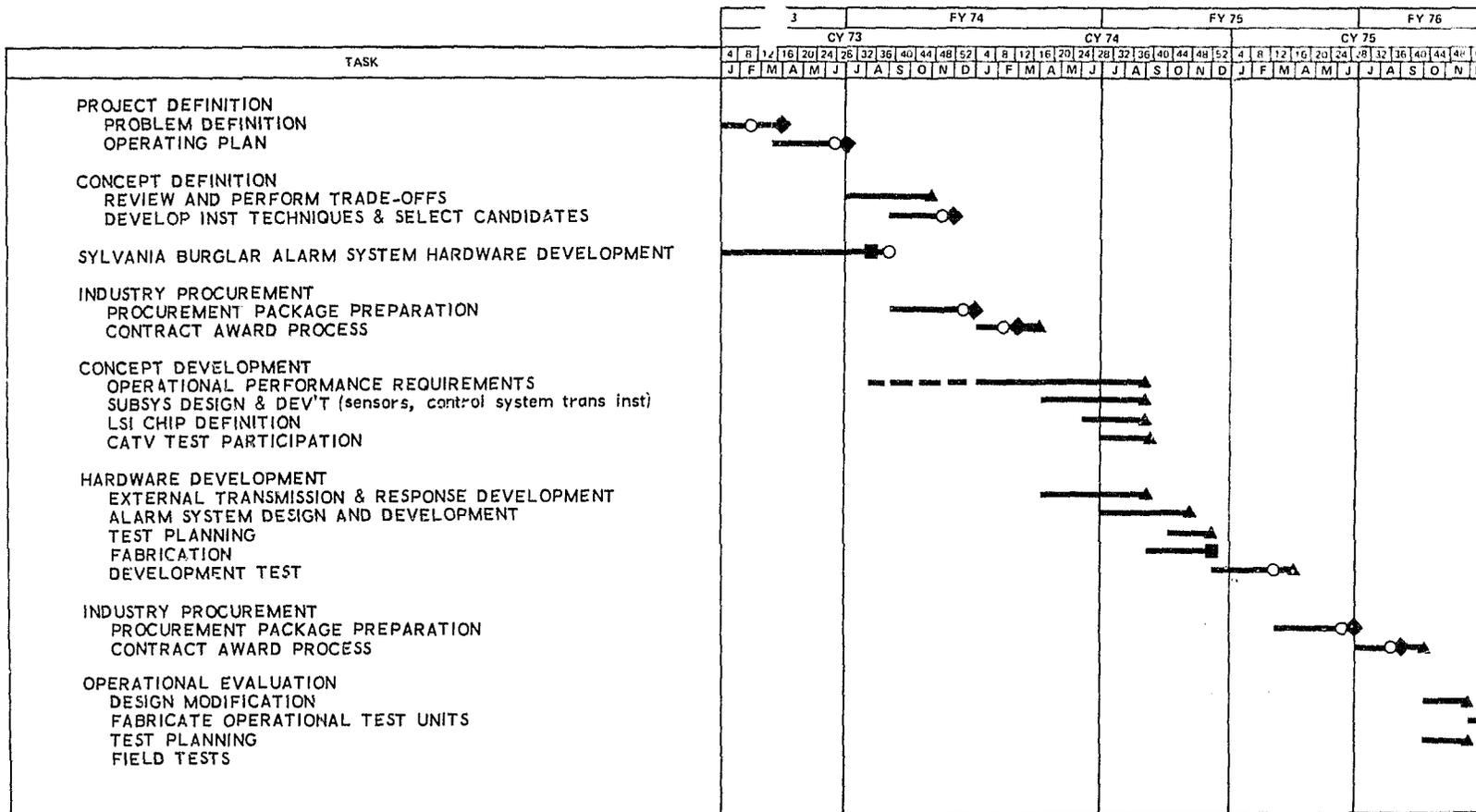
The following documentation will be submitted to the Institute during FY 74 to support subcontract activities:

1. Procurement package for external transmission hardware development subcontract - December 1973
2. Documentation and contractor selection for external transmission hardware development subcontract - February 1974

COST EFFECTIVE SECURITY ALARM SYSTEM

NEW CONTINUING

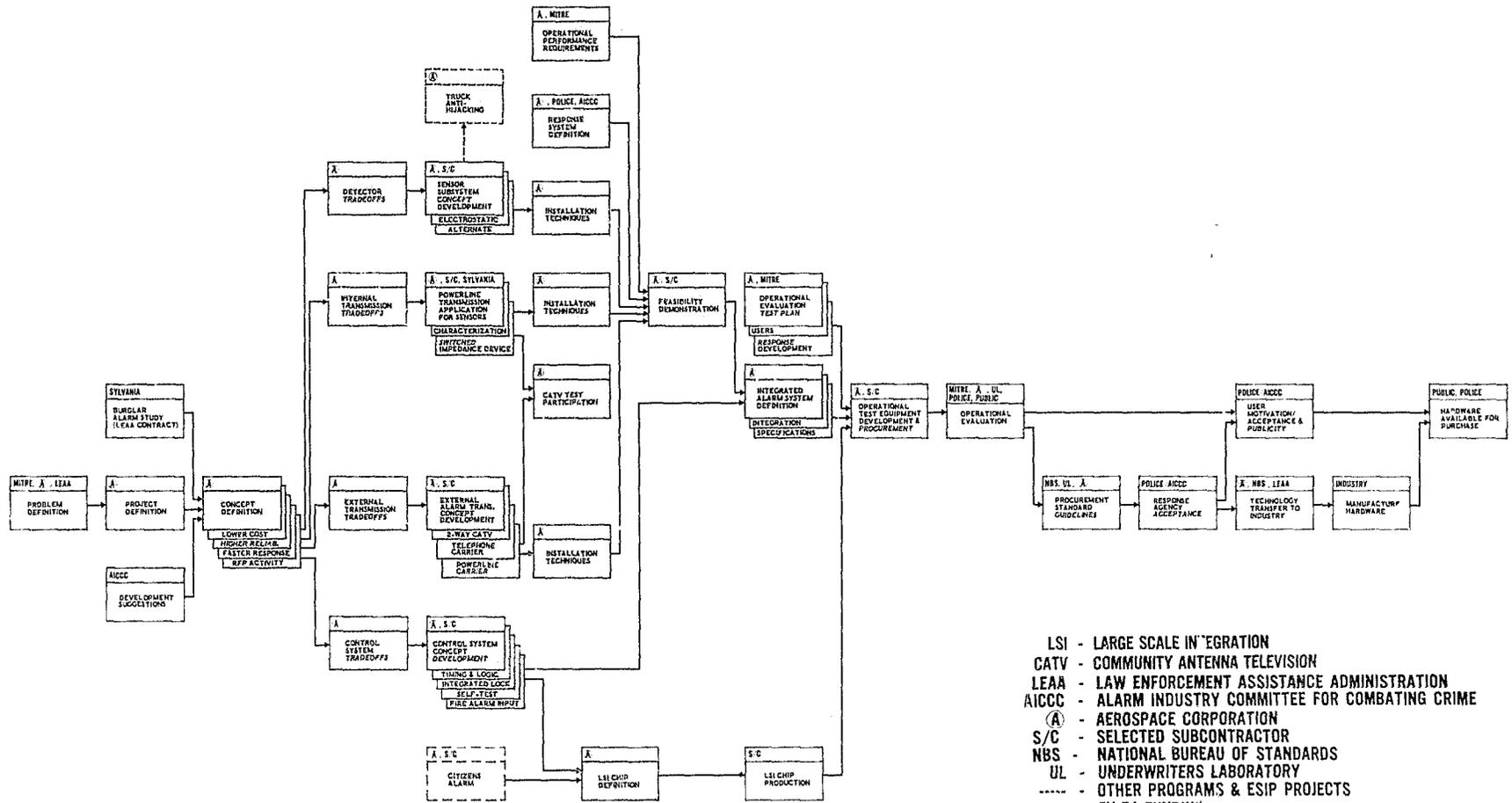
HARDWARE DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
◆ NILECJ APPROVAL ▲ TASK COMPLETION

COST EFFECTIVE SECURITY ALARM SYSTEM

3-8



CITIZENS ALARM SYSTEM

PROBLEM STATEMENT

Individuals are subjected to criminal attack in apartments, business establishments, and schools, as well as in public parks and on streets. Improved equipment is required to permit victims of such attacks to call for assistance.

OBJECTIVE

The objective of this program is to develop a citizens alarm system which provides a means for reporting in real time when, where, and to whom a criminal attack or other emergency is occurring. Initially, the intent is to provide a system for use inside of buildings; subsequently, the intent is to provide this same capability in outside spaces.

BACKGROUND

In many urban areas a citizen's need for transmitting a call for assistance under threat of assault or robbery, or for a medical or fire emergency, has never been greater. The threatened citizen must be capable of sending the alarm before, during, or after the threat. Moreover, his actions should not be such as to increase the danger to himself. What is needed is a means of alerting guards and police (as well as hospital or fire officials) that rapid assistance is necessary.

A Citizens Alarm System study was initiated and a system concept developed as part of The Aerospace Corporation effort under the FY 73 Equipment Systems Improvement Program. The effort addressed concept development of a system for use within buildings and covered preliminary definition of requirements, conceptual system design, application to two in-building scenarios, and the evaluation of existing technology. Although commercial sources have already developed component hardware and capabilities useful as elements of a citizens alarm system, a complete system

which meets the objectives of low cost, minimum false alarm rate, and rapid response capability has not yet been developed.

As part of the FY 73 activity a breadboard system, including user and location coding, was assembled and evaluated for technical characteristics. The results showed that a citizens alarm system employing identifier and location coding for use within buildings is technically feasible and steps were taken to initiate industry participation. A work statement was prepared and a request for proposal submitted to qualified vendors to provide a prototype internal system. It is anticipated that a contract will be awarded for a complete system including 20 individual alarm units. The contract will be awarded in FY 73, but will continue into FY 74.

SCOPE

The feasibility demonstration of a Citizens Alarm System for use within buildings contracted for in FY 73 will be performed in FY 74. Among the factors which will be considered are the effect of system design parameters on response time, reliability, and false alarms. Competing radio-frequency and ultrasonic signal actuators will be considered, as will be alternate transmission, control, and display techniques. A field evaluation of an internal system involving approximately 1000 signal actuator units will be initiated in FY 75 and will be coordinated with MITRE.

Effort on the concept definition and feasibility demonstration of a Citizens Alarm System for use outside buildings will also be initiated in FY 74. Where applicable, information on requirements definition and analysis, system design and user interface parameters, and transmission, control, and display procedures previously developed for the in-building system will be used. A breadboard system will be assembled to confirm concept feasibility in areas where technology development needs to be furthered and will be followed by the initiation of industry participation. A work statement will be prepared and a request for proposal issued. A contract for a feasibility demonstration will be awarded in FY 74.

Field evaluation of the external Citizens Alarm System will be performed in FY 76 as part of integrating the internal and external systems into a single system. When the field tests of the integrated system have been successfully completed, steps will be taken to transfer this technology to industry and the public.

