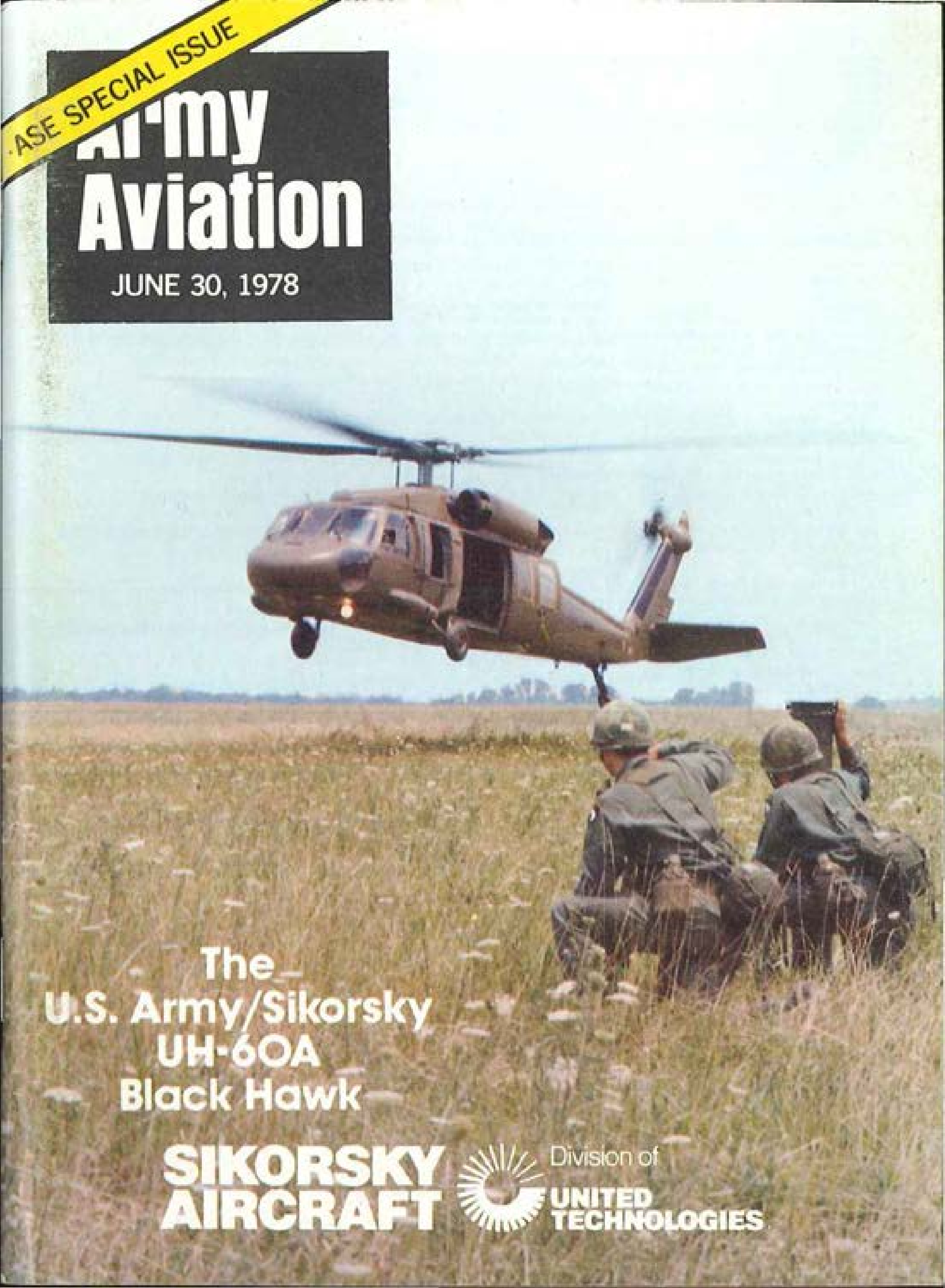
ASE SPECIAL ISSUE

Army Aviation

JUNE 30, 1978



ARMY AVIATION

ASE: The Third of Six "Theme Issues"

That the lethality of air defense weapons in the mid- to high-intensity battlefield environment will be awesome is a fact that most airpower enthusiasts have come to accept.

That fixed- and rotary-wing aircraft can enter this hostile environment, fight, and then continue to support the ground battle, is a fact that everyone is **not** willing to accept.

The growing importance of aircraft survivability equipment (ASE), and appropriate aircraft design that provides enhanced crash and ballistic survivability, confirm that the Army is preparing its aviation support units to "fight and stay" in future combat situations.

This issue - the first we've ever devoted to the broad subject of ASE - discusses the various types of threats close support aircraft will face, and reports on Army Aviation's capability to meet each of these challenges.

We're indebted to both **COL Jack Keaton** and **"Jim" Katechis,** his Deputy, for developing a most comprehensive ASE editorial plan, and then enrolling a top team of military and industrial authors to present the "ASE Story."

An oddity: Three of this issue's 15 authors are named **"Stevens."** There's **"Bob"** and **"John C."** and **"Story C."**

Next Month

The July 31 issue of **Army Aviation** will devote 82 of its 110 pages to the Army's **AH-1S Cobra Program.** The editorial plan developed by **COL Robert P. St. Louis,** AH-1S Project Manager, includes a foreword written by **GEN Donn A. Starry,** TRADOC Commander; a major report by **GEN George S. Blanchard, Jr.,** CINCUSAREUR; and 17 other articles by key Army and BHT officials involved in the **Cobra Program.**

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Other Features

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MAJOR AAAA NATIONAL AND REGIONAL FUNCTIONS FOR THE 1978-1979 PERIOD

October 12-15, 1978
1978 AAAA National Convention
Stouffers' National Center Hotel

November, 1978 (Date to be determined)
Sixth Region—AAAA Convention
Presidio of San Francisco or General Vicinity (Tentative)

March 28-31, 1979
1979 USAREUR Region—AAAA Convention
Garmisch-Partenkirchen, Germany

April 19-22, 1979
1979 AAAA National Convention
Colony Square Hotel, Atlanta, Georgia

May, 1979 (Date to be determined)
1979 Product Support Symposium sponsored by the
Lindbergh Chapter—AAAA
St. Louis, Mo.

May or June, 1979 (Date to be determined)
1979 Avionics Symposium sponsored by the
Monmouth Chapter—AAAA
Fort Monmouth, N.J. Area

June, 1979 (Site and date to be determined)
Fifth Region—AAAA Convention
Fort Hood, Texas Area

June-Sept., 1979 (Site and date to be determined)
First Region—AAAA Convention
Fts Rucker, Monmouth, and Bragg; Williamsburg, Va.
(Sites under consideration)

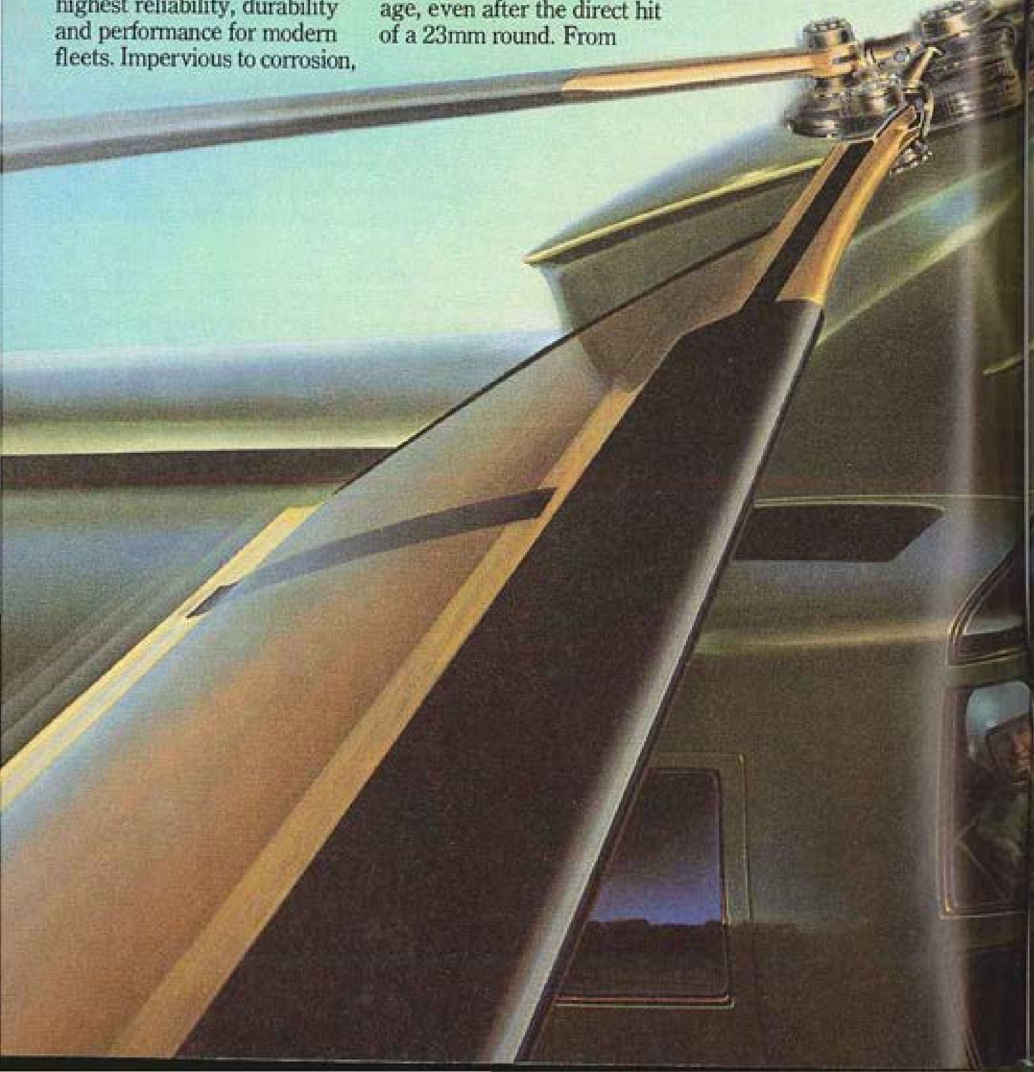
November, 1979 (Site and date to be determined)
1979 Sixth Region—AAAA Convention
West Coast Facility

Boeing fiberglass blades: setting the new standards for the new breed of helicopters.

Now in development for the Army's Chinook helicopter and in production for the Navy's Sea Knight, Boeing's fiberglass blades provide lowest cost of ownership and highest reliability, durability and performance for modern fleets. Impervious to corrosion, service life far exceeds that of metal blades while slashing maintenance and inspection requirements. Boeing blades have fly-home capability after severe field and handling damage, even after the direct hit of a 23mm round. From every aspect, nothing else saves so much.

BOEING VERTOL HELICOPTERS

THE LEADING EDGE



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DA study group rejects aviation separate branch

BY COLONEL JAMES R. HILL, Chairman
Aviation Special Task Force (STF), Department of the Army

THE Aviation Special Task Force (STF) was formed to assess and review the management of Aviation Specialty Code 15 as a follow-on to the warrant officer study.

Its mission was to evaluate the commissioned officer management process for Aviation Specialty Code 15 and include previously approved recommendations in the warrant officer study that had impact or were equally applicable to the commissioned aviator.

Composition of STF

The Special Task Force was activated on 5 December 1977 with the following personnel: **BG Charles E. Canedy,** ODCSOPS, and **BG Richard S. Sweet,** ODCSPER, as Co-Directors: and **COL James R. Hill,** ODCSRDA, Chairman.

Members were **LTC William E. Bailey,** OCLL; **LTC Jack T. Willard,** ODCSOPS; **LTC Charles A. Jolley,** MILPERCEN; **MAJ (P) Billy T. Brooks,** ODCSOPS; and **MAJ Robert H. Johns,** ODCSPER.

Ground Duty. Senior officers indicated to the STF that ground orientation assignments are necessary for the commissioned Army Aviator. Findings by the STF and the **Review of the Education and Training for Officers (RETO)** fully support the view of the Army's senior leaders.

Traditionally, ground duty, especially for combat arms, has been viewed as a requirement to insure that officer aviators retain their close association with their basic branch to insure close ties between the Army's aviation units and the ground units they support.

The officer-aviator must be a fully integrated member of the combined arms team. Consequently, he must understand the ground battle from the ground commander's perspective.

One general officer summed up the relationship in this fashion:

"The Congress and OSD, as well as we in the Army, should demand that the Army's aviation leaders be sufficiently competent so that they can insure that Army aircraft are employed in such a manner so that they can best influence the outcome of the ground battle. Unlike his Air Force or Navy counterpart, his war does not center around the aircraft he flies or those he controls. Instead, his is the ground battle into which the aircraft he controls must be interwoven if they are to be effective."

(DA STUDY/Continued on Page 8)

COMPANY GRADE 1985 – PROFESSIONAL DEVELOPMENT GUIDE

YEARS		1.5	2.3	6.3		8.3	11.3
MONTHS	.5	* 12/24	10	48		* 24/36	36
	BASIC BRANCH COURSE	INITIAL ASSIGN-MENT	FLT TNG	AVIATION ASSIGNMENT	MIL	PRIMARY SPECIALTY UTILIZATION	AVIATION ASSIGNMENT
RANK	LT			CPT 4.5	SCHOOL		MAJ 11

EXPLANATION

- * IDEAL (CAPTAIN SHORTAGE MAY REQUIRE A REDUCTION TO 18 TO 36 MONTHS UNTIL FISCAL YEAR 1986.)
- BRANCH SPECIALTY IS PRIMARY
- AVIATION ALTERNATE SPECIALTY ONLY DURING COMPANY GRADE YEARS
- COMPANY GRADE AVIATORS ARE EXCLUDED FROM HAVING ARMY-WIDE SUPPORT ASSIGNMENTS TO THE MAXIMUM EXTENT POSSIBLE

Ahead of TIME

Ahead of time in Combat Reliability. The 25mm CHAIN GUN.

The Hughes Helicopters 25mm XM242 CHAIN GUN® is a derivative of the proven 30mm CHAIN GUN, developed for the YAH-64 Advanced Attack Helicopter. Exhibiting characteristic high reliability, this weapon is a candidate for the main armament in the U.S. Army's XM2 Infantry Fighting Vehicle and XM3 Cavalry Fighting Vehicle.

The CHAIN GUN fires both NATO and U.S. 25mm ammunition, ensuring interoperability and logistic commonality on the battlefield. Fired cases are ejected forward (overboard) and long-dwell after firing eliminates gun gas buildup in the turreted installation. To date, over 70,000 rounds have been fired through the 25mm XM242.

Based on a simple chain drive principle, the entire gun, with integral dual feed and an internal recoil mechanism, weighs only 230 pounds and demonstrates semi-automatic and automatic fires up to 500 shots per minute.

Design simplicity, external power, ease of maintenance and smooth belt operation ensure the highest reliability at all rates-of-fire under any combat condition.

CHAIN GUN

Hughes Helicopters
Culver City, California 90230

DA Study Group
(Continued from Page 6)

On 15 May 77 the Vice Chief of Staff of the Army approved the STF recommendation that ground duty assignments continue for all combat arms aviators and their entry specialty would be primary during the company grade starting in FY 81. (See **Chart 1** on page 6).

- LT's would serve one to two years in a branch assignment prior to flight training.
- After flight training he'd undergo a four year utilization in an aviation unit related to his basic/entry specialty.
- The long term goal (after FY 86) is to assign captains to ground duty for primary specialty utilization in commander and staff positions for 24 to 36 months. Prior to FY 86 the utilization goal may be reduced in length because of commissioned aviator shortages. Aviation and branch relationship will continue to be a priority management requirement.
- The next assignment would again be in an aviation unit related to his entry specialty.
- Field grade aviators can be primary Specialty Code 15 or alternate SC 15 if the officer does not remain primary/entry specialty qualified. (See **Chart 2** below.)
- The Special Task Force conducted an analysis of force structure authorizations through 1990 and determined that the commissioned officer flight training rate must be increased from 465 to 654 per year to meet force structure requirements.

This action is also needed to provide a viable career pattern that will permit qualifying assignments in both specialties and prevent massive downward grade substitution, i.e., field grade into company grade positions. This analysis also determined that warrant officer flight training must also be increased from 465 to 808 per year. Both increases are programmed for FY 81 output.

Centralized Selection

The STF also recommended that the Army take a look at centralized selection of 0-4 aviation commanders. We feel that this would be extremely beneficial for Aviation Commands; however, all 0-4 commands must be evaluated before a final decision is made. Of the 479 Army-wide 0-4 commands, 152 are aviation.

The complete STF efforts have taken almost eleven months to complete the evaluation of Aviation Warrant Officer/Enlisted Aviator proposal and commissioned officer Aviation Specialty 15 . . . A herculean task by any measure.

However, it is felt the Aviator and the Army will benefit from the efforts of this STF. The commissioned and warrant officer Army Aviator is an expensive individual to train; and only through careful management can this high dollar investment be protected and aviators remain mission-oriented. ★

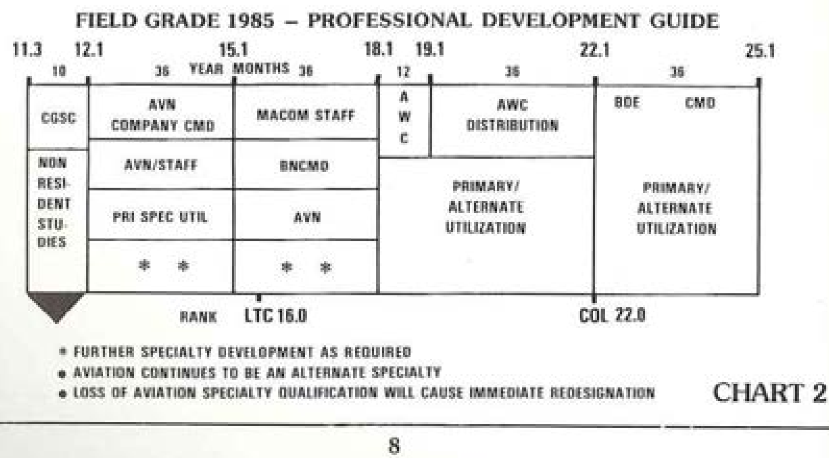


CHART 2

Black Hawk Power

T700-POWERED SIKORSKY UH-60A BLACK HAWK

The T700: Now being delivered to meet the needs of the modern Army

The first production T700 engine has been delivered for the Black Hawk. Backed by the most rigorous engine qualification program in Army history, the T700 is also the most mature new helicopter engine ever to enter Army service. And uniquely well-prepared to live in the Black Hawk's combat environment.

GENERAL ELECTRIC

FAZEKAS RADKE

No "box" can duplicate "real-world" weather!

BY CW3 JAMES P. FAZEKAS and CW2 RONALD L. RADKE, 101st Airborne Division (AASLT), Fort Campbell, Kentucky

THE article by COL Barrie Davis (Ret.), in the 31 March issue of **Army Aviation** "Flight Simulators" was very interesting as well as being professionally written. Obviously, it is a rebuttal to our simulator article in the November 1977 issue. We appreciate the views of an aviator with his extensive experience and qualifications.

While it is undoubtedly true that experience gained in simulators has saved lives and aircraft, identifying simulator training as an absolutely foolproof method of accomplishing aviator instrument proficiency is too simplistic an answer.

The "First Dimension"

Fort Rucker does an excellent job of training new rotary wing aviators. They are, without a doubt, better trained than we were 12 or 14 years ago. This initial day/night contact training is the **First Dimension** of the aviation envelope to which the pilot is exposed. It encompasses not only the physical "hands-on" training he needs to operate the aircraft, but also covers a multitude of ground subjects, i.e., aerodynamics, aircraft systems, regulations, weather, etc.

As he moves along in his training he is introduced to the IFR world, but his initial training in this challenging area is largely composed of simulator periods. This is the **Second Dimension.** The pilot is taught IFR procedures and techniques, but unless he is very lucky he will never see the inside of a cloud.

He develops a "machine control touch" instead of "aircraft instrument proficiency." If it is then said that this fledgling pilot will be exposed to "real-world" IFR flights when he is assigned to an operational unit, we don't agree.

Let's assume our new aviator is assigned to Ft. Campbell. Without a doubt he will soon be very proficient in all the day/night contact maneuvers **(First Dimension).** His mission will be challenging and he will quickly find that the aviation learning process did not stop when he left Ft. Rucker, i.e., with one exception: the IFR world.

In the large majority of cases he will continue to maintain his instrument proficiency (and even renew his qualification) in the "machine **(Second Dimension)".** We do not argue the value of simulator training, as long as it is utilized as a **procedural** trainer. Hours spent in the "box" have helped all of us increase our procedural proficiency.

We maintain that too much emphasis is being placed on them as a substitute for aircraft instrument flight training. Simulators should be utilized instead to supplement a program of aircraft instrument flight training.

Wet, dark, scary, and bumpy

No box will duplicate the **Third Dimension** of the aviation envelope - IMC flight. The instrument rating is a license to operate an aircraft in **real** weather. **Real** weather is wet, dark, scary, and bumpy, and can be quite nasty.

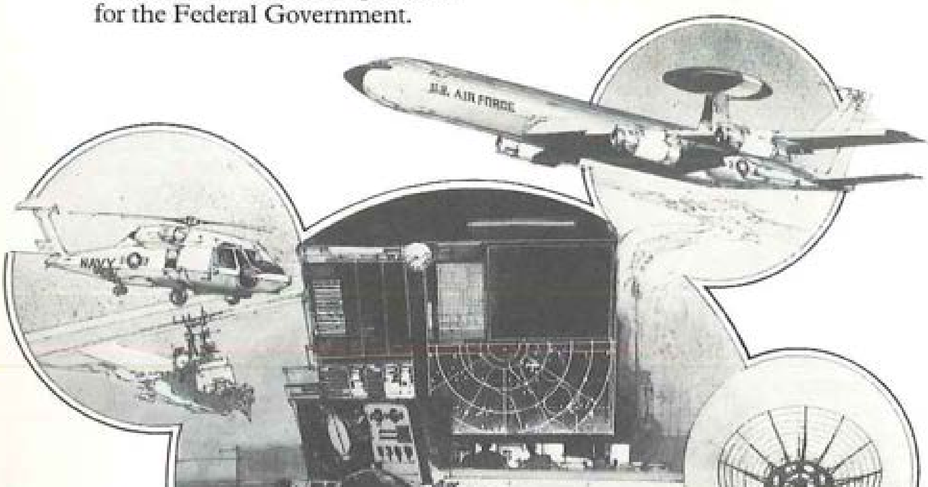
The simulator will never (at its present state of the art) be able to dupliate this critical environment. A pilot's judgment, reactions, ability to "read" weather, and do the correct thing cannot be tested in the box. These attributes can only be evaluated in the specific aircraft he operated, preferably when under IMC.

