AIR MEDICAL EVACUATION SYSTEM (AMES)

DEMONSTRATION PROJECT

EXECUTIVE SUMMARY

JUNE 1970

Conducted under
Contract No. FH 11-7090
U.S. Department of Transportation
National Highway Bureau

By
Engineering Research Center
College of Engineering Sciences
Arizona State University
Tempe, Ariz. 85281
A I R  M E D I C A L  
E V A C U A T I O N  S Y S T E M  
(A M E S) 

D E M O N S T R A T I O N  P R O J E C T  

E X E C U T I V E  S U M M A R Y  

T H E  C O L L E G E  O F  E N G I N E E R I N G  S C I E N C E S  
A R I Z O N A  S T A T E  U N I V E R S I T Y  
T E M P E ,  A R I Z O N A  8 5 2 8 1  

M A Y  1 9 7 0  

C O N T R A C T  N O .  F H - 1 1 - 7 0 9 0  

U . S .  D E P A R T M E N T  O F  T R A N S P O R T A T I O N  
N A T I O N A L  H I G H W A Y  S A F E T Y  B U R E A U  
W A S H I N G T O N ,  D . C .
This report has been prepared under contract with U. S. Department of Transportation, Federal Highway Administration, National Highway Safety Bureau, No. FH-11-7090.

The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily of the National Highway Safety Bureau.
STUDY TEAM
ARIZONA STATE UNIVERSITY

James L. Schamadan, M.D., Director

Victor E. Rothe
Donald F. Schaller, M.D.
Edward B. Waldmann, M.D.
Robert L. Sears, Lt. Col. U.S. Army
Vernon E. Ebert, Major U.S. Army
Dale F. Means, Captain U.S. Army
James C. Connolly II, Major U.S. Army
Thomas E. Peot, Captain U.S. Air Force

Eugene M. Wilson
Michael E. Anderson
Donald F. Carroll
S. Harry Robertson
Dr. Judson S. Matthias
Mrs. Wanda R. Idle
Marcia Simons
Patti Elgas

THE ARIZONA STATE HIGHWAY PATROL

Sgt. Richard L. Sandheger, Project Director

Robert J. Davis
Glenn E. Shultz
Waite M. Blake

Juan Martin, Jr.
Duane L. Lynn

ARIZONA HELICOPTERS, INC.

Jerry P. Foster, Chief Pilot

Lance E. Stewart
Chad L. Haring

Ellery C. Kramar
Lyman A. Jantzen
ACKNOWLEDGEMENTS

Acknowledgement is due many individuals and organizations who contributed their time and effort to bring this project into being and aided in its successful execution.

Arizona Highway Department
Arizona State Highway Patrol
Arizona Hospital Association
Arizona Medical Association
Associated Ambulance Company
Fairchild Hiller Corporation
Gold Cross Ambulance Company
Good Samaritan Hospital
Governor's Emergency Medical Services Committee
Maricopa County Medical Society
Maricopa County Hospital
Pima County Medical Society
St. Joseph's Hospital
U. S. Army Surgeon General
U. S. Department of Transportation, National Highway Safety Bureau

Special recognition is due the nurses, medical staffs and all of the personnel of the Good Samaritan, Maricopa County and St. Joseph's hospitals for their contributions during the para-medic training program and their cooperation throughout the flight operations phase of the project. Special recognition is also due the following individuals:

Jack Byrd, President, Gold Cross Ambulance Company;
Paul Fannin, U. S. Senator, Arizona;
Boyd H. Gibbons, Jr., Governor's Highway Safety Coordinator;
Colonel James J. Hegarty, Director,
  Arizona Department of Public Safety;
Stephen M. Morris, President, Samaritan Health Services;
Duncan McQuarrie, General Manager, Associated Ambulance Company;
Major Walter McMean, Williams Air Force Base;
Brigadier General Spurgeon Neal, U. S. Army Surgeon General;
Sister Mary Ralph, Supervisor, Emergency Room, St. Joseph's Hospital and Chairman, Governor's Emergency Medical Committee;
John Rhodes, U. S. Congressman, Arizona;
Colonel Lloyd H. Robertson, Superintendent,
  Arizona State Highway Patrol;
Lt. Colonel Robert L. Sears, Office Chief of Staff,
  Department of the Army, Washington;
Dr. Lee P. Thompson, Dean, College of Engineering Sciences,
  Arizona State University;
Robert Wachs, President, Arizona Helicopters, Inc.
ABSTRACT

An Air Medical Evacuation System (AMES), which incorporates the helicopter, well-trained para-medical personnel, and a well designed communications system was developed and tested in 1969-1970 by the Arizona State University under a U. S. Department of Transportation demonstration project contract.

