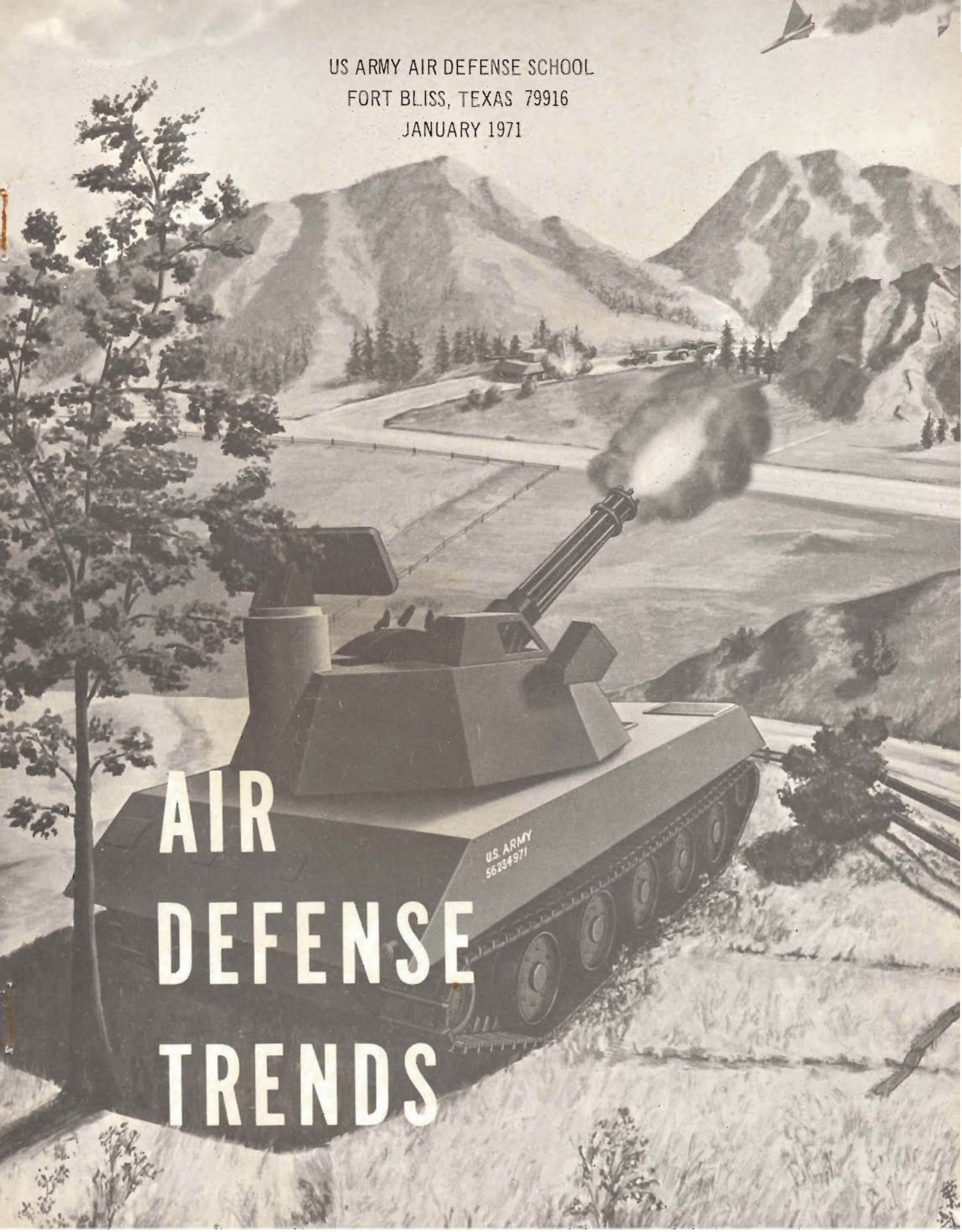
US ARMY AIR DEFENSE SCHOOL
FORT BLISS, TEXAS 79916
JANUARY 1971



AIR DEFENSE TRENDS

AIR DEFENSE TRENDS
US ARMY AIR DEFENSE SCHOOL
Fort Bliss, Texas 79916

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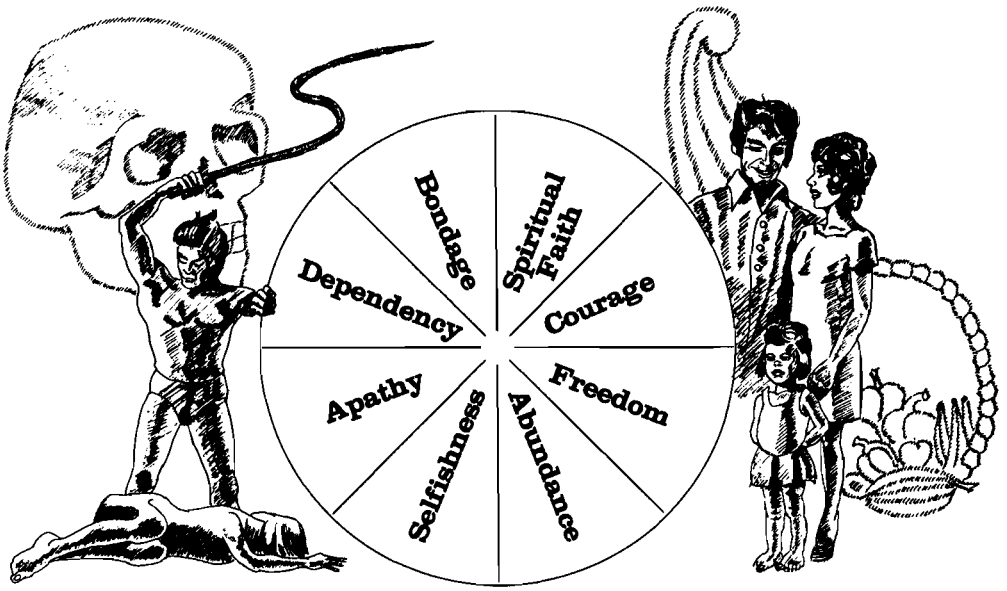
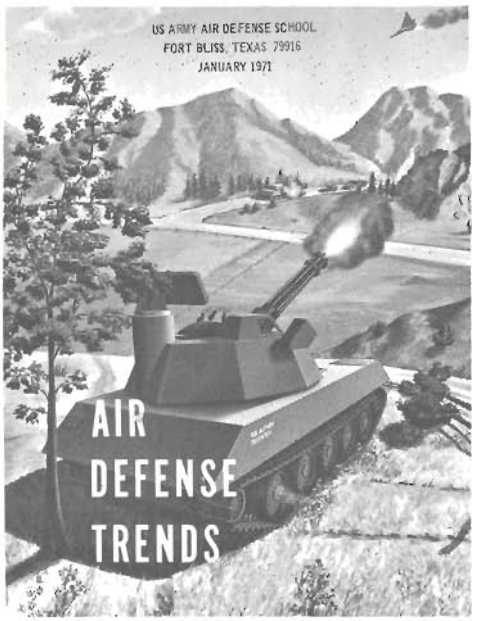
Air Defense Trends is an instructional aid of the United States Army Air Defense School; it is published when sufficient material of an instructional nature can be gathered.



The historical cycle of the body politic indicates that man progresses from bondage to spiritual faith, from spiritual faith to courage, from courage to freedom, from freedom to abundance; then comes the warning, from abundance to selfishness, from selfishness to apathy, from apathy to dependency, and from dependency right back into bondage again.

—DR. JOHN H. STAMBAUGH
Vice Chancellor, Vanderbilt University



COVER The cry for forward area air defense has been heard loud and clear throughout the military world. As a result we will no doubt see newer and more sophisticated weapons for this purpose appearing in the arsenals of the world powers.

Our cover depicts one such weapon system. It is an artist's concept of the Excalibur downing a high-performance enemy aircraft in low-level attack. The Excalibur air defense system is being developed by the Sperry Rand UNIVAC Division with support of the US Army Weapons Command. The weapon has both surface-to-air and ground-to-ground capability. A comprehensive report on Excalibur appears on page 45.

Readers are invited to submit for publication articles and informative notes that are of professional interest to the air defense artilleryman. Articles should be current and forthrightly stated and should relate to some aspect of what air defense units in the field are doing to accomplish their mission, particularly in the technical and tactical areas. Miscellaneous articles expressing either technical or nontechnical ideas that may be of value to air defense will also be considered for publication.

Direct communication to the editor is authorized:

Office of Doctrine Development, Literature, and Plans
US Army Air Defense School
P.O. Box 5600
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AIR DEFENSE TRENDS

An instructional aid of the United States Army Air Defense School, Air Defense Trends is published when sufficient material of an instructional nature can be accumulated. It is designed to keep air defense artillerymen informed of unclassified tactical, technical, and doctrinal developments because it is essential to national defense that all levels of air defense command be kept aware of these developments and their effect on the air defense posture.

Distribution of this publication will be made only within the School, except for distribution on a gratuitous basis to Army National Guard and USAR schools, Reserve component training and ROTC facilities, and as requested by other service schools, CONUS armies, US Army Air Defense Command, Active Army units, major oversea commands, and military assistance advisory groups and missions.

Qualified individuals may purchase copies of Air Defense Trends at fifty cents per copy from the Book Store, US Army Air Defense School, Fort Bliss, Texas 79916. The form below is printed for convenience in ordering.

When appropriate, names and organizations of authors are furnished to enable readers to contact authors directly when they have questions concerning an article.

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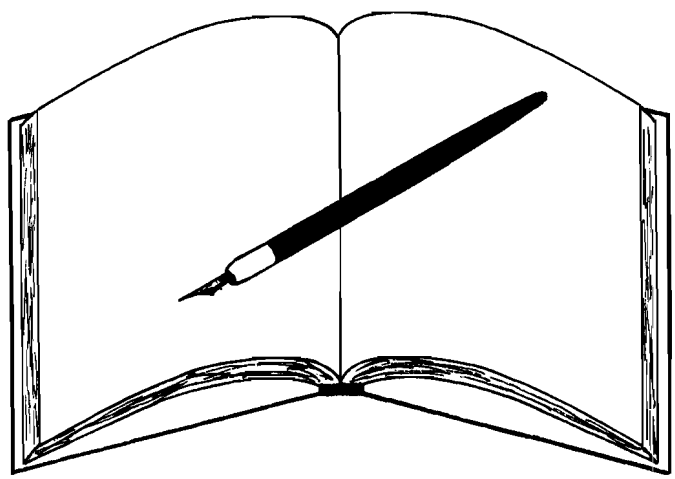


LETTERS

to the Editor

•With reference to the January 1970 issue of Trends, I would like to make some observations concerning self-propelled Hawk.

First, in all seriousness, even though the launchers are now mounted on track vehicles, I fail to see how mobility is enhanced because the towed loads are still only wheel mobile. (According to your picture on page 28, the platoon's combat service support is still wheel mobile.)

Second, by fracturing the Hawk battery; i.e., platoon employment, you must have extremely good communications from the battery to the platoon command post for command and control. Since it was not mentioned, I assume that there is no data link to the self-propelled platoon, which implies manual operations. This would appear to be two steps backward and one step forward.

Third, the article stated the mission of self-propelled Hawk is "to provide all-weather air defense of the division area against low- and medium-altitude aircraft." The mission should be to reinforce the divisional ADA battalion's low-altitude capability and provide defense against medium-altitude aircraft attack.

Finally, rather than going through a retrofit program for Hawk, why was the field army configuration not fielded totally self-propelled back in the late 50's?

—ANONYMOUS

We offer these comments after discussing your observations with our experts on self-propelled Hawk and related doctrine.

Mobility is enhanced by the mere fact that prime movers are track-laying vehicles. Towing a wheel-mounted trailer does reduce the cross-country mobility of the track vehicle somewhat, and the platoon combat service support is still wheel mobile, but throughout the US Army, track vehicle units are supported by wheel mobile elements with the exception of a retriever-type vehicle.

Command and control of the self-propelled platoon is established at the platoon level, using the latest radios with trained operators. Data link is not available to the platoon command post at this time but is programed for the future.

The air defense mission of self-propelled Hawk may be expanded to that of general support, general support-reinforcing, reinforcing, or direct support.

The present concept of employment of air defense artillery weapons is completely different from that of the late 1950's. As indicated by the author, emphasis was placed on static-type defenses, resulting in virtually no emphasis on mobility. Present concepts have led to the development and fielding of forward area weapons with resulting increased emphasis on mobility for air defense artillery weapons.

—Ed.

•During a recent tour in Vietnam I served with an aerial rocket artillery unit (ARA) which employed AHIG Huey Cobra helicopters to deliver direct field artillery fire on the enemy. Having been in air defense operations for the past 14 years, the thought came to mind "Why not AADA" (aerial air defense artillery). I feel there is a possible crack in the air defense ring that could be closed by using the AHIG Huey Cobra.

The AHIG Huey Cobra is capable of carrying a maximum armament payload of 542 pounds internal and 1,640 pounds external. It is presently designed to carry 7.62-mm miniguns and/or 2.75-inch rocket pods under each wing in varying configurations with an "under-the-nose" mounted turret employing 7.62-mm miniguns and/or 40-mm grenade launchers. This payload consists of up to 76 2.75-inch rockets, 4,000 7.62-mm minigun rounds, and 300 40-mm grenade rounds. This payload capability is at an ideal operating temperature, but allowable weight tends to decrease at high temperatures. This temperature limitation is usually compensated for by decreasing the load in hot climates but could be compensated for by different armament configurations, such as two Chaparral missiles per wing configuration for hot climates and three or more Chaparral missiles per wing configuration for temperate climates. The Sidewinder missile could also be considered in lieu of the Chaparral.