Several years ago, Fort Rucker attempted to train students transitioning them in the UH-1 basically from the 2B24 simulator, and giving them a final check ride in the aircraft. The result: The experiment was cancelled after only one or two classes. The lesson: Nothing can replace

(NO BOX/Continued on Page 79)

Serving the national interest.

The IBM Federal Systems Division is devoted to the development and management of computer-based command, space, avionic and shipboard systems programs of national importance for the Federal Government.



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Army Aviation

Photo Stories of Recent Army Aviation Events

SPLICED!—The remanufacture of the first U.S. Army/Boeing Vertol YCH-47D prototype airframe from a CH-47A Chinook model, has been completed ahead of schedule at Boeing Vertol's facility in suburban Philadelphia, Pa. (May 12)

THANK YOU!—BG Hans Drebing (right), Director of Federal Republic of Germany Army Aviation, presents a memento to BG Edward M. Browne, the U.S. Army's AAH Program Manager, following the latter's presentation to the attendees at the 12th International Helicopter Forum at Bueckeburg, Germany. (May9)

SELECTEE!—CPT Linda Horan is congratulated by COL Richard L. Stoessner, Assistant Commandant of the T-School, following the former's selection to compete in the Third World Helicopter Championships in Russia this summer. The David E. Condon Chapter aviator has also been selected by AAAA's Nat'l Board as the official Quad-A entrant. "Army Aviation" is sponsoring the competition week fees of AAAA member MAJ Michael H. Summers as the "magazine entrant." (May6)

GATHERING!—AA pioneers who helped cut the birthday cake at USAAVNC's recent celebration gather with MG James C. Smith, 3d from left. They are, l-r, LTG William R. Peers, BG Jack W. Hemingway, LTG Harry W.O. Kinnard, LTG John J. Tolson, III, and MG George S. Beatty, all retired. Kinnard, Tolson, and Smith are Hall of Famers who returned to the June 10 O-Club ceremonies.

PHOTO LEFT—COL Robert A. Bonifacio, Army Avn Center Chapter AAAA President, presents Earl D. Griffin, Ft. Rucker Nat'l Bank President, with an AAAA "Certificate of Sustaining Membership" indicating that firm's desire to participate in those joint AAAA-community affairs of interest. (May 11)

18th USAREUR Region's AAAA Convention in Garmisch, Germany called "A major success"

AN ON-THE-SCENE REPORT BY LTC RICHARD R. NOACK, VICE PRESIDENT, PUBLICITY USAREUR REGION—AAAA

MORE than 850 attendees converged on on the Armed Forces Receational Center at Garmisch, Germany, during the first week in April for the **18th Annual Convention** of AAAA's **USAREUR Region.**

It proved to be a professionally rewarding and personally enjoyable gathering for the more than 200 AAAA members and their families, many of whom arrived early in the week to participate in the **"Learn to Ski Week"** at AFRC, and to enjoy the many sightseeing and recreational areas in that snow-covered part of the Bavarian Alps.

Major General E.A. Partain, President of AAAA's **USAREUR Region,** officially opened the convention on Thursday morning, April 6, welcoming the members from USAREUR's 11-Chapter Region. Several had come from as far away as Madrid for the annual meeting.

In his kickoff remarks, **General Partain** extended the Region's thanks and appreciation to **LTC Ron Gray,** Regional Secretary, and to the members of the 71st Assault Helicopter Company commanded by **MAJ Vic Donnell,** the 1977 "Unit of the Year" and the Host Unit for the 1978 gathering . . . " for their outstanding suport and preparation for the event."

Speaking for **General George S. Blanchard, Jr.,** USAREUR Commander-in-Chief, **MG Partain** gave the convention's keynote address, reviewing USAREUR's aviation accomplishments in 1977, and focusing attention on the challenges ahead in 1978 with particular emphasis on maximizing the attack capabilities of the Cobra TOW.

A presentation on the functions, roles, organization, and tactics of British Army Aviation was then made by **Maj. Gen. J.,A. Ward Booth,** Director, Army Air Corps. **Brig. Gen. Hans E. Drebing,** General der Heeresfliegertruppe, then provided an update on German Army Aviation, and emphasized the need for continuing progress in the fields of interoperability and standardization.

AAAA's National President, **LTG Robert R. Williams, Ret.,** and **MG Delk M. Oden,** a Past President, represented the AAAA's National Executive Board, and contributed greatly to the USAREUR Region's Executive Board Meeting.

It was at this meeting that **MG George S. Patton,** a 10-year AAAA member and DCG of VII Corps, was elected 1978-1979 President of the USAREUR Region. (See photo).

The convention's second day opened with an outstanding presentation on the Advanced Attack Helicopter Program by **BG Edward M. Browne,** PM-AAH. **LTC James R. Myers,** the Regional VP for Industry Affairs, presented a brief report and was followed by a most distinguished contingent of AAAA Industry Members from CONUS who discussed their companies' most recent R&D efforts.

The April 6-7 industry presenters from CONUS included:

Robert Parnell, Rockwell International.
Sergei Sikorsky, Sikorsky Aircraft.
Philip Norwine, Bell Helicopter.
Floyd Petty, Collins Avionics.
Les Gilbert, Hughes Helicopters.
W.J. Crawford, Jr., General Electric Co.
William Jones, Boeing Vertol Company.

The Saturday morning, April 8, presentations were concluded with a most interesting one on one-handed helicopter flying (assuming pilot/co-pilot combat incapacitation of some form). This briefing was given by **MAJ David Yensan** and **Jack Waugh** of the Human Engineering Lab at Aberdeen.

An Embry-Riddle Aeronautical University presentation was then given by **Robert A. Coleman,** and the Convention's profes-

Rockwell-Collins TACAN specified by all services.

Mission: precise navigation.

Soon now, the Rockwell-Collins new-generation digital TACAN AN/ARN-118(V) will be serving aboard aircraft for all the services. Right now, it's standard with the U.S. Air Force. Gaining wide acceptance with the other services. And it's been selected by over thirty other countries as well.

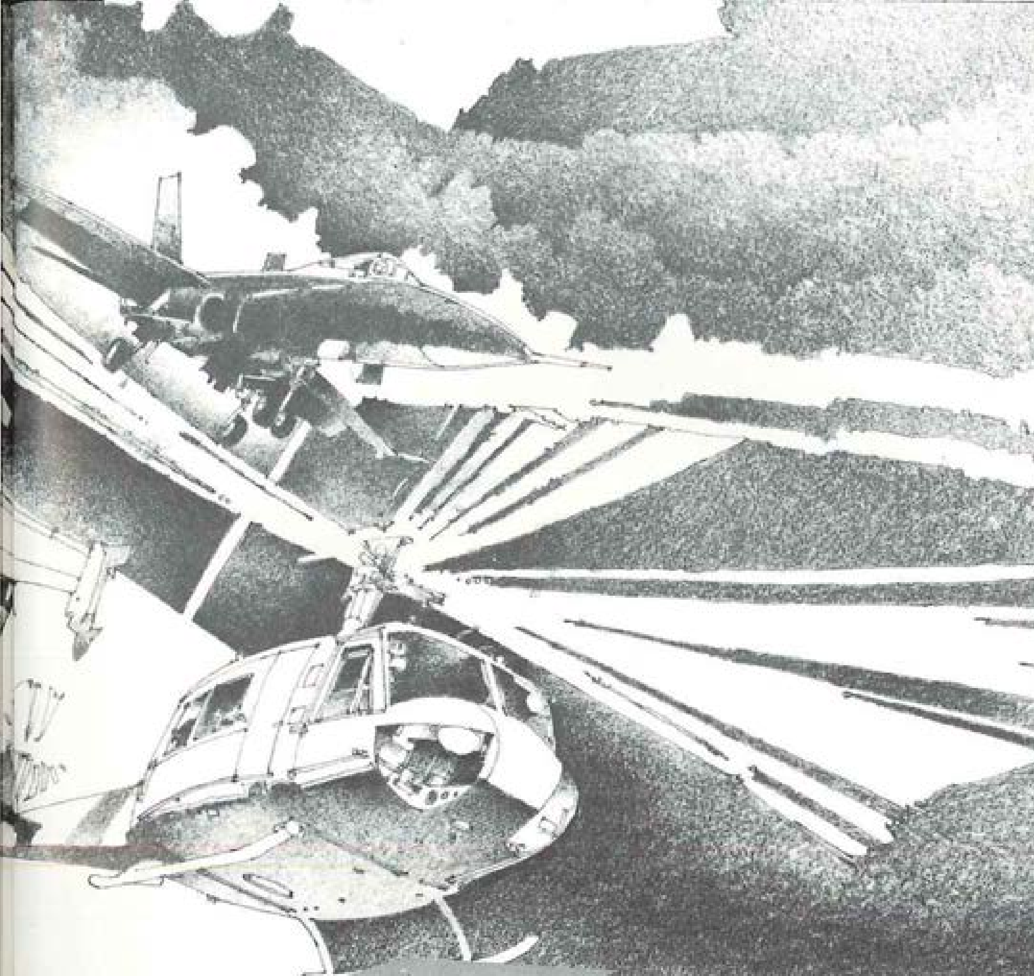
Why the resounding vote of confidence? More capability, for one, thanks to X and Y channels for twice the number of available frequencies, T/R and A/A modes, A/A bearing reception, and improved accuracy.

Greater reliability, for another. Demonstrated MTBF is well past the design goal of 1,000 hrs. Digital circuitry, of course.

Substantial cost savings, for still another. New airframe or retrofit, our TACAN costs less than half as much as some present systems. And retrofit is easy. Special adapters interface with existing displays and wiring. Thirty minutes is usually all it takes.

Service? We offer assistance under reliability improvement warranty (RIW) contract terms or other special maintenance service contracts.

For more information, contact Collins Government Avionics Division, Rockwell International, Cedar Rapids, IA 52406. Phone 319/395-2070.



sional programming was concluded with a "high interest" briefing on Aviation Personnel Management and OPMS by **BG Benjamin E. Doty, Director of OPD, MILPERCEN.**

Regional Awards

The highlight of the day — and the climax of the 1978 AAAA USAREUR Convention — was the Awards Banquet. **GEN George S. Blanchard, Jr.,** Commander-in-Chief, U.S. Army, Europe, was the guest speaker and was assisted by **E.A. Partain,** the Regional President, in making the 1978 Awards.

The USAREUR Region—AAAA Award Winners for the Calendar Year 1977 awards period were:

"Aviation Soldier of the Year"
Sergeant Chris B. Archer, 236th Medical Detachment, 30th Medical Group.

"Army Aviator of the Year"
Major William S. Reeder, Jr., ExecO of the 334th Attack Helicopter Co. and S-3 of the 503rd Combat Avn Bn, and now attending AFSC in Norfolk, VA.

"Aviation Safety Man of the Year"
CW3 James Vick, Company B, 8th Combat Aviation Bn. (First presentation of this new USAREUR Region-AAAA Award).

"Outstanding Aviation Detachment"
Berlin Brigade Aviation Detachment, commanded by MAJ John Urqhart.

"Aviation Support Unit of the Year"
205th Transportation Battalion (Aircraft Maintenance) (AVIM), V Corps, commanded by LTC Earl Hyers.

MG George S. Patton, left, DCG of VII Corps, and newly-elected President of the USAREUR Region—AAAA, accepts "the book" from the outgoing President, MG E.A. Partain, Hq, EUCOM.

SGT Chris B. Archer, AAAA's "Aviation Soldier of the Year" in USAREUR, and his wife, chat with GEN George S. Blanchard, Jr. at the Regional Awards Banquet.

"Army Aviation Unit of the Year"
180th Assault Support Helicopter Company ("Big Windy"), commanded by MAJ John F. Sheehan.

ATC WINNERS

"USAREUR Facility of the Year"
Kitzingen GCA, 14th Aviation Battalion (ATC), commanded by LTC Engle Scott.

"Maintenance Specialist of the Year"
Specialist Sixth Grade Robert H. Stanfield, 14th Aviation Battalion (ATC).

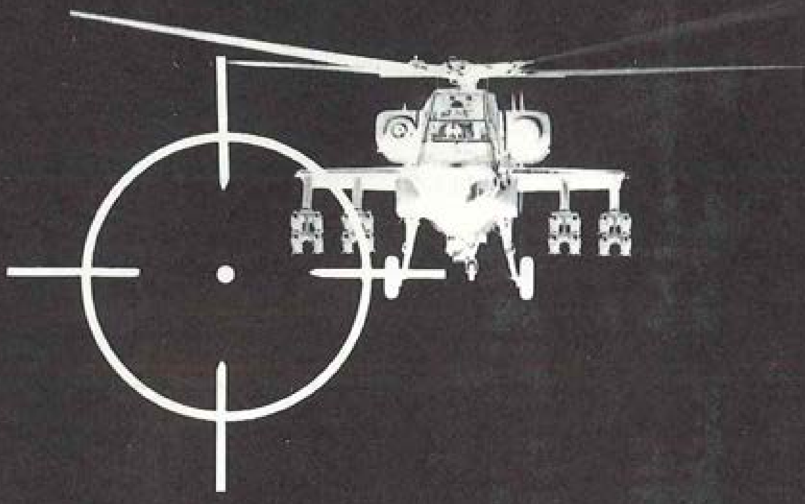
"Air Traffic Controller of the Year"
Staff Sergeant Elliott E. Monroe, 14th Aviation Battalion (ATC).

"Most stimulating"

Having served as a staffer on the AAAA National Convention Committee for several years, and being a frequent participant-attendee at these same conventions, I had the opportunity to compare these meetings with the '78 Garmisch gathering.

The professionalism and social camaraderie are present at both, of course; the major difference is in the nature of the attendees . . . Garmisch brings together the young tigers, the real "cutting edge" of Army Aviation; the D.C. conventions assemble the planners for the most part, the people involved with doctrine, tactics, and hardware. I found this Regional Convention to be most stimulating, and I look forward to attending the next. ★

A comprehensive 65-page report on . . .



Aircraft Survivability Equipment

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22333

The lethality of weapons found on the modern battlefield dictates that survivability be an essential characteristic of all combat materiel. Since the US Army must be prepared to enter the next war out-numbered, we cannot afford anything approaching equal attrition exchange ratios. To ensure our success, we must have not only superior fire power, but also greater survivability. The DARCOM goal for materiel survivability is to remain capable of decisively engaging and re-engaging the enemy even after absorbing attacks we cannot prevent.

The Army Aviation aircraft survivability program (ASE) is one of our most successful. Survivability features and countermeasures equipment are carefully woven into the design of each aircraft in such a manner as to optimize its survivability and ensure its "staying power" on the high threat battlefield. As a result, the ASE program could well serve as a model for all others.

In addition to its obvious contribution to aviation combat effectiveness, I am particularly proud of this program on two other counts. First, it is truly a living, working example of Tri-Service cooperation and equipment commonality. Second, but of equally high importance, it is a program whose success and rapid progress have resulted from the Army's close partnership with and the technical excellence of American industry.

JOHN R. GUTHRIE
General, USA
Commanding

What is the ASE Program?

BY COLONEL JACK L. KEATON, Project Manager for Aircraft Survivability Equipment, USA DARCOM

The early years of Army Aviation are characterized as a period that concentrated on improving aircraft performance and payload.

Aviation missions on the modern battlefield have added the requirements for vastly improved weapons effectiveness, intelligence collection, and electronic warfare.

This same modern battlefield with all of its sophisticated air defense systems has dictated the need to emphasize aircraft survivability - a critical dimension of "staying power".

In response to this need, coupled with the growing concern from many critics that Army Aviation might not be able to accomplish its assigned mission and survive, the Army established the **Project Manager for Aircraft Survivability Equipment (PM-ASE).**

The mission of the PM

The chartered mission of the ASE Project Manager is as follows:

Develop and provide appropriate countermeasure equipment against all air defense threats. This encompasses the entire threat spectrum of Infrared (IR), radar, laser, and optically controlled guns and missiles. This equipment is for application to the current aircraft fleet and all new development aircraft.

Maintain a viable ASE technology base to ensure that Army Aviation is prepared to meet new threats as they arise.

The Project Manager is assigned to Headquarters, **U.S. Army Aviation Research and Development Command (AVRADCOM)** and is located in St. Louis, Missouri. However, since ASE encompasses many technological disciplines, support is provided from several commands and agencies. All electronic ASE is supported from the Electronics Warfare Laboratory which is part of the **U.S. Army Electronics Research and Development Command (ERADCOM).**

Chaff and flare technology is supported by **U.S. Army Armament Research and Development Command (ARRADCOM).** Infrared suppression, ballistic hardening, and the aircraft integration of all ASE is accomplished at AVRADCOM.

Thus, the primary function of the PM-ASE is to provide overall management control and program direction with the day-to-day management functions being accomplished by the supporting agencies.

To assist and guide the Project Manager, the U.S. Army has established an ASE Permanent Steering Group. The membership of this group includes representatives of Hq Department of Army, all TRADOC and DARCOM agencies, Hq FORSCOM, U.S. Army Logistics Evaluation Agency, and observers from the other services. This group meets formally every three to four months, but the members participate almost daily in test meetings, technology and threat updates, logistic reviews, and financial status reviews. The ASE Program is truly an example of a User/Developer Team.

A tri-service organization

The ASE Program is not limited to the U.S. Army. The three services (USA, USN, USAF) maintain a central office and organization in Washington, D.C. which permits us to share technology, test facilities, and appropriate equipments. PM-ASE is the Army principal member of this organization.

This tri-service organization called the **Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS)** recently sponsored a joint service **Memorandum of Agreement (MOA)** on ASE for helicopters and low slow

PROJECT MANAGER

COLONEL JACK L. KEATON
3961/3962

CHIEF, PROGRAM MANAGEMENT DIVISION

MS. THYRA A. BONDS
3964/3106

DEPUTY PROJECT MANAGER

MR. JAMES C. KATECHIS
3961/3962

CHIEF, LOGISTICS MANAGEMENT DIVISION

MR. WAYNE KUSCHEL
6496/6497

CHIEF, TECHNICAL MANAGEMENT DIVISION

MR. HEBERT B. MURCH
6746/6747

CHIEF, PRODUCT ASSURANCE DIVISION

MR. JERRY DETIMER
6888/6889

PROCUREMENT & PRODUCTION OFFICER

MRS. FRANCINE HOUSMAN
2386/2387

ASSISTANT PROJECT MANAGER FIELD OFFICE FT. MONMOUTH, NJ★

LT. COLONEL KENNETH HERBERGER

Telephone Numbers:
Autovon — 698-XXXX
Commercial (314) 268-XXXX

Address: Hq, AVRADCOM
ATTN: DRCPM-ASE, P.O. Box 209
St. Louis, MO 63166

The U.S. Army Aircraft Survivability Equipment Management Team

ASSISTANT PROJECT MANAGER ELECTRO—OPTICS

LT. COLONEL
RICHARD HAZELWOOD
2057

ASSISTANT PROJECT MANAGER VULRED

LT. COLONEL
WILLIAM A. SCHWEND
2171/ 2172

ASSISTANT PROJECT MANAGER/RADAR

MAJOR
DAVID FORVILLE
2057

ASSISTANT PROJECT MANAGER IRCM

CAPTAIN
ROBERT STAPLETON
6888/ 2280

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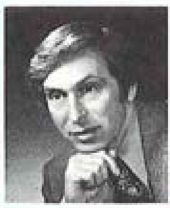