FY 74 PLANNED ACCOMPLISHMENTS

The following hardware items for the In-Building Alarm System will be delivered in February 74:

1. 20 actuators
2. 40 internal receiver/relay sensors
3. 1 external receiver/relay set
4. 2 annunciator display panels
5. Test equipment, special tooling and fixtures

The following reports will be completed during FY 74:

1. System Design and Test Planning of concept development hardware for the In-Building Alarm System - January 1974
2. Feasibility Assessment of the In-Building Alarm System concept development phase - May 1974
3. Concept Definition for the External Alarm System - November 1973

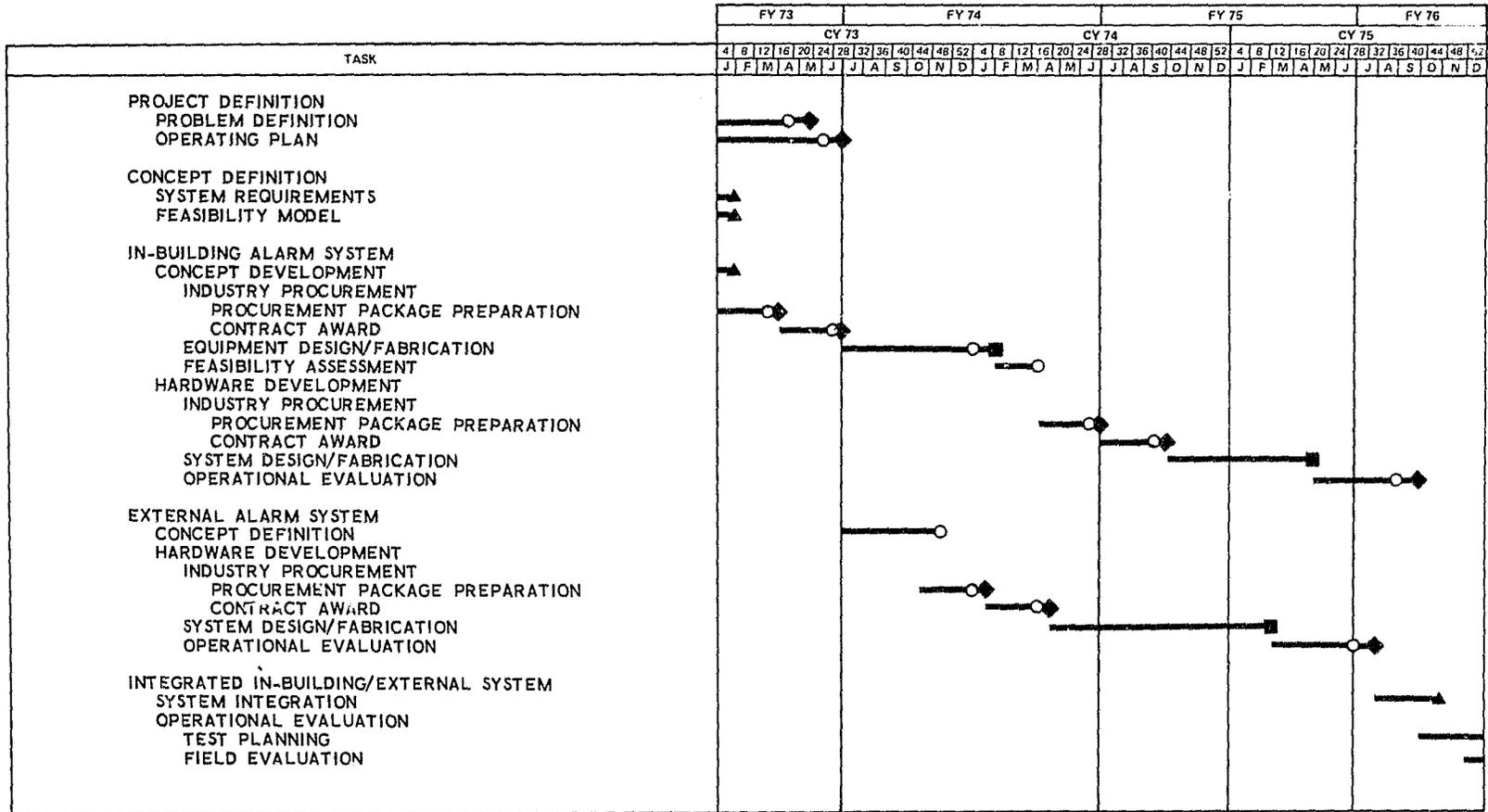
The following documentation in support of subcontracting activities will be delivered to the Institute:

1. Procurement package for the External Alarm System - December 1973
2. Proposal evaluation and subcontractor recommendation for the External Alarm System contract award - March 1974
3. Procurement package for the hardware development phase of the In-Building Alarm System - June 1974

CITIZENS ALARM SYSTEM

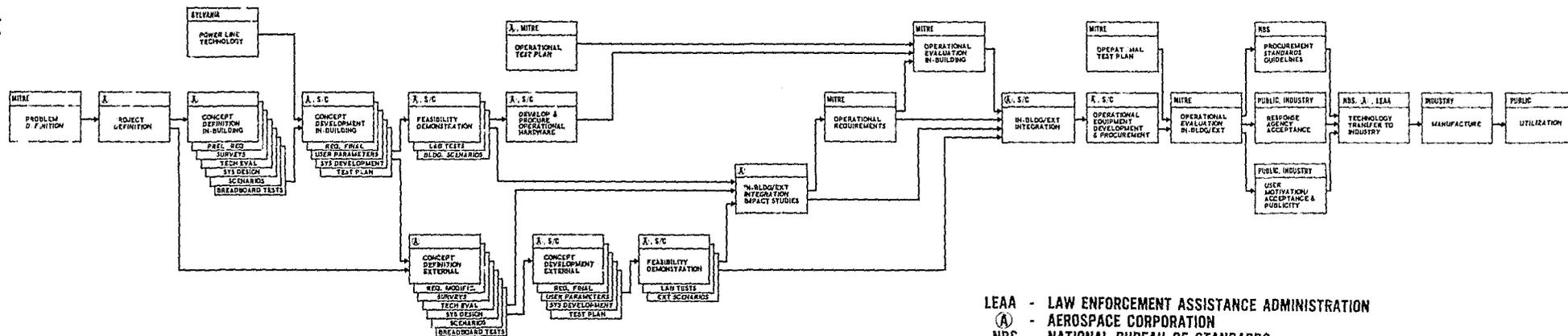
NEW CONTINUING

HARDWARE DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

CITIZENS ALARM SYSTEM



- LEAA - LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
- A - AEROSPACE CORPORATION
- NBS - NATIONAL BUREAU OF STANDARDS
- S/C - SELECTED SUBCONTRACTOR
- FY 74 FUNDING

LIGHTWEIGHT BODY ARMOR

PROBLEM STATEMENT

During the past decade numerous public figures and approximately seven hundred law enforcement officers have been shot and killed.¹ Many of these deaths could have been prevented if adequate body armor had been available.

OBJECTIVE

The objective of this program is to develop lightweight protective garments for use by public officials and law enforcement personnel. These garments must be relatively inconspicuous and inexpensive and adaptable to a number of clothing needs. Both inner and outer garments will be investigated.

BACKGROUND

In the past, body armor has been generally developed by and for the military and then applied to civilian use. It has been conspicuous and heavy and often times not worn unless an immediate danger was foreseen. The military armor has been of two general types: various hard-faced armor (steels or ceramics) for stopping high-velocity projectiles and soft-material armor (nylons) for stopping shrapnel.

The civilian application of these protective armors has concentrated on preventing projectile penetration, but little substantive effort has been undertaken to assess blunt trauma effects on the body even when non-penetration is assured. Furthermore, an assessment of available guns and weapon injuries to law enforcement personnel indicates a threat no worse than that presented by the .38 caliber police special occurs approximately 85% to 90% of the time.

This information on threat severity, coupled with development of new and stronger synthetic fibers by the textile industry, suggests the possibility

¹ Federal Bureau of Investigation, Uniform Crime Reports, p. 44 (1971).

of developing lightweight, inconspicuous, and relatively inexpensive garments that might satisfy the protective needs of public officials and law enforcement officers.

During the last half of FY 73, the Development Group sponsored a program at the Land Warfare Laboratory (LWL) of the U. S. Army to design and test a lightweight protective garment that could be worn by key public officials. The garment is being designed to counter the threat of handguns, including the .38 caliber Police Special. The results of completed initial materials tests are encouraging in that the new materials are significantly better than any nylon type previously tested. Several federal law enforcement agencies have reviewed the progress in this program and have encouraged its continuation and suggested expansion to include development of garments for undercover agents. Similarly, several local police departments have expressed interest in such developments as undergarments, overcoat liners, and, possibly, helmets.

The public-official garment being developed under the FY 73 contract is currently being fabricated and tested. Concurrently, additional materials are being evaluated for other garments suitable for police and federal needs. These latter applications will require tests against additional non-gun threats, environments, and damage criteria.

SCOPE

FY 73 Effort

The effort initiated in FY 73 represents the first step in a comprehensive program which will extend over a several-year period. Much of the subsequent follow-on activity will be guided and influenced by the results obtained and the issues raised during this initial effort. When completed, the FY 73 activity will have provided technology for developing and fabricating an inconspicuous garment to protect public officials against the threat of handguns.

A major issue considered under the on-going program is the blunt trauma effect on the human body. This is the damage that results when the

impact of the bullet (which does not penetrate) is absorbed by the protective garment and the underlying tissues and bone. Evaluation of available information in the literature as well as experiments with animals have been initiated. A tentative correlation between animal and human physiology is being established and will aid in defining subsequent blunt trauma investigations under follow-on programs which will be directed at establishing a quantitative understanding.

Similarly, although the feasibility of preventing bullet penetration through soft body armor has already been established under the FY 73 effort, an analytical explanation of this mechanism does not exist. The feasibility of devising an analytical model to explain the experimentally observed results will be established under the FY 73 activity currently in progress. Subsequent follow-on effort will include the development of such an analytic model and its use in guiding additional materials and garment fabrication research and development.

Effort on this project is being guided by general as well as specific inputs from numerous sources. A survey performed by MITRE will identify specific types of clothing to be fabricated for use by federal and local law enforcement agencies. Also, information on acceptable body damage (injury), threats against which the garments must protect, and garment and design preferences are being provided by individual law enforcement agencies.

The results of both the FY 73 and follow-on effort will provide inputs to the National Bureau of Standards (NBS) to aid in establishing standards for protective garments.

FY 74 Activity

The development program proposed for FY 74 will involve the following efforts:

1. Follow-on to the current LWL and Edgewood Arsenal contract for development of law enforcement garments.
2. Competitive industry contracts for garments to support field evaluation.

3. Garment(s) field tests and the evaluation of the field test results.

The continuation of the current contracted effort includes additional ballistic testing by Edgewood Arsenal aimed at providing an understanding of the penetration mechanism, pressures at impact points, body cavity shapes, and energy absorption characteristics of protective materials. These tests will aid in obtaining a quantitative assessment of the blunt trauma results. If preliminary ballistics tests performed by the Lawrence Livermore Laboratory show that it is feasible and desirable to develop a soft body-armor analytic model (that would include an analytic ballistic material interactive code and empirical blunt trauma response), the task will be undertaken. NBS will obtain and analyze anthropometric data on a representative sample of law enforcement personnel for specific specialized clothing needs.

The Hardware Development phase involves the competitive procurement from industry of approximately 200 protective garments for preliminary field test. Five general garment types will be procured. Under consideration are vest, sport coat, reefer coat, raincoat, and car coat designs.

The Operational Evaluation phase involves preliminary field evaluation of these garments by selected federal and local law enforcement agencies. The field evaluation will consist of routine wear of the garments by designated personnel to assess their comfort and mobility. MITRE will define the specific field evaluation criteria for the garment types in coordination with both Aerospace and NBS. In conjunction with the field evaluation, participation of protective-garment manufacturers will be encouraged in assessing the market potentials of such lightweight garments for law enforcement agencies.