The concept I envision is to keep the present turret armament for self-defense, however dropping the present under-the-wing armament and replacing it with two Chaparral missiles in a touching fin configuration or three missiles in an integrated fin configuration. A folding fin or disappearing fin configuration could be adapted to carry more missiles in each payload. However, the present pod mounts under the wing could be modified to accept either the 2.75-inch rocket pods or the missiles, thereby giving the ground commander a flexible choice of armament. The 2.75-inch rocket pods could be dropped and the missiles mounted in a relative short period of time to adapt to the mission requirements.

The employment concept of aerial air defense artillery is for protection of vital areas from low- and medium-altitude aircraft at ranges up to 349 nautical miles from the center of the vital area with the defense unit positioned either in or near the vital area. The operational altitude would be from ground level up to approximately 18,000 feet above sea level. The AADA aircraft would be vectored to the target by early warning ground stations or by Army or Air Force ground control approach (GCA) stations.

The Huey Cobra, not being hampered by ground conditions and terrain features, would give the ground commander a weapon that could protect convoy activity, heliborne operations, and ground troops from either air assault or ground assault in most weather conditions or

terrain. The AADA could operate effectively from improved airstrips, unimproved or partially destroyed airstrips, or any fairly level open area. In particular cases where the operation would be outside the operational range of the Huey Cobra, a "Jump Command Post" could be established well forward for refueling and rearming purposes, thereby greatly extending the range of operation.

The ground commander would have the choice of having all Huey Cobras carry missiles and retrofitted with 2.75-inch rocket pods, as the situation arises, or have a preselected number of the Huey Cobras carry missiles and the rest carry 2.75-inch rocket pods, thereby providing a wide array of aerial armament to support almost any type of operation.

An AADA unit could use the aerial rocket artillery MTOE (T) (with 12 Huey Cobras) with minor changes. The employment of a 12-aircraft AADA battery in the two-missiles-per-wing configuration would give an airborne firepower of 48 missiles, increasing with modifications which allow more missiles to be carried on each wing.

The Huey Cobra can become airborne from a cold start in 2 minutes or less. This has been proven time and time again under actual combat conditions. The AHIG and Chaparral are both combat veterans, so the research and development on these two components would be considerably less than for new systems.

The Huey Cobra is equipped with a cockpit firing system which integrates an intervalometer to control the rate of fire, and the number of 2.75-inch rockets fired from single to salvo. With small adaptations, this system would serve the same purpose, using missiles, and so enabling the pilot to select the number of missiles to be fired according to the raid size of attacking aircraft.

This concept could also be adapted for surface missions, especially on vehicles or vessels with an identifiable IR signature. The turret-mounted 7.62-inch minigun and 40-mm grenade launcher are effective weapons for ground fire in either offense or defense, being used to lay down suppressive fire for friendly troops or break up ground attacks, respectively.

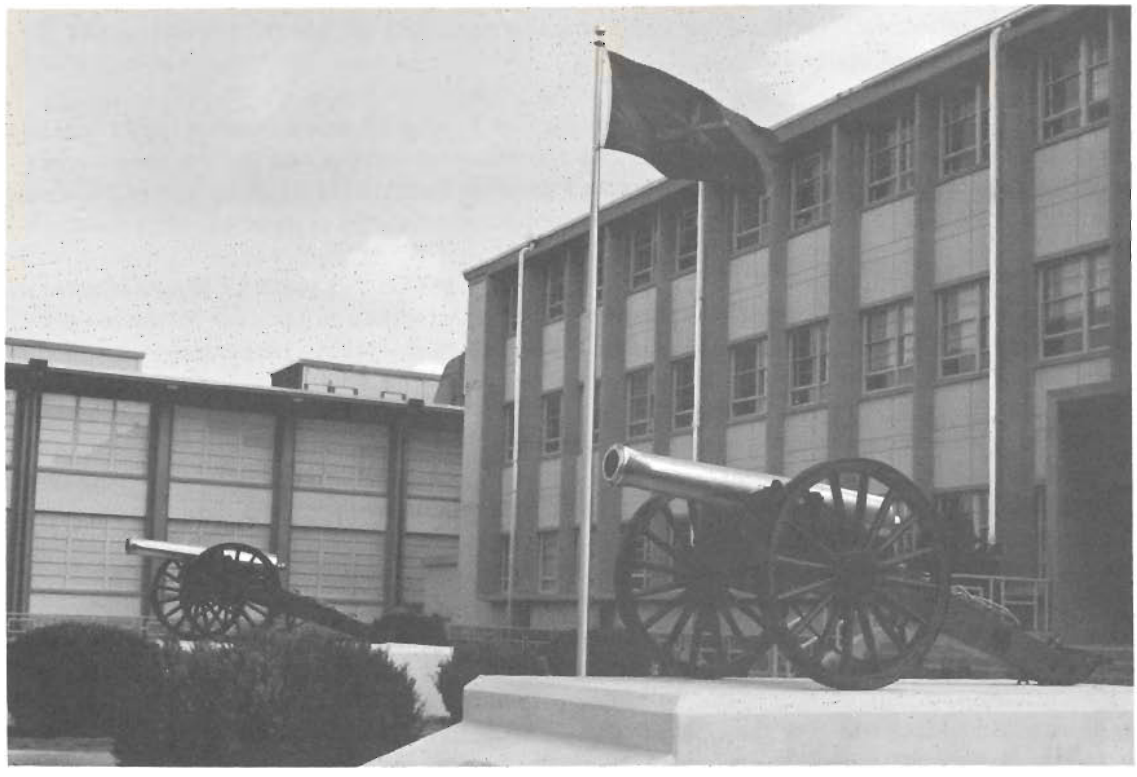
In summary, the development of an aerial air defense artillery (AADA) could close the crack in the air defense ring by providing quick close support for ground troops or vital area defenses.

JACK H. MARSHALL
MSG, Op SGT
USAADS, DDL&P
Doctrine Division

Your idea is well documented and seems logical. We recommend you submit it through official channels for evaluation by experts. As far as we know, this is an original concept. It could be very valuable to the Army.

—Ed.

USAADS Instructional Notes



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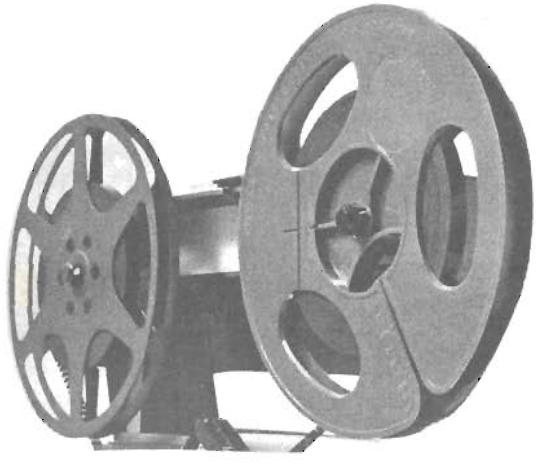
OFFICE OF DOCTRINE DEVELOPMENT, LITERATURE, AND PLANS

AIR DEFENSE ARTILLERY TRAINING FILMS



During the planning and development of programs and schedules for Chaparral/Vulcan training, the US Army Air Defense School programed several training films to reinforce both

individual and unit training. Six of these films—three each for the Vulcan and Chaparral weapon systems—have been completed and are now available in audio-visual support centers.

TF 44-4063, Air Defense Artillery Weapon System, Vulcan, Self-Propelled—Part I—Introduction: The Vulcan Squad in Action, introduces this weapon system by describing and showing its capabilities and limitations. This 28-minute film opens with a sequence introducing a new family of low-altitude, forward area weapons—Chaparral and Vulcan. Then the film portrays a tactical situation, explains some of the considerations that affect employment of the Vulcan system, and outlines a requirement for an air defense mission to which four Vulcan squads are assigned. As this Vulcan platoon moves forward it provides mobile air defense for a supply column. Actions of crewmen are shown as the column comes under attack and the Vulcans successfully engage the hostile aircraft. Then the Vulcan platoon leaves the supply column and moves into its assigned position to defend a forward landing strip. The actions of one Vulcan crew are described and illustrated as they emplace their weapon, reload the ammunition drum, establish the command post, and start improving the position. Several alerts are illustrated and described as squad members follow appropriate engagement procedures. Finally, the effectiveness of the Vulcan—with its devastating firepower—employed in a ground support mission is portrayed as the Vulcan platoon assists in repelling an enemy ground attack.

TF 44-4094, Air Defense Artillery Weapon System, Vulcan, Self-Propelled—Part II: Target Engagement Techniques, is designed to teach the techniques of fire that a squad follows when the Vulcan is used against aerial or ground targets. This 25-minute film opens with a sequence showing the Vulcan completing a successful engagement. The reason why the six Vulcan barrels create a wide dispersion pattern—larger than the average aircraft at a range of one kilometer—is illustrated and explained. Additionally, the high rate of fire of this weapon system with its six rotating barrels is stressed. Major controls in the gun turret are pointed out as their purpose and use are stated. Receipt and processing of range-only radar data by the fire control system is explained and traced to the gun sight where correct lead angle and superelevation are generated to permit target intercept. The purpose of each mode of operation that may be used for engagement of aerial targets is explained, and the conditions under which each mode should be employed are stated. For each mode of operation the techniques that a gunner must know and use are demonstrated and explained. During these sequences the importance of smooth, steady tracking to permit generation of correct lead angle is stressed, proper use of the electrical cage switch and the mechanical cage knob is emphasized, and the proper time to uncage the sight is explained. The last sequence of the film demonstrates and explains the procedures for engagement of ground targets, using both direct and indirect fire methods.

TF 44-4095, Air Defense Artillery Weapon System, Vulcan, Self-Propelled—Part III: Ammunition Handling and Loading, is designed to teach the procedures employed by Vulcan crew members during the loading of the ammunition drum of the Vulcan weapon system. This 21-minute film opens with the Vulcan crew engaging a hostile target that leads to the requirement to reload the ammunition drum. While preliminary preparatory steps are performed by the crew members their duties during ammunition loading are shown. Then the step-by-step procedures are demonstrated and explained as the senior gunner and gunner reload a partially filled ammunition drum. During this reloading operation safety measures are stressed and the importance of following prescribed procedures emphasized. Adjustment of

the slack point is demonstrated and explained as the crewmen complete reloading. During ammunition resupply, inspection of the ammunition, linking the ammunition to form one belt, and placement of the belt on the stowage rack are shown. Finally, the additional steps required when an empty drum is being loaded are shown.

TF 44-4133, Air Defense Artillery Weapon System, Chaparral, Self-Propelled—Part I—Introduction: The Chaparral Squad in Action, introduces this weapon system by showing and describing its capabilities and limitations. This 28-minute film opens with a sequence showing a Chaparral weapon engaging a low-flying, hostile aircraft. Some factors that influence employment of the Chaparral weapon system to insure the best low-altitude, forward area defense against low-flying aircraft are stated. In the next sequence a Chaparral squad occupies and organizes a position to provide air defense to a convoy, energizes the power unit, prepares the mount for action, and installs communications to the command and observation posts. As the convoy appears, the Chaparral squad successfully engages a hostile aircraft as it attacks the convoy. A short time later another aircraft is spotted, acquired, and tracked until the squad leader identifies it as friendly, emphasizing that positive visual identification by the squad leader is a prerequisite to actual engagement of an aircraft. Next, the airspace control element at the division tactical operations center is shown as they plan the defense of a vital area and state some of the considerations that influence their selection of positions for the Chaparral weapon system. The last sequence shows a Chaparral squad correctly positioned to fulfill the latest assigned mission.

TF 44-4135, Air Defense Artillery Weapon System, Chaparral, Self-Propelled—Part II: Emplacement and Preparation for Action, is designed to teach the procedures followed during emplacement of the Chaparral weapon system and the duties of each crewman during preparation for action. The opening sequence of this 24-minute film shows the Chaparral squad as it approaches a new position. The actions of each squad member are described as he performs his duties during the selection and occupation of the weapon position, command post, and observation post. Then, actions of squad members are shown as they emplace the weapon system. Preparation for action by the senior gunner is suspended while he points out the controls and indicators used to operate and control the weapon as the narrator describes them and states their various purposes. Then the senior gunner proceeds with the energizing checks required to prepare the system for action. Although the actions of all crew members occur simultaneously, their actions are shown separately to emphasize the duties of each individual. Finally, when the squad leader has received a READY report from each crewman and has completed his communications check, he reports to the platoon leader that the squad is ready for action.