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MR. MAX ADLER

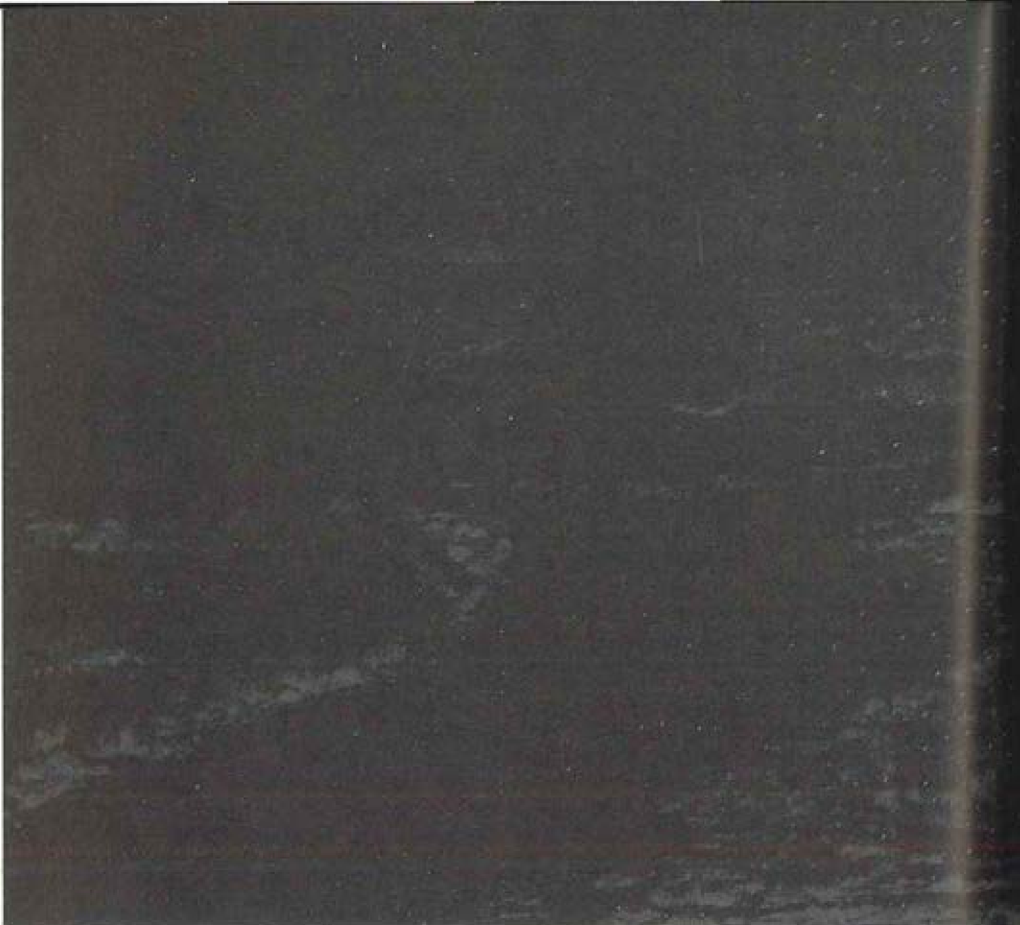
AVIATION SYSTEMS DIVISION, ODCSRDA (ASE DASC)*

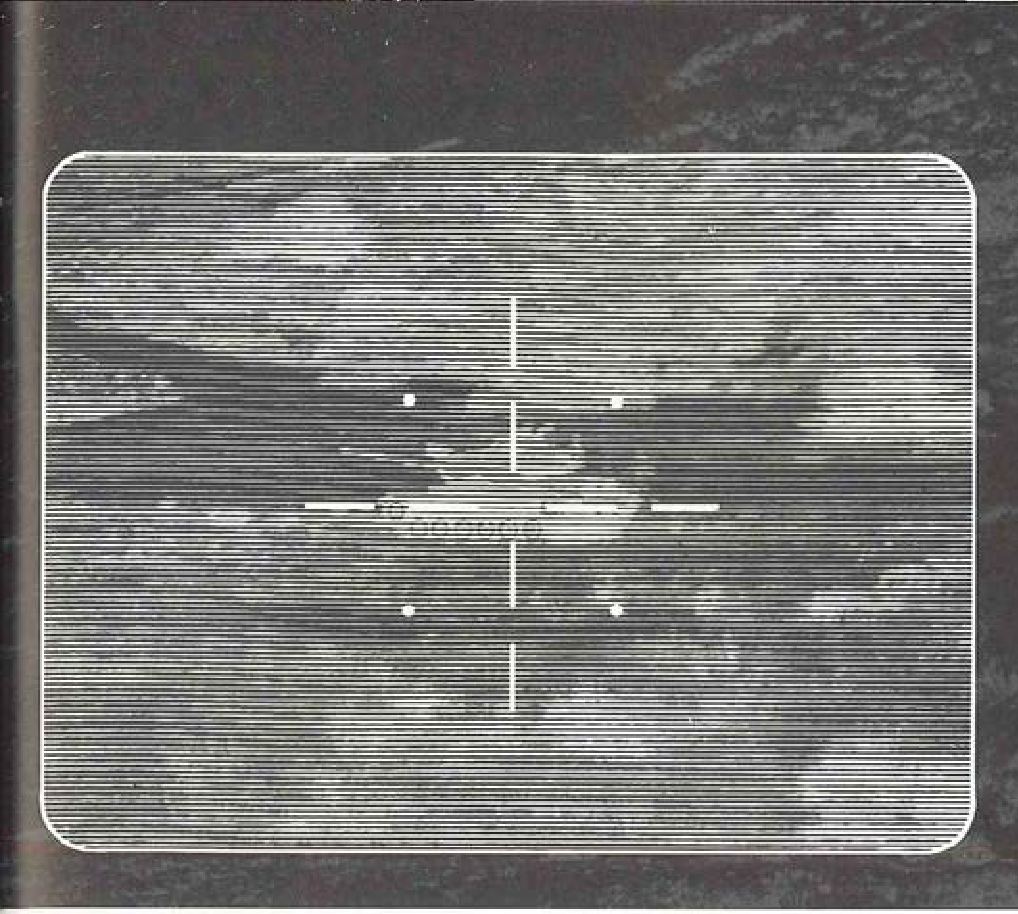
LT. COLONEL
JAY B. BISBEY

ASE PO DIR. OF COMBAT DEV. USAAVNC FT. RUCKER, AL*

CAPTAIN
HARRY K. STAUB

*Not on Management Team.





AND SURVIVE

security purposes in photo above.)

Army AAH requirements for direct view, day TV, day/night forward looking infrared, laser tracker, laser rangefinder, laser designator and stabilized platform have been successfully demonstrated in previous Northrop systems.*

In five years of producing electro-optical systems for tactical aircraft and helicopters, Northrop has met all commitments for cost, schedule and system performance.

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Northrop Corporation, 1800 Century Park East,
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NORTHROP

What is ASE?
(Cont. from Page 17)

fixed wing aircraft. The MOA which was signed at the Service Hq level assigned the following responsibilities

- The Army will be lead service and will be responsible for the development and procurement of the following ASE for all service users:

a. Infrared (IR) jammers for small helicopters and designated fixed wing (ALQ-144, ALQ-147).

b. Lightweight low cost radar warning receivers (APR-39, APR-44).

c. Radar jammers for application to attack helicopters and other selected aircraft (ALQ-136).

d. Missile Detection System - pulse doppler (ALQ-156).

e. Laser Warning Receiver for application to helicopters and selected fixed wing aircraft.

- The Navy will be the lead service for the following:

a. IR jammers for large helicopters.

b. Radar jammer to counter CW radar-controlled weapons.

c. Missile detector that uses an ultra-violet (UV) sensor for detection.

- The Air Force is lead service for a missile detector that uses an IR sensor for detection.

As can be seen from the above, there is very close cooperation within DOD on all ASE programs. Further, it clearly demonstrates that the other services agree with and have confidence in the Army's program since they are in the process of adopting much of the Army's ASE for their own aircraft.

ASE cooperation is not limited to the U.S. Department of Defense. PM-ASE has been Chairman of a **Special Working Party (SWP)** on survivability as a part of the Quadripartite Working Group on Aviation. (Members are the US, United Kingdom, Canada, and Australia). The SWP is devoted to the exchange of information with the potential of adopting selected items of ASE for common use.

In November 1977, PM-ASE was invited to provide an information briefing to Panel X (Aviation) at NATO Hq. The purpose of this briefing was not only as an information exchange, but to discuss the potential of adopting selected items of ASE for common NATO use. Subsequent to the November meeting there has been a considerable amount of information exchange. It is quite likely that the future could bring about a NATO level program for selected items of ASE.

Survivability for its own sake has little value. If it's to be the primary measure of success, then our ASE task is relatively easy — stay home and don't expose yourself to danger . . .

The value of ASE

Survivability is a function of many interrelated factors such as tactics, training, aircraft performance, target detection/acquisition, weapon effectiveness, navigation, command and control, the threat, etc., and ASE. Thus, the requirement for any item of ASE is dependent upon its use and how it fits with the other factors.

Survivabililty for its own sake has little value. If survivability is to be the primary measure of success, then our ASE task is relatively easy - stay home or at least don't expose yourself to danger. Unfortunately, we can't collect much intelligence, acquire targets, or kill many tanks by hiding.

ASE to be of real value must not only reduce attrition, but it must also aid the pilot in the accomplishment of his primary mission. For example, a **radar warning receiver (RWR)** can reduce attrition by providing warning of an impending radar weapon engagement.

However, the RWR provides much more; it gives the pilot the confidence to expose himself more often and do things that he might not do without a RWR. With the addition of an active radar countermeasure such as a jammer or chaff, the aviator can remain in an exposed position longer, permitting the acquisition of more targets and in the case of as AH-1S the completion of a TOW kill that might otherwise have been aborted.

In summary, the total value of ASE is measured in combat effectiveness, and not just survivability. ★

Since 1775, the objective of the U.S. Army is to win the land battle, and as a member of the combined arms team, Army Aviation offers dynamic new dimensions to land combat in terms of reconnaissance, intelligence, command and control, firepower, and battlefield mobility.

Long thought of as combat support vehicles, development in tactics and technology over the past decade have thrust Army aircraft into the forefront of combat itself. Integrated into the ground commanders maneuver plan, Army aircraft will operate worldwide, both day and night, under adverse weather conditions and in the face of an ever increasing air defense threat.

An analysis of this threat clearly indicates that the days of true low intensity combat where helicopters operate with relative impunity are over. As we experienced toward the end of combat action in Southeast Asia, even an unsophisticated guerilla force can employ advanced air defense systems.

How do we fight and survive?

Now, the question becomes one of how do we fight and survive in an air defense environment where the enemy is fully aware of our capabilities? Or, how do we reduce our vulnerability to this air umbrella which is going to be shooting at us with deadly accuracy?

Part of the answer lies in **Aircraft Survivability Equipment (ASE).** The general approach to ASE has always been to take maximum advantage of tactics and doctrine in an effort to limit the requirement for expensive and sometimes heavy ASE hardware. For example, our approach to the whole aircraft survivability problem has been first to examine the aircraft and its combat mission and to determine what the aircraft can do through tactics and agility to defeat the threat, and then develop specific ASE predicated on need.

Nap-of-the-Earth (NOE) flying is a good example of this. Helicopters are agile, and because the primary anti-helicopter threat weapons that we can expect to face require line of sight for initial target acquisition, our survivability will be enhanced by tactical flying. Tactical flying is the technique of flying the aircraft utilizing the folds in the earth, vegetation, and man-made objects to degrade the enemy's ability to acquire the aircraft as a target.

Secondly, we examine the radar and infared signature of the aircraft and seek to eliminate or reduce as much of it as possible within the restraints of dollars and weight. The use of IR suppression devices and low reflective paint is an example of the equipment approach.

Additional equipment, such as warning devices and active countermeasures, normally are considered only after all efforts have been made to do the job with tactics and signature reduction. As a matter of fact, in most cases the reduction of signature permits the use of simpler and more effective active devices.

Multiple mission roles

The aviation member of the combined arms team consists of a variety of aircraft that are called upon to operate in a variety of combat situations. **(Figure 1)** As seen in the figure, each aircraft has multiple mission roles having different objectives and creating multiple threat encounter situations. Thus, there can be a distinct ASE requirement for each aircraft

Establishing ASE Requirements

BY CAPT. HARRY K. STAUB, EW Employment Officer, Director of Combat Development, USAAVNVC

tailored for a particular mission role.

For example, a UH-1 operating in its normal lift mission, using tactical flight techniques in relation to distance from the threat, can get by with the simple APR/39(V)1 radar warning receiver due to the relatively low density of radar signals normally found within the areas to be flown.

This same UH-1 used in rear echelon units, where flights occasionally may be at somewhat higher altitudes, would prefer the APR/39(V)2 version which can effectively deal with the larger number of radar signals present at higher altitudes.

How do we decide what each aircraft needs?

The process of establishing ASE requirements is one of choosing the best ASE system from a wide range of potential equipment to meet the operational needs of each aircraft in each of its mission roles. In addition, the specific requirements for each piece of equipment in the ASE system must be considered so that the overall system for a given aircraft achieves effectiveness, reliability, maintainability and logistics support goals within reasonable cost and penalty constraints.

Figure 2 depicts the systematic approach used by the ASE developers when performing requirements analysis for each application to Army aircraft. The approach consists of a series of inter-related computer-aided analyses, progressing from inputs **(Circles 1, 2,** and **3)** through analysis, trade-off, and assessment **(Blocks 4, 5,** and **6)**, resulting in the output **(Blocks 7** and **8)**.

Aircraft mission profiles

Aircraft mission profiles, roles, **(Circle 1)** are combined with threat intelligence data and air defense target arrays to provide the detailed operational situations **(Circle 2)** which form the basis for ASE requirements. The mission profiles also establish the aircraft mission performance parameters (endurance, altitude, speed configuration, ordnance, etc.), which are utilized in the penalty assessment to determine the impact of ASE, if any, on each aircraft mission.

Each candidate ASE **(Circle 3),** and all appropriate combinations, are evaluated in **Block 4** to determine the survivability benefit provided, performance penalty incurred, and the unit cost of the ASE. In **Block 5** (trade-off data) the penalty effectiveness and cost effectiveness are evaluated and the most effective "least cost combinations" of ASE are identified. **Blocks 4**

FIGURE-1 AIRCRAFT

CH-47C

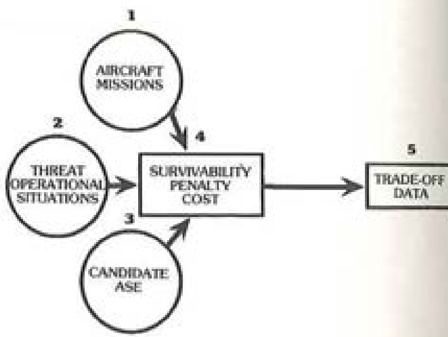
- LOGISTICS
- ARTILLERY MOVES
- AMBUSH INCIDENT

OV/RV-1

- QUICK LOOK
- SLAR
- IR/PHOTO

RU-21

- CEFIRM LEADER
- CEFLY LANCER
- GUARD RAIL



MISSIONS EVALUATED

UH-1

- ANTI-ARMOR TEAM INSERTION
- TROOP DISPLACEMENT
- COMMAND & CONTROL
- SPECIAL ELECTRONIC MISSIONS
- MEDEVAC

OH-58

- SCOUT
- TARGET ACQUISITION

AH-1S

- ANTI-ARMOR
- ESCORT

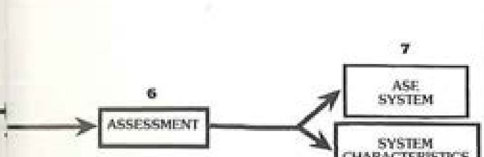


FIG. 2 — REQUIREMENTS ANALYSIS

and **5** are repeated through each aircraft mission, theater, and set of threat assumptions to derive the trade-off data for each case.

The results of the trade-offs are evaluated even further in the assessment step **(Block 6)** where additional decision factors are considered: these include development risk, operational rates, threat growth, priorities on theaters of operation, special mission requirements/constraints, mission frequencies, overall penalty and dollar restraints, maintenance factors, personnel, training, and, lastly, logistics considerations.

The final result is the systematic identification of the overall ASE suit for each aircraft and the individual characteristics for that suit. Once the ASE suit has been identified through the requirement analysis model, it then undergoes the development process from requirement to actual hardware in the field.

Training is a major factor

Lastly, we must remember that ASE is only as good as the people who use it. Therefore, training becomes a big part of the final ASE product as it is deployed. Like the infantryman who is vulnerable to machine-gun fire and the tank that is vulnerable to the anti-tank missile, the helicopter will operate only as long as it is employed in accordance with tactically sound concepts within the framework of the combined arms team and its commanders and crews know the threat.

Helicopters and their crews can survive on the battlefield populated with sophisticated air defense weapons if the crews are well-trained in survivability techniques and if they understand the threat. Simply stated, helicopter survivability is a function of its onboard aircraft survivability equipment coupled with exposure time, exposure attitude, and engagement range.

It can be done!

Aircrew training in survivability techniques, such as **NOE** flight, plus a thorough knowledge of ASE hardware and its application to the threat, will allow the helicopter and its crew to fight and survive on the future battlefield.

Aircraft survivabililty is a product of mission planning, flight discipline, training, sound concepts, and good aircraft, and the best use of aircraft survivability equipment.

The combination of aircrew professionalism and the best use of survivability equipment will insure that aircraft will return from today's mission to fly tomorrow's. ★

A basic: The APR-39 (V) Radar Warning Receiver

A Report by
EARL J. DIEHL,
ECM
Product Manager
E-Systems
Melpar Division

THE U.S. Army has developed the **AN/APR-39 (V)** Radar Signal Detecting Set as the basic radar warning receiver to be used in the Aircraft Survivability Equipment Program.

The (V)1 configuration of the warning receiver is shown in **Figure 1.** This receiver provides one of the most effective survivability techniques available to cope with the severe threat to tactical aircraft - either fixed wing or helicopter - that are operating in a mid- to high-intensity hostile radar environment.

A need for safe routes

The threat consists of radar-directed enemy ground-based air defense weapons systems as well as airborne interceptors. These radar-directed systems are operationally effective, self-contained mobile units that have been specifically developed to support the highly mobile tactics that will be employed in any expanded hostile environment. The mobility of such air defense systems negates the value of routine electronic intelligence - even that which is less than an hour old - and it greatly broadens and intensifies the need for real-time electronic warning equipment.

The radar-controlled weapons must be detected and avoided so that combat and mission support aircraft can achieve safe routes to and within battle areas. The APR-39 receiver provides the aircraft crew with the ability to detect these sophisticated weapons systems and thereby either avoid them, or reduce the threat exposure by low level nap-of-the-earth (NOE) flight.

The prime threats against low-flying Army helicopters are the conical scanning fire control radars used to automatically direct antiaircraft weapons ranging from the highly mobile rapid fire 23mm and the high velocity 57mm guns to the low level missile systems. In order to cope successfully with these hostile weapons systems, it is necessary for the aircrews to know the location and operating status of the various fire control radars.

The APR-39 radar warning receiver provides azimuth and approximate range information each time the aircraft is illuminated by a radar threat. **Figure 2** shows a typical APR-39 signal display on its 3-inch diameter **cathode ray tube (CRT)** indicator mounted for easy visual monitoring by the pilot or other aircrew members.

In addition to visual warning, an aural signal is provided in the crew member's headphones. This aural warning makes it unnecessary to constantly monitor the CRT indicator as well as providing aural information to aid in identifying the signal as a threat and determining its operating status. The special modulation characteristics of a radar in the search-versus-tract mode will make the pilot aware of an im-

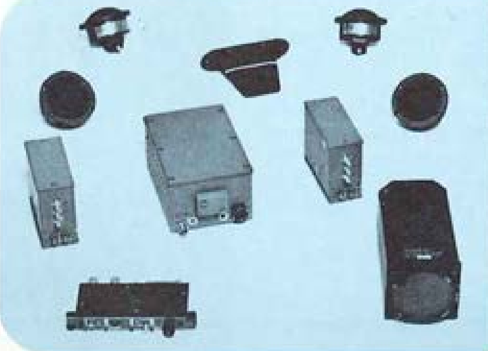


Figure 1

minent threat situation. In the search and acquisition mode, wide variations in signal amplitude will take place as the radar beam scans back and forth across the aircraft. In the tract mode, the signal is a steady tone with a modulation frequency equal to the pulse recurrence frequency of the tracking radar. The pilot can tell at a glance the relative direction of the radar threat by the azimuth indication on the CRT indicator and the approximate range by the length of the signal strobe from the center of the indicator.

Estimating the various threats

The pilot can then estimate the imminence of the threat and take suitable action to mitigate it. He may immediately decrease his altitude until the radar is unable to illuminate and track the aircraft due to ground clutter, or he may change direction to increase the range between the aircraft and the radar threat.

The APR-39 radar warning receiver operates over the entire frequency spectrum presently used by fire control radars. It also provides for the detection of missile guidance radars as well as the associated tracking radars. **Direction bearings (DF)** and special warning indications are given when an activated missile radar complex is detected.

The APR-39 **(Figure 2 — top, right)** weighs less than eight pounds and is powered directly from aircraft 28 Vdc power. The CRT indicator is equipped with an adjustable day-night optical filter. The warning receiver set has **built-in-test provisions (BITE)** which checks out the complete receiver except for antennas. BITE can be activated at any time by the operator and does not interfere with normal operation of the warning receiver. The APR-39 and its **special test equipment (STE)** are in production and quantity deliveries have been made.

Simulator/Trainer now available

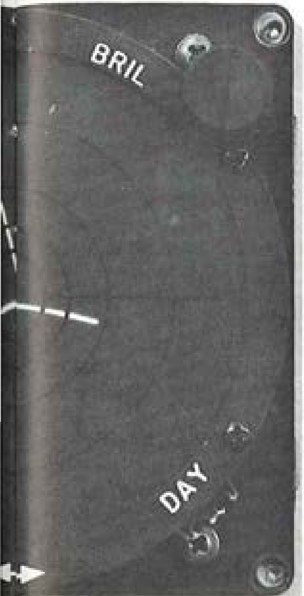
A training aid, the Signal Simulator/Trainer, **(Figure 3)** has been developed and is being procured. The unit interfaces directly with the APR-39 in its test adapter or in an actual aircraft installation and provides search, acquisition, and tract simulations of the key threat radar. These simulated threat strobes are displayed on the pilot's CRT to provide in-flight training.

Two simulated radars and their various operational modes can be generated simultaneously with their relative DF bearings and amplitudes individually adjusted. Use of the trainer in no way interferes with the normal operation of the APR-39. As indicated, the unit can be used in flight training as well as in the classroom. **Figure 3** shows the control unit of the training aid.

Aircraft Survivability Equipment for Army applications have stringent requirements in terms of size, weight, and power. As the need for more ASE increases so that the Army aircraft can accomplish its prime mission, existing Army systems must be flexible in terms of being up-dated, expanded, and/or integrated so that a minimum of new equipment is required. Already the APR-39 indicator has been shared with other systems such as laser warning receivers to minimize hardware required.

For aircraft operating at altitudes above low level and NOE a more sophisticated radar warning receiver is required to permit sorting out non-threat radars from actual threats. The ASE approach to this is the

ABOVE: A 2 LB, 3" DIAM. CRT INDICATO PROVIDES RANGE AND DIRECTIONAL INF ON DETECTED THREAT SIGNALS.



BELOW: IMPROVED "MAP TYPE" CRT DISPLAY OF SAME DETECTED RADAR SIGNALS AS CONVENTIONAL FORMAT ABOVE.

development of a special processing unit that is directly interchangeable with the basic APR-39(V)1 processor. Called the V2, this processor prioritizes the threats and displays them on the CRT as Alpha Numerics rather than strobes for easier pilot identification.

Rapid upgrading to (V)2 permissible

Any flight line crew chief or pilot can upgrade his basic APR-39(V)1 to the APR-39(V)2 configuration in a few minutes by the addition of the V2 processor. All aircraft that have V1 provisions will automatically have V2 provisions; thus, there will be no future retrofit requirements for V2. The deployment concept is to issue V2's to all EH-1 and RU-21 aircraft, plus a specified quantity to all aviation units. The unit can then equip, as required, selected aircraft for special missions such as command and control, etc. The V2 processor will add approximately ten pounds to the basic APR-39(V)1.

Special interface provisions are included in the basic APR-39 for integration with other onboard systems performing a warning function. One such ancillary system that is presently available and can be readily interfaced with the APR-39 is the AN/APR-44 radar warning system.