FY 74 PLANNED ACCOMPLISHMENTS

The following hardware will be delivered during FY 74:

1. Two sports coats, one vest, one dickey - July 1973
2. Soft body armor model (if required) - April 1974

Lightweight Body Armor

The following reports will be completed during FY 74:

1. A final report which summarizes the efforts and work performed by Edgewood Arsenal and Land Warfare Laboratory under the FY 73 contract - August 1973
2. Body Damage Criteria Report as final output of blunt trauma efforts - May 1974
3. Garment Procurement Specifications submitted for approval - May 1974

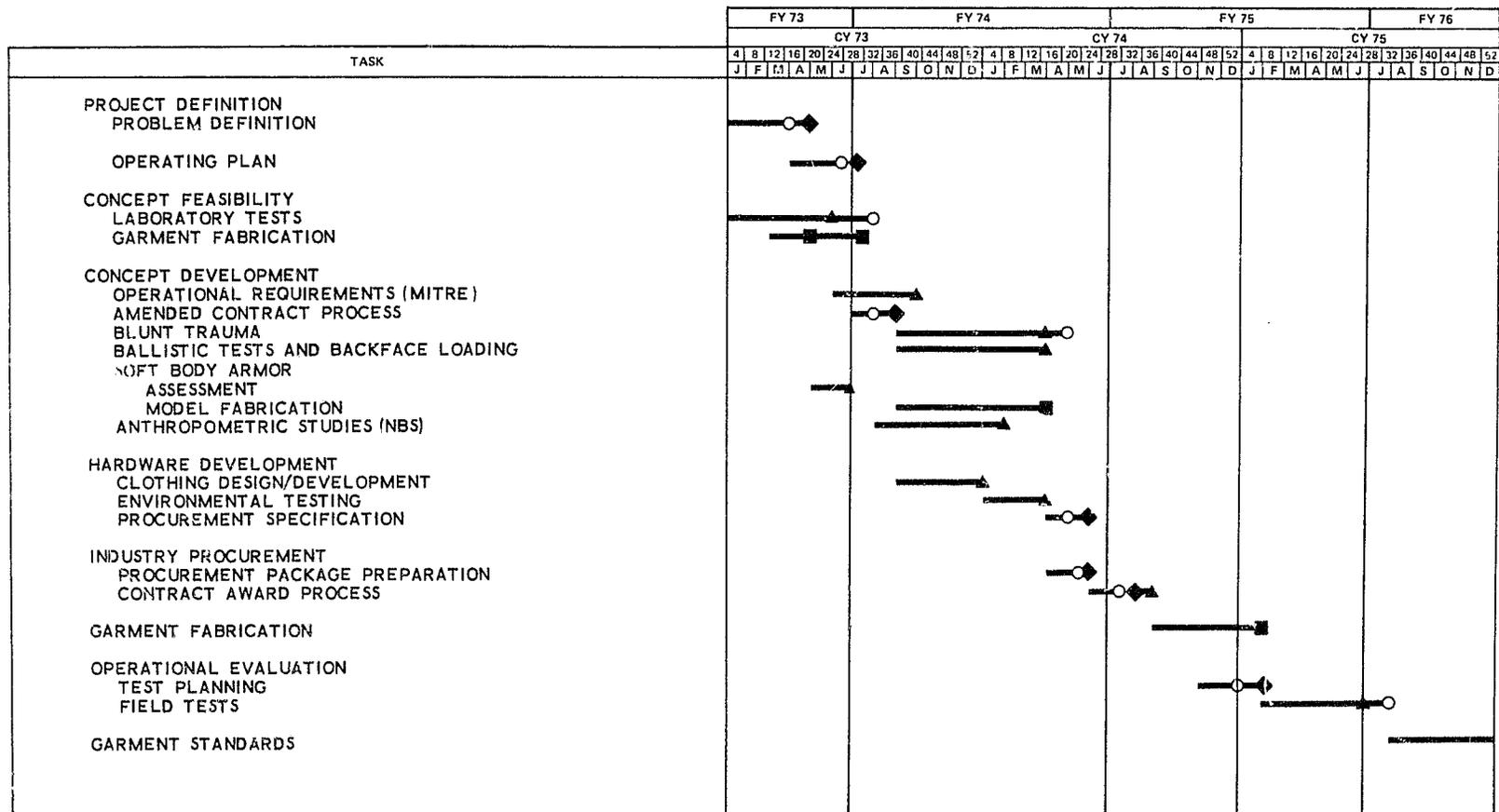
The following documentation will be submitted to the Institute during FY 74 to support subcontract activities:

1. Ammended contract procurement package - August 1973
2. Procurement package for garment fabrication for operational evaluation and field tests - May 1974

LIGHTWEIGHT BODY ARMOR

NEW CONTINUING

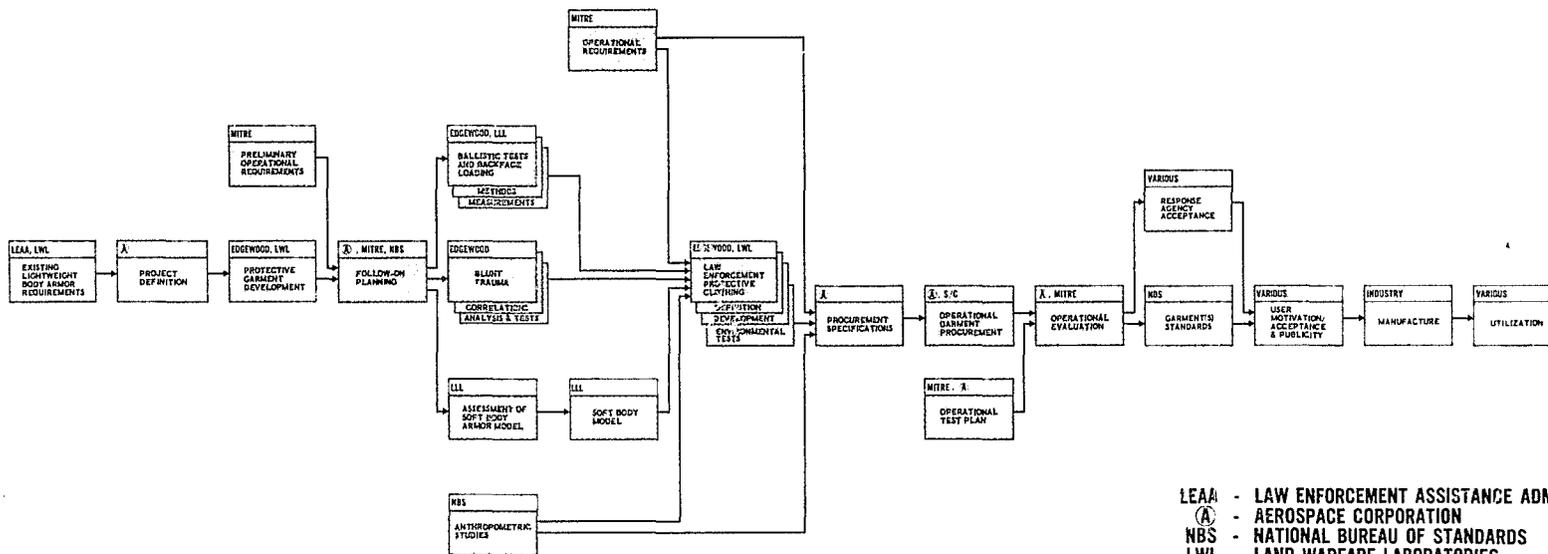
HARDWARE DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

LIGHTWEIGHT BODY ARMOR

3-20



- LEAA - LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
- A - AEROSPACE CORPORATION
- NBS - NATIONAL BUREAU OF STANDARDS
- LWL - LAND WARFARE LABORATORIES
- S/C - SELECTED SUBCONTRACTOR
- LLL - LAWRENCE LIVERMORE LABORATORIES
- FY 74 FUNDING

SPEAKER IDENTIFICATION

PROBLEM STATEMENT

Present voice identification techniques are more of an art than a science and are highly dependent upon the skill of the examiner. The increasing use of voice spectrograms as courtroom evidence requires the development of improved scientific methods for identifying a specific individual from his recorded voice and speech pattern.

OBJECTIVE

The objectives of this program are (1) conduct investigations to improve voice spectrogram technology and properly validate areas for its applications, (2) provide an interim semi-automated speaker identification system along with statistical evidence of its capabilities, (3) provide the basis for improved reliability of speaker identification (optimum voice feature selection), (4) provide a voice classification system to allow the search of large files for identification purposes, and (5) provide new techniques for voice identification.

BACKGROUND

Voice spectrograms, which have been accepted in some courts, have been subjected to a scientific experiment to determine error rates. This work was conducted by Dr. O. Tosi at Michigan State University, supported by NILECJ Grant NI-70-004. After one month of training, 29 examiners were tested with spectrograms from 250 different speakers in a large variety of tests (34,992 trials). The results of the experiment showed significant examiner error rates.

Machine-assisted speaker identification programs have not yet developed a set of optimum voice features nor acquired sufficient evidence

to demonstrate that the results of computer analysis can be used as courtroom evidence. Michigan State Police, supported by NILECJ Grant NI-71-079G, subcontracted with Stanford Research Institute (SRI) and Texas Instruments (TI) for machine-assisted speaker identification research. Both SRI and TI, each using tape recorders and other general purpose equipment as a base, developed systems for extracting features from speech and processed those features with digital computers. Their results were comparable and indicate that (1) this technique supplements information available from the voice spectrogram and warrants further effort, and (2) additional research on feature extraction and analysis is desirable.

SCOPE

A comprehensive speaker identification project was initiated by The Aerospace Corporation under the FY 73 Equipment Systems Improvement Program. The total project will extend over several years, and it is anticipated that most of the effort will be subcontracted. An overview of the total program is given by the separate tasks described below.

The initial state-of-the-art investigation and planning phase were completed in FY 73. In addition, as indicated below, effort was also initiated in FY 73 on several of the other tasks.

Task 1 - Voiceprint Technology Extension

The goal of this task is to document the technical aspects of the Voiceprint system and to conduct a practical validation of its accuracy. The effects of the following on voiceprint reliability will be assessed: female voices, mimicry, equipment performance, disguise, speaker behavior and background, word context, etc. In FY 73 a validation program is being defined and system specifications are being prepared. In FY 74 a subcontract will be negotiated for the validation test program. It is anticipated that the most significant portions of this program will be completed in FY 75.

Task 2 - Computer-Aided Voice Identification System

The goal of this task is to provide an interim computer-aided voice identification system based on previous Institute-supported research. In FY 73 a subcontract is being negotiated for development of this system. In FY 74 the equipment will be developed and laboratory tested. Operation of this system will provide error rate statistics which will be the basis for courtroom testimony. The bulk of these statistics will be gathered in FY 75.

Task 3 - Optimum Voice Feature Selection

The goal of this task is to provide a basis for improving Voiceprint and computer-aided techniques by identifying the most invariant features in speech. In FY 74 a state-of-the-art survey will be conducted and a program will be identified for implementation when resources are available.

Task 4 - Voice Classification System

The goal of this task, which will be based in part on Task 3, is to provide a method of classifying people by their voice characteristics. A large data base could then be searched and criminals could be identified in much the same manner as by the present use of fingerprints. Voice classification also has other potential application areas such as voice-actuated locks, speaker verification in police radio nets, and area access control. In FY 74 a minimal effort will be conducted to develop an understanding of current research activities which may support this program when it is implemented.

Task 5 - Advanced Development

The goal of this task is to identify new concepts for speaker identification. Of significant potential are the use of optical and holographic techniques for speech processing and speaker identification.

If techniques such as these could be applied to speaker identification, the decrease in complexity of equipment and increase in operating speed may open many new uses for identification by voice, e.g., driver's license ID, check cashing, and credit card verification. No activity is planned for FY 74.

During the period covered by this plan, a group of recognized experts will be assembled to review the speaker identification program.