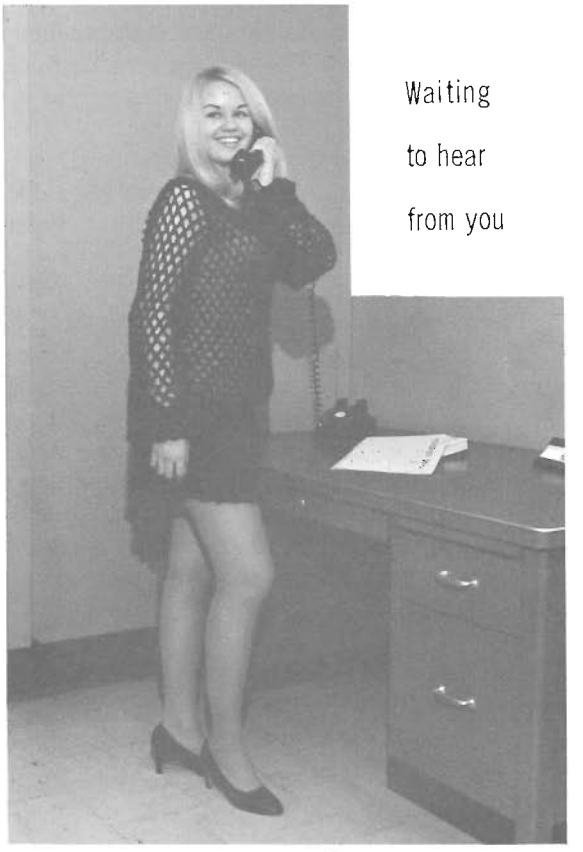
TF 44-4134, Air Defense Artillery Weapon System, Chaparral, Self-Propelled—Part III: Target Engagement Techniques, is designed to teach Chaparral crewmen the procedures that should be followed during target engagement. This 20-minute film opens with a sequence showing a Chaparral squad visually acquiring and tracking a target which is subsequently identified as friendly. A quick look at the position occupied by a Chaparral squad follows. The need for clear fields of fire is emphasized and the organization of the squad to provide 360° coverage, both for observation and target engagement, is illustrated. First using a friendly and then a hostile aircraft, the actions of squad members during the observation, acquisition, tracking, identification, and, if appropriate, engagement of a target are described as they are shown. The friendly aircraft is used to emphasize the fact that each aircraft is acquired and tracked as if hostile until the squad leader identifies the aircraft as

either friendly or hostile. During the several alerts, the visual acquisiton of the aircraft by observers, the acquisition and tracking of the target by the senior gunner, the squad leader's determination that the aircraft is hostile and his decision to engage the target, followed by launching of the missile by the senior gunner, are used to portray the duties of each member of the squad.

The United States Army Air Defense School is responsible to the United States Continental Army Command for the formulation and submission of an annual training film program to support individual and unit training in air defense artillery subjects. Additionally, this School provides or arranges for production support required to complete these films.

Personnel at the United States Army Air Defense School try to anticipate the training needs of air defense artillery units and develop visual aids to enhance individual and unit training in such units. However, training films that satisfy the training requirements of air defense artillery units best are those developed as a result of constructive recommendations from personnel in these units.

Therefore, recommendations are requested at any time from air defense artillery units for development of training films to fill a substantiated void in audio-visual aids to support their individual and/or unit training needs. Requests for development of training films should indicate the specific subject to be covered, together with a brief outline indicating the scope of coverage desired. These requests should be forwarded to the Commandant, US Army Air Defense School, ATTN: ATSAD-DL-C, Fort Bliss, Texas 79916.



Waiting to hear from you

FORTHCOMING REVISION OF TM 9-1410-550-34/12
(Hawk Missile DS/GS Maintenance Manual)
Missile and Munitions Materiel Digest
May 1970

The revised training manual will require cross-coupling checks to be performed when any chassis is replaced that could affect the cross-coupling error. The present training manual requires cross-coupling checks to be performed only upon replacement of the target antenna section.

Recent studies have indicated that missile cross-coupling checks need to be performed upon replacement of not only the target antenna section, but any other chassis in the guidance section which could affect cross-coupling; e.g., speedgate, antenna control, target and fuze doppler amplifier, etc.

The Hawk Project Office, USAMICOM, has requested assistance from USAMMCS in preparing this revision. Further information on the revision can be found in USAMICOM Hawk Missile System Information Bulletin 49, 20 October 1969.

CHAPARRAL HYDRAULIC PROBLEM

Mr. Rex Boyette, a missile maintenance technician in the LCMM Branch, Missile Maintenance Division, Directorate of Logistics, has submitted a suggestion for the solution of a problem experienced on the Chaparral missile system in training exercises.

The problem is in the hydraulic system. Specifically, hydraulic coolers have ruptured because no automatic protection was provided against extreme pressure (2,000 psi) that occurred when power was applied to the hydraulic pump unit while the return line was not fully connected.

The return line coupler is provided to permit filling the reservoir. When recoupling is not fully accomplished, the self-sealing valve in the coupler is closed, thereby blocking fluid return and resulting in extreme pressure buildup when power is applied.

Mr. Boyette's suggested device provides protection for the expensive hydraulic coolers by relieving pressure at 150 psi and warning the operator of the system malfunction. He placed a relief valve in the inlet line before the cooler that will open at 150 psi and bleed fluid into the elevator servo overflow bottle. The pressure relief valve incorporates a switch that removes power from the hydraulic pump unit and energizes a warning indicator when the pressure relief valve opens.

This device has been proven on equipment used in training. Although the training environment, where students disconnect and reconnect the self-sealing coupler, is the ideal place for use of this device, the same problem could occur in the field.

DIRECTOR OF INSTRUCTION

AIR DEFENSE ARTILLERY BRIEFING TEAM

The Air Defense Artillery Briefing Team, first announced in Air Defense Trends, October 1969, is busily engaged in enlightening military audiences throughout the nation about air defense. When the Air Defense Artillery Branch was split from the Artillery Branch to become a separate combat arm, officials at the US Army Air Defense School, Fort Bliss, Texas, conceived a plan for a traveling briefing team to inform and educate the other Army branches and sister services concerning the organization and functions of air defense artillery. The current team is headed by Lieutenant Colonel Harry B. Stoudemier who is flanked on his right by Major Thomas J. Le Cleir and on his left by Major Francis C. Collins in the photograph above.

NONRESIDENT INSTRUCTION DEPARTMENT

HOW THE NONRESIDENT INSTRUCTION DEPARTMENT ASSISTS THE ADA OFFICER IN HIS MAAG ASSIGNMENT

Lieutenant Colonel Wilmer O. Gray, Jr
Nonresident Instruction Department
US Army Air Defense School

As published in the July 1970 issue of Army Digest, the Secretary of the Army in a recent graduation address at the District Senior Advisor Course of the Foreign Service Institute described an advisory assignment in Vietnam as "an assignment of great importance." This description, though aimed at advisory duty in Vietnam, points up the importance placed on advisory duty. In many other countries besides Vietnam the US Army maintains an advisory element and performs advisory duties. These duties are extremely important in furtherance of the Department of Defense objectives.

What does an advisory assignment involve? AR 551-50 defines military assistance advisory groups (MAAG) as representatives of the Secretary of Defense in the countries to which they are accredited. Their duties involve military activities having social, economic, political, and psychological impact.

You have been selected, or you volunteered and were selected, for advisory duty. The required training for your assignment is behind you and you are "on station."

As you go about performing your duties as a soldier-diplomat, you find a need for materials or for training assistance not readily available to you in your host country. If your duties involve advising on air defense matters, the Nonresident Instruction Department, USAADS, can provide much assistance to you in these two areas:

- In response to your request, the Nonresident Instruction Department will acquire and ship prepared unclassified instructional material on air defense weapon systems and tactics. If you find it necessary to prepare lesson plans and present or assist in presenting instruction on air defense tactics and weapon systems, write the Nonresident Instruction Department, outlining your requirements. The Department will obtain the latest material available and ship it to you.

- The Nonresident Instruction Department will administer correspondence courses to host country military personnel.

The Nonresident Instruction Department will enroll foreign military personnel in air defense correspondence courses when applications have been forwarded through, approved, and their need-to-know established by the servicing MAAG, military mission, or military attache. The Nonresident Instruction Department is currently administering correspondence courses to foreign military personnel in nine foreign countries and routinely provides instructional material support to MAAG's and military missions around the world.

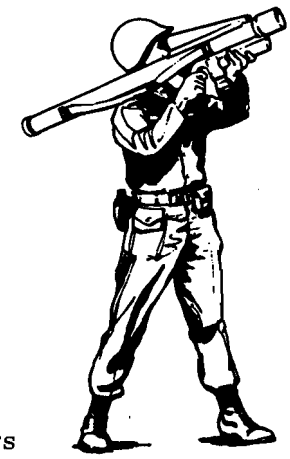
If you are an ADA advisor and need assistance on air defense weapon systems and tactics, write:

Commandant
US Army Air Defense School
ATTN: NRI Department, P.O. Box 5330
Fort Bliss, Texas 79916

Notes From
US Army Air Defense Center and Fort Bliss

REDEYE PERSONNEL

Comments have been received from various sources by the US Army Air Defense Center and Fort Bliss indicating a desire for changes in the current policy in assignment and handling of Redeye personnel. The problems and proposed resolutions are enumerated in a position adopted recently by the Air Defense Center Team.



- The Redeye system should be redesignated as an air defense artillery weapon system.

- Redeye should be controlled and manned by air defense artillery personnel.

- A detailed study should be made to evaluate the assignment of Redeye to Chaparral/Vulcan (C/V) battalions. The study should not be performed before C/V battalions have been deployed to all theaters for which they are scheduled and more field experience is generated.

By designating Redeye as an air defense artillery weapon system, and manning Redeye sections with air defense artillery personnel, the following areas would be improved.

Operations. At present low-altitude air defense near the forward edge of the battle area is left to the discretion of non-air-defense junior officers and enlisted personnel. The final decision to engage aircraft lies in their limited ability to distinguish between friend or foe and to rapidly apply local air defense SOP's under combat conditions. Redeye sections, consisting exclusively of air defense artillery personnel, would receive primary training in air defense and would be better able to apply air defense SOP's and make identification more quickly and with greater certainty than is presently possible. Since it is recommended that the Redeye weapon system be manned and controlled by air defense artillery personnel, the system designation should be changed from all-arms to air defense artillery. This redesignation of Redeye will facilitate the classification of the follow-on system; i.e., Improved Redeye, man-portable, air defense system, as an air defense artillery weapon system.

As Chaparral/Vulcan battalions become operational and gain field experience, consideration should be given to assigning Redeye to those battalions. This proposal should be studied in detail and reports from the field carefully weighed before a decision is made. The C/V battalions activated and trained at the US Army Air Defense Center and Fort Bliss are being prepared to absorb Redeye sections. However, all theaters where C/V units are deployed must be considered to insure that decisions made are based on valid and usual circumstances.

Career Progression. Under this new concept, Redeye sections would be supervised and manned by air defense artillery personnel. Section members would be awarded a primary military occupational specialty (PMOS) with a definite career progression pattern in air defense artillery.

Morale. The morale of Redeye personnel is adversely affected because section members are sometimes required to perform various administrative or sundry details more frequently than other members of the unit. If Redeye personnel were designated air defense artillery, these situations should be alleviated by providing more supervised training and time devoted to air defense subjects. Commanders would tend to rely more heavily on Redeye personnel as their personal air defense forces and therefore should encourage additional time for air defense training and discourage mismanagement of Redeye-trained personnel.

Training. The final decision to engage an aircraft with Redeye is based on visual aircraft recognition and local SOP's. The effective engagement time is extremely short, especially against high-performance aircraft. Therefore, every effort must be made to insure that section members will quickly recognize all combat aircraft. Air defense personnel, through experience and training, are best qualified to apply aircraft recognition techniques and to maintain the high state of proficiency required to insure that only hostile aircraft are engaged. With the advent of a follow-on system, the training problem will increase in magnitude. Improved Redeye/MANPADS will have greater performance characteristics, thus making target detection and identification more crucial.

INTERIM CHANGE TO AR 135-215

Recent inquiries from the field to DA indicate that officers are not aware of the interim change to AR 135-215 effective 1 July 1970 as announced in DA message 192139Z Jun 70. It is imperative that officers concerned know their possible REFRAD and the current policy on short-term extension of less that 24 months. Reference to the interim change is necessary in any further actions involving short-term extensions and release from active duty of officers currently serving on, or approved for, a short-term extension of less than 24 months as of 1 July 1970.

AIRBORNE VULCAN

Activated in June 1970, the 7th Battalion (Airborne) (Vulcan), 60th Artillery, claims the distinction of being the only active airborne air defense artillery unit in the US Army. This unit is also the first air defense battalion to be armed solely with the towed Vulcan weapon system. The Vulcan is a 20-mm, six-barrel, automatic weapon which operates on the Gatling gun principle.

The 7th of the 60th, nicknamed "Vulcaneers," is commanded by Major Joseph W. House, an Air Defense Artillery Branch officer who is also both airborne and ranger qualified.

The unit was formed to create a combat-ready battalion which will be able to transport and drop men and equipment (including 48 Vulcan guns). These can be deployed for combat in a total of from 5 to 8 minutes from the time they leave the aircraft. Actually, the four-man crew of each gun can deploy and fire the gun in a combat situation in about a minute after gun and crew are united on the ground. The Vulcan is operated electronically and can fire up to 3,000 rounds per minute, with a malfunction factor of almost zero.

Battalion training at Fort Bliss included airborne refresher courses and training drops. When training was completed in December 1970, the "Vulcaneers" moved to Fort Bragg, North Carolina, to join the 82d Airborne Division.

Notes From the US Army Air Defense Board

BALLISTIC AERIAL TARGET SYSTEM (BATS)

The US Army Air Defense Board recently conducted suitability tests on the ballistic aerial target system (BATS).

BATS is a low-cost, booster- and sustainer motor-propelled, training target, operated by a three-man crew, for use with the Vulcan, Redeye, and Chaparral weapon systems.

The primary purpose of BATS is to provide a realistic 300- to 450-knot training target. It is anticipated that approximately 50 percent of all target presentation requirements will be accomplished by BATS.

The BATS exhibits certain radar reflectivity and infrared emission characteristics necessary for use as an aerial target. The radar reflectivity of the target, which displays a broadside area of 20 square feet, is an important consideration in employment of the target in training exercises involving the Vulcan system's range-only radar. Infrared emission characteristics are also critically important in the employment of the target in training exercises involving the Redeye and Chaparral weapon systems.

The BATS has no recovery system and is expended upon intercept or impact. Target trajectories vary in range, speed, altitude, and direction, being determined by booster propulsion of two to five folding-fin aerial rockets and the predetermined elevation and azimuth of the zero-length launcher.