The APR-44 is a small CW alarm receiver that covers a specific class of radar threats. It can be operated as an independent system or interfaced with the APR-39 to eliminate its control unit. Also available from the APR-39 manufacturer is a similar CW alarm receiver that was designed specifically for use with the APR-39. This alarm receiver has its antenna integrated directly into the receiver which mounts as a single unit on the underside of the aircraft. All control and output indications of this receiver are by way of the APR-39 system, another step in the direction of integrated ASE.

Better display on hand

An improved indicator display format has been developed by the APR-39 manufacturer. By the addition of a small unit between the signal processor and CRT indicator of the APR-39, a display inverter unit, the APR-39 display becomes a "map presentation" of the detected radar DF indications, i.e., is the DF strobes start at the outer edge of the display and increase in length, with increasing signal strength, toward the center of the display which represents the aircraft location.

The map or "inside out" display provides for a faster and more accurate analysis of weak signal displays. Since all strobes start at the outer edge of the display, it is easier to translate their angular position into relative bearing information. (**Figure 4 — bottom left**). The map type display is generally more in keeping with a pilot's map training and he therefore relates more quickly to its presentation.

A firm base

In summary, the Army has a firm base in radar warning survivability equipment with the AN/APR-39. The capability of the APR-39 is being optimized and expanded by industry and Army-sponsored programs in order to provide the Army with the most effective ASE in keeping with its various aircraft missions. ★

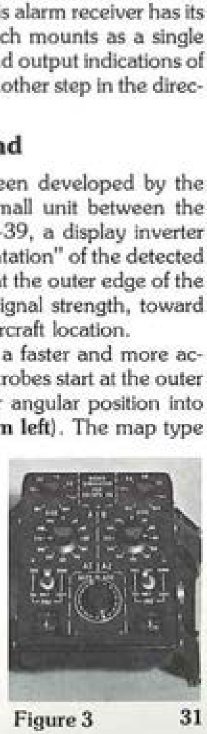
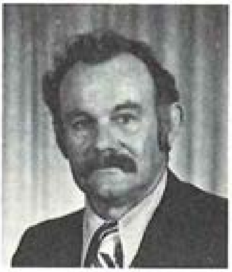


Figure 3



The Reduction of Radar Cross Section

BY J.N. FISCHER, Chief of Systems Analysis
Bell Helicopter Textron

ACHIEVEMENT of low signatures is a fundamental means of improving the combat survivability of aircraft. Signatures of primary concern are those which are both beneficial to accomplishment of the air defense mission and readily exploitable.

Radar provides air defense systems with information necessary to detect and identify air targets and track target movement in range, bearing, and elevation. Radar accomplishes this by exploiting the physical characteristics of the target which reflect or re-radiate electromagnetic energy.

These target characteristics produce an aircraft signature called radar reflectivity or **radar cross section.** Due to the effectiveness of radar-controlled air defense systems, radar cross section reduction is an attractive method for degrading the radar's capability and thereby improving aircraft survivability.

Need for application

Application of radar cross section reduction to Army aircraft has been low relative to infrared radiation and visual signature reduction. This is possibly due to several reasons. The cause and effect relationship between radar cross section reduction and survivability improvement are not immediately obvious.

Radar cross section reduction technology, while far advanced and well documented in the classified literature, has not been readily available in a usable form for design application. And, radar cross section reduction technology is more related to electromagnetic theory and design practices than to airframe design-related disciplines.

Before proceeding with a discussion of radar cross section reduction, it is perhaps worthwhile to provide some background and definitions.

The Threat

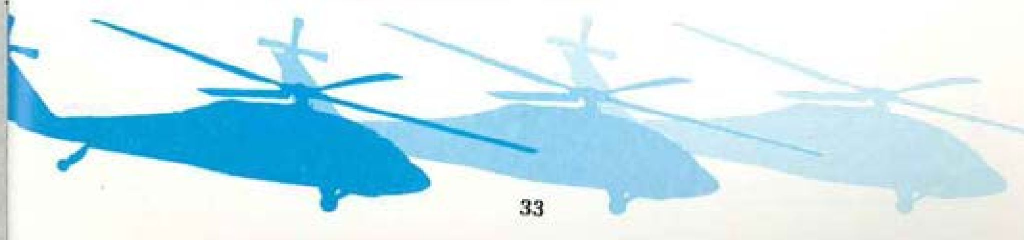
Let's take a look first at the role of radar and its influence upon survivability by examining the familiar expression for aircraft survival probability, P_S.

$$P_S = 1 - P_D \bullet P_I \bullet P_H \bullet P_{K/H}$$

where

P_D is the probabilility of detection; P_I is the probability of identification; P_H is the probability of a hit; $P_{K/H}$ is the probability of kill given a hit.

With radar-directed anti-aircraft systems, radar provides the means of detection, thus determining the value of P_D. By interrogating a transponder in the target aircraft, radar determines P_I. By tracking the target, radar supplies input to the fire control solution to influence P_H. These capabilities are provided at long ranges and under day, night, and adverse weather conditions.



Reduction of Radar Cross Section

Radar's high degree of utility to air defense has caused its technology advancement to be emphasized. Modern armored forces are accompanied by ever-increasing numbers and varieties of mobile radar-directed air defense systems of both anti-aircraft artillery and missile types. Air defense reliance upon radar makes it imperative that this threat be recognized and that all possible means be used to degrade its capability. Radar cross section reduction is one means to accomplish this objective.

What is radar cross section and how is it defined, estimated, and measured?

Radar cross section, σ, is a measure of an object's reflectivity when illuminated by radar, is expressed in area units (typically square meters), and is a function of target size, shape, viewing aspect, material electrical properties, and radar characteristics such as frequency and polarization. By definition, a conducting sphere of one square meter silhouette area has a radar cross section of one square meter.

The effect of shape is shown dramatically by comparing the conducting sphere with a square panel made of conducting material and having the same silhouette area as the sphere, i.e., one square meter.

At 10 GHz radar frequency, the broadside radar cross section of the panel is 14,000m_2 while the sphere's radar cross section is one m_2.

Radar Cross Section Assessment

Radar cross section is analytically estimated using a variety of techniques for determining radiation patterns from geometric shapes. Complex shapes such as aircraft require extensive modeling to provide radar cross section estimates for the entire aircraft. Computer programs have been developed to assist in the analysis and estimation of aircraft radar cross section.

Radar cross section is measured at radar test ranges equipped to provide a wide range of radar frequencies, control clutter, and process data. Testing can be conducted with scale models or full size articles. Scale models must be completely representative of the geometric shape and material properties of the full-size article.

Benefits

The benefits of radar cross section reduction in terms of degradation of radar capability are as follows:

- Reduction of the radar's detection range.
- Reduction of the cost, weight, and power penalties of electronic warfare systems (radar jammer or chaff) to be carried by the aircraft.
- Reduction in the capability of the radar to detect the aircraft in a nap-of-the-earth clutter environment.

The effect of radar cross section reduction on radar detection range is best shown by examining the common form of the radar range equation shown below:

$$P_R = \frac{P_T \bullet G^2 \bullet \lambda^2 \bullet \sigma}{(4\Pi)^3 \bullet R^4}$$

where:

P_R is the power received from the target.
P_T is the power transmitted by the radar.
G is the radar antenna gain.
λ is the wavelength of the radar operating frequency.
σ is the target radar cross section.
R is the range to the target.

With further simplification to emphasize the relationship between radar cross section and range, the above expression can be reduced to the following expression:

$$R_{MAX} = k\sqrt[4]{\sigma}$$

where:

$$k = \sqrt[4]{\frac{P_T \bullet G^2 \bullet \lambda^2}{(4\Pi)^3 \bullet P_R}}$$

This expression shows that the maximum detection range varies as the fourth root of the radar cross section. In order to obtain a 50% reduction in detection range it is necessary to reduce the radar cross section by approximately 94%, or 12 db. Reductions of this magnitude are practical goals.

Electronic warfare systems (radar jammers or chaff) use the principle of denial of target information to the radar. Reduction of the target radar cross section permits reductions in the weight, power, and cost of the electronic warfare systems. Trade-offs have been conducted on aircraft and missiles to determine the penalties associated with electronic warfare systems for various levels of radar cross section reduction.

These studies indicate that penalties are minimized when radar cross section reduction is utilized in conjunction with electronic warfare systems.

Methods for Reduction

The general objective of radar cross section reduction is to minimize the energy returned to the radar when the radar-transmitted energy illuminates the aircraft. Two basic techniques are available. These are **physical shaping** and **control of the aircraft materials' electrical properties.** These may be used separately or combined.

The effect of **shaping** was previously illustrated by the comparison of a conducting sphere and a flat plate. Exploitation of shaping to achieve radar cross section reduction must take into account the most likely viewing aspects of the aircraft by the radar. Shapes are chosen, subject to other design constraints, to reflect or re-radiate incident energy in directions other than the direction of the radar.

Since we are referring to the basic shapes of the exterior of the aircraft, this method of radar cross section reduction is most effectively applied when the aircraft is designed.

Control of an aircraft material's electrical properties can be achieved by using many approaches. These range from providing conductive coatings to surfaces which would otherwise permit entry of incident energy to broadband radar absorber materials designed to serve as the skin of the aircraft. It should be noted that composite materials, excluding graphite and boron, are classified as dielectric materials.

survivability?

Reduction of Radar Cross Section

Also included are glass, plexiglass, polycarbonate, and radome materials. These dielectric materials, when used for external surfaces, reflect a portion of the incident energy and allow the remainder to pass through to be reflected from other objects within the structure. This characteristic prevents the construction of an invisible aircraft with composite materials.

On the other hand, entry of the incident energy permits its trapping or absorption. Techniques for accomplishing this operate on the incident energy's electrical field or its magnetic field or upon both fields. These materials, generally called **radar absorbing materials (RAM),** range widely in their effective bandwidths and absorption, physical properties, and cost.

RAM technology, while already well developed, is continually expanding. Analytical assessment techniques are being improved and new RAM technical approaches are being investigated. This technology, like **shaping,** can be most effectively utilized when the aircraft is designed. However, both **shaping** and RAM application can be retrofitted and in some instances this has been accomplished with very small penalties.

Applications

Development efforts have explored radar cross section reduction of a light obervation helicopter, canopies, antenna domes, engine inlets and exhausts, and skin panels, and rotor blade, hubs, and rotating controls. Radar cross section reduction technology has been applied

FIGURE 1

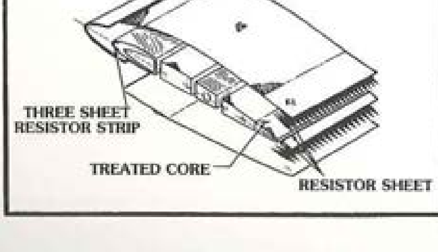


FIGURE 2—ROTOR HUB COVER

to space vehicles, re-entry vehicles, remote piloted vehicles, air-to-surface missiles, and cruise missiles. These programs have provided a basis for low-risk technology application to Army aircraft weapon systems.

Examples of the application of radar cross section reduction technology to a helicopter rotor are shown in **Figures 1 and 2.** The hub cover for the AH-1S helicopter shown in **Figure 1** was developed under contract to the US Army Applied Technology Laboratories by Tulsa Division — Rockwell International and Bell Helicopter Textron.

The hub was selected as an appropriate area for application of this technology because of its doppler return even when the helicopter is hovering and because it is the high point on the helicopter. **Figure 2** shows a design concept for application of radar cross reduction technology to a composite material main rotor blade. These design concepts significantly reduce the radar cross section of the rotor.

Summary

There are a number of desirable features associated with radar cross section reduction. It operates continuously, yet requires no attention from the air crew. It is passive, broadband, and not subject to obsolescence or saturation as the number of air defense radars increase or change operating characteristics.

Finally, it incurs a one-time cost of installation whose benefits are enjoyed throughout the life cycle of the weapon system.

The technology necessary for radar cross section reduction of aircraft is available. Application of this technology can make significant contributions to the combat survivability of these aircraft. ★

Tomorrow's Radar Jammer Today!

BY JOSEPH GRAZIANO, ENGINEERING MANAGER, AND THOMAS E. CULLEN, PRODUCT MANAGER, ITT AVIONICS DIVISION

ON today's battlefield — and surely the hypothesized one of tomorrow — the capability of the attack helicopter to jam an enemy radar will be the determining factor of its survival.

The attack helicopter is dependent upon the synergistic effects of radar jamming and tactics to derive the necessary staying power to assure mission success and aircraft survivability.

Radar jammers are available in all shapes and sizes; they are not newcomers to the battlefield. Indeed, generations of these systems have been developed since World War II, all of which have provided varying degrees of protection against radar threats.

A systematic Soviet increase

In the past 12 years, the Soviet Union has been systematically increasing the number of highly mobile, radar-directed weapon systems deployed throughout Eastern and Western Europe. These include Anti-Aircraft Artillery, Surface-to-Air Missile and Surface-to-Surface Missile Systems.

Faced with the possibility of confronting massed armor concentration and sophisticated weapon delivery systems, it becomes imperative that we tip the scales of survivability in favor of the United States and NATO forces in the initial hours of combat.

Accordingly, the radar jammer is a very important resource since it will provide aircraft protection and allow more on target time during this critical period.

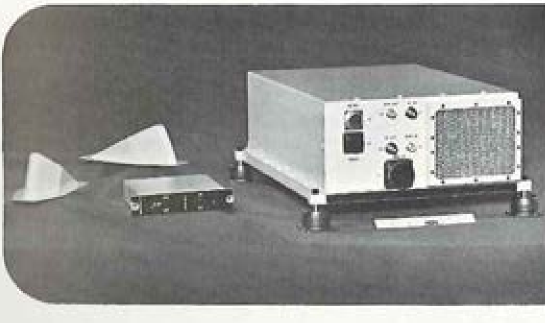
As previously noted, radar jammers have been around for awhile. The Army's sister services, the USAF and USN, have in the past and will continue in the future to rely heavily upon radar jammers for aircraft protection. However, these systems have not easily lent themselves to helicopter use since they have most often been large and complex (Frequently costing hundreds of thousands of dollars) and always have been too heavy for helicopter usage.

Lighter, cheaper, smaller

This is no longer the case. A new chapter in the history of Electronic Countermeasures has evolved with the development of an ALQ-136 radar Jammer, under the sponsorship of AVRADCOM and ERADCOM.

The AN/AL-136 weighs less than 45 pounds. Its production cost will be a small fraction of the customary ECM price tag. Additionally, by utilizing advance packaging techniques, the AN/ALQ-136 occupies less than 3/4 of a cubic foot in volume.

To address the role of the active jammer as



Joseph Graziano
Engrg Manager

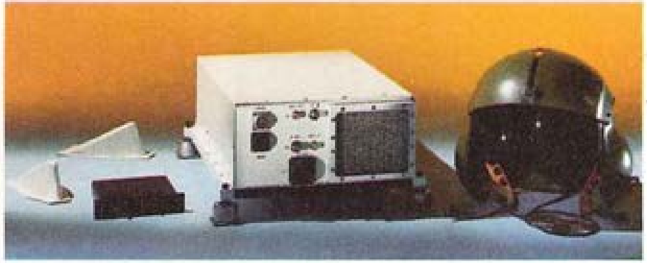
Thomas E. Cullen
Product Manager


ARMY
UNITED STATES ARMY

The ALQ-136 radar jammer is synonymous with helicopter survivability.

Flight tests demonstrate that attack helicopters equipped with the advanced ITT ALQ-136 radar jammer are assured significantly greater survivability on the modern battlefield.

The ALQ-136's unique design delivers effective ECM performance that will keep pace with ever-changing threats well into the 1990's. Its light weight and straightforward configuration make it compatible with every U.S. helicopter and with NATO rotary-wing aircraft as well. That makes it a protective system with the benefits of equipment commonality and force interoperability – important advantages for both U.S. Army



and NATO units. Judged by any standard, the ALQ-136 is a major advance in ECM technology. If the performance and survivability of helicopters are among your responsibilities, contact: Product Line Director, Electronic Defense Systems, ITT Avionics Div., 390 Washington Ave., Nutley, N.J. 07110, (201) 284-0123.

ITT AVIONICS DIVISION

Member, ITT Telecommunications and Electronics Group—North America

Tomorrow's Radar Jammer Today

part of the **Aircraft Survivability Equipment (ASE)** suite in an attack helicopter, we must first define the problem, then establish the need and finally identify the system requirements to satisfy that need.

Time is our worst enemy

If we examine the battlefield scenario, we find the attack and assault helicopter confronted with "smart" weapon systems. Aided by radar, these systems can detect, track and destroy the assault force. The hostile radar system has become an important factor because it is impervious to weather and visibility conditions. Although ASE systems exist to detect these hostile radars, we are confronted with the problem of detecting and destroying them before we are detected and destroyed.

Means such as reduction of helicopter cross-section, radar warning systems and use of terrain can be employed to reduce detection and allow the attack helicopter to obtain a favorable firing position. Once we have established a firing position, time becomes our worst enemy. An active radar jammer can provide the precious time needed to complete the mission objective.

Radar-directed systems have two basic modes of operation; acquisition, the initial location of target positions, and tracking where the range, azimuth and elevation of the target is accurately and continuously measured.

A radar system accomplishes target acquisition and tracking by extracting range, azimuth and elevation information from the target echo. The amplitude of the echo is a function of the radar transmitter power, radar antenna gain, path loss to and from the target and target reflectivity.

A typical example of these factors and their effect on the return signal is depicted in the opposite page table, which demonstrates that increasing the distance between the aircraft and radar or decreasing the target size will reduce the signal return but not substantially enough to render the target undetectable. Typical radar systems are capable of detecting signal levels at less than 80 dBm.

If we examine the time during which a weapon system can detect, track and destroy a moving target, we will find that it takes certain periods of time to perform various functions; that is, if it takes two to three seconds for acquistion, four to five seconds for complete tracking data and four to five seconds to impact, then our on-target operational time is limited to less than 10 to 13 seconds. Conversely, we must locate, and destroy the weapon system in less than 10 seconds. An examination of these basic radar capabilities, target acquistion and tracking, will help define the jammer requirements.

Two basic requirements

An active jammer must meet two basic operational requirements; first, to deter, delay or inhibit acquistion of the attack helicopter position and second, to deny the radar tracking information for any time greater than two to three seconds. Since radar technology is always being improved and characteristics are continually changing, the active radar jammer must meet an additional requirement of design flexibility and provide an expansion capability. In addition to meeting the operational challenge, the active jammer must be lightweight, low-cost and simple to install in order to provide maximum protection with minimum penalties of size and weight.

The System

The AN/ALQ-136 system designed and developed for U.S. Army attack helicopters has accomplished all of these objectives. To meet the challenge, hybrid packaging technology was employed to maximize performance in the minimum amount of space.

Unique cooling techniques were utilized to provide maximum reliability with minimum weight penalties. Computer-controlled electronic countermeasures techniques provide flexibility via software in all areas of interest. In addition, space has also been provided for future system hardware expansion requirements.

The AN/ALQ-136 system consists of three line replaceable units (LRU's) which are depicted in **Figure 1.** LRU-1 is the receiver/transmitter which contains all the electronics necessary to analyze the incoming signals and automatically provide the appropriate ECM. LRU-1 is six inches by 13 inches by 18 inches and weighs 40 pounds. LRU-2 consists of one receive and one transmit antenna. Each antenna weighs 3/4 lbs. LRU-3 is the operator control unit, which allows the operator to select the operating modes of the jammer. LRU-3 is 1-1/8 inch by five inches by five inches and weighs 1-¼ lbs.

LRU-1, the receiver/transmitter, performs the functions of signal detection, processing and amplification. The major subassemblies contained in LRU-1 are the receiver for signal detection, five printed wiring boards for signal processing, the radio frequency assembly for frequency analysis and the transmitter for power amplification.

RANGE	3 KM	6 KM	6 KM
TARGET CROSS-SECTION	10 SQ METER	10 SQ METER	5 SQ METER
TRANSMITTER POWER	+ 70	+ 70	+ 70
TRANSMIT'R ANTENNA GAIN	+ 40	+ 40	+ 40
PATH LOSS TO AIRCRAFT	− 126	− 132	− 132
TARGET SIGNAL GAIN	+ 50	+ 50	+ 47
PATH LOSS FROM AIRCRAFT	− 126	− 132	− 132
RECEIVE ANTENNA GAIN	+ 40	+ 40	+ 40
RECEIVED SIGNAL AT RADAR	− 52	− 64	− 67

ALL READINGS POSTED ABOVE ARE IN DBM'S.

A continous update

The AN/ALQ-136 automatically analyzes the incoming signals. From the pulse characteristics, modulation index and RF characteristics, it will determine whether this signal originates from a threat weapon system. Once this analysis is made the system continuously updates this information. After the threat radar is identified, the appropriate electronic countermeasures are applied. Pulse and frequency analyses will determine the ECM program to be applied to counter the radar's range measurements.

Analysis of the modulation characteristics determines the ECM program that will be applied to counter the radar's angle measurement. Activation of these ECM programs is automatic within the active jammer and is accomplished in a fraction of a second. The following system features are pertinent:

- Simultaneously handles multiple threats
- Accurately measures complex radar pulse trains.
- Accurately measures radar radio frequency.
- Generates effective range ECM techniques.
- Maintains effective jamming power at high transmitter duty cycle.

System flexibility

Flexibility requirements are established by examining the three key radar parameters of the radar-directed weapon systems. Radar systems use PRI for range measurements, amplitude modulation for angle tracking measurements and have a fixed radio frequency. An active radar jammer will measure these characteristics and apply the appropriate electronic countermeasures to defeat the range and angle measurement circuits in the radar system.

To accomplish this, the active radar jammer must be adaptable and flexible in responding to these characteristics or any changes to these characteristics. Present and future requirements have been addressed by the use of a computer to control the ECM techniques employed against these characteristics. Computer control provides flexibility without requiring additional hardware. Changes are accomplished by software (Programming) modifications:

Future potential and variants

Although the software provides the design flexibility, future growth potential can be satisfied by the addition of memory to the computer-controlled functions. This eventuality has already been provided for by leaving space for additional memory.

An expansion capability is also available to add circuits and RF components for electronic countermeasures techniques for other applications, or for addressing new threats. The space necessary to provide these capabilities is presently available within the existing system form factor.