FY 74 PLANNED ACCOMPLISHMENTS

The following hardware will be delivered during FY 74:

Computer-Aided Voice Identification System - April 1974

The following reports will be prepared and submitted to the Institute during FY 74:

1. Amendment of the "Concept Development Plan for Voiceprint Validation Testing" which was submitted in May 1973 - July 1973
2. An interim validation testing report for the Computer-Aided Voice ID System - June 1974
3. A Concept Development Plan for selection of optimum voice features for differentiation of individuals - May 1974

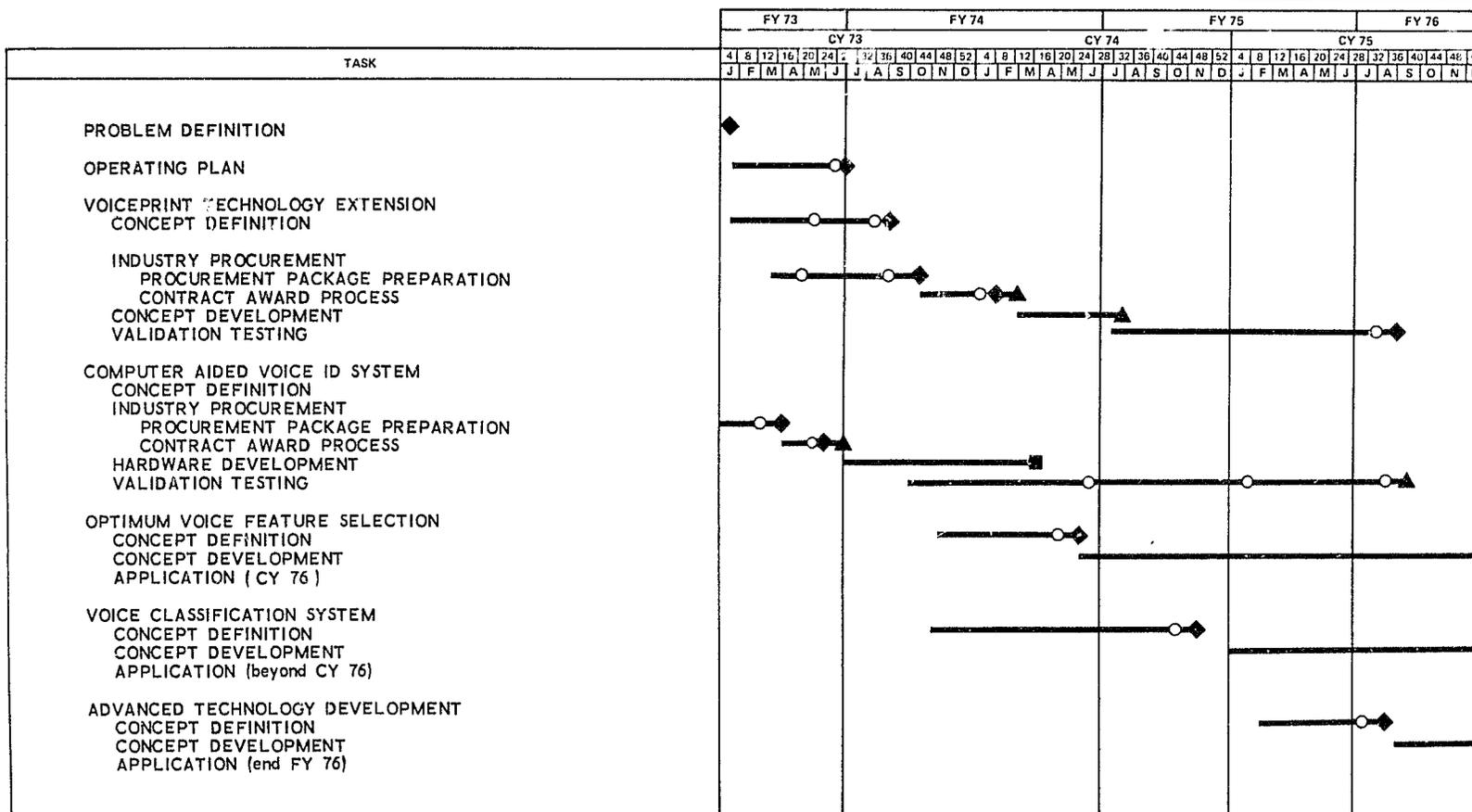
The following procurement documentation will be submitted to the Institute for approval during FY 74:

1. Procurement package for Voice Spectrogram Validation Testing subcontract - September 1974
2. Documentation and recommendation for subcontractor for Voice Spectrogram Validation Testing subcontract - January 1974

SPEAKER IDENTIFICATION

NEW CONTINUING

CONCEPT DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

TRUCK ANTI-HIJACKING SYSTEM

PROBLEM STATEMENT

Hijacking and stealing of commercial cargo trucks is a national problem. A means is needed for alerting authorities when a truck is stolen and for indicating its location so that appropriate action can be taken.

OBJECTIVE

The objective of this program is to develop a system for determining when a cargo-carrying truck has been hijacked or stolen and for providing information on the identity and location of the truck.

BACKGROUND

A significant portion of both finished and partially finished commercial goods is transported or delivered by truck. Theft, pilferage, and hijacking of commercial truck cargo has reached alarming proportions and has become a national concern. Benjamin O. Davis, Asst. Secretary of Transportation for Safety and Consumer Affairs, said in a November 1972 talk before an insurance group in Dallas that cargo thefts account for \$1 to \$2 billion of the nation's \$16 billion annual crime cost. A senate committee recently estimated that of this amount almost \$1 billion was attributable to cargo losses shipped by truck.² Even if most losses are covered by insurance, the net result is increased cost to the consumer.

Although the preponderance of truck hijacking is in urban areas, the event occurs and the cargo is frequently disposed of before the crime is even reported to the authorities. A truck anti-hijacking system is required to detect that a hijacking is being attempted, to provide a way to notify the

² Report of the Select Committee on Small Business. United States Senate on Effect of Cargo Loss, Theft, and Hijacking in the Trucking Industry, based on hearings before the Committee, June 5, 1970 and June 8, 1971, USGPO, Washington, D.C. (June 1972).

dispatcher that a hijacking is under way, to provide a method of identifying and locating the specific truck, and to provide a technique for notifying the proper police agency. In addition, the police must have a rapid way of confirming the identity of the truck and some method of quickly locating the truck once the approximate location has been reached. Systems requiring no action by the driver are needed to rapidly detect the occurrence of truck hijacking. Systems are also needed to provide real-time information on the location of the hijacked truck so that appropriate action can be taken.

The Department of Transportation (DOT) is developing two systems which can be used for truck location. The Automatic Vehicle Monitoring system, such as demonstrated in Philadelphia, can be employed in an urban area. This concept requires additional technical development and, as proposed, will involve use by public agencies and police and fire departments, as well as by private agencies such as taxi cabs and trucking firms. The schedule for deployment of an operational system is undefined.

A second system under development by DOT involves a transponder on the truck and a police helicopter to locate the hijacked truck by interrogating the transponder and tracking the vehicle. The initial group of transponders for field testing is now being procured.

Conceptual systems undertaken in FY 73 as part of the Equipment Systems Improvement Program activity were designed to allow an individual trucking firm to implement an anti-hijacking system, independently of other agencies, by choosing from various options of detection devices, location devices, vehicle disablers and truck identification schemes. A specific objective of the FY 73 effort was to demonstrate one or two concepts for locating a hijacked truck.

SCOPE

The conceptual locator systems undertaken in FY 73 were designed so that various options of detection devices, location devices, vehicle

disablers, and truck identification methods might be selected by the user. As equipment for these options is developed, retaining a flexibility of choice may become difficult. Some of this flexibility may be dropped as development proceeds, but as much as possible will be retained during prototype development. Before an initial production-type unit is produced, a system study will be made to define the subsystem options which should be retained.

Design feasibility tests of the combined locator system and detection system will follow prototype development. Various kinds of devices for precisely locating a truck within a limited area, including any transponder developed by DOT, will be considered. After design feasibility tests, operational equipment, with two or more options for some of the subsystems, will be developed. Field evaluation tests will be followed by the preparation of equipment standards.

In FY 74 the prototype development of one or two of the location concepts considered in FY 73 will be initiated. Conceptual devices for the detection function will also be investigated. Any of the detectors developed in the Cost-Effective Security Alarm System which appear applicable to trucks or tractors will also be considered. If appropriate, conceptual development of a detection system will be initiated. Monitoring of similar developments by other agencies, especially those concepts which use radio frequency techniques for vehicle location, will continue. Feasibility testing of the prototype equipment will begin in FY 75. If successful, the development of operational equipment will begin in FY 77.

FY 74 PLANNED ACCOMPLISHMENTS

The following reports will be submitted to the Institute during FY 74:

1. Concept Definition Report for the RF Locator and the detection system will be submitted for approval - October 1973
2. Concept Development Report for the RF Locator and the detection system - April 1974
3. Concept Development Report for the Odometer Locator - July 1973

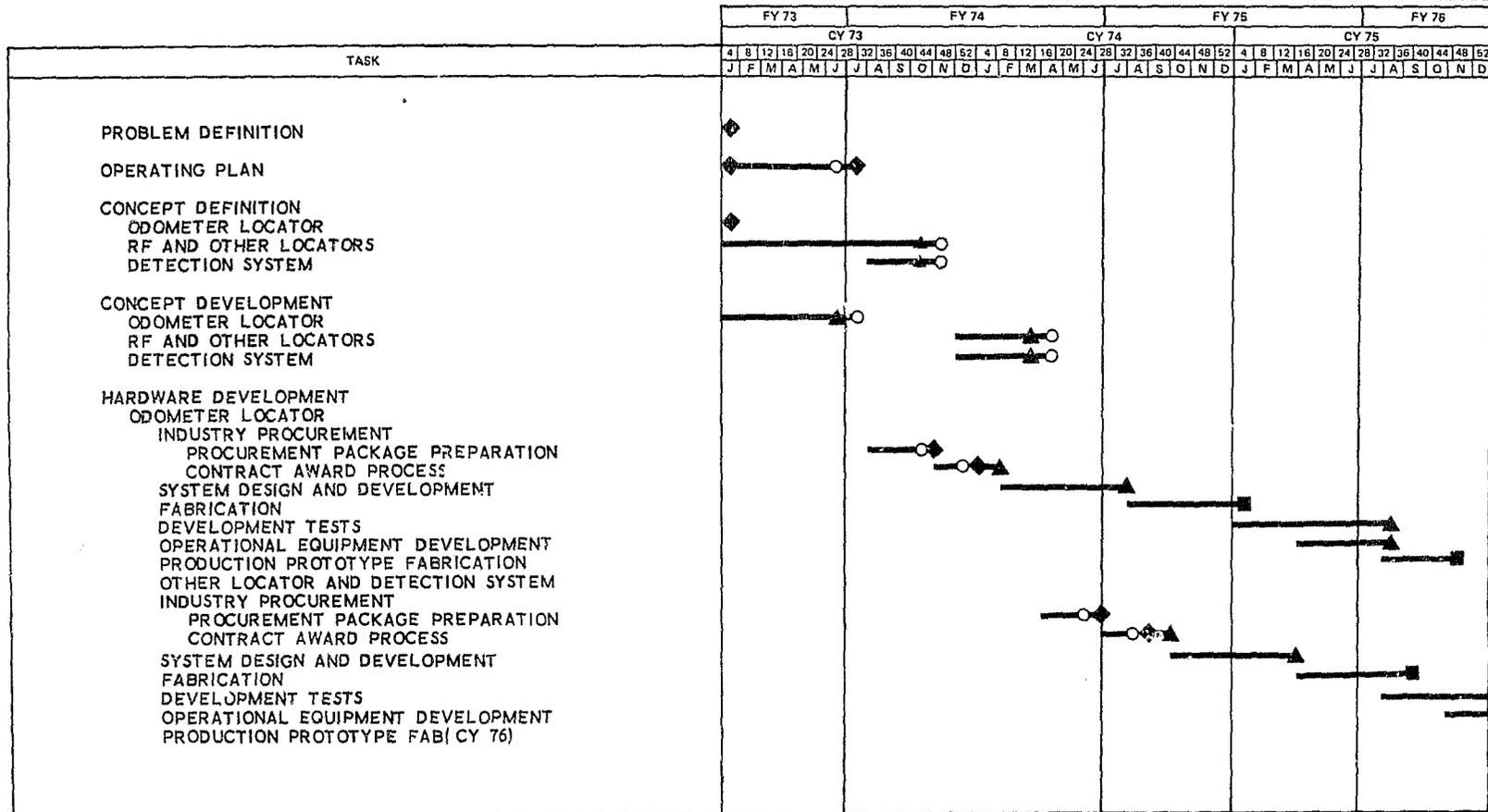
The following documentation will be submitted to the Institute to support subcontracting activities:

1. Procurement package for the odometer locator subcontract - October 1973
2. Procurement package for the RF locator and detection system subcontract - June 1974
3. Documentation and subcontractor recommendation for the odometer locator subcontract - December 1973

TRUCK ANTIHIJACKING SYSTEM

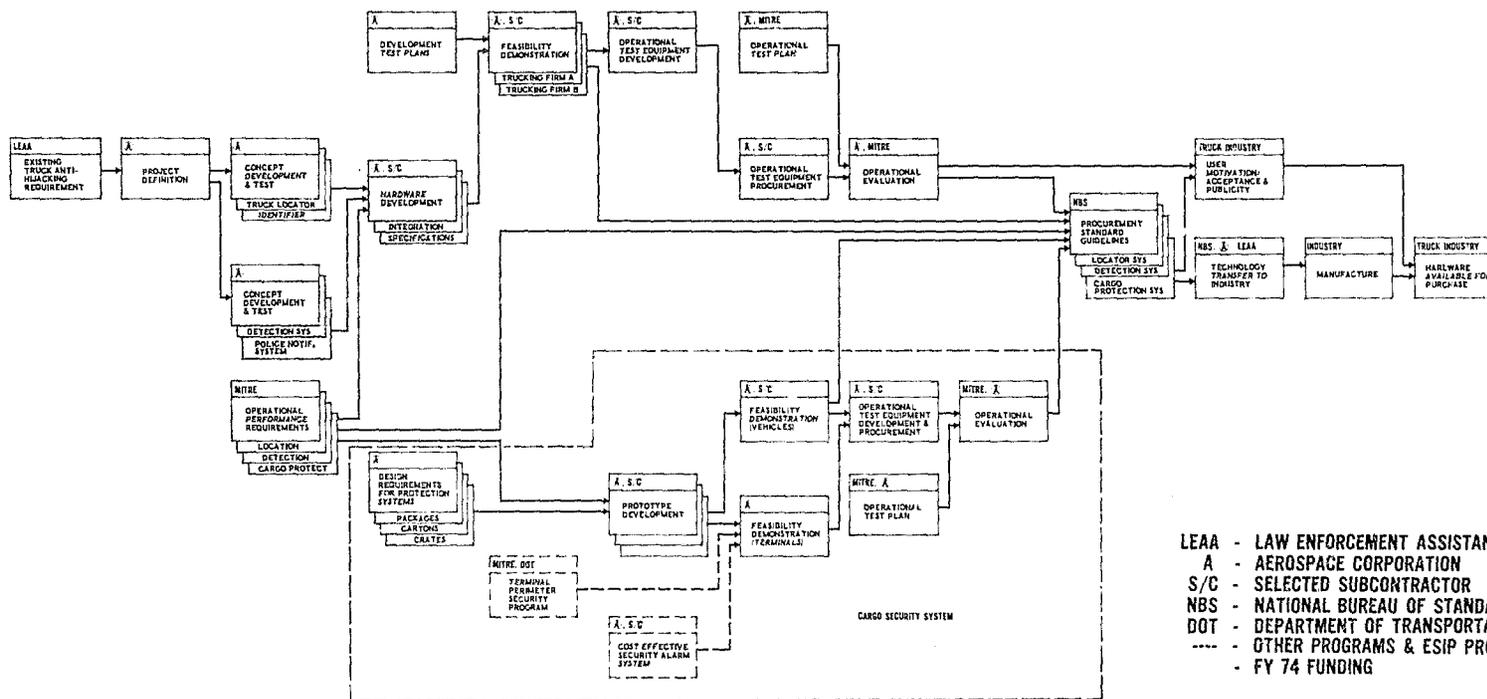
NEW CONTINUING

CONCEPT DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

TRUCK ANTI-HIJACKING SYSTEM



LEAA - LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
 A - AEROSPACE CORPORATION
 S/C - SELECTED SUBCONTRACTOR
 NBS - NATIONAL BUREAU OF STANDARDS
 DOT - DEPARTMENT OF TRANSPORTATION
 ---- - OTHER PROGRAMS & ESIP PROJECTS
 - FY 74 FUNDING

NEW PROGRAMS

Study of Latent Fingerprint Research

Blood and Bloodstain Analysis

Explosives Detection and Identification

STUDY OF LATENT FINGERPRINT RESEARCH

PROBLEM STATEMENT

Classifying, coding, and matching of latent fingerprints is presently done manually and is both slow and excessively dependent on the skill and memory of the operator. There are no systems presently in use which permit fingerprint files to be automatically searched against a latent print.

OBJECTIVE

The objective of this program is to explore the application of advanced technology to improve the coding, file searching, and matching of latent fingerprints in order to provide rapid, quantitative, and objective methods for fingerprint tracing and identification. This is to be a study of the applicability of advanced technology and not a state-of-the-art review or assessment of present off-the-shelf technology.

BACKGROUND

Several major problem areas provide incentives for a forceful and well-planned effort to improve fingerprint identification technology.

Fingerprint files on the national as well as local level have grown very large, making print matching by current manual methods very slow and wasteful of trained manpower. For example, the criminal fingerprint files of the FBI number about 20 million; the total current files contain approximately 90 million cards. There are 10 fingerprints to a card, so the number of single prints in the national files is almost one billion. The Chicago Police Department files contain a total of 30 million prints alone, and are indicative of the file size of a large city police department. The magnitude of the searching and matching task is exemplified by the fact that the number of requests for identification reaching the FBI is approximately 30,000 per day.

Study of Latent Fingerprint Research

The problems of classifying latent prints and of matching single prints for identification against one card in such vast files have led police departments to establish separate latent print files of habitual criminals so as to reduce the scope of the search effort. Often these files have additional classifications pertaining to type of crime, sex, age, etc., to further reduce the scope of the search effort. In spite of this, latent prints are rarely used successfully in detecting the criminal. For example, latent prints are responsible for solving only about 0.1% of all burglaries, although it has been estimated that fingerprint clues can be found in about 40% of such crimes.³

The law enforcement community is well aware of the problems pertaining to current fingerprint classification and search-and-match methods. Efforts have been under way since the early 1960s to introduce automatic techniques to the field of fingerprint identification. The FBI has been particularly active in sponsoring development work and has been assisted in this by the National Bureau of Standards and by nongovernmental and industrial organizations such as CALSPAN, Stanford Research Institute, North American Rockwell Information Systems Co., etc. Others, such as IBM, Argonne National Laboratories and the Jet Propulsion Laboratory, have also developed advanced concepts of possible great utility in expanding the automation of the fingerprint identification process.

The coding and matching systems which have been explored to varying degree have been based on holographic techniques, optical/digital methods, and spectrum analyzers. Transform techniques have been proposed as new coding schemes to produce data compaction. Classification schemes have involved variations of the Henry system, deterministic approaches such as distance measurements between reference points and print features, and stochastic approaches such as regression analysis or Bayesian schemes.

Advanced concepts exist for complete automation of the entire identification process from scanning, coding, classification, to matching and

³Study by J. Peterson and B. Packer, Physical Evidence Utilization in the Administration of Criminal Justice, NI-032 (1972).

verification, but these need analysis and development to at least the feasibility demonstration state. The example cited earlier of 30,000 daily requests for identification reaching the FBI alone is indicative of the need to achieve more automation, particularly for the encoding and searching tasks. There appear to be many potential applications of advanced technology in this area. It is intended that this project will complement other Law Enforcement Assistance Administration (LEAA)-sponsored activities aimed at assessing the state of the art of both current fingerprint search methods as well as systems presently under development.

SCOPE

The proposed effort during FY 74 will constitute a broad examination of those advanced concepts showing promise of improving the latent fingerprint identification techniques. If sufficiently promising technology can be identified, the project will establish a rational basis for follow-on programs leading to hardware development.

The tasks to be accomplished will include a search for advanced concepts in the areas of fingerprint classification, coding, and matching. Of particular interest in this search will be fields of pattern recognition and image processing. In addition, an objective will be to identify methods capable of fully automatic operation. Both analog and digital technology will be considered. Communication will be established with originators of promising advanced concepts to ensure that all new systems are being considered.

Classification schemes will consider analog and digital encoding requirements in the selection of points of comparison. Both deterministic and stochastic classification approaches will be examined. Feature extraction technology is one of the most difficult problems in pattern recognition and will therefore only permit preliminary analysis within the scope of this project. Associated with the classification analyses will be consideration of file formatting and retrieval techniques to assure full compatibility.

Coding and matching analyses will consider analog technology including holographic, as well as direct image, space matching. Both coding for file storage and for transmission will be evaluated. In the coding analyses, false alarm rates and correct identification probability will be important evaluation criteria. For analog coding, both predictive and feature selection techniques will be analyzed. Digital coding techniques will include pulse code modulation and delta pulse code modulation, as well as predictive techniques and digital feature extraction.

Both direct and indirect digital matching modes will be evaluated. The latter will concentrate on transform techniques such as Fourier, Hadamard, and Haar.

The evaluation of transmission concepts will emphasize the goal of rapid print identification. Data quantity constraints of candidate electronic transmission systems will be analyzed and will be compared to special requirements of police car, intercity, and interstate links.

It is anticipated that the results of the technology analysis will permit description of major components and system design of an advanced fingerprint identification system. Close liaison will be maintained with other LEAA-sponsored fingerprint research to insure that the advanced technology recommended for development is realistic and represents a meaningful advancement over present systems and techniques.