Two specially equipped turbine-powered helicopters operated 24-hours a day out of the main AMES base in central Arizona. The aircraft carried two internal litters, the pilot and an Arizona Highway Patrolman. Both men were trained as para-medical specialists and had over 150 hours in an advanced in-hospital training program (I.C.U., Burn Unit, Delivery Suite, O.R., Emergency Room, etc.). Three physicians, all with military air evacuation and rescue experience (Army, Navy and Air Force), monitored the system continuously. The AMES responded to medical emergencies such as highway accidents, hunting, camping and boating mishaps, and inter-hospital transfers. The communication system could reach any point in the state utilizing the Arizona Highway Patrol frequencies and a separate medical channel. The net could also be "patched" into the telephone system, whenever desired.

After several months of intensive training, statewide service was initiated on 30 May, 1969. By 31 January, 1970, the completion date of flight operations, the aircraft had flown 1,185 hours and evacuated 225 persons in the course of 213 missions. In addition to the medical experience which included evacuation of accident victims, hospital and premature infant transfers, venomous animal bites, tetanus, burns and general trauma, the AMES flew 613 "other" missions, including manhunts, aircraft searches, patrol, surveillance, etc.

Detailed records were maintained on all flights and medical follow up was conducted on every patient. Patients were evaluated with a quantitative scoring system called "SIMBOL".

Clinically, the AMES developed sound criteria for:

1. The types of patients suited for this service, as well as those definitely NOT suited;

2. Necessary "on-scene" preparations, procedures, and medications;

3. Standards of evacuation care;

4. Strategies and devices for comfort and telemetry; and,

5. Choice of receiving facility.
In addition, this program provided quantitative answers to the questions of cost and operational effectiveness of civilian air medical (helicopter) systems.

The expense of such a system is substantial. The high operating costs can, however, be justified if the aircraft are used for other supporting missions, such as law enforcement, patrol, surveillance, without sacrificing the medical evacuation capabilities or priorities of the system.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>STUDY TEAM</td>
<td>i</td>
</tr>
<tr>
<td>ACKNOWLEDGEMENTS</td>
<td>ii</td>
</tr>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>v</td>
</tr>
<tr>
<td>LIST OF TABLES AND FIGURES</td>
<td>vi</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Phase I - System Development</td>
<td>2</td>
</tr>
<tr>
<td>Phase II - Computer Simulation</td>
<td>2</td>
</tr>
<tr>
<td>Phase III - Demonstration</td>
<td>2</td>
</tr>
<tr>
<td>OPERATIONS PLAN</td>
<td>8</td>
</tr>
<tr>
<td>The AMES Concept</td>
<td>8</td>
</tr>
<tr>
<td>Evaluation System</td>
<td>9</td>
</tr>
<tr>
<td>FLIGHT OPERATIONS</td>
<td>10</td>
</tr>
<tr>
<td>Type Missions</td>
<td>10</td>
</tr>
<tr>
<td>Evacuation Missions</td>
<td>14</td>
</tr>
<tr>
<td>Search and Surveillance Missions</td>
<td>16</td>
</tr>
<tr>
<td>Other Missions</td>
<td>17</td>
</tr>
<tr>
<td>PROJECT EVALUATION</td>
<td>18</td>
</tr>
<tr>
<td>General</td>
<td>18</td>
</tr>
<tr>
<td>Cost Effectiveness</td>
<td>18</td>
</tr>
<tr>
<td>Operational Effectiveness</td>
<td>19</td>
</tr>
<tr>
<td>Public Attitude and Acceptance Survey</td>
<td>19</td>
</tr>
<tr>
<td>CONCLUSIONS</td>
<td>22</td>
</tr>
<tr>
<td>RECOMMENDATIONS</td>
<td>24</td>
</tr>
</tbody>
</table>
## LIST OF TABLES AND FIGURES

<table>
<thead>
<tr>
<th>Table/Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE 1</td>
<td>Distribution of Patients</td>
<td>15</td>
</tr>
<tr>
<td>TABLE 2</td>
<td>Distribution of All Missions Flown</td>
<td>16</td>
</tr>
<tr>
<td>Figure 1</td>
<td>THE AMES CONCEPT</td>
<td>3</td>
</tr>
<tr>
<td>Figure 2</td>
<td>RANGE OF FLIGHT OPERATIONS</td>
<td>5</td>
</tr>
<tr>
<td>Figure 3</td>
<td>AMES PROGRAM MANAGEMENT CONCEPT</td>
<td>7</td>
</tr>
<tr>
<td>Figure 4</td>
<td>SIMBOL SYSTEM STATUS AND PREDICTOR TABLES</td>
<td>9</td>
</tr>
<tr>
<td>Figure 5</td>
<td>MISSION ACTIVATION</td>
<td>11</td>
</tr>
<tr>
<td>Figure 6</td>
<td>AMES HELICOPTER ARRIVAL AT THE SCENE</td>
<td>11</td>
</tr>
<tr>
<td>Figure 7</td>
<td>PREPARATION OF THE MEDICAL LITTER</td>
<td>12</td>
</tr>
<tr>
<td>Figure 8</td>
<td>PREPARATION OF THE PATIENT FOR EVACUATION</td>
<td>12</td>
</tr>
<tr>
<td>Figure 9</td>
<td>LOADING THE PATIENT INTO THE HELICOPTER</td>
<td>13</td>
</tr>
<tr>
<td>Figure 10</td>
<td>DELIVERY OF THE PATIENT AT THE HOSPITAL</td>
<td>13</td>
</tr>
<tr>
<td>Figure 11</td>
<td>OPERATIONAL EFFECTIVENESS MATRIX</td>
<td>20</td>
</tr>
</tbody>
</table>
AIR MEDICAL EVACUATION SYSTEM