Truly, the AN/ALQ-136 is tomorrow's radar jammer today. ★

EQUIPMENT EVALUATION, PRODUCT IMPROVEMENT REDESIGN, PROTOTYPE FABRICATION, TEST EQUIPMENT FABRICATION

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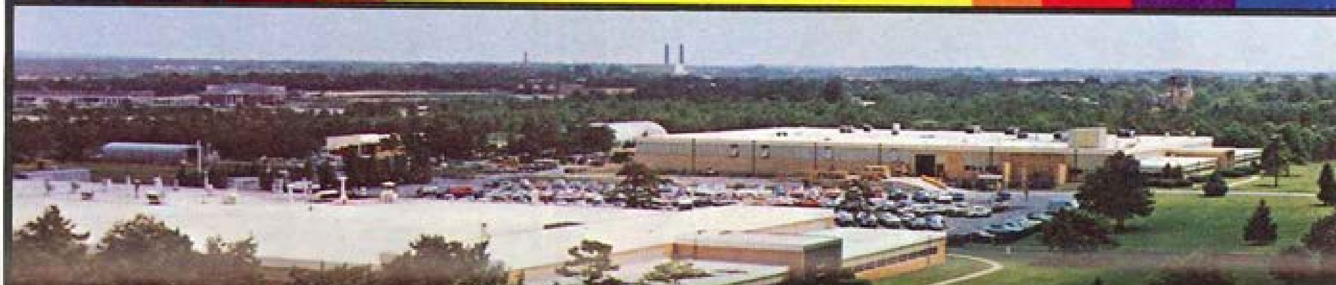

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The Army Aviation need for countermeasures is well established. The coherent program of development under control of the Project Manager (ASE) has produced survivability equipments and systems which offer full operational and configuration flexibility.

The survival of Army Aviation in the forward area is an essential condition of mission accomplishment. Hostile air defenses have an integrated combination of all-weather weaponry with which to execute their doctrine of complete denial of airspace use to their opponents. An essential condition of survival is the ability to suppress, degrade, or deny hostile air defense operations in the forward area.

SINGLE DISPENSER CONFIGURATION

THE USE OF CHAFF AGAINST RADAR-DIRECTED WEAPONS

BY JOHN C. STEVENS, TRACOR SCIENCES AND SYSTEMS

Radar fundamentals

Many hostile weapons systems use radar as surveillance, target acquisition, and tracking type sensors. Radar operates on the principle of transmitting radio frequency energy, usually in a directive nature, and determining range to the target from the time it takes to receive a reflected echo.

The size of a radar target is called the **radar cross section, (RCS)** and is measured in square meters. RCS is a complex function relating radar wavelength, aspect angles, transmission paths, target shape, and many other factors. The important thing, operationally, is relative RCS, whether one target has a larger RCS than another and hence a larger return of energy to the radar.

Modern radars actually measure more than range. They are capable of measuring angle, velocity, relative velocity, etc. The majority of air defense radars have excellent resolution in all measured data. The concept of **the Radar Resolution Cell (RRC)** is essential to understanding chaff as a decoy; the RRC is a volume bounded by the azimuth and elevation of the radar beam and in range by the distance equivalent of one pulse width.

The size of the RRC is constant in range, but grows in angle as the beam expands as the range increases. For example, a 1° beam in azimuth covers 53 meters at three kilometers, but increases to 177 meters at ten kilometers. Conversely, a one microsecond pulse covers 150 meters, regardless of the range.

Some radars use **Moving Target Indicator (MTI)** techniques to eliminate ground clutter and enhance targets with motion. The techniques usually are based on some type of return correlation as a function of time delay and coherence of phase between the transmitted signal and the reference within the radar. This allows detection of doppler frequency differences which are characteristic of moving targets. The use of MTI against low altitude targets forces the radar to use its clutter cancellation to eliminate stationary ground targets.

In doing so, other means of clutter, such as wind-blown chaff, will have an effect on the radar because cancellation of chaff clutter will result in losing the low flying target in the ground clutter. In short, the radar operator

Chaff and its Use
(Cont. from Page 47)

cannot have an advantage both ways simultaneously.

Chaff Fundamentals

Chaff is a radar countermeasure. Chaff consists of myriads of small dipole reflectors, thus presenting a real target to the radar.

To be an effective real target decoy, chaff must be dispensed in a timely manner. For self-protection, this is when the aircraft is threatened by radar-directed weapons. The tell-tale indication is when a tracking radar locks on the aircraft, just prior to initiating firing of the weapon.

Most modern aircraft carry radar warning receivers which will allow detection of the radar activity in sufficient time to allow the crew to dispense chaff, make a manuever, and otherwise degrade the hostile engagement.

Chaff tactics are based on the characteristics of the radar and the characteristics of chaff. Most fire control radars use manual detection

Chaff decoys the radar from the aircraft in tracking the chaff's greater return. The radar's manual re-acquisition process takes a finite time in which the aircraft may pursue engagement or survival action

and acquisition with automatic tracking, locking a range gate on the target. The dispensing of chaff from the aircraft presents a return that is larger than the aircraft in the RRC.

A decoying action

This decoys the radar from the aircraft, since the radar tracks the chaff's greater return. When this condition is recognized at the radar, it is forced to go into a manual reacquisition mode, searching for the aircraft to re-establish lock prior to firing. This process takes a finite time in which other survival or engagement actions may be taken by the aircraft.

The behavior of chaff at low levels and nap-of-earth conditions differs somewhat from higher altitude. At low levels, convection currents and other wind conditions cause the chaff to have a low fall rate, in effect making it hang for extended periods above the earth. This phenomena occurs in the region up to about 100 feet above mean terrain level. However, chaff dipoles are very light, and consequently will move in the direction of the wind vector at any altitude.

Chaff differs from active countermeasures in threat dependency. Electronic countermeasures, such as jammers, are very effective in countering known threats for which they have been designed. However, parametric or mode change by current radars, or introduction of new radars, can degrade the jammer.

Chaff, a passive countermeasure, is not threat dependent, beyond the requirement that the chaff dipoles are cut to some frequency equal to or lower than the threat frequency and are dispensed in sufficient quantity.

M-130 Dispenser

Tracor, Inc., has completed development for the U.S. Army, of its M-130 Dispenser System, including the associated M-1 Countermeasures Chaff and M-206 Aircraft Countermeasures Flare.

The M-130 is in production and the expendable payloads will soon enter production. The program was executed through USAAVRADCOM for the PM-ASE, and is the culmination of prior Advanced Development Programs for the Mini-Flare Dispenser and the Mini-Chaff Dispenser.

The M-130 shown in **Figure 1,** is a lightweight, modular, dual-mode, chaff/flare dispenser system, consisting of a cockpit control unit, and electronics module, and one or more dispensers. Each of the dispensers has a capacity of 30 payloads.

A single dispenser aircraft configuration, as shown on the UH-1, **(Figure 2),** can carry either 30 chaff or 30 flares; a dual dispenser configuration can carry 60 chaff; 30 chaff and 30 flares; or 60 flares. A 30 payload system configuration weighs less than 30 pounds.

The cockpit control unit allows pilot selection of operating modes, has a counter that indicates the number of payloads remaining, and has dispense and ripple fire switches. The dispense switch is usually wired in parallel with some control button on the flight controls to allow the pilot to dispense countermeasures without removing his hands from the controls. The ripple fire switch allows rapid off-loading of flare payloads for emergency use.

The electronic module is a programmer which allows the number of chaff units, the interval between chaff units and groups, and group intervals to be set according to preflight criteria for optimum effectiveness in a given threat environment. Thus, one activation can initiate a program of, say, eight chaff units in groups of two with intervals of 100 milliseconds between the units, and intervals of two seconds between the four groups of two units.

The system design is such that provision for automatic dispensing of chaff and flares is integral, allowing activation of the M-130 by the AN/APR-39 radar warning receiver and by the AN/ALQ-156 Missile Approach Detector, if so desired.

The chaff and flare payloads for the M-130 system have been specifically designed for optimum effectiveness against the threat in the forward area. While the results of testing are classified, the designs have been confirmed in extensive testing. On-going tests are in progress to assist in the development of improved tactics.

Test equipment has been designed, tested and is scheduled for production. Much of the technology employed in the M-130 is derived from the U.S. Air Force's AN/ALE-40 Countermeasures Dispenser Set. There is commonality within the electronics and spare parts of the two systems.

A REPORT BY JOHN C. STEVENS, TRACOR SCIENCES AND SYSTEMS

Future growth

The M-130 is capable of dispensing any payload that is compatible in form factor. Other payloads under consideration are dual chaff and flare units, expendable jammers, smoke laser expendables, and chemical units. The basic M-130 is also adaptable to miniature **Remote Piloted Vehicle (RPV)** operations, for delivery of special payloads to selected areas, rather than self-protection.

The use of chaff and flare expendable countermeasure provides new opportunities to Army Aviation in the development of tactics which will meet and neutralize the hostile threat on the modern battlefield. The availability of the M-130 provides one means to meet the challenges. ★

THE M -130 DISPENSER SYSTEM AND ASSOCIATED M-1 COUNTER-MEASURES CHAFF AND M-206 COUNTER-MEASURES FLARES

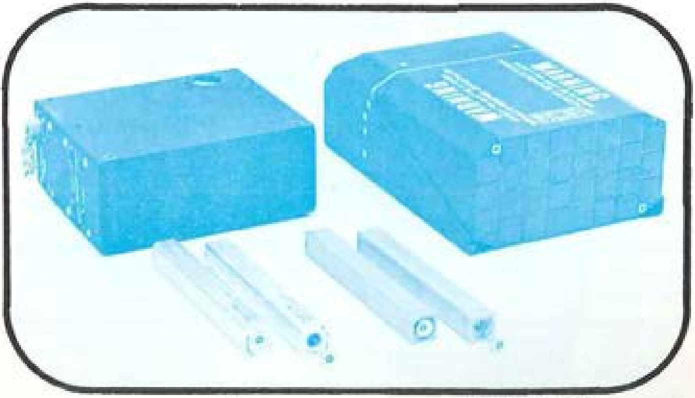


FIGURE 2

A report on today's ASE Developmental Testing

By COLONEL WILLIAM E. CROUCH, JR., Commander, USA Aircraft Development Test Activity

THE U.S. Army Aircraft Development Test Activity (USAADTA) of the U.S. Army Test and Evaluation Command is involved in the developmental testing of **Aircraft Survivability Equipment (ASE)** which will protect Army aircraft on future battlefields.

In support of the Project Manager-ASE, USAADTA is now testing 18 ASE items for use against the threat areas of radar and **infrared IR.** These items can be divided into categories based on the techniques used to deny the use of electro-magnetic radiation by enemy fire control systems.

Testing is being accomplished on the entire tive countermeasures, and threat warning. Equipment currently being tested includes radar warning receivers, hot metal plume suppressors, radar jammers, and chaff/flare dispensers.

Testing is being accomplished on the entire spectrum of Army aircraft and will include the UH-60A **Black Hawk** and YAH-64A Advanced Attack Helicopter when these latter aircraft enter the inventory. ASE is designed to assure the aviator that his aircraft and he will complete the mission with a high probability of survival.

Many test sites

Much of the ASE testing is accomplished in the area surrounding Ft. Rucker. Climatic testing is conducted by USAADTA at various test sites to assure that all equipment will perform in the climatic extremes to which it may be exposed. Testing is conducted at such locations as Ft. Drum, NY, during the winter months; at the Tropic Test Center in the Panama Canal Zone; Ft. Bliss, TX; White Sands Missile Range, NM; Nellis AFB, NV; and Eglin AFB, FL.

One of the more crucial factors to be considered in testing ASE is the question of effectiveness. Testing is accomplished at the above mentioned sites against various threats to examine and assess the effectiveness of the ASE devices. The results of this testing indicate how effective the equipment is at warning, countering, or reducing the aircraft vulnerability to the threat and they also indicate the ways in which the effectiveness of the equipment may be improved.

Reliability evaluated

Another area of interest is that of reliability. Reliability tests are designed to assess the mean-time-between-failure or mission reliability against stated requirements, and to subjectively evaluate the factors which tend to degrade the system's reliability. Maintainability specifically, and maintenance characteristics in general, are evaluated relative to required mean-time-to-repair and other maintenance related indices.

In addition, a subjective and quantitative assessment is provided in areas of design for maintainability, special tools, test measurement and diagnostic equipment, and adequacy of technical publications.

Human factors and safety are also addressed in ASE testing. The importance of assessing the interface of the man - both as an operator and as a maintainer - cannot be overemphasized. In providing this analysis, the expertise of other members of the Aviation Center community, such as the Army Aeromedical Research Laboratory, Army Research Institute, and Army Agency for Aviation Safety, can be brought to bear on a given question.

Items under test

Several kinds of ASE have been tested by USAADTA. Representative of the category of signature reduction is the infrared engine suppressors being tested on the OV-1D and RU-21 aircraft. These suppressors are designed to reduce the infrared engine exhaust emission by either dissipating the heat through a more gradual transfer along the length of the suppressors or through introduction of free air into the suppressors to provide cooling of the exhaust gases.

The M-130 is representative of the active countermeasures type. It is a general purpose dispenser designed to dispense chaff to counter radar tracking or flares to defeat heat-seeking missiles. It can be used in conjunction with a missile detector or a radar warning receiver.

The APR-39 (V)1, a radar warning receiver is representative of the category of threat warning equipment. It is a lightweight system designed to provide helicopter pilots with visual and aural warning that their aircraft is being illuminated by search and/or tracking radar elements of a fire control system. These are examples of the type of ASE under developmental testing; however, they certainly do not cover the total spectrum of development.

A base of expertise

A group of test officers, engineers, equipment specialists, and enlisted men of the Materiel Test Division of the Activity are dedicated to ASE test projects. The test officers and engineers work closely with the PM-ASE and have aided in the design and fabrication of the M-130 General Purpose dispenser azimuth and deflection variable mounting brackets for the AH-1 and OH-58 helicopters.

Their responsibility is not only associated with active test but also includes being knowledgeable and current in all aspects of aircraft utilization, tactical doctrine, and maintenance management. The consolidation of all ASE test personnel in Systems Test Branch has given a base of expertise that will be an invaluable asset during future ASE test projects.

FT. CAMPBELL—During a recent Air Assault Chapter AAAA meeting, MG John N. Brandenburg, left, 101st Abn Div CG, presented "AAAA Sustaining Member Certificates" to local area firms supporting AAAA membership-wise. Shown l-r are MG Brandenburg, BG Joseph H. Kastner, ADC(S) and Chapter President, James Tidwell (Filter Queen Co.) and Bob Bales and John Loreant (Augustine Insurance Agency). □

USAADTA uses all test sites at their disposal to insure that the equipment issued to the user has met or exceeded the military requirements for that type equipment. The developmental tests conducted by USAADTA will essentially prove or disprove the concept feasibility, determine the degree to which stated requirements have been achieved, and assess the value of an item of equipment as related to anticipated roles in future combat.

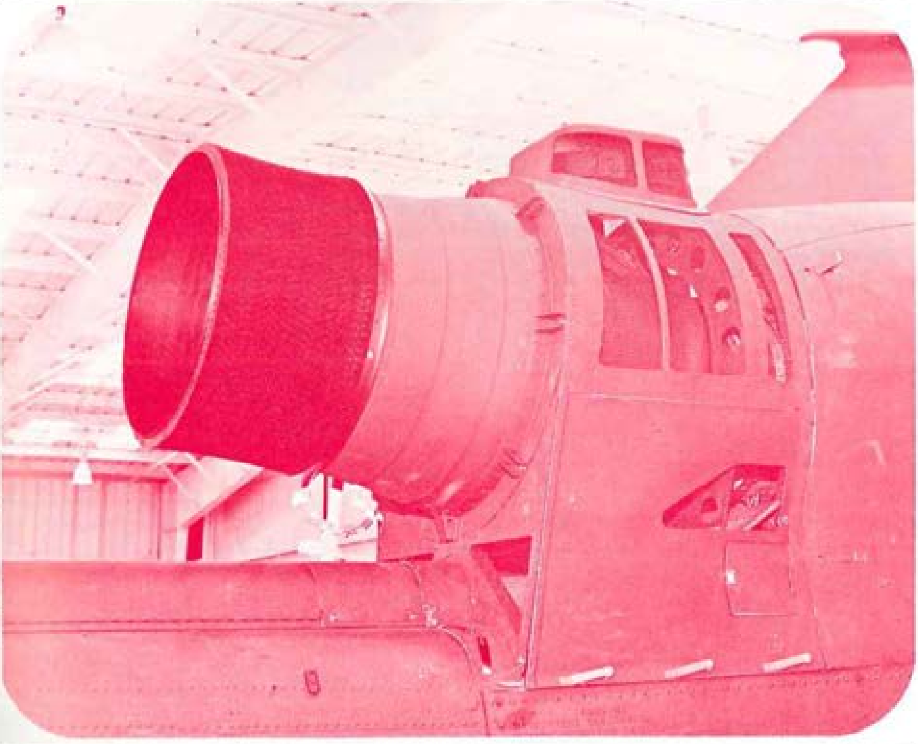
"Trial Before Combat"

Aircraft Survivability Equipment is tested as closely as possible to the scenario of the future battlefield by using known threats and employing current Army doctrine tactics. Aircraft Survivability Equipment can mean the difference in the outcome of the first battle **IF** it has been properly designed and **IF** that design, as reflected in the developed hardware, has been proved in the crucible of testing.

The Aircraft Development Test Activiity, by adhering to its motto of **"Trial Before Combat,"** will continue to provide that critical development testing crucible upon which success on future battlefields is dependent. ★

IR SUPPRESSORS ARE LIFESAVERS!

BY R.E. MOORE, MANAGER, R&D HUGHES HELICOPTERS DIVISION



AH-1S "Hot Metal plus Plume" Suppressor

THE basic concept for countering the **Infra Red (IR)** missile threat is to reduce the IR signature of the aircraft by the use of engine IR suppressors and low reflective IR paint on the fuselage.

For smaller helicopters and light fixed wing aircraft, IR suppressors and paint alone normally are sufficient to beat the less sophisticated missiles. For the more sophisticated IR missiles the reduced IR signature lowers the effective ranges of these missiles and makes it feasible to develop effective active countermeasures such as IR jammers and flare decoys.

Beginning in calendar year 1976, IR paint and first generation IR suppressors were applied to the aircraft of selected high priority U.S. Army units worldwide. Over 1,500 aircraft were involved and they included the AH-1, UH-1, OH-58A, and RU-21. IR paint has been adopted as the standard Army paint and it is being applied routinely on production, modification, and overhaul lines.

OH-58A "BHO" Suppressors

RU-21 "BHO" Suppressor

Examples of the first generation IR engine suppressors are shown on **Figure 1.** The OH-58 and RU-21 are shown with the **"Black Hole" (BHO)** suppressors designed by Hughes Helicopters. The AH-1 and UH-1 suppressors are the **"Bell Scoops"** designed by Bell Helicopter Textron. The technique used on these suppressors is to provide an insulated tail pipe that prevents the hot metal on the inside of the pipe from being visible to the missile seeker.

Further, it turns the pipe upwards (OH, AH, UH) or away (RU-21) from the missile so that the seeker does not have a view of the inside of the pipe nor into the hot turbine section of the engine. These first generation suppressors were fielded for interim protection of front line combat units worldwide.

Second Generation Suppressors

A new generation of suppressors has been developed to provide protection against the more sophisticated IR missile threats. The advanced technology employed has resulted in improved surface cooling while achieving reduced aircraft performance penalties. The OH-58C suppressor **(left, below)** developed by Hughes Helicopters adds less than one-half pound weight to the aircraft, provides upper hemisphere and plume protection, and creates no measurable engine penalty.

Full Spherical Coverage

The AH-1S suppressor developed by Garrett AiResearch also provides full spherical coverage and plume protection, and is less penalizing to the aircraft than the original scoops. This AH-1S suppressor is being investigated for possible application to the UH-1. Full hemisphere and plume suppressors have been developed by Grumman Aircraft Corporation for OV/RV-1 **Mohawk** and by Lycoming for the CH-47C **Chinook (both at top of opposite page.)**

Improved Design Integration

Recent work at Hughes Helicopters has been concentrated on advanced exhaust IR sup-

UH-1H "Bell Scoop" Suppressor

OH-58C "BHO" Suppressors

CH-47C Lycoming Suppressor

OV-1D Grumman Suppressor

pressors that minimize impact on the aircraft and, where possible, benefit its overall operational capability.

Examples of this current state-of-the-art are shown for the AH-1J and UH-1N helicopters **(opposite);** the YAH-64 Advanced Attack Helicopter **(bottom left);** and the HH 500M-D Defender **(bottom right).**

The AAH BHO does double duty: it suppresses the exhaust IR and it also pumps cooling air through the oil cooler system. All this is accomplished with the following low power and weight requirements. Effective power requirement: % of maximum - 1.3. Suppressor effective weight: % of gross weight - 1.7. The 500M-D provides exhaust IR suppression for zero power loss and zero weight penalty.

The evolution of IR suppressor technology for Army aircraft, as employed in the latest generation of suppressors, has reached the point where future signature reduction probably is not required and probably would not be a penalty nor cost effective, if attempted. Because of this fact,

AH-1J w/Black Hole Suppressor

optimum IR countermeasure systems (suppressors plus jammers and/or decoys) can now be defined for all Army aircraft.