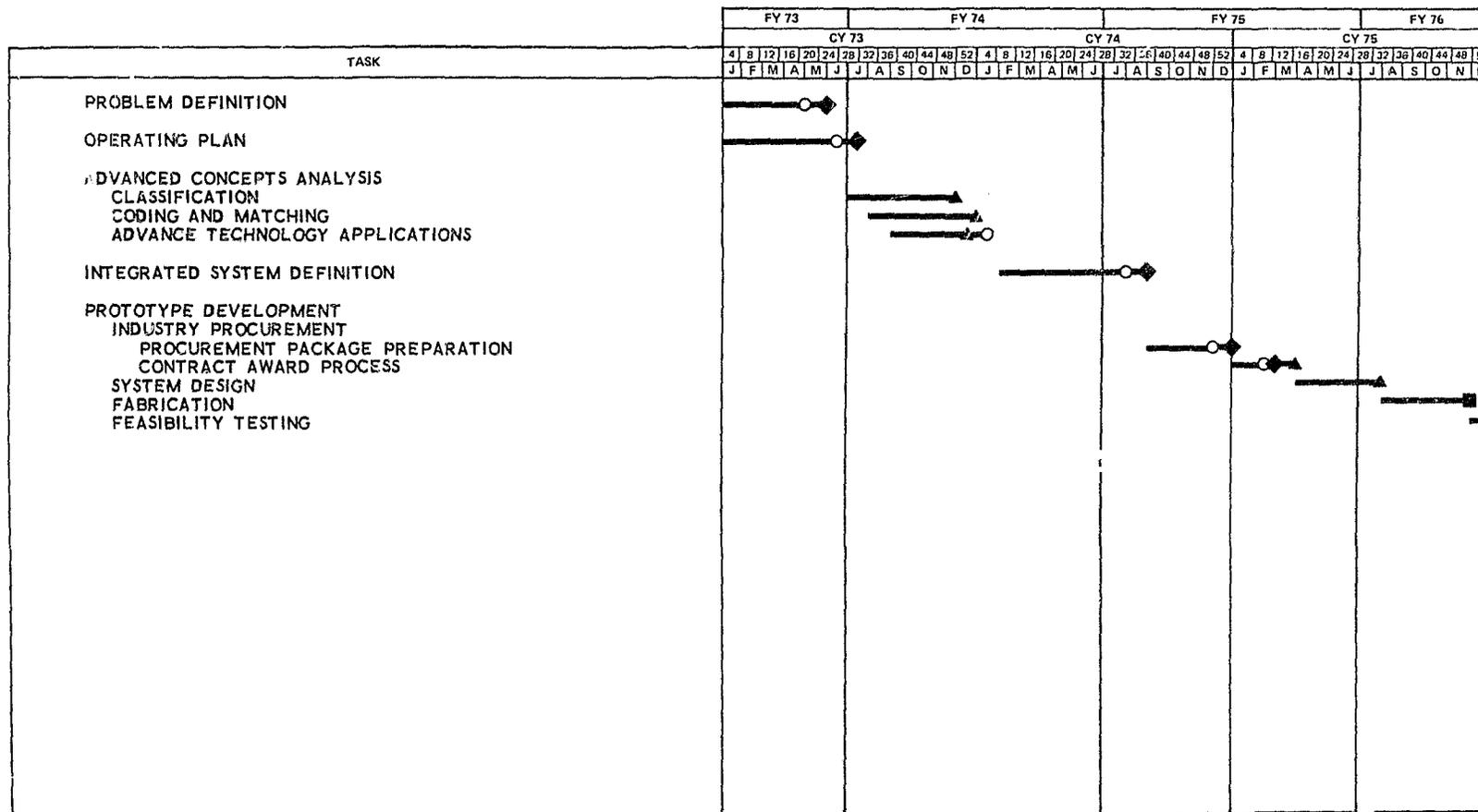
FY 74 PLANNED ACCOMPLISHMENTS

The major accomplishments of the initial phase of this project will be a report summarizing the applicability of advanced technology for solving latent fingerprint problems. This report is planned for completion approximately six months after the project is initiated.

LATENT FINGERPRINT RESEARCH

NEW CONTINUING

TECHNOLOGY DEVELOPMENT

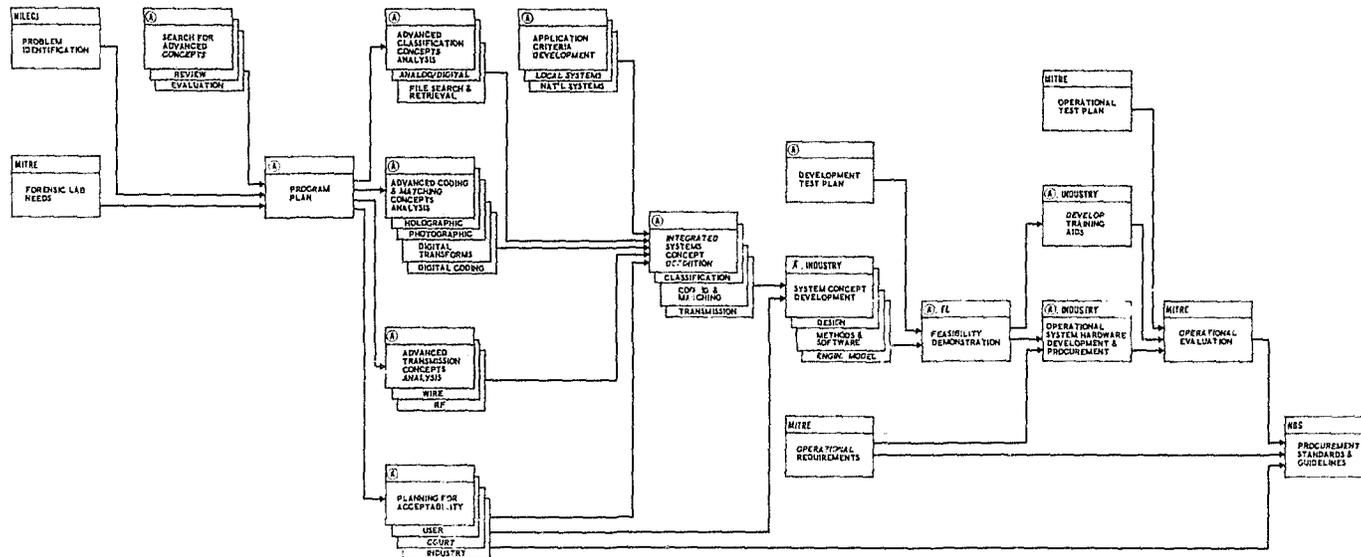


○ REPORT SUBMITTAL
◆ NILECJ APPROVAL

■ HARDWARE DELIVERY
▲ TASK COMPLETION

STUDY OF LATENT FINGERPRINT RESEARCH

3-38



- (A) - AEROSPACE CORPORATION
- WILECI - NATIONAL INSTITUTE FOR LAW ENFORCEMENT AND CRIMINAL JUSTICE
- NBS - NATIONAL BUREAU OF STANDARDS
- FL - FORENSIC LABORATORIES
- FY 74 FUNDING

BLOOD AND BLOODSTAIN ANALYSIS

PROBLEM STATEMENT

Blood and bloodstains are frequent clues found at the scene of a crime. Relating a specific individual to a criminal incident by liquid blood or bloodstain analysis could be an effective means of identification.

OBJECTIVE

The objective of this program is to facilitate utilization of modern techniques of blood individualization by developing a statistical data base, a blood data bank, reliable sera, and reliable, easy-to-use blood analysis equipment and methods for police laboratories.

BACKGROUND

Human blood is among the most common of physical clues recovered at crime scenes. Blood is not only found in association with crimes of violence but is also quite commonly found after a burglary (minor cuts are an occupational hazard for the burglar).

Techniques are now available by which blood can be highly individualized. In addition to the ABO system, the individualization of blood has been enhanced in recent years by including the Rh factor, and MN grouping systems, and the various polymorphisms of serum proteins and enzymes which can be distinguished by electrophoresis techniques. One in 100,000 probability of ambiguity is readily obtained and one in a million is not uncommon.

Analysis of enzyme and protein polymorphisms is routinely employed for blood individualization in criminal investigations by police laboratories in Great Britain; B. C. Culliford of the Metropolitan Police Laboratory, London, has done the pioneering work in this area. Among the serum proteins and enzymes routinely analyzed in Culliford's laboratory are hemoglobin, haptoglobin, erythrocyte acid phosphatase, polyphosphoglucomutase, and

adenosine kinase. The Law Enforcement Assistance Administration (LEAA) has already made an effort to stimulate the wider application of Culliford's techniques by sponsoring courses and preparing manuals describing these techniques. Blood individualization would be accepted by courts in the United States if police laboratories could more widely employ these methods with reliability and confidence. These techniques are now accepted without question by the courts in Great Britain.

In view of the importance of blood analysis in establishing conclusive proof of innocence, or a very strong indication of guilt, further effort is required to ensure the adoption of blood individualization techniques in the shortest possible time. The proposed project will address several shortcomings of the Culliford method. Among these are the long time periods (often up to 20 hours) involved in analyzing a single sample by the currently available electrophoretic equipment, the high proficiency required by the operator to produce reliable results, and the need for improvement in the analysis of dried blood stains. A major need also exists in the extension of the data base concerning blood composition of the many ethnic and geographic groupings in the United States.

SCOPE

The project will concern itself with two primary activity areas. The first consists of the collection and statistical interpretation of blood composition data covering the many ethnic groups collectively making up the nation's population. The second activity area includes the improvement of existing blood analysis equipment, methods, reagents, and more reliable sera, or if needed, the development of new equipment, etc., capable of quick and accurate determination of blood composition factors found critical to the blood individualization objective.

The project will rely heavily on cooperative activities involving, in addition to MITRE and the National Bureau of Standards, various government

agencies which are capable of aiding the blood data collection effort. It is essential that this effort be as broadly based as possible in order to assure rapid accumulation of the statistical information needed.

The following discussions provide additional detail concerning individual project tasks with emphasis on the effort planned for FY 74.

While program planning has been initiated during FY 73, the first task will be to expand this effort by undertaking a concept development phase in order to lay out a detailed program plan for the entire project. The program plan will provide a recommended management approach for the cooperative blood composition data collection effort, as well as detailed work scope and schedules for the tasks directly under Aerospace contractual control. Particular emphasis will be placed on the planning of long lead-time items, such as the setting up and maintaining of a block data bank.

The second task, which is a survey and technical assessment activity, will be initiated concurrently with Task 1 in early FY 74 in order to develop information essential to the program plan and to provide a data base for future work. The survey work will be completed in FY 74 and will include the collection of technical information and its preliminary evaluation for relevancy concerning the selection of candidate blood analysis equipment and methodology. In addition, this task will assess current utilization of blood enzyme and protein analysis techniques in the law enforcement community. It is anticipated that renewed contact with British practitioners of this analysis technique will be desirable to ensure availability of the latest procedures.

An equipment survey will be conducted to assemble a technical library of currently available blood analysis instrumentation and methodology as well as proposed new approaches. An agency survey will be conducted, involving such organizations as the National Institutes of Health, the National Science Foundation, the Veterans Administration and other public hospital administrations, and forensic laboratories to ascertain interest and capability for participation in a cooperative blood data collection effort.

The third task, covering equipment evaluation, will start in FY 74 and is scheduled for completion in FY 75. It is intended to develop data essential

to planning follow-on equipment improvement and development activities. Commercially available blood analysis equipment and reagents will be tested and evaluated in order to assess available techniques and their possible shortcomings. Of particular interest will be performance criteria such as rapidity of operation, operator proficiency required, accuracy and reproducibility of results, cost, and adaptability to the special objective of blood individualization. Of prime interest is the capability for analyzing dried blood stains. This task will also consider proposed techniques which are not yet commercially available and which may use other separation principles.

Concurrent with the survey and equipment evaluation effort, a task will be undertaken to develop guidelines for determining the criteria for court and crime lab acceptability of blood identification. This must be established relatively early in the project and will include use of outside consultants and assessment of the reliability of various methods. British experience is available to assist in this effort, since blood individualization is accepted in the courts in England.

Extensive data are available on the frequency of occurrence of these blood groupings which are currently being determined for medical and forensic purposes. These include the ABO, MN, and Rh factor groupings. Data concerning the frequency of occurrence of other blood constituents important to full individualization, and perturbations associated with ethnic groupings and geographic distribution, are not well known for the population of the United States. These other constituents, up to eight polymorphic serum enzyme and protein system groupings, will require an extensive statistical population base to permit frequency-typing. A reasonable approach to this statistical data base is to utilize the resources of a number of governmental institutions routinely engaged in blood testing for medical reasons.

The data derived from the cooperative blood data effort will be involved in the data bank and statistical analysis task, starting in FY 75, for sorting and filing in accordance with special procedures to permit automatic data retrieval. This will require the development of data formats and of

coding systems designed to facilitate file matching for identification purposes. Computer routines will be developed to permit automated data reduction and statistical analysis to determine blood group frequencies as a function of ethnic and geographic origin. Both the data bank and statistical analysis techniques will be developed from the point of view of eventual transition from a project to an institutional status.

Based on requirements developed during the equipment evaluation task and the blood constituent analyses, subcontractors will be selected to perform design improvement on existing analysis equipment and/or to develop new equipment. The objectives of this development task will be to provide prototype equipments and reagents capable of inexpensive, rapid, and reliable individualization of both whole blood and blood stains. Although electrophoresis methods may be the basis for such equipment design, the adoption of newer and more effective methods as developed under this project will be considered.

Investigation of new approaches to blood typing will also be undertaken. For example, blood group systems do exist which permit more precise blood individualization than those used by Culliford. Other anti-sera need therefore to be developed, together with appropriate test methodology to benefit from their application. Non-organic blood constituents should be examined for their individualization potential, and so on. Of particular interest will be methods capable of reliable analysis of old bloodstains, an area in which current electrophoretic techniques are deficient.