CHECK TEST OF IMPROVED HAWK MAINTENANCE PACKAGE

During the service test of the Improved Hawk missile system in October 1969 it was determined that an incomplete maintenance test package had been provided. Consequently, the accomplishment of sufficient testing to satisfy test objective requirements specifically related to maintainability was precluded. At that time, plans were initiated to provide an Improved Hawk battery set (IP No. 3) and maintenance package for a check test in June and July 1970.

The material being tested is the Improved Hawk maintenance package (organizational), comprised of organizational maintenance equipment, special and common tools (organizational level), preliminary operating and maintenance manuals complete with maintenance allocation charts, a list of authorized tools and test equipment, and a representative sample of organizational-level repair parts. The test is supported by use of the Improved Hawk battery set IP No. 3.

The overall objective of the check test is to determine the adequacy of the maintenance package to support the Improved Hawk battery in the field at the operator and organizational maintenance levels. Specific subobjectives include determination of the adequacy of tools and test equipment provided to perform the preventive maintenance functions and repairs as prescribed by the maintenance allocation charts; determination of whether the Improved Hawk mechanics have sufficient training and knowledge to employ the tools and test equipment properly; identification of any special tools and/or test equipment required, but not available, in the maintenance package; evaluation of preliminary operating and maintenance manuals for accuracy, simplicity, clarity, and completeness with special attention afforded to correction of errors reported during the service test; and performance of a maintainability demonstration applying techniques from MIL-STD-471 to determine corrective and preventive maintenance times for the battery.

The check test of the Improved Hawk maintenance package was conducted at Fort Bliss from 6 July to 7 August 1970. Industrial prototype equipment was used, and, whenever possible, the test was conducted under simulated tactical conditions. The test team, organized insofar as practical in accordance with the proposed Improved Hawk TOE structure, maintained and operated the system as prescribed in appropriate available operating manuals. Test operations included maintenance, a maintainability demonstration, and the collection of maintenance data to prepare maintenance evaluation forms required by US Army Test and Evaluation Command. The test was limited to operational and organizational maintenance functions.

Notes From the Human Resources Research Organization

The following technical reports have been prepared by HumRRO Division No. 5:

1. TR 70-2. Methods of Training for Engagement of Aircraft With Small Arms.

a. The research described in this report was done to develop methods of training infantrymen to use small arms to engage low-flying aircraft without actually firing the service weapon during the training program. One training approach used full-scale facilities and a specially designed leading/tracking training device; the other used a 1/10th-scale miniaturized training facility.

b. While the data for the full-scale study (adjusted for size of target) showed more hits than in the miniaturized study, both were effective training approaches, and certain aspects of the full-scale study could be adapted effectively to miniaturized training.

c. This report should be of interest to those concerned with doctrine and training for air defense and infantry, as well as those interested in simulation and miniaturization in training.

2. TR 70-4. Auditory and Visual Tracking of a Moving Target.

a. This report describes research conducted to compare auditory and visual tracking localization of a moving sound source. The research is part of a continuing effort to improve individual training and performance in aerial target detection and other aspects of use of forward area air defense weapons.

b. Tracking performance data were obtained under eight test conditions resulting from the combinations of two levels of each of three factors: sensory modality (auditory and visual), response (aiming and pointing), and target direction (right-to-left vs left-to-right). Observers were tested individually and 88 records were made for each, providing general performance data on target localization and tracking for the auditory mode in relation to the visual mode.

c. This report should be of value to personnel responsible for training in air defense and especially to those interested in the potential for using auditory perception in tracking and aiming performances in general.

One draft technical report has recently been prepared by HumRRO Division No. 5 and is awaiting approval by Department of the Army. The report, in support of Work Unit Man in Control (MANICON), is entitled, "Analysis of Human Command Functions in an Automated System."

Air Defense Missiles for the Army

Major George J. Geiger, United States Air Force, Retired

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Photo courtesy of General Dynamics.

During the Spanish Civil War (1936-39), Soviet flying "volunteers" made the first decisive use of modern tactical airpower when 125 fighter bombers routed an entire Italian armored division at Guadalajara. This testing ground for the interdiction of enemy forces, especially armor and infantry, formulated both German and Soviet air tactics for World War II.

German Stuka's and fighter bombers rained destruction on the Polish ground forces during the lightning campaign at the beginning of World War II. And after Germany attacked the Soviet Union, Soviet Stormovik aircraft rendered whole columns of German armor inoperative on the steppes. The defense of ground troops against close air attack during this period consisted of machineguns, 20-millimeter, 30-millimeter, or 40-millimeter antiaircraft guns in single or multiple mounts. However, against an enemy who had achieved air superiority, these weapons were largely inadequate.

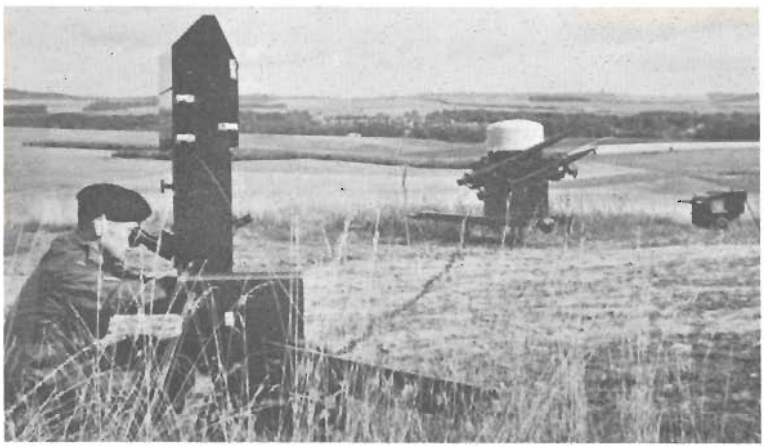
After World War II, much thought and research were devoted to air defense weapons. But the needs of the infantry or armor columns were largely lost in the prevailing strategic picture. First priority was given to the development of air defense systems intended for

Major George J. Geiger, United States Air Force, Retired, is an aeronautical historian and an aviation and missile journalist, contributing to publications in the United States, Europe, and South America. He was commissioned in 1943 and served 21 years' active duty. During World War II, he flew 26 combat missions in the European theater.

protection against strategic bombers. Gradually, with the advance of technology and miniaturization, small mobile weapons were evolved.

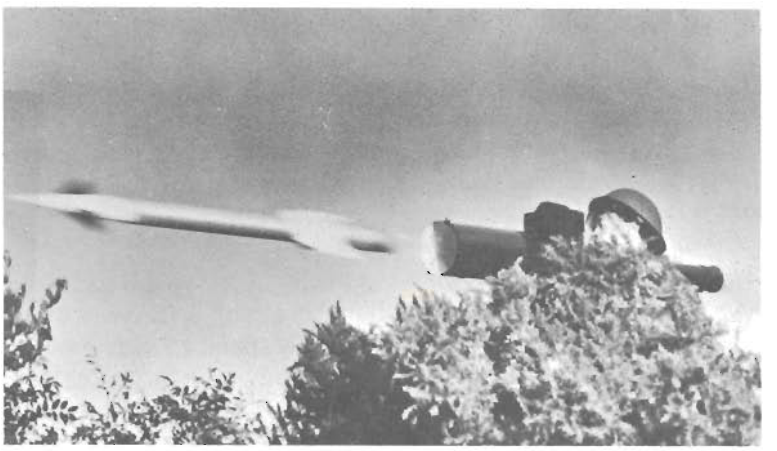
Many examples of these second and third-generation air defense weapon systems were displayed at the 28th International Aerospace Exhibition held in Paris during May and June 1969. These systems are mounted on trailers, trucks, or tracked vehicles, self-contained units oriented toward automatic or semiautomatic operation, and are especially designed for use against low-flying subsonic and supersonic aircraft.

The United States and the Soviet Union did not exhibit any weapons of this type at the exhibition although they have been the foremost developers in the field, and any comparison would be incomplete without examining their efforts. Great Britain had two of these low-altitude, high-speed aircraft defense weapon systems on display: the Blowpipe and the Rapier.



The British Rapier missile system with the firing section in the center, power cart on the right, and tracking head on the left

British Aircraft Corporation, Ltd.



The British Blowpipe, a shoulder-fired, close-range air defense missile leaving its launcher

Short Brothers & Harland, Ltd.

The Blowpipe is a close-range, one-man antiaircraft weapon using a command link guidance system, and capable of engaging aircraft while they are making an approach attack.

The weapon was developed to give forward area protection to infantry and armored units against low-flying aircraft or helicopters, and can be immediately ready for action. The Blowpipe is fired from the ground or from moving vehicles, and can also be used to destroy light armored vehicles or small naval vessels.

The system consists of a sealed, missile-launching container and an aiming unit with a total weight of less than 40 pounds. The operator uses a monocular sight on the aiming unit to sight and track the target. Power for the aiming unit and missile is provided by thermal batteries in the aiming unit.

The aiming unit is also fitted with a sensor which detects the position of the missile with relation to the line of sight. The error signals generated in the sensor are transmitted to the receiver in the missile, and the missile is automatically brought on to the line of sight to the target. For longer range accuracy, the aiming unit is fitted with a simple thumb guidance control which gives visual manual guidance of the missile all the way to the target. An explosive charge is used to expel the missile from the launcher, after which the solid propellant motor is ignited automatically.

Range of the Blowpipe is about 2.3 to three miles, and it mounts a six to eight-pound, high-explosive warhead fitted with a proximity fuze. The missile itself is 4.3 feet in length, three inches in diameter, and has a fin span of 10.5 inches.

Rapier is a third-generation, tactical surface-to-air missile system which combines mobility with lethality and cost effectiveness with ease of operation and maintenance. The system is essentially designed to be operated and controlled as a one-man antiaircraft defense weapon for protection against low-level supersonic air attack.

The Rapier weapon system consists of a rotatable turret containing the automatic target detection and acquisition radar, electronics, the computer, powerpack, and four missile launchers, arranged two on each side. The turret is mounted on a two-wheeled trailer, towed by a Land Rover or $\frac{1}{2}$-ton truck which also carries a four-missile reload and the tracking head.

When the approach of attacking aircraft has been detected, an alarm is sounded to alert the operator, and the missile launcher and optical head of the tracker are automatically aligned in the direction of the target. The operator, usually in a concealed position some 50 yards from the firing unit, then switches to manual tracking of the target using the optical sight. A signal from the computer tells the operator when to fire, and he continues to track the target while the computer keeps the missile on a collision course.

The Rapier missile is 7.4 feet in length, five inches in diameter, with a fin span of 15 inches. It is powered by a solid propellant rocket motor to a missile speed of over Mach 2 and, with its fast-reaction time, it can engage supersonic and subsonic aircraft and helicopters from near ground level to altitudes of 45,000 feet. The system is air transportable and is being produced for the defense forces of Libya, as well as the British armed forces.

Although it was not exhibited, the British Army and Royal Air Force have for years been using the Tigercat antiaircraft missile operationally. This is a land version of the highly

successful Seacat missile. The Tigercat consists of a three-missile launcher and separate director system, each mounted on a two-wheel trailer, towed by Land Rovers.

The Crotale and Javelot were the two French weapon systems shown at the exhibition. The Crotale is a low-altitude, all-weather, surface-to-air weapon system which provides close air defense of areas, critical zones, or field units. The system can be mounted on cross-country vehicles, semimobile platforms, or ships.

The Crotale is generally mounted on two vehicles, one for the acquisition and target designation radars and one for the firing section. The acquisition vehicle mounts a pulse Doppler radar with clutter attenuation, and an information-processing and target-evaluation computer, with all data processing being entirely digital.

The firing section is equipped with a tracking radar and a turret carrying four missiles in 18-inch-diameter cruciform containers which also serve as launchers ready for firing. Reaction time for the first combat operation is less than six seconds, and one firing section can launch two missiles at the same target in less than three seconds of each other.

The Crotale missile is powered by a two-stage, solid propellant rocket motor and weighs 165 pounds. It is 9.5 feet in length, seven inches in diameter, and the rear, spring-loaded, flip-out triangular fins span 21.5 inches. The missile has tremendous acceleration, attaining Mach 2.5 in less than 2.5 seconds.

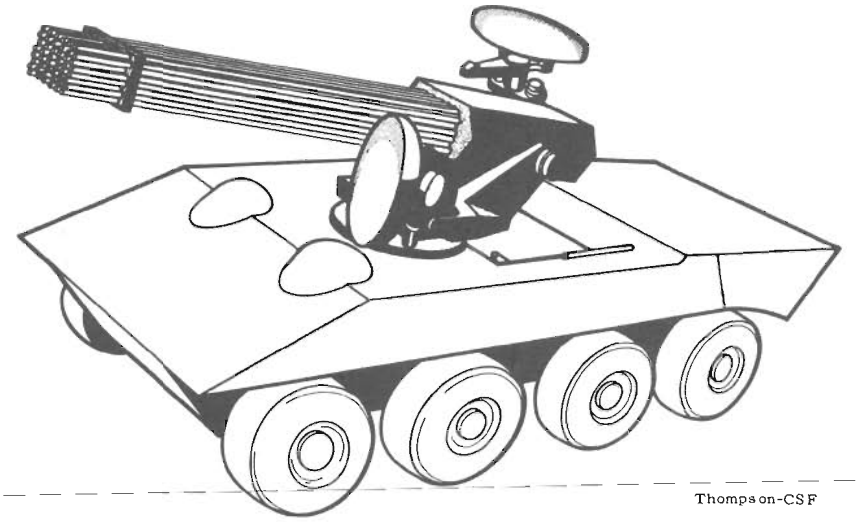
It has a range of 11.2 miles carrying a 33-pound, high-explosive warhead fitted with a proximity fuze. It is air transportable in C-130-size aircraft, and can be prepared for firing in less than five minutes.