The future challenge for IR suppression lies in the development of engine suppression that is integral (built-in) to the design of the new aircraft. This will provide optimum suppression with the least aircraft penalty. ★

YAH-64 (AAH) Suppressor

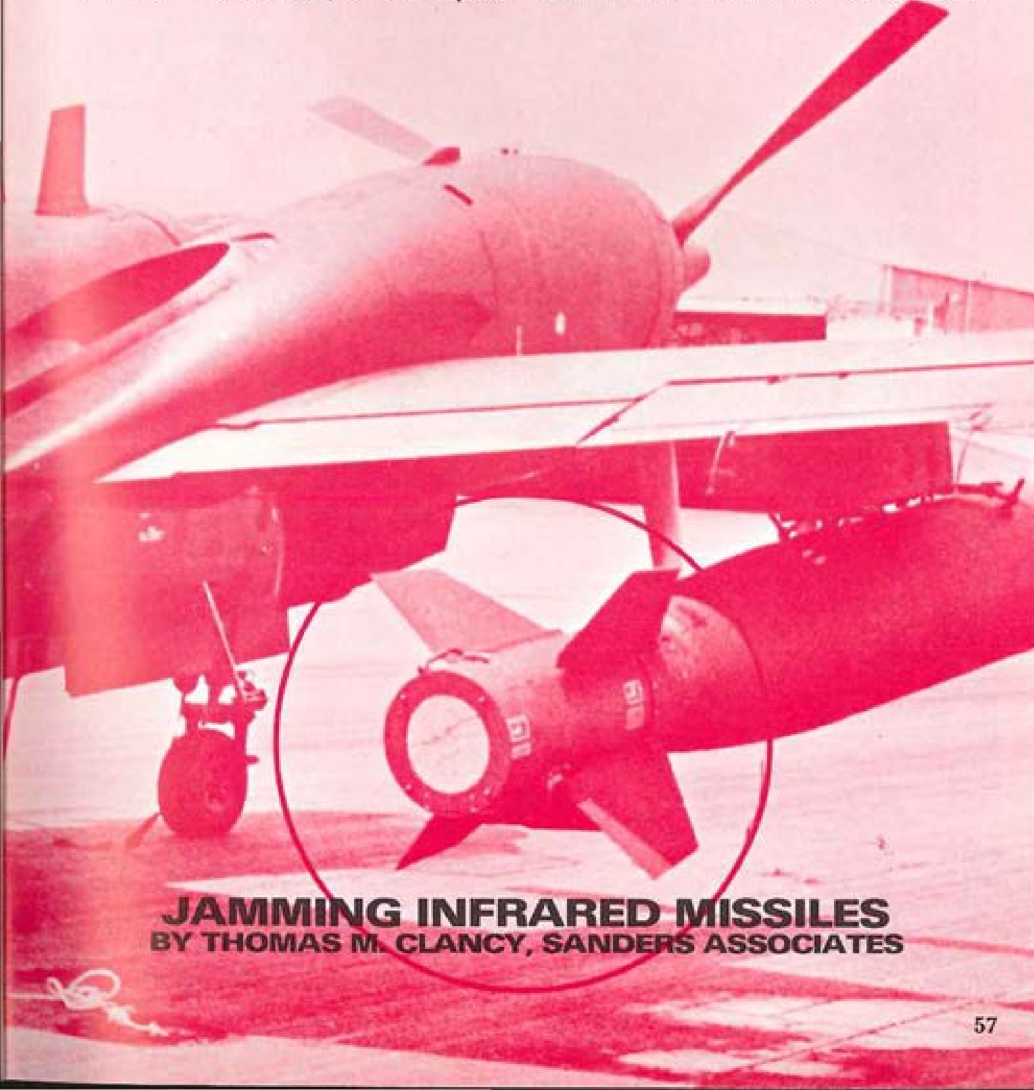
500M-D Defender Suppressor

Over the past ten years, the number and quality of **Infrared (IR)** missiles has dramatically increased. This hostile environment limits Army aircraft from performing its attack and transport mission as was demonstrated in the closing days of the Vietnam conflict.

To counteract this threat, the U.S. Army has been actively engaged in the development of **Infared Countermeasures (IRCM)** techniques and systems.

These missiles home in on the infrared emissions from the aircraft. Thus, the initial emphasis was placed on suppressing the aircraft signature. However, as the level of suppression increased, the penalty to the aircraft became prohibitive. Active jamming systems were then developed to compliment the suppressors and together provide total protection at a minimum penalty to the aircraft.

Two distinct **IRCM** systems called the **Hot Brick** have been developed by Sanders Associates. One is a directable system for fixed wing aircraft now nomenclatured the AN/ALQ-147. As shown below, it fits in the aft end of the 150



JAMMING INFRARED MISSILES

BY THOMAS M. CLANCY, SANDERS ASSOCIATES

gallon fuel tank for the OV/RV-1D. Due to the limited electrical power available for ASE on these aircraft, a fuel-fired version was chosen which consumes only 200 watts of electrical power.

No visible emissions

The heart of this jammer is a ceramic source which is heated by burning a small amount of JP fuel with ram air. The IR output from the source is then mechanically modulated to provide the jamming signal. The system contains a covert filter to minimize the visible emissions and cannot be detected visually at night. The AN/ALQ-147 is modular in design in that the fuel tank or modulator can be removed by means of a single clamp. The system has been extensively tested

Thomas M. Clancy, Department Manager, IRCM at Sanders Associates

both on the ground and in the air.

Over 3,000 hours of reliability testing have been accomplished in a simulated environment and nearly 1,000 actual flight hours have been recorded. This system is presently deployed in Europe and the Far East.

A second generation system (**Figure 2**) no-

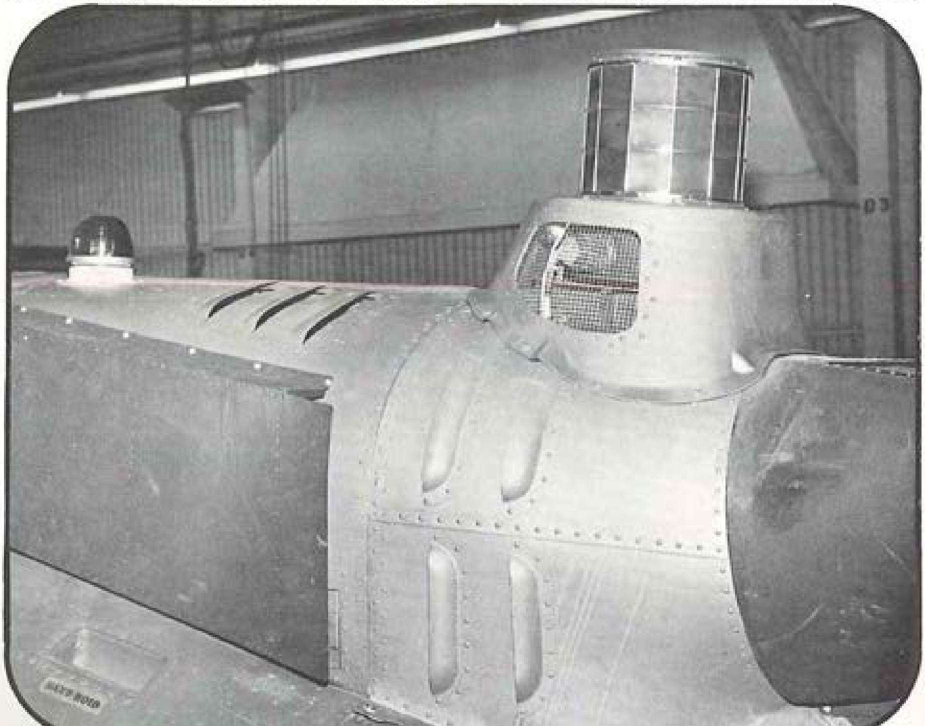


FIG. 3 — THE 30 LB. AN/ALQ-144 AS USED ON THE AH-1 AIRCRAFT.

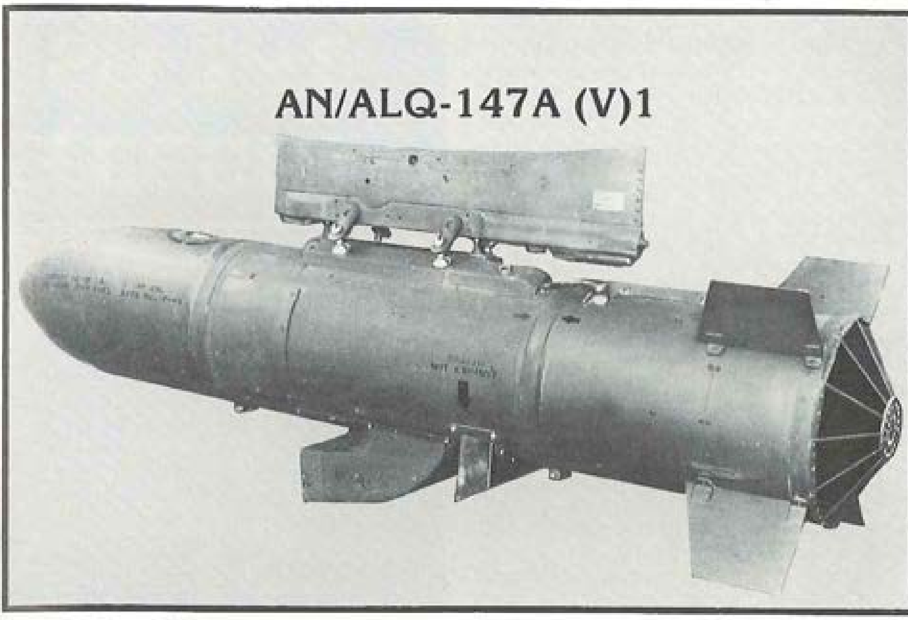


FIG. 2 — POD-MOUNTED STAND ALONE VERSION THE OV-1D MOHAWK

menclatured the AN/ALR-147(V1) has been developed which will be a pod-mounted stand alone version specifically for the OV-1D. This will permit the aircraft to have IR protection without the need to carry the heavy external fuel tanks.

The helicopter system is an omni-directional, electrically-fired unit. This system nomenclatured the AN/ALQ-144 is shown in **Figure 3** on the AH-1 aircraft. It weighs less than thirty pounds and consists of a cylindrical source surrounded by a highly efficient modulation scheme to minimize the aircraft power requirements.

The system has recently undergone a strenuous DT/OT II test on the AH and UH aircraft and judged suitable for world-wide deployment. The ALQ-144 is designed for installation on the Army's AH-1 and UH-1 as well as the Navy/Marines AH-1 aircraft. It is presently being tested on the **Black Hawk,** and will be installed on that ship and the AAH.

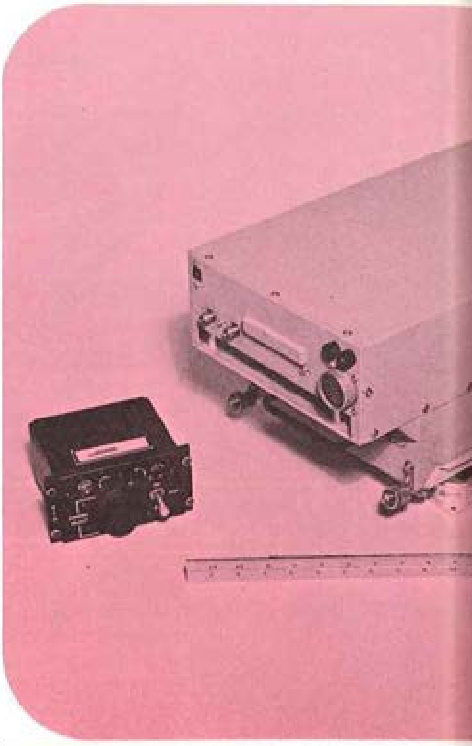
Either system can be turned on from the cockpit prior to take-off and be fully operational in less than one minute. Thus, by the time the aircraft is in the air, it's completely protected. These countermeasure systems, being mainly mechanical, have been easy to maintain by Army personnel. They have a demonstrated reliability exceeding 300 hours. In addition, both systems are equipped with **Built-In Test Indicators** to isolate problems down to the board level.

Single maintenance kit

A single set of **Special Test Equipment (STE)** is used for all levels of maintenance. It measures the important voltages, currents, and frequencies with the change of a switch and allows the maintenance personnel rapid isolation of any problems. For ground operation, the AN/ALQ-147 requires a source of air which is also supplied as part of the STE.

New countermeasure techniques are continuously being developed in the laboratory to defeat advanced missile threats. The technology required to implement these techniques is also being actively pursued, so that when new threats are deployed, U.S. Army aircraft will have adequate protection to perform their mission. ★

THE USE
MISSILE



THE ARMY'S ALQ-15
AN ALTERNATE IRCM
AS DESCRIBED BY BO
OF SANDERS ASSOC

Previous articles have discussed countering **Infrared (IR)** missiles by the combination of IR suppression and the use of jammers. This is an excellent **IR Countermeasure (IRCM)** techjque when dealing with smaller aircraft, but can get rather expensive for large aircraft such as the CH-47C **Chinook.**

An alternate IRCM is the use of flares to decoy the missiles away from the target aircraft. The XM-130 flare dispenser (discussed in an earlier article) was developed specifically for the CH-47C and RU-21 aircraft as an IR decoy.

With earlier flare systems the flares were ejected manually by the pilot. However, this is an impractical approach in view of the short flight times of missiles when fired from the relatively short ranges associated with Army Aviation engagements.

The need for a sensing device to automatically dispense the flares led to the development of the Army's ALQ-156 missile detection system. The initial prototype model was developed by Sandia Corporation. Sanders Associates, Inc. was subsequently awarded a competitive contract to conduct full scale engineering development based on the design principles established by Sandia.

AN/ALQ-156 Detection System

The ALQ-156 missile detection system is actually a pulse doppler radar mounted on the aircraft. The radar senses an incoming missile and automatically causes the XM-130 to dispense the decoy flares. ERADCOM is the development agency with overall project responsibility resting at PM-ASE in AVRADCOM.

Included in the development program is a bench test set (TS-3609) which will test the radar at the intermediate maintenance (AVIM) level. The ALQ-156 has been flight tested successfully on a CH-47C.

The ALQ-156 functions by setting a continuous radar detection ring in space around the aircraft and it detects targets exhibiting the proper closing velocity characteristics in sufficient time to initiate a flare and decoy the threat. The radar exhibits a high probability of detection while operating in the extreme clutter of nap-of-the-earth.

The radar approach offers the inherent advantage of detecting only targets approaching the host aircraft and is immune to battlefield

DF FLARES
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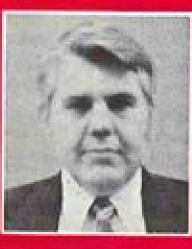

background which tend to false alarm IR and ultra-violet detection systems. The ALQ-156 system does not rely on launch pulse emission and as such will not be rendered ineffective by long range missile launches.

The ALQ-156 is a compact, highly durable all solid-state pulse doppler type. It consists of four units, a Receiver/Transmitter (R/T), and Control Indicator, and two identical antennas, as shown at the left. The R/T is mounted in a chassis occupying .75 cubic feet. The chassis is then attached to a standard vibration isolation tray. The complete package, including the mounting tray, weighs approximately 45 pounds and requires only 300 watts of standard AC 400Hz power.

Operationally, the system is controlled by the pilot via the Control Indicator. The system is activated by going from "Off" to "Standby"; then readiness is indicated with a green light. At "turn on" the system first tests itself very rapidly, then proceeds to alternately radiate and receive through the two antennas. When an approaching missile is detected, a countermeasures "CM" light is illuminated to notify the pilot that a flare decoy has been expended.

The system has built-in test capability by the continuous monitoring of certain functions while others are periodically checked. A permanent indication of a failed subassembly is displayed on the front of the R/T to facilitate rapid replacement of the failed line replaceable subassembly.

The R/T unit, which houses over 99% of the electronics, is checked out and trouble-shot on the bench using the TS-3609. Most faults are rapidly and automatically isolated to a failed subassembly. Facilities and access are provided to secondary test points to aid in the analysis of more difficult problems or for a thorough evaluation.

The use of the Microprocessor and a programmable digital signal processor permits the rapid adaptation of the ALQ-156 from a helicopter to a fixed wing configuration. In addition, the ALQ-156 can be used in conjunction with other systems like a Laser Warning Receiver or Radar Warning Receiver to select the most appropriate countermeasure and to optimize its deployment.

It is expected that the ALQ-156 will play a major role in the future survivability of Army aircraft. ★

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OPERATIONAL TESTING OF ASE

BY COLONEL ROBERT A. BONIFACIO, PRESIDENT, USAAVNBD

"**SOUNDS impressive, but does it work?"** is a very simple explanation of the view which the U.S. Army Aviation Board at Ft. Rucker, AL takes when preparing to test the various items which comprise the Aircraft Survivability Equipment (ASE) suites (or any other item, system or aircraft) intended for Army Aviation use on battlefields in the future.

The ingenious ASE devices are among the most sophisticated ever installed on Army aircraft. Some reach to the limits of current U.S. technology.

Aircraft survivability operational testing of equipment examines the training programs of both operator and aircraft maintainer, publications, human factors, safety, and compatibility with other aircraft systems. The validation of proposed tactics or the effects of a "black box" on present tactics and doctrine are also tested.

Operational testing is an essential step in the materiel acquisition process and although there are some exceptions, normally a new item must successfully complete Operational Test II before it can proceed to a production decision.

"The Aviation Board represents the user." That's a strong statement and it should be able to be said about anyone who is in the business of improving the equipment, tactics, and, therefore, the odds for the Army in the next war. By charter the Aviation Board has the responsibility to protect the man in the "green suit."

In the case of **ASE**, the ultimate "proof of the

Operational Test
(Cont. from P. 63)

pudding" is measured by increasing the odds of surviving against various threats in a hostile environment. An aircraft crew must not only stay alive, but must be able to continue effectively to perform their combat mission until the battle and the war are ultimately won.

Operational testing attempts to measure the increased odds that a particular piece of ASE will give to the aviator. It is not always possible to say that a black box increases survivability by a specific percentage. Realism in testing is necessarily influenced by a desire for safety, lack of funds, unavoidable artificialities, i.e., logistics support system, and other limitations.

Effectiveness is only one of 12 topics which are examined during operational testing. If an item fails to function properly at a critical point during battle, it usually has a more devastating effect than if the item had never existed at all.

Dependability is a prime factor in examining ASE and is described in terms of **Reliability, Availability, and Maintainability (RAM).** Operational RAM considers not only the inherent facilities or deficiencies of the equipment, but also the ability of the individual to repair and maintain a particular piece of equipment using concepts which are provided in repair manuals.

It is important that equipment work not only in the laboratory in the hands of technicians, but in the field as well. It must be diagnosed and repaired by the typical user working within the constraints of the tactical unit facilities using a typical prescribed load of repair parts.

To date, the Aviation Board has conducted operational tests on the AN/APR-39(V)1 Radar Warning Receiver, the XM-130 Aircraft General Purpose Dispenser, and the AN/ALQ-144 Countermeasures Set. The Operational Test III of the AN/APR-39(V)1 **Radar Warning Receiver (RWR)** assessed the operational suitability and effectiveness of the RWR to provide reliable and timely warning of radar-directed threats to Army aircraft in an operational environment.

Suitability testing of the AN/APR-39(V)1 RWR was conducted at Ft. Bliss, TX, and effectiveness testing against multiple radar simulators was conducted at Eglin Air Force Base, FL. As a result of operational testing, recommended changes to the equipment were submitted. These changes were incorporated into production models, thus providing a higher quality product to the user.

The XM-130 is a chaff/flare dispenser designed to protect Army helicopters against radar-guided weapons systems and **Infra Red (IR)** missiles. The system was tested on a UH-1 and CH-47 helicopter at Ft. Bliss, TX, White Sands Missile Range, and Ft. Rucker, AL. The XM-130 (Chaff) is dependent on the use and proper interpretation of the Radar Warning Receiver indications while the flare mode of operation is designed to operate with a missile approach detector.

The AN/ALQ-144 is an IR jammer designed to defeat IR threats to Army helicopters. It is an active electronic device which can be turned on and forgotten during the mission requiring little additional workload on the aviator. The system was tested for effectiveness at White Sands Missile Range and endurance testing was completed at Ft. Rucker, AL.

Four systems were flown for a total of 750.5 operating hours on two UH-1 and two AH-1 helicopters. Findings during the OT/DT II resulted in minor modifications to the hardware to make the operator's control unit compatible with night vision goggles and improve maintainability. Recommendations were adopted changing the maintenance concept to allow more organizational maintenance and to include an intermediate or **Aviation Intermediate Maintenance (AVIM)** level where none existed to effect faster repair turn-around time for the unit.

Tests in planning stage

Tests currently in the planning stage are the AN/ALQ-136 Radar Jammer, the AN/APR-39(V)2 Radar Warning Receiver, and the AN/ALQ-156 Radar Missile Detector.

The Aviation Board recognizes the demand to outfit Army aircraft against current threat systems; however, "fidelity to the user" during the full scale engineering development phase is a necessity. The future battlefield will be characterized by sophisticated avionics equipments and threat systems.