DEMONSTRATION PROJECT

INTRODUCTION

One approach to the "post-crash" problem of reducing the numbers of deaths and permanent injuries is to provide the earliest possible first-aid, rescue, emergency transportation, and competent medical care for persons involved in motor vehicle accidents. If such measures are taken, the resulting mortality and morbidity rates can be reduced. This is particularly appropriate for remote and rural areas, where death follows injury with the greatest frequency.

An obvious means to achieve reduction in the time-distance factor between accident site and competent medical therapy is the utilization of an emergency vehicle which is fast, reliable, and capable of operating independently from the road traffic environment. In terms of present technology, that vehicle is the helicopter and the utilization of a well-trained, adequately supervised, properly supported para-medical specialist is also essential to the system (in some circumstances, a physician or nurse might be a more effective team member).

In June 1967 a group of engineering faculty and students at Arizona State University initiated a systems analysis study on the use of helicopters for providing immediate emergency medical care and subsequent transportation of highway accident casualties to medical facilities for definitive care. The study resulted in recommendations for the development of an Air Medical Evacuation System (AMES) to serve the State of Arizona. The system was designed to take advantage of the experiences of the U. S. Army Medical Service air ambulance units and helicopter units of the Air Force's Aerospace Rescue and Recovery Service.

The general concept for AMES provided for certain helicopter rescue and evacuation teams to be on ground alert and others on airborne surveillance or patrol, with computer-assisted dispatching at selected hours of the day or night, over roads and recreation areas with a high accident history. When an accident occurred, one of the AMES teams would be directed to the scene. In some cases, the team on airborne patrol might be the first to actually see the accident.

Upon arrival at the scene of the accident, a specially-trained two man team would rescue, sort, and treat the injured according to need. The injured would be promptly evacuated to the nearest medical facility capable of providing definitive treatment. The AMES team would have the capability for direct radio communication with a medical consultant, who could advise on emergency treatment measures to be taken at the scene or while enroute to the hospital. After the casualties had been delivered
to the hospital emergency room, the AMES helicopter would then return to the base for refueling, or proceed to another patrol route, as dictated by the situation. The concept is illustrated in Figure 1.

The concept was based on requirements to provide a quicker response to the accident, particularly in rural and remote areas, than could be attained with conventional ambulance services, while maintaining operational compatibility with those services. AMES would also have the capability for day and night operations and for adaptation to requirements caused by expanding population centers and advanced technology.

As a secondary benefit, AMES could also serve as an alternate means for highway patrol and surveillance and for general law enforcement activities; as an aid to improved accident investigation; as a base for Civil Defense and disaster systems; and as a model for use by other states or communities.

A project plan was then established to develop the AMES concept in three phases, as follows:

Phase I - System Development: During this phase, systems analysis and management decision-making techniques were applied to determine operational procedures, organizational structures, equipment needs, base heliport locations and a suitable area in which to operationally demonstrate the AMES concept. The results of this phase provided the basis for a master's thesis by Lt. Colonel Robert L. Sears, U. S. Army, a graduate student at Arizona State University.

Phase II - Computer Simulation: During this phase a computer program was developed to simulate the operation of an air and ground ambulance system. The computer program was designed to accept historical accident data obtained from the State of Arizona. This program could then be modified with the experience data of the Phase III demonstration program.

Another computer program included surveillance patrol routes which the aircraft were to fly at times and days which have proved statistically high in accident probability. Data to establish these high probability areas was based on accidents which occurred in previous years and could be continually updated on the basis of experience gained during the Phase III demonstration project. Ideally a final computer model developed after the Phase III demonstration could then be utilized by any community as the foundation upon which to develop their own system.

Phase III - Demonstration: During the demonstration phase of the program, AMES teams were to operate in a specified region
THE AMES CONCEPT

Figure 1

SURVEILLANCE (SIGHTINGS POLICE CALLS)

MISSION CONTROL

COMPETENT MEDICAL TREATMENT

EVACUATION

RESCUE

EMERGENCY TREATMENT
of the state with two helicopters, as determined by Phases I and II of the study. Data were compiled from which the "in use" operational and cost effectiveness of the AMES concept could be determined. Human engineering studies were also undertaken concurrently to determine optimum characteristics of the AMES helicopters, the para-medic teams, additional needs for special training and equipment, improved methods for rescue and handling of casualties, and the development of new concepts for discovery and notification of motor vehicle accidents.