The French Crotale air defense missile system deployed for action

Thompson-CSF

Javelot is a high-efficiency, short-range, surface-to-air missile system presently under development for the French armed forces. The weapon gains its efficiency because of the natural dispersion of small, unguided rockets. This dispersion of the rockets forms a cone around the attacking aircraft so that it flies into one or more of the rockets. The system is

radar directed, using the same components as the Crotale system, with a reaction time of about five seconds, and can engage up to four attacking aircraft at one time.

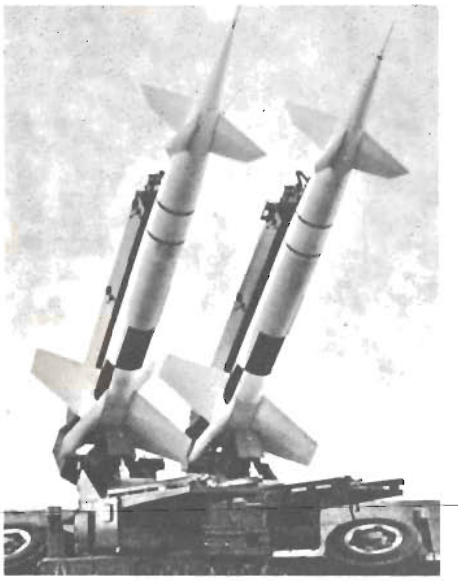


Thompson-CSF

Drawing of the proposed Javelot short-range, multiple unguided rocket air defense system presently under development in France

Firing System

The Javelot fires four, eight, or twelve 40-millimeter rockets in salvo, and can also be used for barrage-type fire in a surface-to-surface role. The rockets are fired from tubes at supersonic velocity by a shell-cased powder charge. After the rocket leaves the tube, the tail fins pop out, and its own solid propellant rocket motor ignites to maintain the supersonic velocity.



Jane's All the World's Aircraft

The Swiss Micon missile mounted on a twin-launcher trailer deployed in the firing position

The Javelot system is to be mounted on tracked or other cross-country vehicles and will also be air transportable. A version for shipboard use is also being considered. It is said to have a 70-percent destruction ability at ranges up to one mile within two to four seconds after target acquisition.

Switzerland's entry in the close support, air defense missile field was the Micon. This missile system was designed for use against Mach 2 targets at ranges up to 20 miles. It is presently being developed in fixed-base, mobile, and shipboard versions. The mobile version is mounted on a twin-launcher, four-wheeled trailer towed by a truck with the radar guidance equipment mounted inside a van-type body.

The Micon missile is powered by a two-stage, solid propellant rocket motor built into a single combustion chamber. Length is 17.7 feet, diameter is 1.38 feet, and the missile mounts two sets of cruciform fins—at the nose and tail. Launch weight is 1.8 pounds, and it is equipped with a high-explosive warhead with proximity fuze.

West Germany displayed the Roland, a joint French-German development in the low-altitude air defense missile field. Roland is a completely automatic surface-to-air missile system mounted on a tracked armored vehicle for close antiaircraft protection of ground forces.

Air Force and Space Digest

Roland II mounted on a German SPZ-neu. Visible are the collapsible radar antenna and the launching containers of the Roland missile attached to the vehicle's turret rails

The Roland system comprises two main components: a surveillance and acquisition radar, and an optical and infrared automatic guidance system. Radar surveillance is performed continuously, even while the vehicle is on the move. As soon as a target is identified, the vehicle stops, and the firing engagement commences.

The firing section of the Roland system includes: the turret to which are attached two missile-launching arms that can be aimed, fired, and reloaded automatically; the panoramic radar; the infrared sight and deviation meter; and the transmission antenna for missile guidance signals. Inside the vehicle are the radar operational systems, guidance computer, and missile storage magazines.

The Roland missile is powered by a two-stage, solid propellant rocket motor. It is 7.9 feet long, 6.3 inches in diameter, and weighs 139 pounds. The complete missile round with the container weighs 165 pounds. Missile speed is Mach 2 and ranges are from .3 to 3.8 miles. Roland also incorporates a powerful warhead fitted with a proximity fuze. The weapon system is scheduled to be placed into full-scale production soon.

The Redeye and Chaparral are the US Army's latest efforts to provide forward area forces with an effective missile for protection against tactical airstrikes. The Redeye is a shoulder-fired missile designed to be effective at altitudes and ranges commensurate with a close-in defense of field positions against low-level air attack.

The complete Redeye system is about four feet in length, about three inches in diameter, and weighs 29 pounds. The sealed launching tube (which also serves as a transport container) contains the missile and is mounted on the aiming unit. The missile itself contains a high-explosive warhead; a dual-thrust, solid propellant rocket motor; and an electronic guidance system of the infrared homing type.

To operate the weapon, the gunner has only to track the attacking aircraft in an optical sight and activate the missile's guidance system. A buzzer informs the gunner when to fire the missile. Upon firing, a booster charge propels the missile out of the launch tube. When the missile has attained sufficient distance to protect the operator from blast effect, the main rocket motor ignites and propels the missile to the target.

A production contract has been awarded for more than 25,000 Redeye missiles to be issued to the Army and the Marine Corps.

Philco-Ford Corporation

The Chaparral weapon system mounted on the XM548 vehicle

Basically, the Chaparral is a battlefield surface-to-air missile system adapted from the Sidewinder 1C infrared-homing, air-to-air missile and joined to XM548 tracked self-propelled vehicle. The fire unit—with four missile mountings—is also designed for semimobile emplacement dismounted from the vehicle, or as a trailer version, whichever the situation warrants. The missile is aimed by the gunner in the fire unit turret by keeping an optical sight aligned with the target. The missile's own infrared homing system takes over automatically after launch.

The Chaparral missile is 9.5 feet in length, five inches in diameter, and weighs about 185 pounds. Speed is Mach 2.5 over a range of from 100 feet to more than two miles.

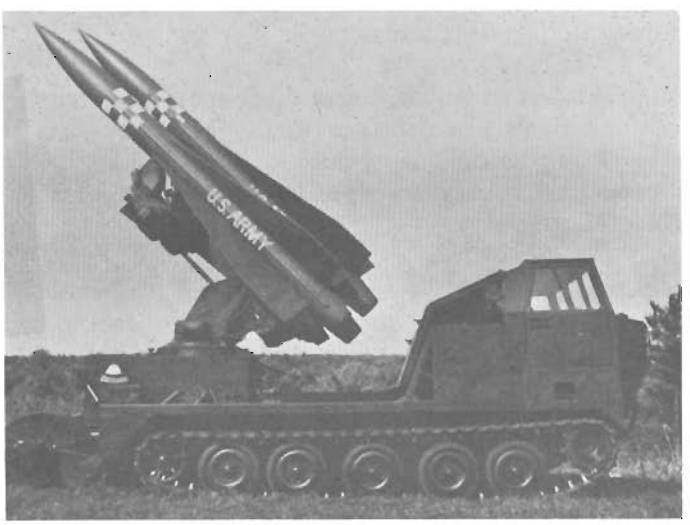
Some 154 Chaparral weapon systems are on order to equip the US Army's new Chaparral-Vulcan air defense battalions.

Until now, the HAWK missile system had been the mainstay for the United States in the forward defense of ground troops. The missile was designed for defense against low-flying aircraft, but a more mobile unit was desired since it took 35 H-37 helicopters or 21 C-124 aircraft to airlift a Hawk battalion.

The weapon was placed into operation during 1960, and there are now HAWK battalions deployed by the US Army in West Germany, the Panama Canal Zone, Okinawa, and Vietnam. In addition, five North Atlantic Treaty Organization nations use the HAWK: West Germany, Italy, France, Belgium, and the Netherlands. Sweden, Israel, Saudia Arabia, Japan, and the Republic of China have also purchased the HAWK system for their defense. The US Marine Corps placed the HAWK in operation during 1962 and have also deployed it in Vietnam.

Editor's Note:

Hawk battalions have recently been withdrawn from the Panama Canal Zone.



HAWK air defense missiles on new self-propelled triple launcher

Jane's All the World's Aircraft

Under development currently is the surface-to-air missile development (SAM-D) which is intended as a terminal defense system for field armies against sophisticated future aircraft. It will replace the HAWK starting in the early 1970's. It is also expected to be effective against short-range tactical missiles launched by opposing field armies or from submarines. SAM-D will be mounted on tracked carriers and be capable of rapid fire from a six-round launcher at several different targets simultaneously.

The Soviet Union has also been quite active in the development of air defense missiles for use against low-altitude air attack. Since 1960, the Soviets have been using the Guild, a 30-foot-long, single-stage antiaircraft missile, in much the same manner as the US Army deploys the HAWK. It is an effective missile, but again is large and requires much equipment to maintain its effectiveness.

The newer, more mobile Goa is a two-stage antiaircraft missile that is compact enough to be carried on a pair of launching rails mounted on a standard Soviet Army YaAZ-214 heavy cargo truck. It was first shown in public in November 1964 and is also in operational use aboard Soviet naval vessels. It is probably intended for use by field forces for short-range defense against low-flying aircraft. Guidance is by radio command, and both stages have solid propellant rocket motors.

The Goa missile is 20 feet long and has a diameter of two feet on the booster and 1.5 feet on the second stage. Speed is about Mach 2 at ranges of up to 20 miles. Launch weight of the Goa is some 2,460 pounds, and it is believed to carry a 25-pound, high-explosive warhead. The Goa has been in large-scale production for over seven years and is probably in the same class as the US HAWK missile.

Soviet Goa air defense missiles on truck-mounted twin launchers

Aviation Magazine (France)

The Ganef is reputed to be highly successful in the forward area air defense role. It is fired from mobile tracked launchers equipped with twin launching rails. The missile is ramjet powered and launched with the aid of four strap-on, solid propellant booster rockets. The air-breathing, ramjet engine has an annular air intake located just behind the warhead section which is separated by explosive bolts during the final powered portion of flight. The warhead

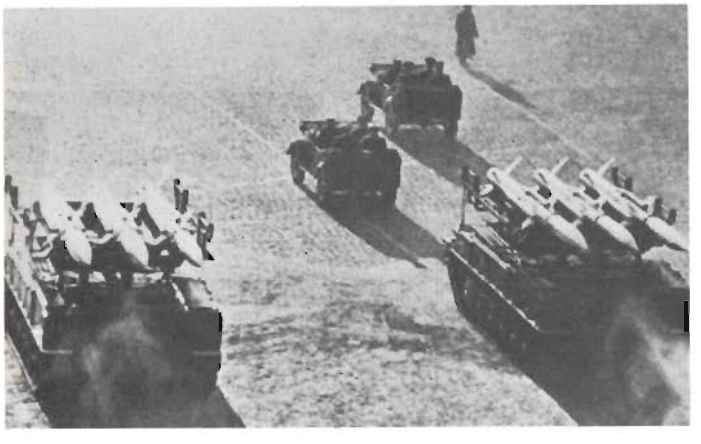
then coasts to the target on a ballistic trajectory. Guidance is by radar, and control is by means of the all-moving wing equipped with yaw or pressure sensors at the tips.

Length of the Ganef is 30 feet, with a diameter of 2.8 feet, and a launch weight of some 4,400 pounds. It can attain a speed of over Mach 2.5 with a range of more than 45 miles, and is equipped with a large 188-pound, high-explosive warhead.

This weapon system may also be used as a short-range, tactical surface-to-surface missile in close support of ground troops. For this role, there is speculation that it may be armed with a nuclear warhead. Ganef is air transportable in the An-22 heavy cargo aircraft, and may be placed in action immediately after off-loading.

Soviet Information Bureau (Paris, France)

The Soviet Ganef battlefield air defense missile system mounted on a tracked vehicle



Aviation Magazine (France)

Soviet Gainful air defense missiles triple mounted on tracked vehicles

Gainful is a new, compact surface-to-air weapon system that was first shown in public in a Moscow parade in November 1967. Each unit consists of a PT76 amphibious carrier, with three solid propellant missiles of simple cylindrical shape, with cruciform mounted

wings. Length of the missile is 19.5 feet, with a diameter of 1.5 feet, and a fin span of three feet. Guidance is probably radio and radar from a separate van.

Speed of the missile is estimated to be on the order of Mach 2, with altitude capabilities of zero to 60,000 feet, over a range of 10 to 12 miles.

This system is the latest addition to the Soviet Army's battlefield capability, and is designed to combat low-flying, supersonic aircraft. It is probably employed in much the same manner as the HAWK, but has increased mobility over its US counterpart.

The most common Soviet air defense missile is the Guideline. The original version of this weapon was similar to the US Nike Ajax and generally comparable in performance. Consistent refinements have been made to the system, however, as it is a standard Soviet air defense weapon. The 288-pound, high-explosive warhead may be either proximity fuzed or command detonated.

The Soviets have given or sold many thousands of Guideline antiaircraft missiles to their allies or friends. While the Guideline missile is not in the same class as the US Army's HAWK or the newer European missiles, there are, nevertheless, great numbers on operational status in Cuba, Indonesia, Iraq, North Vietnam, Red China, the United Arab Republic, and the Warsaw Pact nations.

If It's Not Definitely Wrong, It's Probably Right

Captain Robert L. Reinhardt

The method I am going to describe is a simple but effective mathematical tool suitable for use by anyone desiring to check the accuracy of his calculations. It can be mastered in a few minutes and used effectively in checking any addition, subtraction, multiplication, or division problem. This method will show when an answer is definitely wrong. And if it's not definitely wrong, it's probably right.

This method depends upon one's ability to find and use the reduced sum of a number.

Rule 1. Any rational number can be reduced to a one-digit reduced sum. This reduced sum is equal to the remainder after the number has been divided by nine. The reduced sum is also equal to the sum of the digits in the number.