The U.S. Army Aviation Board will continue to strive to protect the interests of the combat aviator by insuring that all ASE items are subjected to thorough operational type testing which will enable the U.S. Army to acquire high quality ASE systems during production. ★

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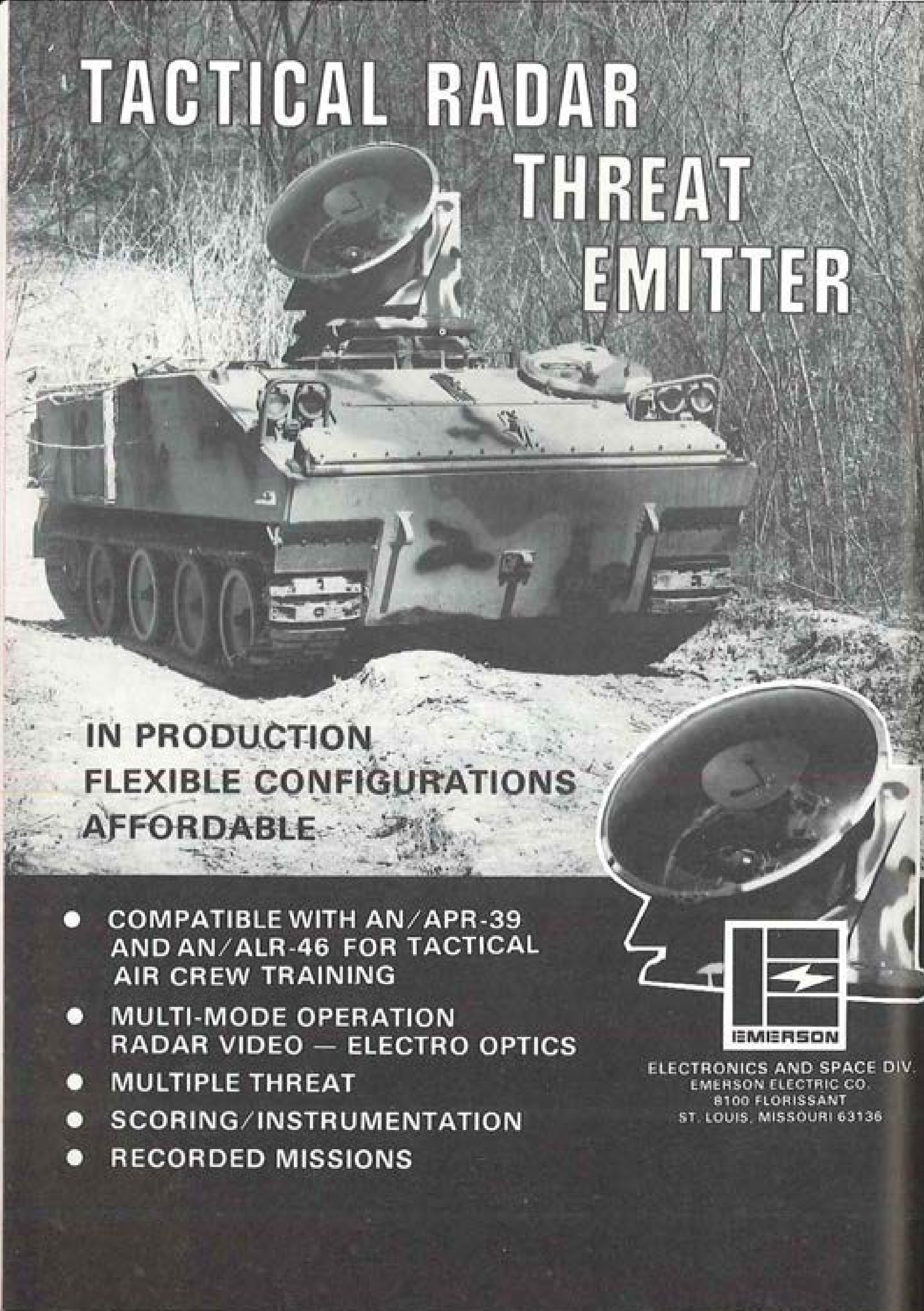
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The Challenge: Optical Signature Reduction

BY RICHARD R. PRUYN
Preliminary Design, Boeing Vertol Company

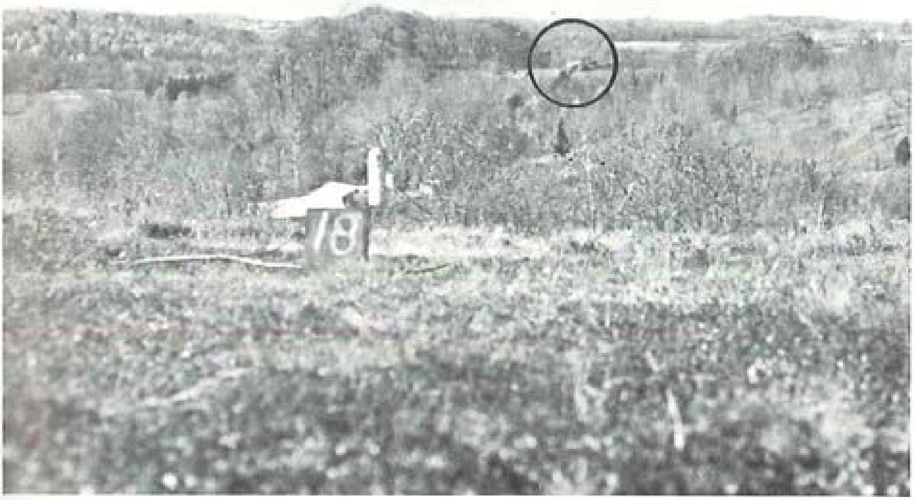


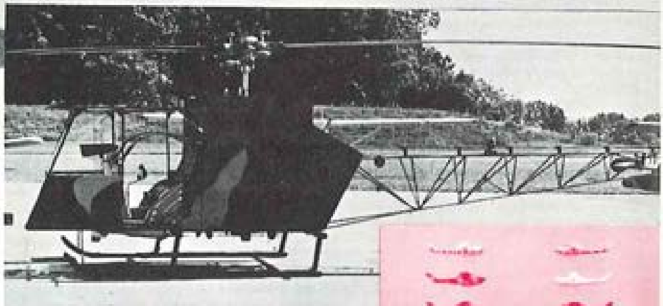
FIG. 2—AIRCRAFT HIDDEN UTILIZING TWO-TONE PAINT

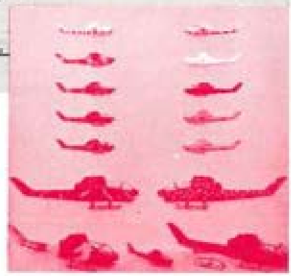
A SOVIET ZSU23-4 is a highly effective weapon in the optical mode. From the enemy's viewpoint, the optical mode is preferable since the radar modes can give away his location.

To counter this threat, the **Aircraft Survivability Equipment (ASE)** program has been developing design approaches and equipment so that our helicopters will have the low visual signatures needed to make the enemy's detection task difficult. The equipment designs and technology are now available to ensure that our helicopter crews will have a significant visual detection advantage over the enemy.

At the ranges of interest, helicopters are inherently difficult to detect visually. For example, at three kilometers a small helicopter such as the future ASH will subtend only eight to eleven minutes of arc in the side view. Against the terrain clutter background provided by nap-of-the-earth (NOE) flight, a target of this size is almost impossible to detect.

If the helicopter design eliminates the give-away detection clues, the enemy will be forced to use his high magnification optics to have a





ABOVE: Actual AH-IG with special paint. RIGHT: Modified H-13 used in program. FAR RIGHT: Small scale models used to determine best approaches.

manageable probability of detection. High magnification results in a small field of view and requires long search times. The resulting slow scan rate will allow the helicopter to slip by and remask without being detected.

Helicopter visual detection research has been a continuing effort for several years. The ASE Program has provided funding and support to this research. The Army Applied Technology Laboratory at Fort Eustis, Virginia, has directed this work, with **Joe Ladd** and **Earl Gilbert** as the two technical monitors. This research included development of an analytical method of evaluating canopy designs for glints and glare as well as visual detection probability testing.

The test program began with small scale models to determine the best approaches. A modified H-13 helicopter was used to provide a full scale flying simulation of the best configurations. Tests of actual AH-1G helicopters with standard and special paint were also included.

The scale model test program used photographs taken with the model positioned against a real terrain background. The **Page 67 photo** is one of the test photographs which shows a standdard AH-1G with a two-color paint scheme. Color photographs were shown to the test observers who were carefully positioned to represent full scale conditions.

The models did not have rotors so a separate model test program was conducted to understand rotor visual detection. The model test results were later found to correlate well with full scale results. The major limitation in this corelation results from the lack of loss of detail due to atmospheric attenuation.

The modified H-13 testing gave nearly full scale conditions with a helicopter that could be readily changed in appearance. The testing verified the detection advantages of the flat-panel canopy and the truss tailboom. This testing also showed the potential of mirrored surfaces to camouflage the fuselage. This reflective camouflage offers very low detection potential if, in the future, the problems of reflected ground motion, sky reflections, and glints can be resolved.

The AH-1G testing was conducted at Ft.

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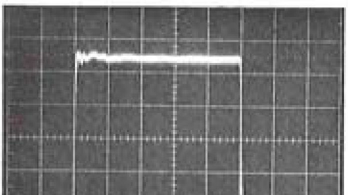
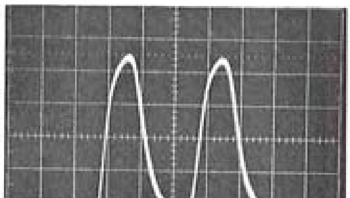


RF Output Pulse, 1 μsec Wide. Horizontal Scale 200 nsec/cm. Rise Time 10 nsec, FallTime 20 nsec.



Two closely spaced rf output pulses. Horizontal scale 20 nsec/cm. 40 nsec recovery time.

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TABLE 1 — CONFIGURATION ALTERNATIVES TO REDUCE VISUAL DETECTION

✓ **Sun Glints and Glare**
Solutions: Flat-panel canopy, Low-reflectance paint, Airframe shaped to avoid glints.

✓ **Sky Reflections in Transparencies**
Solutions: Minimum transparent area, Proper angles to the transparencies, Fences, and Surface treatment.

✓ **Blade Shadows on Airframe**
Solutions: Shaping to avoid shadows, Fences

✓ **Rotor flicker by hubs and/or blades**
Solutions: Multibladed rotor, Hub fairing, Small-dia. (high rpm) rotor, Increased blade root cutout, Minimum-size blade shanks.

✓ **Shapes with readily detectable signatures**
Solutions: Open-truss tailbook (avoid a cigar shape fuselage), Reflective camouflage.

Rucker with aircraft supplied and specially painted by the Aircraft Test Activity. Painting with low-reflectivity paint included the blades and rotor hubs. The observers, enlisted personnel who were selected to be representative of enemy air-defense weapon operators, were tested for eyesight and were well-motivated.

This testing was accomplished with the aircraft positioned so as to avoid canopy glints since the tests results were to be representative of helicopters with flat-panel canopies. Air-to-ground and air-to-air visual detection were also included in this testing.

Canopy alteration

Accomplishments of this program included establishment of the design requirements for the flat-panel canopies now in production on the AH-1S and AH-64. In addition, the dark olive drab low-reflectivity paint now being used on Army helicopters was found to reduce visual detection significantly when seen against a deciduous foliage background. Flat-panel canopies and low-reflectivity paint are effective in reducing sun glints and glare, which were the major visual giveaway clues.

This testing also provided an understanding of the other giveaway clues that can make a helicopter easy to detect. The configuration alternatives needed in future helicopters to eliminate these clues are noted in **Table 1**. A continued effort is being conducted presently to further reduce glints and reflections from transparent areas.

The following features can reduce the probability of detection of a future helicopter the size of the ASH:

. . The rotor hub fairing needed for reduction of radar signature will eliminate hub flicker and will also reduce the moving shadows on the fuselage.

. . The failsafety of the helicopter dynamic systems must allow painting of the external surfaces with low-reflectivity paint without the need for visual surface inspection.

. . Fuselage shapes need to be improved to eliminate noticeable blade shadows, to eliminate glints, and to avoid the characteristic fat cigar shape of the helicopter. An open-truss tailboom can eliminate this characteristic shape.

Future developments

Possible future developments include improved surface treatments. A low-reflectance paint that is smooth enough to be used on the forward half of the rotor blades without performance loss is expected to be developed. Present low-reflectance paint makes a significant reduction in rotor flicker when used on the aft half of the blades, but this paint is too rough to be used on the forward portion of the blades.

Another future possibility is the use of liquid crystal paints to adapt to changing conditions. These paints change color as a result of small amounts of heating. This has the potential for adapting the color to better match the background and to produce a paint pattern that changes to reduce motion clues.

A problem of ensuring low visual detection of future helicopters is the need for an accepted quantified requirement. With a firm quantified requirement. low visual detectability will have the same stature in the helicopter design trade-off process as cost and performance.

We understand that TRADOC is working with DARCOM to develop a quantified requirement for ASH visual detection so that it will be difficult for this requirement to be traded away. This will ensure that the helicopter industry provides the Army with helicopters that have the low visual detectability needed for the modern battlefield.

Designing for Ballistic and Crash Survivability

An article by JAMES B. FOULK, Sikorsky Aircraft Division, UTC

AIRCRAFT survivability in the battlefield environment is recognized universally as a fundamental requirement for all new military helicopters.

Although helicopter design for the high-threat environment must emphasize reduction of detectability and increased threat avoidance, two essential aspects of survivability for all threat environments are **reduced vulnerability,** or increased ballistic survivability, and **crash survivability.**

Ballistic survivability is the ability of an aircraft to tolerate projectile impacts without such adverse effects as a crash, forced landing, mission abort, or long repair time. The degree of crash survivability attained also relates to the recoverability of the aircraft and its personnel.

Preliminary design stages

It has been well documented that the most cost-effective method for reducing vulnerability is to take necessary steps in the earliest stages of design as an integrated design discipline. This gives designers the opportunity to apply innovative solutions to vulnerability problems and eliminate the need for heavy armor to shield critical components.

The Army paid attention to the lessons learned from SEA and incorporated ballistic survivability requirements into the Specifications for UTTAS (now **Black Hawk**), AAH, HLH, and ASH. The UH-60A **Black Hawk** helicopter, now committed to production, is a good example of designing for ballistic survivability in the very beginning.

Many different survivability design techniques were used; however, the major innovative techniques were Simplification, Redunfancy and Separation, Fire Reduction, Ballistic Tolerance, and Back-up or Auxiliary Systems.

This approach eliminated the need for component armor protection; however, the **Black Hawk** helicopter is virtually immune to small arms impacts and largely immune even to 23 mm high explosive rounds. This was accomplished at an overall weight penalty of about 1% of the aircraft total weight. **(Figure 1, See Chart on the next page)**

The simplified Modular Approach

The UH-60A main rotor hub assembly has been greatly simplified with elastomeric bearings in place of conventional anti-friction bearings. These bearings require no lubrication; thus, the oil leakage failure mode is eliminated for all threats.

In addition, the elastomeric bearings are much more tolerant to ballistic impact than the conventional bearings. The simplified one-piece forged titanium hub is small and compact but has survived multiple 23mm API and HEI impacts while under flight load conditions.

Like the main rotor hub assembly the UH-60A tail rotor hub assembly has been greatly simplified. The composite cross-beam tail rotor design has no bearings to hit and damage or jam and there is no lubrication required; thus, no oil to leak out. This design eliminates many parts, reducing vulnerability compared to a conventional design.

The UH-60A transmission system is one of the best examples of a simplified modular approach to reduce vulnerability. The system consists of four interchangeable modules (two inputs and two accessory) and a main module. The widely separated redundant engine input modules provide an ideal location for the redundant accessories, eliminating the need for separate engine nose gearboxes and accessory gearboxes.

This modular concept has also eliminated exposed high speed shafts and multiple lubrication systems with their exposed oil components, while providing inherent shaft restraint.

The UH-60A has a modularized redundant hydraulic system which consists of two identical systems with a third electrically-driven system for back-up. This compact design eliminates many vulnerable exposed components and lines, and only uses flex hoses to connect the power modules to the system; manifolds with self-sealing quick disconnect couplings are used elsewhere.

In addition, the integrated hydraulic power modules contain the reservoir, pump, pump drive, filters, and valving, completely eliminating leak prone lines and reducing the exposed area of the vulnerable components.

Redundancy and Separation

Many systems are redundant for reasons of safety; however, with imaginative design, adequate separation can also provide ballistic survivability. The UH-60A has a redundant and separated engine system, electrical system, mechanical controls, and fuel system.

The fuel system has redundant fuel tanks and suction feed lines with engine cross feed capability. Leakage from one tank does not result in total system loss.

The control system has several unique redundancy features incorporated in the normally vulnerable bellcranks and rod end attachments. They are redundant links, tri-pivot attachment, encapsulated rod end, and concentric redundant attachment.

Another unique concept applied to the UH-60A is the redundant tail rotor quadrant which converts the entire tail rotor cable control system to a redundant separated system. Positive control is maintained after loss of either cable.

Redundant structural load paths have been incorporated throughout the entire airframe as well as redundant attachments at all critical points. This provides the capability of withstanding impacts by most small explosive shells without causing a crash or forced landing.

Fire Reduction

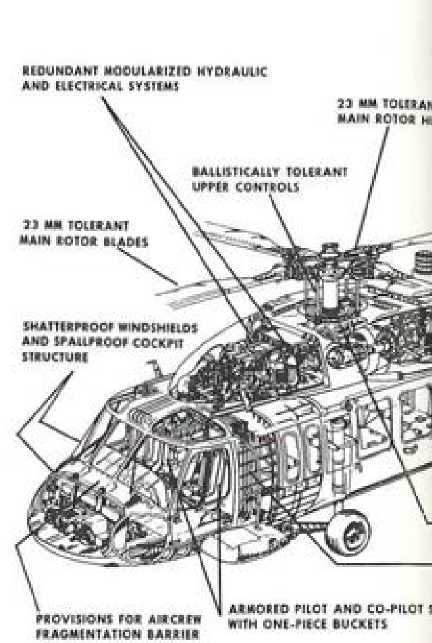
The UH-60A tanks are not only redundant and self-sealing, but are also surrounded by void-filling foam and specially-designed structures to further reduce the possibility of in-flight fires and hydraulic ram damage by any type of projectile hit. The engine-mounted fuel boost pumps transfer fuel from the tanks to the engines under a slight negative pressure which prevents fuel spewing when the lines are cut.

A fire detection and two-shot extinguishing system provides additional fire reduction for the engine and APU compartments. The hydraulic system is designed to use MIL-H-83282 fire resistant hydraulic fluid.

Ballistic Tolerance

Ballistic tolerance design concepts have been applied to the UH-60A's upper rotating controls, rotor hub assembly, and composite titanium spar main rotor blades. Ballistic tests have demonstrated rotor blade ballistic tolerance to 23mm impacts. Careful selection of material type and thickness played an important role in providing damage-tolerant tail rotor drive shafting. In addition, jam-proof design concepts have been incorporated in the flight control boost servos and main rotor primary servos.

THE U.S. ARMY UH-60A BLACK HA
A BALLISTICALLY TOLERANT DES



Back Up or Auxiliary Systems

The UH-60A transmission has successfully demonstrated back-up operating capability of more than one hour for the entire system, including the high speed engine input modules, after all oil was drained out. Selection of optimum bearing materials and construction along with trapped oil at key locations play a major role in the successful oil-starved operations.

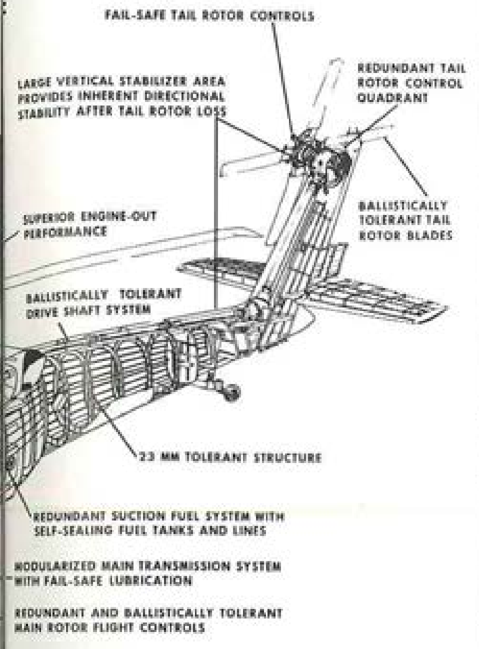


FIGURE 1

The redundant hydraulic system contains transfer valves that allow the electrically-powered back-up hydraulic system to operate either or both primary flight control systems. The hydraulic system also contains a unique reservoir level sensing and logic system to shut-off damaged portions of the hydraulic system automatically.

The UH-60A tail rotor system contains several back-up design features. Viscous-damped bearing supports for the drive shafting provide damping for ballistically-damaged shaft elements and prevent secondary damage effects.

A unique centering spring, located on the servo input linkage, drives the tail rotor blades to a predetermined optimum pitch angle if both directional control cables are shot away. Tests have demonstrated that the tail rotor remains stable after a pitch change rod is shot away.

The large vertical stabilizer area with a long moment arm, and short fuselage forward of the main rotor, provide inherent protection for loss of tail rotor control, thrust, or the entire tail rotor.

The high mounted and canted tail rotor provides extra lift for the tail and aft sections as well as extra vertical stabilizer area. Yaw stability is possible for nearly all control and drive failure modes, regardless of flight condition at the time of failure. The canted tail rotor, and consequent aft CG of the aircraft, provide back-up flight capability for loss of the tail rotor by preventing catastrophic CG shifts.

The UH-60A can maintain safe forward flight and make low speed landings with the entire tail rotor and gear box shot away. In addition, the tail rotor location also provides inherent protection against secondary damage to the fuselage or main rotor blades; ballistically-damaged parts of the tail rotor will be thrown away from and not into the aircraft.

Crash Survivability Design

Obviously, no matter how safe helicopters are made, accidents due to human error can be expected, particularly in the stress of a combat environment where missions are attempted that demand the fullest capability of both men and machine.

Significant effort by the Army during the 60's defined the Army crash environment and established design concepts and criteria to reduce injuries and aircraft damage. With this background as a guide, the UH-60A **Black Hawk** helicopter was designed with over 40 specific features to overcome hazards found in accidents involving Army utility helicopters.

The five basic crash survivability objectives have been achieved: 1) Maintenance of a Protective Shell Around Occupants, 2) Limitation of Load on Occupants to Non-Injurious Levels,

Designing for survivabilty

3) Prevention of Post Crash Fire, 4) Provision of Non-Injurious Interior, and 5) Provision of Adequate Emergency Escape Capability.

Maintenance of a Protective Shell

The UH-60A structure is designed to maintain at least 85% of the living space in 42 fps vertical, 30 fps lateral, and 40 fps longitudinal crash impacts. To minimize penetration of the living space by the high mass items above the cabin, they are designed to resist load factors of 20g, 20g, and 18g forward, downward, and sideward respectively.

The landing gear cushions vertical impacts by controlled energy absorption, decelerating the aircraft at an average 9g through a distance of 23 inches, effectively preventing fuselage ground contact at sink speeds up to 35 fps.

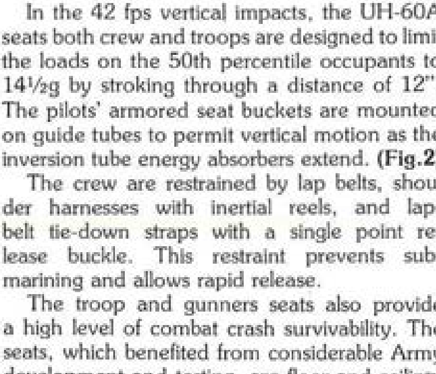
Limitation of Load on Occupants

In the 42 fps vertical impacts, the UH-60A seats both crew and troops are designed to limit the loads on the 50th percentile occupants to 14½g by stroking through a distance of 12". The pilots' armored seat buckets are mounted on guide tubes to permit vertical motion as the inversion tube energy absorbers extend. **(Fig.2)**.

The crew are restrained by lap belts, shoulder harnesses with inertial reels, and lap-belt tie-down straps with a single point release buckle. This restraint prevents submarining and allows rapid release.