The information developed under Phases I and II formed the basis for a proposal to the National Highway Safety Bureau of the Department of Transportation, soliciting their support for a program to demonstrate the concept developed during the study phases. On 11 February 1969, a one year contract (FH-11-7090) in the amount of $304,072, was awarded to Arizona State University for a demonstration of the AMES concept. In November 1969 the contract was extended for a period of three months, for an additional cost of $115,423. The three months extension permitted the acquisition of snow and cold weather operational experience during the winter months.

The first three months of the demonstration program were devoted to the development of the details of the data collection and evaluation system; the training of personnel who were to participate in the program; and the acquisition of equipment, including the helicopters.

The following nine months were devoted to operation of the air and ground systems participating in the program. During the operations period two turbine powered, Fairchild Hiller FH-1100 helicopters were flown as air ambulances. The flight program was conducted in a generally circular region with a radius of 150 miles, the center of which was the Phoenix Metropolitan area. Satellite bases were also set up at 50 to 75 miles distance from the main base of operations, in order to extend the range of operations. Figure 2 is a map of the State, showing the main base of operations in Scottsdale with the satellite bases and the general area covered by the operation. During the three month extension, one of the aircraft was operated out of Flagstaff, Arizona where the winters are normally severe.

The final three months of the contract were devoted to analysis of the program results and the preparation of the final report.
Figure 2

RANGE OF FLIGHT OPERATIONS

Figure 2
During the planning phase of the project a directive document was developed, which included the objectives of the project, an organizational plan, operating procedures, and the assignment of responsibilities for each of the identifiable tasks necessary to execute the demonstration project.

Sub-Contracts were negotiated and awarded to the Arizona State Highway Patrol to furnish the patrolmen who would serve as the paramedics, to set up and operate the communications system, and to direct the field operations; and, to Arizona Helicopters, Inc., to furnish the two helicopters, the pilots, maintenance for the helicopters, and a base of operations. Agreements were also made with the Associated and Gold Cross Ambulance Companies of Phoenix and with hospital and medical groups for their participation in the program.

The concentrated training and preparation period for the paramedics and helicopter crews began in April 1969, approximately one month before actual flight operations were initiated. A total of 23 air and ground ambulance personnel participated in the three day American Academy of Orthopedic Surgeons Course on the "Care and Handling of the Sick and Injured". This was followed by a two week on-the-job training program in the emergency rooms, operating and delivery rooms, and in the intensive care units of three major hospitals in the Phoenix area. The helicopter crews, Highway Patrol district personnel, doctors and hospital personnel were then instructed on the procedures for calling the AMES helicopters and coordinating the actions during a mission. An operations plan was also developed using the AMES concept as the basis for the development of the demonstration area and the detailed operating procedures. The AMES program management concept is illustrated in Figure 3.
AMES PROGRAM MANAGEMENT CONCEPT

Figure 3
The AMES Concept: The AMES mission was derived from a combination of the assigned missions of the U. S. Army's Air Ambulance Operations, the U. S. Air Force Rescue and Recovery Service, and the definition of the AMES concept originally established by the study team. The three-part mission of AMES was basically to:

1. Rescue persons injured in motor vehicle accidents within the State of Arizona in the shortest possible time with emphasis on service to rural and remote areas.

2. Preserve the lives of injured persons through competent emergency first aid at the accident scene.

3. Transport the injured from the accident site to the nearest medical facility capable of rendering definitive treatment.

In addition to the foregoing basic mission, the AMES is also ideally suited for the rescue and evacuation of persons injured in other than motor vehicle accidents, from rural and remote areas, such as hunting, mountain climbing, water sports, etc. The AMES can also be used effectively for accident prevention through surveillance or patrol operations and for general law enforcement operations. Operational plans, therefore, included the use of the AMES for these additional missions.

The AMES operations plan was developed primarily around the basic evacuation mission stated above and was predicated upon the following functions:

1. Responding to emergency calls relayed from a central agency.

2. Moving with speed and accuracy to the accident area at any time, day or night.

3. Gaining access to the accident site.

4. Gaining access to the injured.

5. Removing the injured from wreckage without compounding the injury.

6. Administering life-saving first-aid at the accident site.

7. Identifying the type and severity of injuries, perform triage* when more than one person is injured and treat victims according to need.

*Process of sorting sick and wounded on the basis of the urgency and type of condition presented, so that they can be properly routed to medical installations appropriately situated and equipped for their care.
8. Administration of fluids, oxygen and/or other emergency medical aid to the injured while enroute to a medical facility.

9. Carrying a minimum of two internally stored litters in each helicopter, with sufficient room to allow the para-medec to administer some measure of inflight treatment.

10. Flying a two man crew with two patients at altitudes from sea level to 12,000 feet.

**Evaluation System:** An evaluation system was developed including the design of the forms to be used in the collection of data necessary to evaluate the results of the project. The data acquisition system was designed to provide data which would permit a comparison of cost and operational effectiveness between the AMES and ground operations -- ambulance and police. One part of the data acquisition system dealing with the patients was called SIMBOL. It was designed to provide a simple, yet concise system for quantitatively evaluating the present condition of an injured person and for predicting the future course of that person's condition. The system was designed for use by trained medical technicians, corpsmen, nursing personnel, physicians, dentists, etc. The SIMBOL format is shown in Figure 4.