Rule 2. A reduced sum nine is equal to a reduced sum zero. Notice the symmetry of the count in the following table:

Counting numbers

Counting number	Counting number divided by nine. Nine goes into the number a certain number of times plus a remainder.						Reduced sum
	Times	Remainder	Times	Remainder	Times	Remainder	
0	0	0					0
1	0	1					1
2	0	2					2
3	0	3					3
4	0	4					4
5	0	5					5
6	0	6					6
7	0	7					7
8	0	8					8
9	0	9	1	0			9=0
10	0	10	1	1			1
11	0	11	1	2			2
12	0	12	1	3			3
13	0	13	1	4			4
14	0	14	1	5			5
15	0	15	1	6			6
16	0	16	1	7			7
17	0	17	1	8			8
18	0	18	1	9	2	0	9=0
19	0	19	1	10	2	1	1
20	0	20	1	11	2	2	2
21	0	21	1	12	2	3	3

Counting number 21 has been extracted from the table to demonstrate how the reduced sum is obtained.

Example 1. Obtain the reduced sum of 21 by dividing by 9.

$$\begin{array}{r} 2 \\ 9\overline{)21} \end{array} \text{ Remainder } 3$$

The reduced sum is equal to the remainder by rule 1.

Example 2. Obtain the reduced sum of 21 by adding the digits.

$$21 = 2 + 1 = 3$$

The reduced sum is equal to the sum of the digits in the number. Notice that the reduced sums in each of the remainder columns in the table also equal 3.

Example 3. Obtain the reduced sum of 1,090,000 by dividing by 9.

$$\begin{array}{r} 121111 \\ 9\overline{)1090000} \end{array} \text{ Remainder } 1$$

The reduced sum is 1.

Example 4. Obtain the reduced sum of 1,090,000 by adding the digits.

$$1090000 = 1 + 0 + 9 + 0 + 0 + 0 + 0 = 1 + 9 = 10 \qquad 10 = 1 + 0 = 1$$

The method shown in example 4 is the fastest and easiest way to obtain the reduced sum of a number. We can further simplify the reduction of the number in example 4 by noting that a reduced sum nine is equal to a reduced sum zero (rule 2). The number 1,090,000 yields immediately a reduced sum of 1. And by extension of rule 2 any two or three or more numbers that add up to 9 can be immediately disregarded in obtaining the reduced sum.

Now that we have the idea of reduced sums let us apply them to checking our computations.

Rule 3. Treat reduced sums exactly as regular numbers in doing arithmetic operations.

Example 5. Add:

	5 4 2	2	(reduced sum of 542)
	1 3 2	6	(reduced sum of 123)
	7 8 9	6	(reduced sum of 789)
	1, 4 6 3	1 4	
reduced sum	5	5	

The reduced sum of the answer (5) matches the reduced sum of the problem (5). The answer is not definitely wrong and therefore is probably right.

Example 6. Perform the indicated operation.

59		5	(reduced sum of 59)
-12		-3	(reduced sum of 12)
47		2	
2	reduced sums	2	

Example 7. Perform the indicated operation.

55		10
-14		-5
41		
5	reduced sums	5

Notice that the reduced sum of 55 was left as 10 so that the subtraction of the reduced sums could take place without introducing a negative number.

Example 8. Multiply:

51		6
4		4
204		24
6	reduced sums	6

Example 9. Assume you are checking this problem. Is the answer right?

112 x 7 x 3 = 2,352 The reduced sum of 2,352 is 3.

reduced sum multiplication 4 x 7 x 3 = 84 = 12 = 3

The reduced sums agree so the answer is probably right.

What will happen if the answer is definitely wrong?

Example 10. Is the answer right?

41		5
3		3
223		15
7	Reduced sums do not agree.	6

The reduced sums do not agree so the answer is definitely wrong.

Division presents a small problem since the operation may produce a remainder. We know that division is the opposite of multiplication. The best way of checking division is by multiplying and adding the remainder.

Example 11. Divide:

$$\frac{62}{4} = 15 \text{ plus remainder } 2$$

To check: $15 \times 4 + 2 = 62$

$6 \times 4 + 2 = 26 = 8$ This agrees with the reduced sum of 62 which is 8.

Decimal numbers are reduced the same as regular numbers. The decimal point is disregarded.

Example 12. Multiply:

17.2		1
.5		5
8.60		
14 = 5	Reduced sums agree.	5

The check operation, however, cannot determine the correct placement of the decimal point.

When you start using this method you may add reduced sums while checking multiplication. This is a common error and will be corrected as you become more familiar with the system. This method is not foolproof. It will not discover an error if the error is a multiple of 9. Its value is its capability to tell us quickly that an answer is definitely wrong. And if the answer is not definitely wrong, it probably is right.

Hi! We recently published a thought-provoking article by LTC Roscoe H. Munroe of the Combat Developments Command Air Defense Agency. Here are two more. I would especially like to read your comments on them. Drop me a line!

ASP - Who Needs It? or "What Price Emotionalism"

There is no air defense artilleryman who is worth his salt that has not participated in ASP (if you are a brown-shoe man) or SNAP (if you are a newcomer), and most of them recognize these exercises as the "proof of the pudding" or a real test to determine the proficiency of a unit to perform the mission. Actually, this was the case for all units several years ago and still is the case for some units. However, many things have changed over the years and the philosophy that what served granddad must be good is no longer valid and must be reexamined to apply the philosophy only where applicable.

The requirement for ASP or SNAP can be justified for any weapon system that requires the demonstration of human skill for the completion of an engagement. A good example is that of Vulcan (or the quad .50) where there is active participation of the gunner throughout the engagement and where a live target of some sort is required. Nike Hercules, Hawk, Chaparral, and Redeye are poor examples in that the human proficiency is adequately demonstrated only to the point where the weapon is fired. The success of the mission then rests in equipment reliability. Certainly, the crew demonstrates proficiency in system operation, assembly, and adjustment, as applicable, but all of these functions can be adequately demonstrated without actually firing. Case in point—Nike Hercules units do more on site in view of TPI's, ORE's, DCE's, and CMMI's than can ever be accomplished in SNAP. In fact, the major differences lie in trips to McGregor Range, Juarez, and actually firing a missile.

Action must be taken to apply ASP only where required. Why? The almighty dollar! Items that are vital necessities are being questioned because they are expensive. Why isn't SAM-D being expedited? Why is identification such a problem? There is only so much money, and it behooves the sensible person to allocate funds where the real need lies and to avoid waste. When one considers the cost of a large range complex, the systems that are tied up, the number of range personnel, the targets (or simulators), chartered aircraft used for transportation, and expended missiles that are no longer produced, the cost is one that staggers

the imagination. All this is expended when there is no supportable need for it. Why? Because of the morale factor? Illogical. The same honors can be won on site. Because of the trip to McGregor Range and Juarez? A rather expensive R&R ploy. To demonstrate proficiency? More can be done on site to evaluate a unit.

Should all ASP be terminated? Definitely not. There is and will always be a requirement to demonstrate proficiency with visually directed gun systems. In fact, gunners do not currently enjoy the level of practice required to develop the required skill. However, ASP for Nike Hercules, Hawk, SAM-D, Chaparral, and Redeye is not, repeat not, a valid requirement, and the enormous sums saved by the termination of those ASP's can be applied to ASP's for Vulcan, the development of needed items, and possibly even to the reduction of taxes.

The Munroe Doctrine or How to Hit With Vulcan

Dauntless aeronauts of bygone days generated the requirement for air defense when caught performing such ill-mannered acts as dropping grenades and mortar shells on hapless doughboys who were already fully occupied with trenchfoot, machineguns, artillery, rifles, and gas. Insult was added to injury when the same misguided aeronauts found that machineguns could be mounted on their flying machines so that they could then strafe trenches, thus causing more consternation. The aircraft-antiaircraft race then began. The aviators try to develop better ways to hit the ground-pounder, and the latter tries to develop better ways to stop them. Technological development over the years has permitted the air defense community to make remarkable strides in the development of sophisticated means to meet and counter a very sophisticated threat. However, the requirement exists for literally hundreds, and perhaps thousands, of simple, short-range air defense weapons to cover the innumerable avenues of approach that cannot be covered by the longer range systems. Why? Simply because the large systems cost too much to put one in every dale and glen and the systems up front can and do get knocked out for a variety of reasons. Also, they generally must be able to react more rapidly than the longer range systems. The Vulcan was developed to assist in the defense of the forward area. The following is an account of a conversation between two Vulcan gunners after a hard day on the range:

"Hi, Sam, howdja do t'day?"

"Don't ask!"

"Whassamatter, man, you look lower than a snake's belt buckle. Didn't do so good, huh?"

"Actually, I can't say. I shot like a B____d but who can tell if he's hitting anything or not. That flag doesn't crash like a self-respecting airplane should, so who knows?"

"Don't give me that, man. You had RCAT's too?"

"Yeah, one!"

"Well?"

"Nothing. Absolutely nothing! They were all behind. They almost always are. I can't figure it. I did everything just right and nothing happened."

"Well, actually you didn't. Don't get me wrong, you tried. I know you tried but the way that little feller is built, the odds are stacked against you."

"Gazelle you say! Look, if you know something I don't, spit it out!"

"Easy, compadre. Did you track smoothly?"

"Sure. As well as I could. But nobody can keep the same image ALL the time. After all, as the airplane passes, it seems to be going faster and faster until it gets to midpoint and then it seems to be slowing down. This causes the gunner to overshoot, undershoot, overshoot, undershoot, you know."

"Yep. I know. And that's the whole problem."

"I don't get it."

"Well, you probably stayed on the airplane all the time, but those little corrections you kept putting in to stay on the target are not exactly the smooth input the computer needs to generate the right lead."

"Hold it! I'm the best tracker in the outfit; Sarge said so!"

"Not good enough. The fact that you happen to be a human being means that you have a measurable delay in detecting the need for correction, applying the correction, determining the result, and applying more correction."

"Well, sure. So what's new? What else can I do?"

"I saw a new technique demonstrated the other day that really cleans the skies!"

"You're kidding!"

"Nope. It flat got with the program! Never saw anything like it in my life. A bunch of the old guys that were around way back when said the same thing."

"C'mon, give. What's the scoop?"

"Well, the idea is NOT to track the target. Hold it! Wait 'til I finish. The gunner tracks THROUGH the target. He gets behind the target and then starts tracking like mad so that he goes right through the target and keeps going. As he passes the front of the target he starts firing and keeps firing until he hits or the target is out of range. It's a real fast rate of traverse, much faster than you would use just to track."

"Hey, that sounds a helluva lot easier!"

"That's what the gunner said. He said he had never had so much fun. There were no cripples either. Just big balls of flame."

"Is that all there is to it?"

"No. Get this. They didn't use the computer or the range-only radar. They just boresighted, caged the sight, and let the good times roll. Oh yes, they used the ground fire clamp instead of the air defense clamp so that a concentrated stream of fire went through the target. It was a real blast!"

"When can we do that?"

"Dunno. Letters have been sent in months ago, but a real test of the technique takes funding, instrumentation, targets—all that stuff. The way money is, it could take quite a while."

"This new technique, will it work on any kind of course?"

"Sure. Anyway, it would seem so. The people over at the Combat Developments Command Air Defense Agency have run quite a bit of mathematical analyses, and it looks like the best thing since sliced bread."

"Man, I sure hope they get on the stick and test this thing out so we can use it."

"Me, too."

Education: Eternal Enrichment

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University of Texas at El Paso

This title seems to imply that education and enrichment are synonymous, and I think they are. Let me cite a few examples. While visiting a museum recently I noticed that some people just looked briefly at art objects and walked on. They actually seemed bored. By contrast, other visitors lingered before the same objects, examining them, discussing them, and obviously getting a great deal of pleasure from the experience. I wondered about the difference in attitude and concluded that those people who were enjoying themselves had some education in art.

Another somewhat similar situation can be observed where books are concerned. Did you ever notice that some people will simply leaf through a book or magazine, glance at illustrations, then lay it down as if they had simply looked at it to kill time? Then another person picks it up and is soon engrossed in reading something that keenly interests him. It occurs to me that the latter of the two individuals has a broader education.

Surely in instances such as these there is enrichment in the lives of the educated that the others cannot experience. Just as in the case of the man who is enjoying a music recital or play while his neighbor is simply putting up with it because his wife wanted to go. Which one is educated?

These examples hold true for almost every human experience. Let your memory run over the spectrum of activities you have observed, and you can readily decide which of the participants was better educated. They invariably get more out of what they are doing. It is manifestly true that each step forward we take in education opens doors to further knowledge and rewards that were previously out of our reach.

Let's revert to the title. We are saying that education and the synonymous enrichment are eternal. What we mean is that the enrichment one derives from education cannot be taken from him. Everything else we may have—wealth, job, family, health—these can all be taken from us, but our education cannot. It is eternal to us as individuals. Knowledge we gain can and often is projected beyond our life span. Much of the literature, art, and science that enrich man's life are the harvest of educational products left to him by his predecessors. These legacies date back thousands of years—and will doubtlessly go on for thousands of years to come, and they are continuously augmented as the years roll on.

And so we say, with full justification, that as it involves man, education is indeed eternal enrichment.

A Plan to Help Establish an All-Volunteer Armed Force

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and
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This article is not a thorough research report backed by extensive data or a complete economic analysis. The general spirit of the presentation is that the Department of Defense should further investigate the feasibility of ideas presented herein.

It should be noted that the suggestions found in this study are aimed primarily at the enlisted man. However, this does not preclude modifying these suggestions for application to the officer corps.

Insufficient incentives exist today to encourage enough young men to remain in the Armed Forces for a career. Consequently, conscription has been necessary to maintain the force level required to satisfy our national objectives.