Once the equipment and methodology tasks have resulted in the development of engineering prototypes, extensive field testing will provide data necessary for the establishment of the production prototype design. This field testing will be coordinated with MITRE. This subcontracted task will support the MITRE effort by providing test hardware and engineering support. Field test results will also be analyzed under this task for impact on equipment design. Redesign requirements will be formulated and transmitted to the equipment development subcontractor for incorporation in the prototype production.

Rapid acceptance by the forensic laboratory of a new technique for blood individualization can be assisted materially by audiovisual educational aids. A final task will provide such aids in the form of film, CCTV tape, and written documentation. Detailed instruction material concerning equipment operation will, however, be provided by the commercial manufacturer of the equipment.

Both interim technical progress and special task reports will be issued under this project. Interim technical progress reports will be provided at six-month intervals. Special task reports will be provided at the conclusion of each task. Task reports covering work performed under contract may consist of the contractor-submitted report with an attached evaluation by The Aerospace Corporation. A final report will be issued two months after termination of the entire project which has an estimated duration of three years.

FY 74 PLANNED ACCOMPLISHMENTS

The following reports will be submitted to the Institute during FY 74:

1. Report documenting the work and summarizing the conclusions accomplished under the Survey and Technical Assessment Subtask - January 1974
2. Report summarizing the Equipment Evaluation Subtask - June 1974

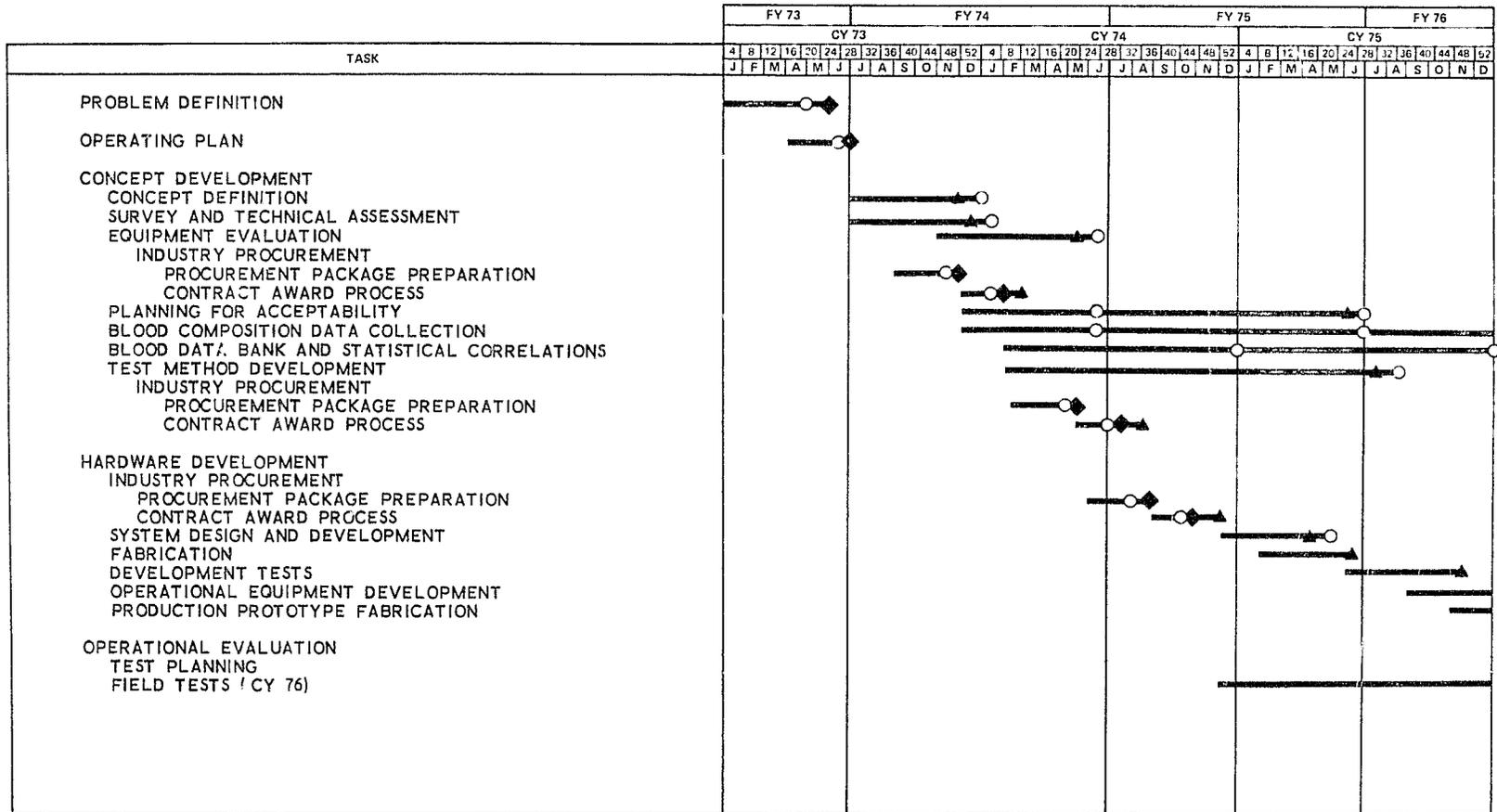
The following documentation will be submitted to the Institute for approval during FY 74 to support subcontractor procurement activities:

1. Procurement package for Equipment Evaluation Subcontract - November 1973
2. Contractor Selection documentation and recommendation for Equipment Evaluation - January 1974
3. Procurement package for Test Method Development Subcontract - April 1974

BLOOD AND BLOODSTAIN ANALYSIS

NEW CONTINUING

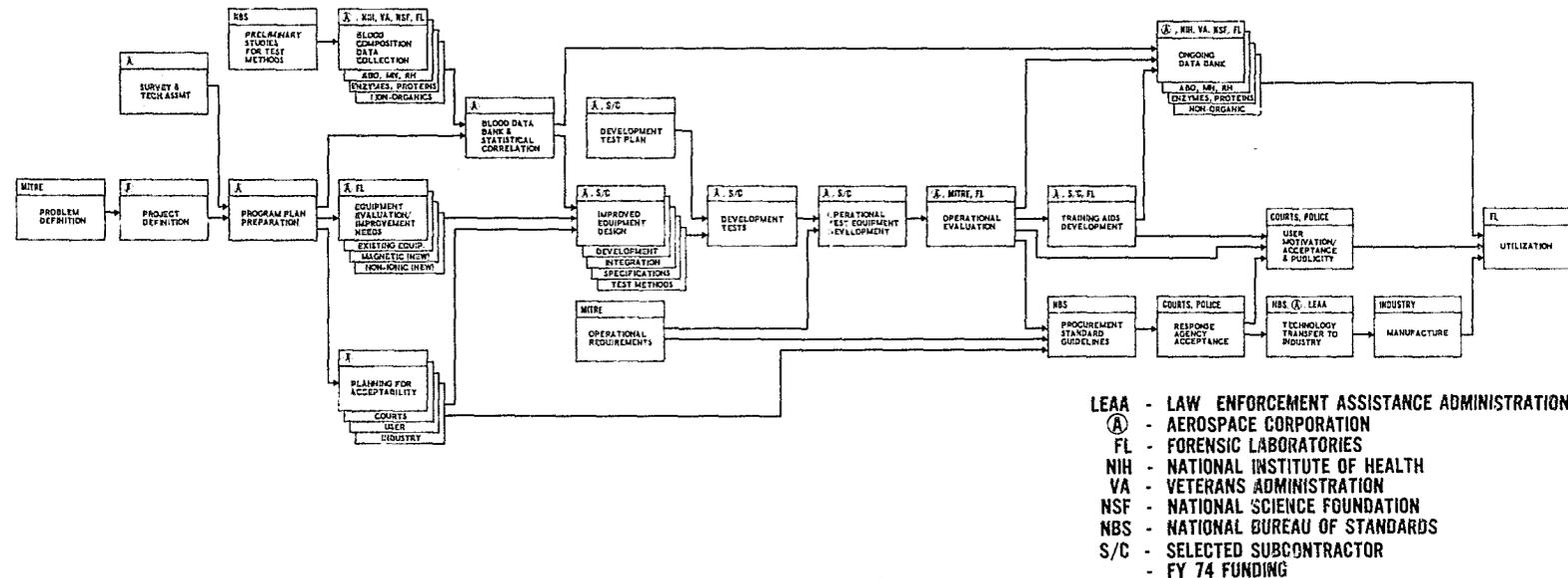
CONCEPT DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

BLOOD AND BLOODSTAIN ANALYSIS

3-46



EXPLOSIVES DETECTION AND IDENTIFICATION

PROBLEM STATEMENT

The use of explosives for skyjacking, extortion, and militant attacks upon the public necessitates developing new and improved methods for detecting concealed explosives and for determining the origin of explosives in both pre- and post-explosion situations.

OBJECTIVE

The objective of this program is to develop practical systems utilizing sensitive and reliable instrumentation for detecting explosives and determining their origin. Specific objectives include (1) the development of equipment and techniques to detect concealed explosives by means of characteristic vapors, and (2) the development of a tagging system that will permit pre-detonation detection of explosives and/or post-detonation identification.

BACKGROUND

The increase in illegal use of explosives has resulted in an urgent need for rapid and reliable methods for the detection of concealed explosives. Law enforcement agencies must be able to detect explosives ranging from letter size, capable of killing or maiming a person, to bulk packages that can cause widespread death and destruction. Personnel engaged in preventing skyjacking appear to have found an effective interim deterrent against weapons by use of metal detectors and search techniques, but detection of explosives still presents a problem.

An Ad Hoc Panel was created early in FY 73 to provide a preliminary analysis of techniques available for detecting both untagged and tagged explosives and for tagging explosives so as to provide pre- and post-detonation identification of the explosives origin. Personnel of The Aerospace Corporation have actively participated in this panel.

Detection of the characteristic vapors emitted by explosives may be accomplished by using a variety of analytical instruments. Vapors are either directly detected by the instruments or processed to obtain a decomposition product that can be identified. These techniques do not require tagging of the explosives and appear applicable to explosives which contain sufficiently volatile compounds. Instrumentation development is required to detect explosives which are concealed in "vapor tight" containers or to detect explosives with low vapor pressures. (Alternatively, preconcentrators have been considered as a means for providing sufficient vapor for detection.) Some general problems which need to be quantitatively assessed are the effects of barriers (wrapping, suitcases, etc.) and interference by non-explosive vapors that may provide a false alarm. An immediate specific problem is the lack of information on vapor signatures of explosive materials. Very little data are available on the identity of the vapors and their rates of escape.

Other possible methods for the detection of untagged explosives include neutron activation, x-ray fluorescence, x-ray fluoroscopy, and magnetic resonance techniques. Some of these have high potential and should be part of any comprehensive program.

The use of tags to provide an effective detection source appears feasible with commercial explosives. The problem may be complicated by military explosives which are subject to different regulatory controls. Thus, tagging techniques suitable for commercial explosives may not be acceptable for military explosives. A simple approach to tagging for detection employs an electronegative tagging material [sulphur hexafluoride (SF_6), freons, etc.] that would be continuously evaporating from either the blasting cap or impregnated explosive, and could be detected by electron capture techniques. Nuclear activation techniques also appear feasible but are more expensive. Atomic excitation with subsequent x-ray fluorescence also offers a potential approach.

The identification, either pre- or post-detonation, of tagged explosives is being investigated by various agencies and several techniques appear promising if manufacturing safety can be established. One of the more advanced experimental techniques employs coded phosphor particles which are retrieved using an ultraviolet lamp to make them visible and are decoded using a fluorescence spectrophotometer. Another technique employs survivable microspheres containing tagging elements. Other possibilities for analyzing tagged explosives include thermal neutron activation, x-ray fluorescence, and x-ray excited optical fluorescence.