---

**SIMBOL TO CALCULATE STATUS SCORE:**

<table>
<thead>
<tr>
<th>SIGNS</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pupils</td>
<td>small and responsive to light</td>
<td>unequal or sluggish</td>
<td>dilated, fixed</td>
</tr>
<tr>
<td>Pulse</td>
<td>between 60-100</td>
<td>less than 60</td>
<td>more than 100</td>
</tr>
<tr>
<td>Respirations</td>
<td>between 10-20</td>
<td>less than 10</td>
<td>more than 20</td>
</tr>
<tr>
<td>Blood Pressure (Pulp Systolic)</td>
<td>more than 100</td>
<td>between 60-100</td>
<td>less than 60</td>
</tr>
</tbody>
</table>

**OR**

<table>
<thead>
<tr>
<th>SIGNS</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>dry and normal color</td>
<td>ashen, blue lips, moist</td>
<td>waxy, colorless or mottled</td>
</tr>
<tr>
<td>Level of Consciousness</td>
<td>awake, coherent</td>
<td>difficult to awake</td>
<td>sleepy</td>
</tr>
</tbody>
</table>

**NOTE:** Use Skin color only when Blood Pressure has not been evaluated.

**TO CALCULATE PREDICTOR VALUE:**

1. **STATUS Score**
2. **WEIGHT:** Markedly overweight
3. **AGE:** Less than 2 or over 70 years of age
4. **TRAUMA:**
   - (a) over 50% of body burned
   - (b) open chest or abdominal wounds
   - (c) unconscious
   - (d) inability to move fingers and toes in a conscious patient

**PREDICTOR VALUE** = Sum of 1 + 2 + 3 + 4 above.

---

**SIMBOL SYSTEM STATUS AND PREDICTOR TABLES**

Figure 4
Type Missions: After completion of the training and equipment check-out, the flight operations phase of the project was initiated on 30 May 1969. Flight operations were conducted on a continuing basis, 24 hours per day, seven days a week, until 31 January 1970 (nine months). Flight operations included the evacuation of persons injured in highway accidents, in non-highway accidents in remote areas, and in local area non-highway accidents. Transfer missions were also flown including dangerously injured or ill persons from one hospital to another hospital, and premature infants. Patrol and surveillance, search and rescue, and a variety of "other" missions were also flown during the project.

Flight operations included, essentially, five categories of flight missions, as described below:

1. **Evacuation missions**: These were missions which involved the flight evacuation of a sick or injured person from the scene of the incident to a hospital. A further breakdown of this category follows:
   a. **Highway accidents**: An accident involving one or more automobiles (vehicles) on any type road.
   b. **Remote area accident**: An accident in an area where there is no immediate access from roads, such as on a mountain, in the desert, etc., generally not involving road vehicles.
   c. **Non-remote, non-highway accident**: An accident not involving a vehicle, but in a place accessible by ground vehicles.
   d. **Non-patient evacuation**: Missions that were flown but did not carry a patient because the person was obviously dead at the scene, not injured sufficiently to require evacuation, the person was removed by ground ambulance, or the flight was terminated enroute by the requesting agency.

   A pictorial history of a typical evacuation mission is presented in Figures 5 through 10.

2. **Transfer missions**:
   a. **Hospital transfer**: These were missions involving the transfer of dangerously ill or injured persons from one hospital to another hospital within operational range. Some of the hospital transfers had been previously injured in auto accidents and were moved from outlying rural hospitals to special care centers (burn, spinal and neurological) in Phoenix and Tucson.
A request for assistance is received at the AMES Operations Center. The crew prepares the helicopter for take-off.

MISSION ACTIVATION
Figure 5

Upon arrival at the scene the helicopter is guided to landing by the Highway Patrolman.
The pilot and the paramedic remove the litter from the helicopter and move to the injured person.

PREPARATION OF THE MEDICAL LITTER
Figure 7

The paramedic prepares the patient for evacuation.

PREPARATION OF THE PATIENT FOR EVACUATION
Figure 8
The pilot and the paramedic load the patient and litter into the helicopter.

The hospital attendants receive the patient at the hospital helipad.
b. **Premature infant**: These missions involved the transfer of an infant born prematurely from one hospital to another hospital — from an outlying hospital to special care centers in the urban areas.

3. **Search missions**:
   a. **Missing vehicle**: A search for a stolen or lost vehicle.
   b. **Missing person**: A search for a lost person or persons.
   c. **Criminal suspect**: A search for a person suspected of a crime.

4. **Surveillance missions**: Observation of major roads for traffic violations, unsafe conditions, and unusual happenings.

5. **Other missions**:
   a. **Training**: Pre-operations and in-service training.
   b. **Public relations**: Flights conducted during special press and community leadership conferences.
   c. **Demonstration**: Special flights for medical and law enforcement groups.
   d. **AMES support**: Supply runs, photo missions, liaison, etc.