President Nixon stated that it will be a national objective to move toward an all-volunteer military as soon as possible. To accomplish this objective it is necessary to examine the current military personnel programs. The result of this examination must be the generation of a comprehensive set of new proposals. When employed, these new programs must make military life desirable to the point of causing enough capable men to voluntarily enlist so that conscription becomes unnecessary.

As a candidate for President, Mr. Nixon promised that he would take the necessary steps to move toward an all-volunteer military.

On 27 March 1969, the Gates Commission was established for this specific purpose. The objective of this study group was "to develop a comprehensive plan for eliminating conscription and moving toward an all-volunteer armed force."

In February 1970 the group released its unanimous findings. Although supported wholeheartedly by the commission, this controversial report is far from being a panacea.

The basic tenets of the Gates Commission report are to:

- Raise the pay of first-tour enlisted men and officers.

- Provide an assortment of other pay benefits; i.e., increased hostile fire pay, and specialty, pro pay, and reserve pay increase.

- Give faster promotions for specialty skills.

- Replace many military positions with civilian workers.

The objections levied against the study center around:

- Questioning the economic feasibility of the study.
- Questioning the timetable proposed.

Several important possibilities were not presented in the Gates Commission report. The ideas presented herein represent a coherent set of proposals aimed at solving the problem of the all-volunteer military force more economically.

The approach to the problem of an all-volunteer military used in the Gates report was purely monetary. In other words, this study group felt that by removing the pay inequities between military and civilian personnel, the recruitment problem would be solved. Working under this basic tenet, it is believed that the method of remuneration can be adjusted to yield a greater amount of response for a given dollar input.

The following plan was not generated by any empirical or statistical process; it is a set of proposals that, when taken together, indicate a method of reaching an already stated goal faster and more economically.

Modifying the existing retirement program, reducing the uncertainty of assignment, and offering the soldier a few monetary incentives at critical times in his career would induce more men to stay in the Armed Forces longer (see chart I).

1. Two cash awards. One of the most critical times in a man's military career is the day when he makes the initial decision to leave civilian life for the service. To make this transition more enticing, offer any man volunteering for military service a $1,000 award. This could be paid in two $500 blocks, one upon entering duty and the other after 18 months' duty. Another critical period is at the end of a soldier's first enlistment. A reenlistment bonus system is currently in effect. It is suggested that this bonus system be altered so that limits of compensation be set at not less than $3,000 or more than $6,000. The exact size of the bonus would be determined by the present method.

2. Retirement. Make the soldier eligible for retirement in 15 years at $37\frac{1}{2}$ percent of his basic pay. Count every day served on a hardship oversea tour as 2 days toward retirement. Count every day served in a hostile fire zone as $2\frac{1}{2}$ days toward retirement. A minimum time in service for retirement should be set at 12 years. If a soldier remains on active duty for only 6 years, he qualifies for a retirement income at age 60 of 17.5 percent of his base pay.

3. Assignment stability. During the soldier's first 3-year tour, assign him to a 1-year short tour (hardship or hostile fire) and a maximum of two other assignments during that 3-year period. After completion of his first short tour, guarantee the soldier that he will not serve another short oversea tour for 3 years. Default of this latter promise, concerning the return to a short oversea tour area, would incur a penalty on the part of the Government of $1,000. This would be paid directly to the individual soldier.

In order for a man to take any action, the outcome of such action must place him in a more favorable position than that in which the man perceives himself to be. This idea is the

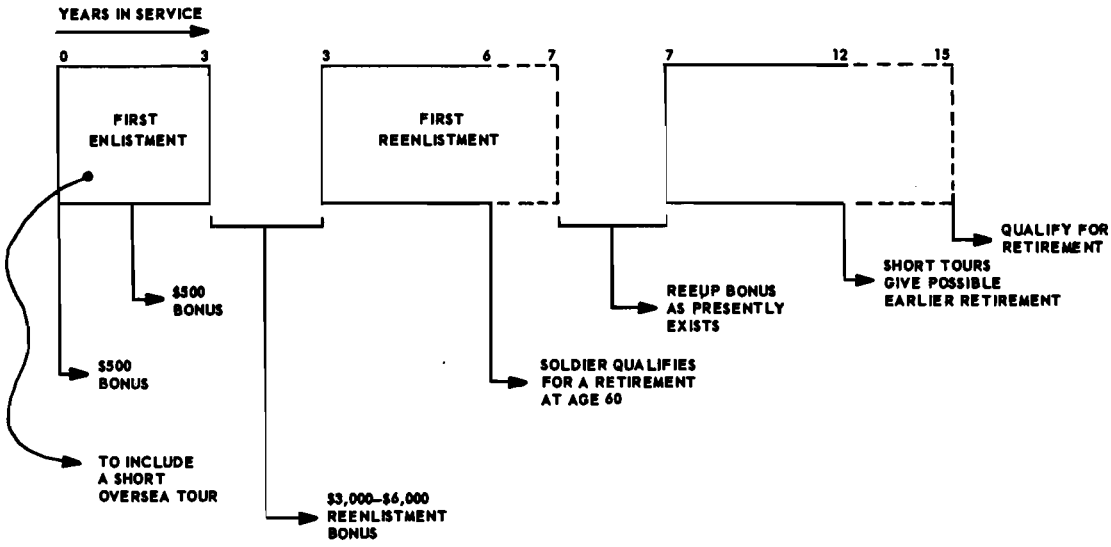

Chart I. Career plan

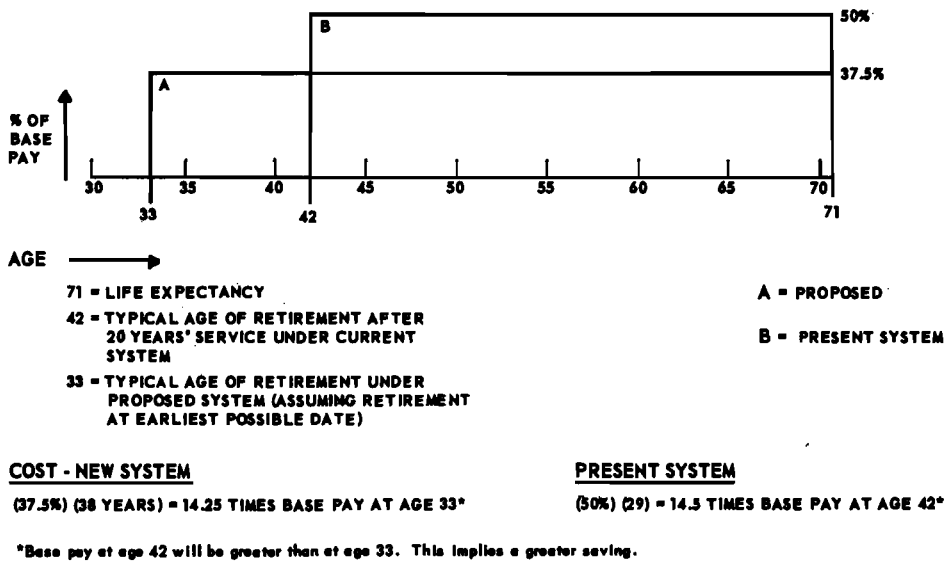

Chart II. 15-year retirement

basic premise of these suggestions. By offering the soldier sufficient inducements at certain critical periods in his career cycle, he can probably be retained in the service. These are the critical periods: (1) Entering active duty, (2) at the end of his first enlistment, and (3) after his second enlistment.

Now consider the inducements. For a civilian contemplating military service for only 3 years, there is a $1,000 enlistment bonus, certainty as to assignments to a short tour during the first 3 years, more stability as to military job and location than at present, and all present military benefits.

At the end of his first tour the soldier considers reenlistment. This a particularly special time in a young man's life since at this age the average American male is in the process of starting a family. It is likely that the man would be attracted by financial awards. Now he is faced with an immediate bonus of between $3,000 and $6,000. Also, he is confident that he won't have another short tour for at least 3 years from the time he last returned. Also, a reenlistment for a period of 3 years would qualify him for an annuity at age 60.

At the end of the second term of service, the soldier has accrued 6 to 7 years' service and has between 7 to 10 years' credit toward retirement. At this point, the 15-year retirement would probably persuade the soldier to reenlist for a period of time that would qualify him for retirement. At retirement age, he would be 31 to 35 years old and readily acceptable to civilian employers. This is very important to him.

Costs involved in the program include:

1. $1,000 entry bonus - Very small additional cost over that proposed in the Gates Commission. Rather than raise the salary to the point suggested in the Gates report, raise the salary to within $750 to $1,000 of that level. Lump this freed money into an enlistment bonus.

2. Annuity at age 60 from 6 years' service - Small extra cost.

3. Reenlistment bonus - Small or no extra cost.

4. Penalty paid by Government - Very small or no extra cost.

5. 15-year retirement - No extra cost (see chart II).

All the advantages of an all-volunteer force are explained in detail in the Gates Commission report.

Excalibur Air Defense System

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Tough, fast, and deadly is how Sperry Rand describes Excalibur, their concept of the Army's advanced forward area air defense gun system. Utilizing their vast air defense background, Sperry Rand's UNIVAC Division has conceived an exciting new system that would provide a substantially greater close-in, low-altitude air defense capability than that provided by past or presently fielded systems. Our engineers believe that a high-performance gun system will continue to fill a very important role in close-in air defense for at least the next decade, and their system has been tailored to effectively counter the threat anticipated in that time frame. Throughout the formulation stage of the system close liaison has been maintained with the Army to insure that it is compatible with Army requirements.

Two configurations of Excalibur are envisioned, one being categorized as a fair weather day-night system and the other as an all-weather system. The all-weather system concept is shown in figure 1. Against air attack, the system would be capable of responding quickly with unprecedented firepower and with the lethality and accuracy required to kill with the first strike. It would also be very effective as a ground-to-ground weapon by using antipersonnel and armor-piercing ammunition. Lightweight enough to be phase II air-transportable, it could be rapidly deployed wherever needed. The major characteristics this system would provide that are improvements over present Army equipment include on-board target detection/acquisition radar; integrated IFF; stabilized optical tracker with image intensifier;

Figure 1. All-weather Excalibur air defense gun system.

digital fire control and targeting computer; high-performance, medium-caliber, multibarrel Gatling gun; jam-resistant communications; CBR protection; and monopulse-pulse doppler radar tracker (all-weather system only).

Other noteworthy characteristics are armored turret and hull, highly mobile vehicle, multimission capability, and phase II air-transportability.

Advanced development work toward the fair weather system is well underway, having been initiated more than 2 years ago. US Army Weapons Command, Frankford Arsenal, and Watervliet Arsenal have been supporting this development effort. A series of firing tests at Yuma Proving Ground were completed during February 1970 when newly developed hardware was evaluated under firing conditions. The test bed used for these firing tests was very heavily instrumented, providing much data that can be effectively used in the system design of Excalibur.

Any new system is built on history. To bring Excalibur into technological perspective and to obtain an overview of this aspect of air defense, a brief review of recent history may be in order.

Immediately following World War II, Skysweeper introduced the concept of a completely integrated, fully automatic fire control system (gun, fire control, and radar) on a single mount. Produced and deployed from 1951 to 1958, the system proved effective against targets flying at speeds over 600 knots. One series of tests resulted in 67 percent hits (15-yard limit) on 540-knot crossing targets. The computer was analog electromechanical, however, making it somewhat vulnerable to environment. The radar was a conventional-pulsed tracker with a spiral search capability. Detection at low altitudes was difficult. Effectiveness was improved by utilizing an off-mount, fan-beam search radar.

With Stinger which followed (1953), also an integrated fully automatic system, we saw the introduction of inertial stabilization, mobility, and the application of linear control theory. Both optical and radar trackers were employed. A narrower radar beam permitted operation at lower altitudes but further limited search capability.

To achieve greater reliability, Raduster (1959) employed a simpler approach to the problem. Tracking was accomplished optically with radar supplying only range. Detection and acquisition were visual. The analog computer was simple and small.

When Vigilante was developed (1959-62), it was concluded that the optimum system for detecting and tracking high-performance tactical aircraft was radar detection, range-only radar tracking, and optical angle tracking. This was largely as a result of the work done on Raduster. Pulse-doppler radar was employed because it had proved to be far superior to pulse radar in detecting low-flying aircraft in ground clutter. Inertial stabilization was very effectively employed. The development of resolvers and shaped pots made possible an all-electrical computer. Although transistors were relatively new at that time, Vigilante electronics were nearly all solid-state. Regenerative track was introduced. Probably one of the greatest achievements of that program was the 37-mm, six-barrel Gatling weapon that achieved a firing rate that has never been equalled for that large a round. The wide application of aluminum in both hull and turret resulted in a self-propelled system weighing less than 27,000 pounds.

The Vulcan air defense system represents a significant shift in air defense philosophy. The keynote is simplicity. The armament approach is the same as that employed on Vigilante (Gatling gun) but scaled down in range and lethality with Chaparral covering the longer ranges. Pulse-doppler radar is employed but only to perform the range tracking function. Detection is accomplished by an off-mount search radar and on-mount visual observation. The fire control performs a simplified solution with some sacrifice in accuracy.

An obvious question at this point might be—is a new air defense weapon system required in the foreseeable future or can present systems or improved versions meet the need? Consider the evidence. Aircraft speeds contine to increase. Operational altitudes are dropping by virtue of terrain following and avoidance techniques. These combine to reduce exposure time to air defense systems. The around-the-clock threat is becoming a reality. Aircraft density continues to increase, compounding the IFF problem. Radar cross sections are decreasing, making targets more difficult to detect, and jamming techniques are reaching higher and higher degrees of sophistication.