The troop and gunners seats also provide a high level of combat crash survivability. The seats, which benefited from considerable Army development and testing, are floor-and-ceiling-mounted and attenuate the loads on the occupants in all directions. The troops, who face

FIG. 2



NORMAL POSITION **AFTER CRASH, SEAT IS 12 INCHES LOWER**

Figure 3. Artist's view of the ABC Helicopter.

forward and aft, have retention systems that include both lap belts and dual shoulder straps.

The two gunners who face sideways need to be able to move from their seats to fire their machine guns. They are equipped with body-harnesses that are attached to the seats by three straps, each on an inertia reel. They are able to extend about 40 inches, more than double the usual crew seat inertia reel. Straps are attached to each side of the waist band, while the third attaches to the body harness behind the gunner's shoulders.

Prevention of Post-Crash Fire

Post-crash fire is minimized in the UH-60A by separating potentially hazardous components. The landing gear is well separated from the fuel tanks. Electronics and avionics equipment are located in the nose; electrical components are located forward in the overhead; the fuel tanks are in the transition section, just aft of the cabin.

Fuel spillage is minimized by suction fuel transfer with engine-mounted boost pumps. The **Black Hawk** fuel tanks have successfully passed the Army's 65 ft. drop test. The fuel and vent lines are crashworthy and large component displacement activates the self-sealing breakaway valves installed in the lines.

A Non-Injurious Interior

The crew and troops are positioned and restrained to prevent head strikes, and all interior equipment is restrained to high G loads. The cockpit is designed to prevent entrapment of feet, and sharp edges and corners are minimized.

Emergency escape is enhanced by jettisonable cockpit doors and, in case the main cabin doors are jammed, by two oversized jettisonable windows in each cabin door.

For long range ferry missions, two large fuel tanks may be installed in the UH-60A cabin. This complete system is also crash-survivable and meets the same standards as the primary fuel system except that these tanks are not of self-sealing construction. The **Medevac Kit,** a special piece of equipment that may be installed in the UH-60A cabin, is designed to carry four patients in standard Army litters.

It is designed to limit the loads on the 50th percentile litter patients to 13g by stroking through a distance of seven and a half inches. Straps are provided to restrain the occupants and their litters on the support structure.

Need for innovative design

The enemy threat against helicopters is ever changing, but always increasing. We have made great strides against the small arms threat and significant gains against the small explosive shell threat, only to be confronted, by threats from the air, and not too far in the future - the laser threat.

On the other hand, tactical helicopter operations in the future may indicate that we should sharpen our design pencils and develop even better concepts for protection against the small arms threat. In other words, if the primary enemy threats become too large we must avoid them, and that usually means increased exposure to small arms fire.

Although we are about to field significantly hardened helicopters, there are many new concepts on the drawing board and in development that will increase the ballistic survivability of future designs.

Some of these are highlighted briefly below:

- **Fly-by-wire control systems** using fiber optics and multiplexers with triple-separated runs will provide multi-hit protection to almost all ballistic threats and also to the electromagnetic pulse threat.
- **Rotor balance restoration systems** that will detect loss of significant blade sections, jettison the residual portion of the damaged blade and its opposing blade, overcome rotor imbalance, and allow continued flight. Analysis, test, and flight simulator evaluation of a prototype system have demonstrated feasibility for the **Black Hawk** tail rotor. This feature would reduce vulnerability to explosive shells of 23-57mm sizes.

James B. Foulk, Silkorsky Aircraft Division of United Technologies Corp.

- The **feasibility of generating hydraulic power** athe tail rotor gearbox for control servo power has been confirmed. This concept eliminates the vulnerable long hydraulic lines in conventional tail rotor servo systems. It also reduces weight/cost and increases system reliability.
- **Laminated metal composite structures** for the airframe and mechanical flight control components reduce projectile damage and increase life strength over monolithic metal structures.
- **Light-weight engine bleed-air nitrogen generating systems** provide inerting capability for fuel tank ullage.
- The conventional helicopter tail rotor system contributes the most vulnerable area to the high explosive shell threat. The **ABC (Advancing Blade Concept)** helicopter eliminates this anti-torque system entirely by use of counter-rotating rotors. **(Figure 3).**

Improved Mission Effectiveness

The level of ballistic and crash survivability in the UH-60A far exceeds that of any helicopter in service today and will result in expanded confidence of both crew and passengers in the performance of their mission. Pilot confidence will be displayed in flying techniques which push the UH-60A to the limits of its maneuver capability, techniques that will be necessary for efficient terrain flying and combat survival.

The confidence of the ground unit commander and his troops in the UH-60A will be evidenced by their willingness to utilize combat air assault wherever tactically feasible, and without concern for high density or alternate load conditions as in the case of the UH-1 today. **Innovative survivability designs** in the future will contribute even more to overall mission effectiveness. ★

DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
P O BOX 209, ST. LOUIS, MO 63166

SUMMARY

ASE is technically complex and must constantly be updated in response to changes in the threat. As is obvious from the articles in this issue, our industry provides a broad and in-depth technological base. This outstanding industrial capability combined with our laboratory excellence gives us the flexibility needed to meet the future threat challenges.

The ASE program has made great progress. It is a program based upon providing individual equipment and combinations of equipment with maximum flexibility and growth potential. However, in spite of the progress that has been made, the future will demand even greater attention to threat changes. It is essential that our ASE technology base keep pace with the rapid advancements in weapon technology. AVRADCOM has and will continue to ensure that ASE is given a priority commensurate with its role in Army Aviation.

We must not lose sight of the fact that proper tactics, doctrine, and training are key factors of survivability. When these factors are combined with the appropriate ASE, Army Aviation can effectively operate on the modern battlefield.

STORY C. STEVENS
Major General, USA
Commanding

month's takeoffs

Colonels

FITCH, JOHN B.
6866 Glenview Drive
San Jose, CA 95120
LUSTER, ALBERT B.
2107-D Crosby St, USNB
Philadelphia, PA 19112
MATTHEWS, RALPH A.
1228 Everette Road
Edgewood Arsenal MD 21010
O'DONOHUE, JOHN D.
9122 Ashmeade Drive
Fairfax, VA 22032
PERNA, FRANK L.
338 Hilltop Drive
North Aurora, IL 60542

Lt. Colonels

ANTROSS, RICHARD C.
2208 Cherokee Trail
Brandon, FL 33594
BEAM, JAMES D.
2801 St. Ives Road
Columbia, SC 29206
CHUNN, DON C., JR.
2d Armored Division (FWD)
APO New York 09355
COLSTON, RAYMOND C.
MAAG-FAT 1, Box 140
APO New York 09230
DICKINSON, ROY B.
Star Route, Box 129
Leavenworth, WA 98826
HAHN, JAMES S.
804 N. Wayne St., Apt 201
Arlington, VA 22201
HANCOCK, BARNEY P.
901 Lost Creek Circle
Stone Mountain, GA 30083
HARRIS, PETER R.
362 Coral Sea Road
Fort Lee, VA 23801
JAMES, JESSE H.
Hq, DARCOM
Alexandria, VA 22304
KUEHN, WALTER, JR.
400 Claymont Drive
Ballwin, MO 63011
McINTOSH, BERNARD W.
SAFSP (10), POB 92960
Los Angeles, CA 90009
THORNTON, ROBERT C.
Route One
Leesburg, AL 35983

Lt. Colonels

TOWER, WILLIAM E.
307 Yoakum Pky Apt 3-401
Alexandria, VA 22304
WENZEL, PAUL J.
USDAO, American Embassy
APO New York 09662
WILLIAMS, FRANK K.
USDAO Amer Embassy, Box 1
APO San Francisco 96356

Majors

ADAMS, RONALD E.
7434 Forestdale Drive
Fairfax, VA 22032
BAKER, MARVIN H.
Hq, 32d AADCOM (G4)
APO New York 09175
BEASLEY, LONNIE S., JR.
534-A Miller Drive
Fort McPherson, GA 30330
CAMPBELL, RICHARD L.
418 E. Mayfield
San Antonio, TX 78214
DODSON, MICHAEL L.
417 Wickham Road
Manhattan, KS 66502
GRAVATT, ARTHUR T.
P.O. Box 237
Marshall, VA 22115
HASSETT, JAMES P.
662 Garth Court
Yorktown Heights, NY 10598
LONGAN, PATRICK B.
318 Stanton Road
New Llano, LA 71461
MERRILL, ROBERT K.
3095 Oldfield Way
San Jose, CA 95121
MULLADY, BRIAN P.
USA Russian Institute
APO New York 09053
MURRAY, THOMAS C., JR.
6th Support Center
APO San Francisco 96212
SCOTT, DONALD R.
P.O. Box 19061
Topeka, KS 66619
SHEFFIELD, RONALD L.
9475 Valley Oak Way
Salinas, CA 93907
SMITH, DAVID R.
327 McFayden Drive
Fayetteville, NC 28303

Majors

STOCKWELL, GENE T.
Co A, 8th Avn Bn
APO New York 09111
WILGUS, WILLIAM D.
ARSEC, Box 700
APO New York 09205
WUENSCH, MARK J.
HHC, 145th Avn Bn
Hunter AFB, GA 31409
YATES, CLYDE P.
55th Avn Co (A)
APO San Francisco 96301

Captains

ANDERSON, GEORGE W.
2550 Wedgefield Ct, Apt 16
Columbus, GA 31903
ATKINSON, ALONZO M., JR.
Hq, Med Research Dev Cmd
Fort Detrick, MD 21701
BARRETT, HAROLD
OSB, USA FAS
Fort Sill, OK 73503
BRADLEY, GREGORY D.
1041 Glendale Avenue
Columbus, OH 43212
BRYAN, HUGH M.
Route 1, Box 1
Spearman, TX 79081
CARR, REGIS J.
3700 Buena Vista, Apt 201
Columbus, GA 31906
CAVERLY, ROBERT A.
2078-B Werner Park
Fort Campbell, KY 42223
CHOPIN, THEODORE, JR.
4367 Laurel Circle, S.E.
Smyrna, GA 30080
CORDER, PHILLIP C.
P.O. Box 363
Sierra Vista, AZ 85635
COULTER, WALTER F.
2101-A Irwin
Fort Eustis, VA 23604
CURTIS, PHILLIP L.
4506 Whitmire
Killeen, TX 76541
CUSHING, CLAYTON M.
1911 Sycamore Drive
Killeen, TX 76541
D'ANDRIES, MICHAEL L.
13th Co, 1st Bn TSB, USAIS
Fort Benning, GA 31905

Captains

DARDEN, JACK M., JR.
330th ASA Co Avn
APO New York 09227
DAVIS, GUY E.
205th Trans Bn (AVIM)
APO New York 09165
DUNN, MARTIN A.
1161 Lester Road
Fort Sill, OK 73503
DURR, GEORGE W., II
P.O. Box 1022
Ozark, AL 36360
GILLIAM, JOHN W., JR.
1100 Lamar E. 32
Arlington, TX 76011
GILLIES, PETER
4010-5 Pine Street
Fort Wainwright, AK 99703
GLASS, CHARLES W.
105 Marak Court
Fort Bragg, NC 28307
HASKELL, ROBERT L.
CMR 2, Box 5375
Fort Rucker, AL 36362
HOWZE, WILLIAM G.
A Troop, 4/9 Cav
Fort Hood, TX 76544
INGRAM, WALTER C.
241 Harvard Avenue
El Paso, TX 79907
KRIEGER, MARK
521 Plaza Drive
Circleville, OH 43113
LAWRENCE, MICHAEL
2-603, 98-707 IHO Place
Aiea, HI 96701
LEE, JAMES M.
P.O. Box 1975
Fort Benning, GA 31905
LEWIS, PAUL E.
625 Richmond Drive
Norman, OK 73071
McKEEGAN, THOMAS J., JR.
103 Graham Place
Fort Bragg, NC 28307
MEHRINGER, KENNETH E.
7823 Morocco Drive
Lawton, OK 73505
MITCHELL, ROBERT A.
68th Med Det (Hel Amb)
Schofield Barracks, HI 96857
MOODY, CHARLES G., II
HHT, 4/9 Cav, 6 Cav Bde-AC
Fort Hood, TX 76544

Captains

MOTLEY, CAMPBELL M.
6 Radford Place
Newport News, VA 23602
PASIERB, E. GARY
10120 NW Freeway, Ste 110
Houston, TX 77092
POWELL, DOUGLAS L., c/o E.L.
Powell, 1740 Long Green Dr
Annapolis, MD 21401
PUHALA, EDWARD R.
c/o MN Savarese, PO Bx 493
Hainesport, NJ 08036
PULLANO, JOSEPH F.
807 Hamilton Street
Wahiawa, HI 96786
ROBERTS, DOUGLAS
807 Tye Road
Santa Barbara, CA 93105
RUNNER, JOHN R., II
214 Sicily Road
Fort Ord, CA 93941
SPRINGER, BARRIE H.
5562-B Hiers Street
Fort Knox, KY 40121
STITT, HAROLD W.
2504 Guenevere Avenue, SE
Huntsville, AL 35803
UNDERWOOD, DONALD L.
HQ USAREUR-ODCSPER Bx143
APO New York 09403
WILDES, DAVID G.
D Troop, 2d Sqdn, 10th Cav
Fort Ord, CA 93941
YOUNG, MICHAEL S.
21683 Summit Road
Los Gatos, CA 95030
ZAK, MICHAEL L.
Headquarters Company FWW
Fort Wainwright, AK 99703

First Lieutenants

HALL, WILLIAM R.
Support Co CATC 7th ATC
APO New York 09114
LOVEJOY, EDWARD
151 Surfway
Monterey, CA 93940

CW4'S

BARNETT, DON E.
Box 5156
Fort Hood, TX 76544

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No 'box' can duplicate
(Continued from Page 10)

hands-on training with an instructor pilot, just as nothing can replace actual weather experience.

Unless the unit commander is willing to accept a "Two-Dimensional" pilot, we must start to re-emphasize aircraft instrument training. Specific time must be set aside to make maximum use of weather (IMC) conditions when they occur. No matter what the dollar cost of this training, we are sure that it will be paid back with dividends in the long run.

A professional aviator who **knows** he can operate his aircraft in all envelopes of the flight regime, and knows he can accomplish his mission with a minimum of risk, is well worth the dollar cost incurred. Ability and self-confidence do have a price.

The bottom line is: **Are we willing to pay for it.** ★

West Coast AAAA Members Activate Sixth Region

Representing all members within the newly-defined seven-State Sixth Region, a six-member Regional Executive Board has been installed in office, and looks forward to a late '78 membership gathering. BG Jack A. Walker, ADC(O), 9th Inf Div, Ft. Lewis, WA, is the new Regional President. His Executive Board slate includes the following Ft. Lewis area members: LTC Dean M. Owen, AO, DPT (Sr VP); LTC William H. Forster, FM Off, DPT (Sec); CW3 Al Ellison, 54th Med Det (Trea); LTC Gene Wilson, 10th Avn Bn (VP, Mem Enrol); and MAJ Morgan G. Roseborough, DAO, DPT (VP, Programs). ☐

CW4'S

KEPNER, ALVA W.
4380 Left White Street
Fort Wainwright, AK 99703

LARKIN, CHARLES E.
552 Sutter Street
Peta Luma, CA 94952

McDONALD, FRITZ J.
Box 533
APO New York 09825

McLAUGHLIN, RICHARD L.
3807 Dunoon Road
Colonial Heights, VA 23834

MILLER, GEORGE C.
48th Avn Co, Box 156
APO New York 09061

OLSEN, JOHN S.
1219 Mountain-Air Way SE
Olympia, WA 98503

CW3'S

AMICK, CARL L., JR.
P.O. Box 1181, NAEC
Lakehurst, NJ 08733

CANNON, FRANK R., JR.
Route 1, Box 1044
Nicholasville, KY 40356

FALLQUIST, CARL
1806 Vaughn Drive
Manhattan, KS 66502

GARDNER, CHARLES L.
Baumholder AAF
APO New York 09034

SMITH, PETER J.
USMTMSA/FLO PSC Box 1388
APO New York 09034

CW3'S

WILLIS, BRUCE L., SR.
230-B Niblo Drive
Redstone Arsenal, AL 35808

CW2'S

BOGER, PAUL D., JR.
43 Merview Court
Charlotte, NC 28210

BRUNSTING, CLIFFORD D.
436-E Dyea Street
Fort Richardson, AK 99505

HANSEN, RANDALL S.
HHT, 3/5 Cavalry
Fort Lewis, WA 98433

HARRIS, JOHN M.
22496 Caminito Esteban
Laguna Hills, CA 92653

HOLLAND, JOHN C.
P.O. Box 254
Cobbtown, GA 30420

LIBBY, FRANK A., JR.
4677 E. Lake Blvd
Carson City, NV 89701

LOAIZA, RODRIGO
Quarters 2848-B
Fort Lewis, WA 98433

MILLER, CARSON J.
8631 S.W. 137th Avenue
Miami, FL 33183

MOORE, EARL F., JR.
4423-C Plaza Vista
Sierra Vista, AZ 85635

SESSLER, ROBERT L.
Route 1, Box 63
Augusta, GA 30906

CW2'S

SHEEHAN, JOHN P.
C Company, 8th CAB
APO New York 09185

SIMMONS, FRANCIS T.
1506 Vernon Avenue
Springfield, IL 62704

WARREN, DENNIS
Route 1, Box 81
Elwood, IL 60421

SFC'S

ABBOTT, FRANK M.
205th Aviation Company
APO New York 09185

SSG'S

DAVIS, MELVIN
D Co, 503rd Cbt Avn Bn
APO New York 09165

JONES, ROBERT H.
A Co, USASCH, Avn Div
Schofield Barracks, HI 96857

KERR, JOHN A.
3749 Crescent Hill Road
Springfield, OH 45502

MINKS, L. C.
607 Meadowlake Drive
Ozark, AL 36360

NUNN, LARRY L.
2709 5½ Avenue
Rock Island, IL 61201

SCHILKE, R. E.
Box 2856, Co A, USAICS
Fort Huachuca, AZ 85613

SGT'S-SP5'S

BUTTERWORTH, ALLEN, JR.
427 Jefferson Drive
Fort Ord, CA 93941

KEENER, ISAAC A.
213th Avn Co (ASH)
APO San Francisco 96271

Retired

BROWN, EDWARD C., LTC
11243 North 23rd Street
Phoenix, AZ 85028

CLUBB, EDWIN R., MAJ
3220 Orange Avenue
La Crescenta, CA 91214

CORNELL, ROBERT F., LTC
P.O. Box 1859 Gen'l Del
FPO New York 09540

HOGAN, WILBUR C., III, LTC
217 Locksley Road
Syracuse, NY 13224

McCULLOUGH, JOHNNY L., MAJ
904-Tremont Street
Chattanooga, TN 37405

STEELMAN, JIMMIE L., CW4
710 Goddard Lane
Maryville, TN 37801

STEWARD, HARVEY E., COL
1501 Oakcliff Drive
Huntsville, AL 35802

SULLIVAN, RALPH, CW4
Rural Route 1, Box 86-C
Woodville, TX 75979

WILSON, LEONARD R., MAJ
Box R BHI, 2825 Corp Hq
APO New York 09202

Retired

YOUNG, GEORGE J., LTC
BHI, 1901 Central Drive
Bedford, TX 76021

Civilians

BOYD, LESTER C.
P.O. Box 839
Odem, TX 78370

HANENBERGER, RICHARD
247-7 Lucas Lane
Voorhees, NJ 08043

LIVINGSTON, HAROLD S.
LAO-K-TSARCOM
APO San Francisco 96301

LUTTRULL, W. RAY, JR.
Ft Campbell Bank, PO Bx528
Fort Campbell, KY 42223

MITCHELL, ROBERT H.
E-Systems, Inc., PO Box 6030
Dallas, TX 75222

NEWCOMER, SAMUEL K.
968 Raford Ct, Bellefontaine
Neighbor, MO 63137

NIEHAUS, PATRICIA
1567 Leonaire Place
St. Louis, MO 63138

POSPECH, FELIX J.
P.O. Box 553
Mathis, TX 78368

WALTON, J.
E-Systems POB 1669 Serv-Air
Greenville, TX 75401

WORLEY, ROY
3618 Bentwood Lane
Corpus Christi, TX 78415

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Join AAAA's Growing "Aces Club"

In enrolling five new members in AAAA, 37 members have become "Aces", and each has since been sent an individual hand-lettered "Ace's Certificate" confirming his or her kills.

All 37 are also competing for the "Top Ace" designation and award to be made at the 1978 AAAA National Convention.

Become an "Ace" yourself! Get five, and the Certificate is yours! Watch this space for your name!

1. Ms. Sylvia Barcak, Corpus Christi, TX. 70
2. Mrs.Mildred L. Stanton, Desoto, MO. 48
3. CSM Alan Owens, Ft. Campbell, KY. 46
4. Ms. Sandra Strub, Corpus Christi, TX. 41
5. Clarence E. Key, APO NY 09205 (Iran). 31
6. CW2 John H. Robinson, Jr., APO NY 09165. 30
7. Ms. Ann Canterbury, St. Louis, MO. 27
8. Mrs. Ethyl F. Heickman, Corpus Christi, and CPT Campbell M. Motley, Newport News, VA. 20
9. 1SG Robert E. Newborn, Ft. Lewis, WA. 19
10. CW3 Charles N. Gibson, Hunter AAF, GA.18
11. SFC Donald J. Gorski, APO NY 09185. 16
12. MAJ James H. Fraser, Jr., Fayetteville, NC. 15
13. CSM Wayne Cantwell, Ft. Lewis, WEA. 14
14. MAJ Charles W. Barnes, APO NY 09031, and CW3 Francis Mays, APO NY 09185. 10
15. CPT Morton Meng, Esfahan, Iran, and CPT Darwin D. Simcoe, Savannah, GA. 8
16. CW4 Donald R. Joyce, Ret, Newport News, VA, and 1SG Robert E. Smith, Ft. Lewis, WA. 7

TIED FOR 17TH WITH SIX EACH:

COL William E. Crouch, Jr., Ft. Rucker; COL Barrie S. Davis, Ret., Zebulon, NC; CW3 Cecil T. Howard, Clarksville, TN; CPT Gregory R. Jenkins, Ft. Knox; CPT Frank C. Kurinec, APO NY 09611; CW3 Michael Roberts, APO NY 09038; and Frank J. Ungricht, Jr., APO NY 09611.

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