Since evacuation and transfer missions (items 1 and 2 above) both involve the movement of sick and injured persons, they have been combined in the discussion and presentation of data in this section of the report.

**Evacuation Missions**: Since the program was designed to obtain as much experience in medical evacuation as possible, certain preliminary actions were taken prior to start-up time. These were primarily in the form of an education program directed toward law enforcement agencies, to inform them of the availability of the helicopters, requesting procedures, and the potential value of the helicopter as a medical evacuation vehicle. It was constantly emphasized that there was no desire to compete with existing ambulance services, and that the AMES system was designed to function in the rural and remote areas of the state. The criteria established for response to a medical evacuation call were a confirmed location and a reasonable need for an ambulance.

Upon receipt of a call, both the pilot and the para-medic verified the location, which was usually given by highway and milepost number in the case of highway accidents, or by landmark reference in off highway locations. Standard VFR flight procedures were followed on daylight missions. Night missions used VOR headings or radar guidance from the Albuquerque center was requested and provided. Because of the fact that both the pilots and the para-medics were very familiar with the state, no difficulty was experienced in locating the scene of any accident or
incident. Highway accidents were particularly easy to locate due to the lights and flares which are always present. In off-road evacuations, particular emphasis was placed on landmark references. Persons on the ground did, at various times, utilize smoke grenades, mirrors, and flashlights to identify the location. At no time did an evacuation fail due to inability to locate the scene. Arrival times were usually within three minutes of the estimated arrival time.

Upon arrival at the scene, the first task of the para-medic was to perform triage, if several persons were injured. In the majority of cases, minimum first-aid had been administered prior to the arrival of the para-medic. In many cases this application of first-aid was inadequate or improper. Para-medics were often required to remove improperly applied splints or bandages. Vital signs were noted and the patient prepared for transportation. The patient was examined and stabilized as much as possible at the scene, because once airborne, the limited working space within the aircraft prevented the para-medic from administering extensive treatment. On board the aircraft, the para-medic could administer oxygen, maintain an open airway, and with considerable difficulty, administer external cardiac massage. More extensive treatment would require the aircraft to land to permit the para-medic to work outside the aircraft. This, however, was not necessary during the AMES operation.

The hospital destination was determined by the location of the accident and the condition of the patient. Due to the lack of adequate facilities in many outlying hospitals, brain, spine, and burn injuries were always brought to Phoenix, and in a few cases to Tucson. There is little advantage in taking a patient to the nearest hospital, only to have him transferred by ground or air ambulance some hours later.

Communications were maintained throughout the return flight, and the hospital was advised of the general condition of the patient and the estimated arrival time. Upon arrival, the para-medic assisted hospital personnel in any manner required.

During the second quarter of the program, the AMES was expanded to include hospital transfers as a part of the normal scope of operations in order to more effectively measure this particular capability of the AMES concept.

<table>
<thead>
<tr>
<th>Type Mission</th>
<th>Number Missions</th>
<th>Number Persons</th>
<th>% of Total</th>
<th>Persons/Mission</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evacuation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Highway</td>
<td>81</td>
<td>116</td>
<td>52</td>
<td>1.42</td>
</tr>
<tr>
<td>b. Non-remote, non-highway</td>
<td>24</td>
<td>25</td>
<td>11</td>
<td>1.04</td>
</tr>
<tr>
<td>c. Remote</td>
<td>11</td>
<td>12</td>
<td>5</td>
<td>1.09</td>
</tr>
<tr>
<td>2. Transfer</td>
<td>55</td>
<td>72</td>
<td>32</td>
<td>1.30</td>
</tr>
<tr>
<td>TOTAL</td>
<td>171</td>
<td>225</td>
<td>100</td>
<td>--</td>
</tr>
</tbody>
</table>

TABLE 1

15
During the flight program a total of 213 missions were flown involving injured or ill persons. Patients were carried in 171 flights of the 213 as shown in Table 1. During the 171 missions, 225 persons were carried in the air ambulances, with 52 percent lifted directly from highway accidents and 32 percent hospital transfers -- many of which had been injured in highway accidents and were being transported for the second time into special care centers. The balance of the medical flights (16 percent) involved non-highway or remote area evacuations.

No patients were carried in 42 of the 213 flights, because the person was obviously dead on arrival of the AMES at the scene, was not injured sufficiently to require transportation to a hospital, had been removed by ground ambulance, or the flight was terminated enroute by the requesting agency. Thus, the 225 patients were flown in 171 missions, for an average of slightly over 1.31 patients per mission. A total of 306 hours of medical missions were flown.

**Search and Surveillance Missions:** During the flight operations 21 search missions were flown -- four of which involved missing persons, six missing vehicles, and eleven criminal suspects. A total of 30 hours were flown under this category of operation.

Patrol and surveillance operations were conducted in support of special studies to determine the effectiveness of the helicopter as an accident prevention tool, and also its effectiveness in a wide range of general law enforcement activities. A total of 520 missions were flown in this capacity involving 765 hours.