In summary, while initial surveys show that a number of potential techniques are available, further studies and development are required to solve various problems. As a result of the Ad Hoc Panel's efforts, a program has been suggested by the Bureau of Alcohol, Tobacco and Firearms. The suggested program, however, does not include a vapor detection technique, but instead suggests the use of neutron activation detection of nitrogen-containing explosives. While detection via the thermal neutron capture reaction in nitrogen may provide for detection of untagged explosives, in practical applications the nitrogen content of other materials will tend to produce false alarms. Thus, for the long term solution, a more specific detection technique appears to be needed.

Since unauthorized use of military explosives or illegally imported explosives (neither of which would be tagged) may occur, a program to provide a vapor detection capability is also appropriate. Current instruments do not have the short detection times desired and are not effective against explosives with very low vapor pressures. The optoacoustic technique being developed for air pollution monitoring appears to offer great potential for a sensitive explosive vapor detection method.

SCOPE

The initial effort of this project will be directed at developing concepts and technology to provide early workable systems with the potential for subsequent improvement in capability. The best approach for an early system

appears to be the development of SF_6 as a tagging medium. For the detection of untagged explosives, the development of the optoacoustic technique is proposed.

The extreme sensitivity to which SF_6 can be determined (a few parts in 10^{13} parts of air, without preconcentration) and the inert chemical nature of the compound (nontoxic to animal life and low chemical reactivity) combine to offer the best current approach for rapid development of a detection system for concealed explosives. The proposed investigation will include (1) evaluation of various polymers as carriers of SF_6 for use in detonator caps, and (2) determination of the feasibility of saturating wrappings or coatings of explosives with SF_6 to provide a detection source. General factors that influence the use of SF_6 as a taggant to be evaluated are:

1. Background determination of SF_6 in environmental use situations.
2. Carrier effects on rate of emission of SF_6 from tagged items.
3. Development of preconcentrators for extended capability.

If the initial feasibility studies are negative, an investigation using either uranium or gadolinium as a taggant will be initiated.

The fine optical frequency control available from laser radiation and the sensitive acoustical detection of pressure changes due to absorption of energy by selectively excited molecules offer the potential for a very sensitive explosive vapor detection system. A program will also be initiated on the development of optoacoustic methods for detecting concealed explosives. The investigation will include:

1. Identification of vapors emanating from explosives that are best suited for detection by the optoacoustic technique.
2. Demonstration of the ability to detect ethylene glycol dinitrate (EGDN) and dinitrotoluene (DNT) in the sub-parts per billion range.
3. Identification of environmental background vapors of interest and evaluation of their impact upon the detection system.
4. Development of an overall technique for detecting concealed explosives.

Effort on both tagged and untagged explosives detection methods will be initiated in FY 74. Both in-house and contractor support will be involved,

and the activity will be directed at technology acquisition and interpretation. This effort will be extended into FY 75 and, if successful, prototype development will be initiated.

The long term development of successful techniques for detecting concealed explosives requires an extensive characterization of vapor species emanating from all types of explosives for which unauthorized use can be anticipated. Such information is needed not merely to assess the adequacy of the Federal Aviation Administration-supported study on the spreading of explosive vapors under special conditions, but to provide basic sensitivity requirements for proposed identification concepts as well. A vapor identification program will, therefore, also be initiated in FY 74. It will consist of:

1. Identification of normal compositional and impurity vapor species emanating from explosives.
2. Precise measurement of vapor pressures for identified vapors.
3. Evaluation of vapors for potential detection and impurity vapors as a means for determining the source of explosives.

Industry support will also be solicited for this activity and the effort will continue into FY 75.

If successful results are achieved during the preliminary activity of FY 74 and FY 75, design limits will be established and prototype equipment design and development will be initiated for a feasibility demonstration. Based upon the results of this demonstration, a decision for an operational evaluation on a larger scale and under controlled but realistic conditions will be performed. At this point, the technology transfer process begins with legislative support, where required, to direct industry to include tagging elements in their manufacturing processes.

FY 74 PLANNED ACCOMPLISHMENTS

The following reports will be submitted to the Institute during FY 74:

1. Feasibility final report and follow on recommendation for optoacoustic vapor detection efforts - June 1974

2. Feasibility final report and follow on recommendation for tagging of explosives for detection efforts - June 1974
3. Study report on explosives vapor characteristics - June 1974

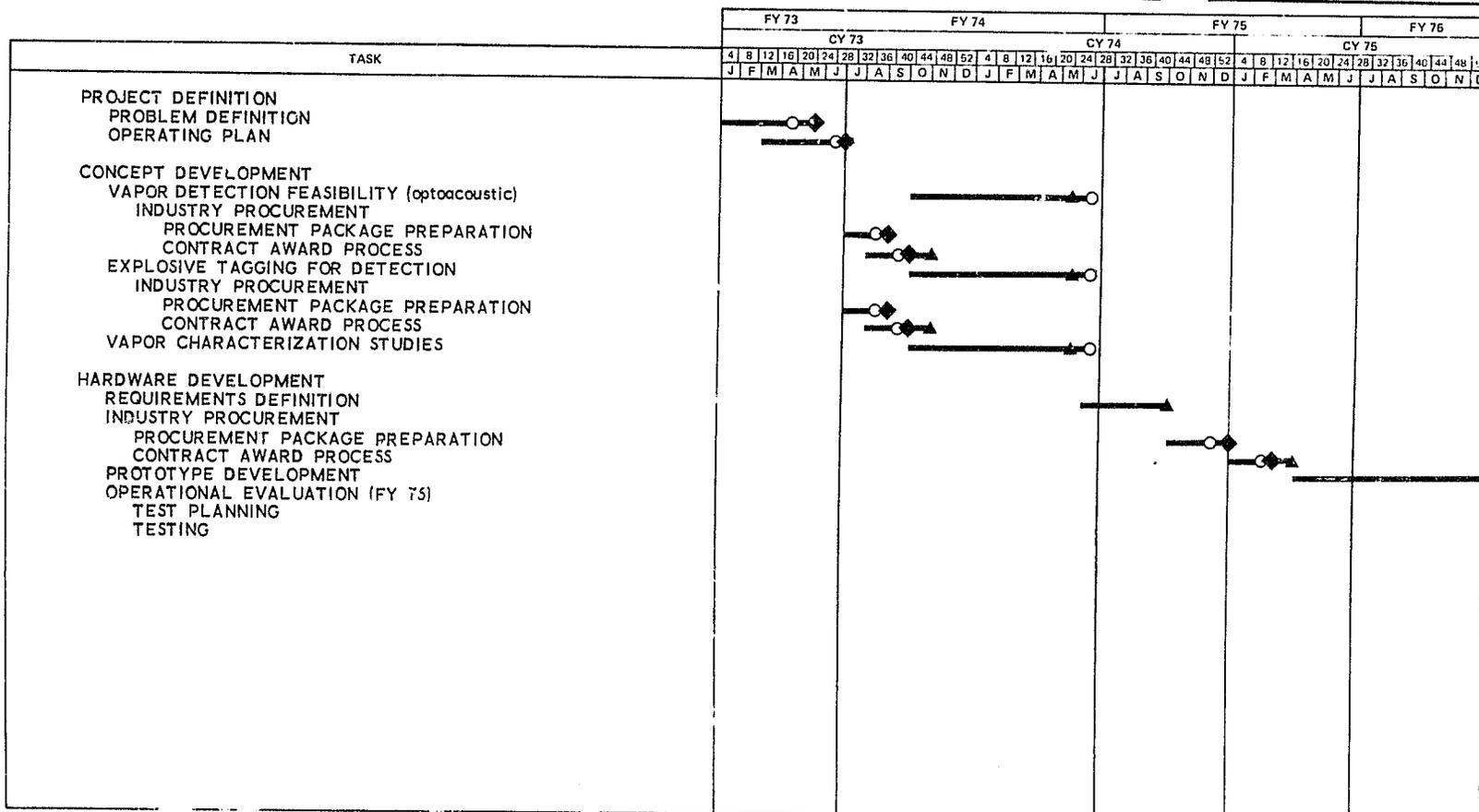
The following documentation will be submitted to the Institute for approval during FY 74 to support subcontracting activities:

1. Procurement packages for Vapor Detection Feasibility (optoacoustic) and Explosive Tagging for Detection subcontracts - August 1973
2. Documentation and recommended subcontractor selection - October 1973

EXPLOSIVES DETECTION AND IDENTIFICATION

NEW CONTINUING

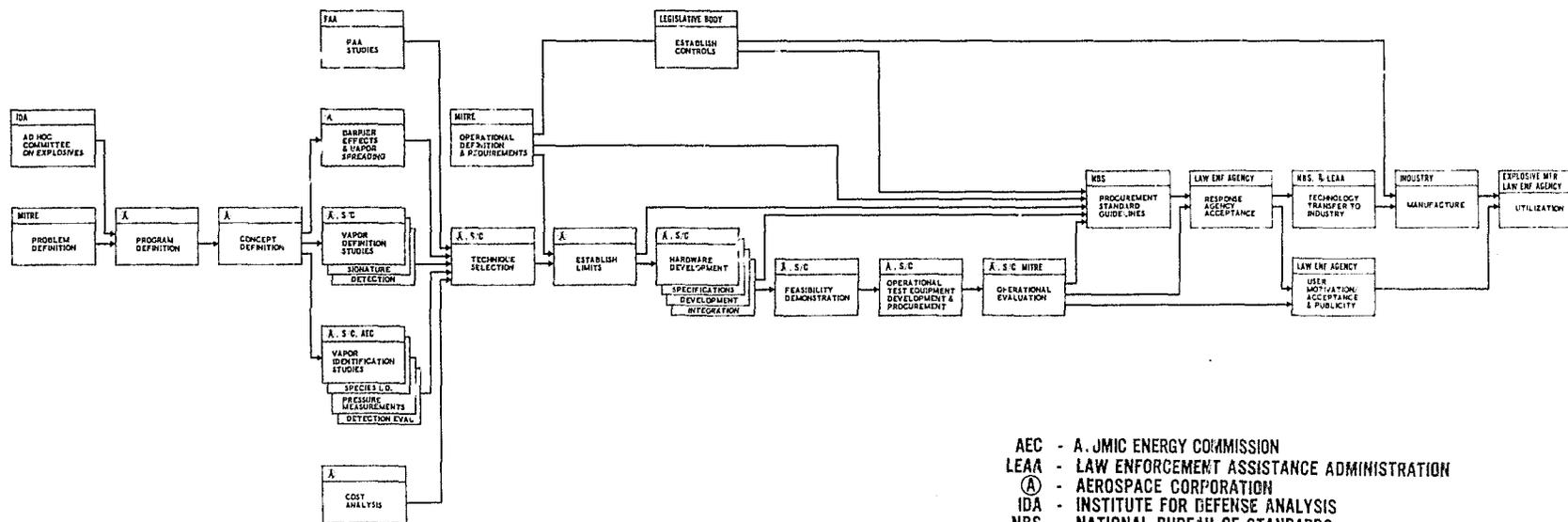
TECHNOLOGY DEVELOPMENT



○ REPORT SUBMITTAL ■ HARDWARE DELIVERY
 ◆ NILECJ APPROVAL ▲ TASK COMPLETION

EXPLOSIVE DETECTION AND IDENTIFICATION

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- AEC - A. JOMIC ENERGY COMMISSION
- LEAA - LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
- Ⓐ - AEROSPACE CORPORATION
- IDA - INSTITUTE FOR DEFENSE ANALYSIS
- NBS - NATIONAL BUREAU OF STANDARDS
- FAA - FEDERAL AVIATION ADMINISTRATION
- S/C - SELECTED SUBCONTRACTOR
- FY 74 FUNDING

END