<table>
<thead>
<tr>
<th>DISTRIBUTION OF ALL MISSIONS FLOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type Mission</strong></td>
</tr>
<tr>
<td>1. Evacuation</td>
</tr>
<tr>
<td>2. Transfer</td>
</tr>
<tr>
<td>3. Search</td>
</tr>
<tr>
<td>4. Surveillance</td>
</tr>
<tr>
<td>5. Other</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
</tr>
</tbody>
</table>

TABLE 2
Other Missions: The balance of the flight operations involved "other" missions, which included training, demonstration, photographic, and blood transfer flights. A total of 70 "other" flights were made, involving 84 hours of flight time.

In summary, 824 missions were flown during the flight operations phase of the project, for a total of 1,185 hours of flight time, as shown in Table 2.
PROJECT EVALUATION

General: During the final stage of the AMES project, each of the various functions performed during the operational phase of the project were evaluated from a cost and/or operational effectiveness point of view.

The evaluation procedure covered the equipment performance as related to the mission and also the performance of the man in this specialized environment. The helicopters, equipment and operating procedures were well designed for the AMES functions. There were no instances during which the system was not able to respond because of inadequacies or malfunctions in any part of the system. The comments and suggestions presented in the final report were provided to further improve the operating efficiency and overall effectiveness of future AMES type operations.

Cost Effectiveness: Cost Models for the AMES, Highway Patrol operations, and ground ambulance operations were developed. The costs for conducting the AMES missions were then compared with the costs that would have been experienced if the same missions had been performed by ground ambulances and/or the Highway Patrol.

The costs presented are representative of the three systems and provide some basis for their comparison. During the project, the AMES performed the functions of both the ground ambulance and the Highway Patrol systems. If it is considered that one AMES helicopter is the equivalent of one Highway Patrol group and one ground ambulance, then some cost comparisons may be presented as follows:

\[ a = b + c \] or \$379,071 = $244,074

In which:

\[ a = \text{Cost of 2 AMES helicopters per year} \] - - - - - - \$379,071
\[ b = \text{Cost of 2 Highway Patrol groups for one year} \] -- 137,078
\[ c = \text{Cost of 2 Ground Ambulances per year} \] -- -- -- -- 106,996

On the basis of time, the AMES operates at an average of twice the speed of a ground ambulance or a patrol car. During flight operations it was found that the AMES performed 171 medical missions (116 evacuation and 55 transfers) in 154.5 hours less time than it would have taken a ground ambulance to conduct the same missions. Because this time can not be properly equated with dollars, the savings of 41 minutes per patient probably constitutes the real value of the AMES in its medical evacuation role.

With respect to the 520 patrol and surveillance missions and the 70 "other" missions involving a total of 849 flight hours, no attempt was made to develop a "time saved" estimate. It was substantial, however, and probably exceeded 400 hours, not counting the many hours saved during search and rescue operations in which large numbers of personnel participated.
It is estimated that the AMES is equivalent to three times the capability of the Highway Patrol or the ground ambulance operations, with respect to area serviced. On this basis, the cost for operating three Highway Patrol groups @ $68,539/per group would be $205,617, and a six ambulance operation (presented in the ground ambulance cost model) would be $329,835 for a total annual cost of $535,452, as compared with the annual cost of $379,071 for the AMES.

Granted that the Highway Patrol-ambulance combination could support other activity in addition to providing the function and area capability of the AMES, when the function or area roles are compromised, then the time factor becomes more significant, as pointed out above.

On the basis of the cost information presented herein, it is concluded that the cost effectiveness of the helicopter is adequately justified, when it is operated as a rural, remote area system — not as a replacement for, but as a supplement to existing ground ambulance and law enforcement operations.

Operational Effectiveness: An evaluation of the AMES medical evacuation operation as compared with a ground ambulance operation was conducted; a special patrol and surveillance study was conducted to measure the accident prevention capabilities of the helicopter when performing such missions; and, a general comparison was made between the AMES and ground based units when performing general law enforcement operations.

An example of the Operational Effectiveness study between the AMES and ground ambulance operations is presented in matrix form in Figure 11.

The results of helicopter surveillance patrols indicate that the helicopter was a successful deterrent force by reducing the number of observations of factors which contributed to accidents and accident severity. Primarily these factors were excessive speed, illegal passing and improper lane position.

On the basis of the experience that was gained during the AMES program, it is concluded that the helicopter can perform a very effective role in general law enforcement operations, while, at the same time, performing its primary mission of medical evacuation.

The helicopter is particularly useful in performing the functions of routine surveillance in which it serves as an accident prevention tool and also as an accident and hazardous conditions reporting vehicle; in direct law enforcement operations wherein the helicopter is used in the search for and apprehension of criminals and also as a crowd control tool; and, in search and rescue operations for missing vehicles, missing persons, and downed aircraft.

Public Attitude and Acceptance Survey: Upon completion of the operations phase, a public attitude survey was conducted to determine the level
## OPERATIONAL EFFECTIVENESS MATRIX

**AMES VS. GROUND AMBULANCE OPERATIONS**

<table>
<thead>
<tr>
<th>TYPE MISSION</th>
<th>TIME TO SCENE</th>
<th>TIME TO HOSPITAL</th>
<th>COST</th>
<th>CARE AT SCENE</th>
<th>CARE EN-ROUTE</th>
<th>NUMBER PATIENTS CARRIED</th>
<th>COMMUNICATIONS</th>
<th>ACCI. SCENE IDENT.</th>
<th>WEATHER</th>
<th>PATIENT RESPONSE</th>
<th>ACCESSIBILITY</th>
<th>EFFECTS OF VEHICLE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EVACUATION</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Highway Accident</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+,-</td>
<td>+</td>
<td>+,-</td>
<td>+,-</td>
</tr>
<tr>
<td>2. Remote Area</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+,-</td>
<td>+</td>
<td>+,-</td>
<td>+,-</td>
</tr>
<tr>
<td>3. Non-Highway; Non-Remote</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+,-</td>
<td>+</td>
<td>+,-</td>
<td>+,-</td>
</tr>
<tr>
<td><strong>MEDICAL TRANSFER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Hospital Case</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+,-</td>
<td>+</td>
<td>0</td>
<td>+,-</td>
</tr>
<tr>
<td>2. Premature Infant</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+,-</td>
<td>+</td>
<td>0</td>
<td>+,-</td>
</tr>
</tbody>
</table>

**CODE**

0 = Equal to ground ambulance
- = Less effective than ground ambulance
+ = More effective than ground ambulance

Figure 11
of understanding of the AMES concept and its acceptance by various groups within the State, specifically the general public, the medical profession, and law enforcement agencies. The results of the survey indicated a high degree of acceptance.
CONCLUSIONS

On the basis of the information developed during the AMES demonstration project, it is concluded that:

1. The Air Medical Evacuation System (AMES) Concept, as developed for use in a civil environment by Lt. Colonel Robert L. Sears during his research thesis, and demonstrated under U. S. Department of Transportation Contract No. FH-11-7090, is a valid system for saving lives and reducing the consequences of highway accidents and other medical emergencies.

2. The use of helicopters reduces the time required to deliver personnel to the scene of an accident or medical emergency, and to move an injured or critically ill person from the scene of the incident to a hospital, when operated in a rural, remote area environment. The greater the distance from a base of operation, the greater the savings in time.

3. The training of ambulance personnel, air or ground, to the level of emergency medical care (para-medic) capability achieved in the AMES project, is an effective measure in reducing fatalities and the consequences of highway accidents or other medical emergencies.

4. A properly designed emergency medical communications system is a key component of an air medical evacuation system operation. It assures prompt notification, proper coordination, and direct communication between the para-medics and the hospitals and doctors.

5. The AMES costs of operation are approximately three times those of ground ambulance operations, on the average.

6. The AMES can also perform patrol, surveillance and a variety of general law enforcement operations while being kept in a state of readiness for the overall first priority medical evacuation mission.

7. When operated in the multiple role capacity (medical evacuation and patrol, surveillance and general law enforcement) the AMES can be justified from a cost effectiveness point of view.

8. When used in patrol and surveillance operations, the AMES significantly reduces driver behavior characteristics which are accident related, i.e., excessive speeding, unlawful and dangerous passing, etc.

9. When used properly the helicopter can significantly reduce the
time and costs involved in search missions for missing persons, vehicles and criminals.

10. The FH-1100 helicopter is well suited for the AMES mission, and can be further improved with several changes to the basic configuration and equipment.

11. A public attitude survey evidenced an overwhelming endorsement of the general public, the medical profession, and law enforcement agencies of Arizona.

12. As evidenced in the public attitude survey, the general population of Arizona would support the establishment of an AMES in the State, in spite of the cost of operation.

13. The AMES project is an excellent example of a "real world" project for university graduate student thesis work. Six masters degrees were awarded to Arizona State University graduate students on the basis of the work done on the AMES project.
RECOMMENDATIONS

On the basis of the information developed and analyzed during the demonstration project and the conclusions set forth herein, it is recommended that:

1. Consideration be given to the establishment of an AMES operation in the State of Arizona (and other States) as a supplement to existing ground ambulance and law enforcement operations.

2. The AMES be used primarily as a rural and remote area system where its speed, observation capability and accessibility to remote locations can be used most effectively.

3. The AMES be used as a dual function system, with priority given to air medical evacuation.

4. Further testing of the patrol and surveillance function be conducted to develop the statistical sample needed to demonstrate the potential accident prevention effectiveness of the AMES.

5. The SIMBOL rating system be adopted by all elements of the medical profession that become involved in medical emergencies to assure the consistent evaluation of the sick and injured. Its use will also develop a sufficient data base to evaluate its effectiveness as a tool for predicting the condition of an accident victim or ill patient.