To be effective against such a potential threat, the engagement sequence must be rapid and positive. Targets must be detected at the earliest possible moment. Visually searching a defended sector and identifying a threat in that sector is too slow. Operation after dark in clear weather, in addition to daytime, will be a minimum. Ordnance must be delivered accurately to maximize probability of hit, and lethality must be great enough so that a hit results in a kill.

A system is needed that can provide such a capability and do it very reliably. Fortunately, the state-of-the-art has advanced very rapidly during the past few years. By taking advantage of the techniques resulting from these advances, a system having the required capability can be realized that will reliably perform the mission. Integrated circuits permit radar and computer electronics that are smaller, lighter, and more reliable than hardware using individual components. Small, highly reliable, lightweight digital computers, compatible with the space and weight limitations on a highly mobile system, are available to perform fire control computation and targeting. Rate integrating gyros small enough to be incorporated directly into a tracking system have been developed. Low light-level amplification that can be incorporated into an optical tracker can greatly enhance SOT usability. Smaller, more reliable servo components are available. Much better and more consistent radar clutter rejection is possible. Monopulse, combined with pulse doppler, can provide excellent radar tracking in clutter. Power traveling wave tubes used as radar power amplifiers permit frequency agility. Increased muzzle velocity and gas gun drive can greatly improve weapon performance.

UNIVAC's Excalibur would take full advantage of these advances to provide a system that would constitute a potent adversary for all aircraft. Excalibur is described in the following paragraphs as well as some of the philosophy that was employed in configuring the system. Figure 2 illustrates the system's capability in both the air defense and ground roles.

Surveillance and Detection

It is a well-established fact that the operator must be assisted in the role of target detection, especially for targets flying at very low altitudes. Excalibur will be equipped

with an on-mount radar detection system with sufficient range so that targets can be detected and successfully engaged without any advance warning from off-mount radars. This capability, coupled with longer range detection systems off-mount that could provide advance warning, provides excellent detection. With such an arrangement the weapon system effectiveness is not seriously degraded if targeting data from an off-mount system are not available or cease as a result of the off-mount system being inoperative or the communication channel between the two being interrupted, jammed, or captured.

Figure 2. Excalibur in action (artist's concept).

The pulse doppler detection/acquisition radar will employ a fan-beam radiation pattern. Such a radar can provide clutter-free data on the entire volume of interest with every revolution of the antenna. Pulse doppler techniques have now been perfected to the point that excellent subclutter visibility can be achieved. Digital video processing utilizing the on-board general-purpose digital computer will greatly assist the operator, especially when aircraft density is high.

Threat Evaluation - IFF

IFF will be integrated into the Excalibur concept as a basic system element. In the high aircraft density situations in which such a system must be effective, off-mount IFF transmitted to the gun system operator is not adequate. An example of this integration is that both the IFF antenna and the detection/acquisition radar antenna have been designed into a single, mechanically steered planar array.

Acquisition

For target engagement to be successfully executed, acquisition must be accomplished in an extremely rapid and efficient manner and automated to as great an extent as possible. With exposure time of a high-performance aircraft to a ground-based weapon probably being less than a minute, every second counts. Accurate positioning of the tracker in azimuth will minimize tracker elevation acquisition time. Accurate target azimuth can be obtained by incorporating an azimuth monopulse tracking capability into the detection/acquisition radar. This approach has been built and system-tested. Computer-derived target data could also be used to accurately position the tracking device in azimuth for subsequent acquisition in elevation.

Target Tracking

The fair weather day-night system will utilize an optical tracker equipped with image intensification as the primary tracker. On the all-weather system the operator can utilize the pulse-doppler monopulse radar tracker or the optical tracker at his discretion.

Stabilization will be incorporated directly into the tracking system, eliminating the complexity of stabilization remote to the tracker. Internal stabilization is now feasible by virtue of the availability of small gyros that can be placed directly on tracker gimbals. Inertial sight-line rate measurement and gun-line stabilization during firing have been established as essential for a highly accurate system.

Stabilized optical tracking of targets by a human operator has been repeatedly established as an essential capability of any effective forward area air defense system that must operate against high-speed, low-flying aircraft. The introduction of human intelligence and judgment into the acquisition, decision-making, and engagement functions is extremely important in the achievement of tactical effectiveness. Such a tracker has been built and successfully system-tested under firing conditions.

The all-weather system will employ a pulse doppler monopulse track radar. The combination of pulse doppler and monopulse techniques results in a device that can track moving targets very effectively in clutter. A narrow elevation beamwidth will be employed to reduce the effects of multipath at low tracking angles. To achieve a narrow beamwidth in elevation while maintaining an antenna size compatible with the total system dictates the use of a relatively high RF frequency.

Tracking the target in range will be accomplished by a digital early-late gate range tracker.

Prediction and Ballistics Computation

Excalibur will employ a small, lightweight, general-purpose digital computer to perform many functions, but by far the most important is the computation of prediction and ballistics. A digital computer is not subject to wear, age, and environmental sensitivity as are the analog computers that have been used for such applications. Also, the reliability of digital computing elements exceed that of analog elements by a substantial margin. At present, the cost of the digital computer is somewhat higher than that of an equivalent analog computer for solving the fire control equations alone. However, the flexibility, multiple-usage, time-sharing features of the digital computer can provide greater overall cost effectiveness. Such functions as self-test and automatic checkout of other subsytems, radar data decoding, targeting decision, and IFF processing can also be accomplished between target engagements.

In computing prediction and ballistics, the computer in the Excalibur system is required to compute the distance that the target will travel during the projectile time of flight and the distance that external forces will displace the projectile during the time of flight. The accurate computation of these two vectors constitutes a complete and accurate fire control solution as compared to the approximate solution obtained with a disturbed reticle computing sight.

Ordnance Delivery

The medium-caliber, six-barrel Gatling gun that would be employed on Excalibur will reflect many advances in weapon design. Muzzle velocity will be significantly increased; hence, the time of bullet flight reduced. Gas gun drive will be employed, allowing the firing rate to be reached more rapidly and maintained throughout the burst.

Secondary Ground Role

Excalibur would be extremely effective as a ground role weapon. The operator, at his discretion, could select armor-piercing or antipersonnel rounds for ground role. The firing rate, of course, will be reduced from that used for air defense.

Conclusions

Few weapon systems have been so exhaustively studied and analyzed prior to full-scale development as has Excalibur. Feasibility has been firmly established. Critical areas have been resolved through hardware design and system test, including firing tests. Extensive data on the effect of gun reaction on the remainder of the system have been obtained. These factors collectively indicate that Excalibur is a highly desirable air defense weapon system.

BY WILLIAM T. LEE

SOVIET MILITARY INDUSTRIAL COMPLEX

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'Officially, the Soviets deny having a counterpart, on the grounds that the absence of a profit motive makes such a complex impossible in the USSR.'

To define strategies and concepts, to develop and produce hardware, to train and maintain forces, and to evaluate the potential effectiveness of various force options, each of the two superpowers employs a large number of people in a variety of military and civilian institutions. The cost to both countries recently has been roughly 10 percent of their respective Gross National Product (GNP), although the relative share of U.S. GNP devoted to national security is now declining and may soon approach post-World War II lows.

In the United States, the term "military-industrial complex," increasingly used in a pejorative sense, has come into vogue to describe the people and the institutions engaged in the broad spectrum of national security activities. Officially, the Soviets deny having a counterpart, on the grounds that the absence of the profit motive makes such a "complex" impossible in the USSR. But, on both sides, most of the individuals involved work for wages rather than for profit, and personal ambitions and the quest for power and perquisites know few national or political boundaries.

To gather some perspective on the Soviet counterpart of the U.S. military-industrial complex, it is useful to distinguish four aspects:

—The institutional structure charged with developing military doctrine and strategy in the USSR;

—The organization of weapon development and production;

—The characteristics and quantities of the weapons actually fielded;

—The budget trends and economic consequences of military (and space) programs. It also is of interest to examine some of the principal tenets of Soviet military doctrine, to compare them with comparable U.S. strategic concepts, and to ask whether or not Soviet doctrine appears to guide force development.

INSTITUTIONS AND STRATEGIC CONCEPTS

In the Soviet Union, the government and the Communist Party constitute highly overlapping bureaucracies. Aside from collective farming and some private housing construction, all economic activity is carried on by the ministries, committees and administrations of the government. The same is true for almost all social services (health, education, welfare) and cultural activities (stage, cinema, publishing).

Premier Kosygin and his two first deputy ministers are members of the Politburo of the party, while all nine deputy ministers are members of the Central Committee. Marshal Grechko, the Minister of Defense, and eight of the eleven deputy defense ministers are also members of the Central Committee. Some 28 other ministers and 40 high officials of the government are also members of the Central Committee, but no organization is so well represented in the highest party circles as the Ministry of Defense.

Taking the general political policies of the party, particularly those of the current dominant party leader, as the basic guidelines, the military officers work out the principles of Soviet military strategy and doctrine, and elaborate force requirements and principles of force application. These activities are carried out by two roughly parallel structures within the Ministry of Defense. One group represents the "line" military officers who take their advanced degrees in military science and history and whose books and articles are published under the auspices of the Military Science Admin-

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istration, the Academy of the General Staff, and the Frunze Military Academy.

The second group represents the "political" officers who take their degrees in Marxist-Leninist philosophy and whose works are published under the auspices of the Lenin Military-Political Academy of the Main Political Administration of the Soviet Army and Navy. Although formally a part of the Ministry of Defense, the Main Political Administration, "acts as a department of the Central Committee." These political commissars not only participate in the elaboration of doctrine and strategy along with the line officers, but are also charged with monitoring the work of the latter to ensure that it corresponds with the party line.

Although some Western writers have been known to complain about the lack of public information on Soviet strategy and doctrine, while others challenge the relevance of that which is published, the literary output of the line officers and of the political commissars is both voluminous and informative.

For example, one of the interesting results of recent research is that the two young colonels whose writings in unclassified journals have been interpreted as militarily "hawkish" by Western analysts of the Soviet scene, apparently are political commissars. The authors, Lt. Cols. Rybkin and Bondarenko, received their degrees in philosophy from the Lenin Military-Political Academy and almost certainly are instructors in the Marxist-Leninist philosophy department of that same academy, in which case they report to General Yepishev, who, as head of the Main Political Administration, is the Chief Commissar of the USSR armed forces. Thus, the "hawks" do not appear to be spokesmen for military "hard-liners" at odds with the political leadership. More likely, they are spokesmen for the Central Committee in the dialogue with the line military officers, particularly when the "young colonels' " articles carry the explicit endorsement of General Yepishev's journal, *Communist of the Armed Forces*, which happens to be their favorite literary outlet.

There are a number of fundamental issues on which it is difficult, if not impossible, to find evidence of disagreement between the "political" and the "military" leaders, e.g., the tenets of Soviet military doctrine, which include both retaliatory (deterrent) and counterforce (war fighting) objectives; the idea that "victory," defined as the survival of socialism and the demise of capitalism, is the objective if a nuclear war occurs; and the primacy of the political goals which the power of the Soviet armed forces are to further. The line military officers consistently attribute the basic political principles of Soviet military strategy and doctrine (e.g., the nature of modern war, the concept of just and unjust wars) to the political leaders.

This is not to say that there are no arguments between politicians and soldiers, some of which are evident and some of which are hidden in Soviet secrecy. We do know that the Soviet marshals and Khrushchev clashed over further reductions in the armed forces below roughly the 3.5 million-man mark, and disagreed fundamentally about Khrushchev's proposal to turn the Red Army into a territorial militia. The marshals won these arguments.

Also, although most military men in the Soviet Union seem to prefer missiles to aircraft, there were those who believed that Khrushchev went too far in deemphasizing the role of aircraft. There were also disputes about the probable duration of a nuclear war and the role of tanks therein. Line military officers were found on both sides of the latter arguments, and, even in the case of the size of the armed forces, the line officers may have found the political leaders less than unanimous in support of Khrushchev.

Since Brezhnev and Kosygin have taken over, evidence of disputes even on such issues is scanty. Much of what has been accepted as evidence of continuing policy disputes between the marshals and political leaders is based upon writ-

Photos: NOVOSTI Press Agency

ings of the military hawks. In view of their institutional location on the political commissar side of the house, one may suggest that, if some of the truculent words written by the young colonels do indeed reflect disagreements on major policy issues, then the contending factions cut across the formal lines of the party, government and military bureaucracies. Moreover, when Lt. Col. Bondarenko extols the primacy of politics on the one hand, while arguing that military affairs are a "relatively independent sphere of social activity" on the other, he may not be challenging party control over the military at all. Bondarenko simply may be trying to define the respective roles of politicians and line officers in military force planning, just as the Soviets have long struggled with the problem of defining the roles of the political commissar and of the unit commander in the field. He may be saying that, although overall policy direction is the province of the political leaders, they should not meddle too much in the details of weapon system design, force planning, organization and tactics, and the like, where the experienced judgment of the professional military officer is not to be regarded lightly.

Whereas U.S. military strategy in the nuclear age has tended to limit itself to deterrence based upon the fear of high levels of destruction that would be inflicted on any attacker by surviving U.S. offensive forces, the USSR has evolved what might be termed a "classic" strategy that emphasizes balanced offensive and defensive forces. The Soviet objectives are quite different from simply destroying as much of the adversary's urban population as possible. Their strategic concepts do not fit neatly into any of our concepts of "finite deterrence," "massive retaliation," or "surprise attack."

Strange as it may seem to many Americans, the Soviets fear a surprise attack from the United States and its NATO allies, but also believe a war between the superpowers would be more likely to arise out of a confrontation-crisis situation. Contrary to the American expectation of complete destruction of each other's societies as the result of a nuclear exchange, e.g., 120 million dead on both sides as stated repeatedly by Mr. McNamara, the Soviets seek to survive the exchange as a viable, recuperable national entity. They do not seem to have the "equal appetite for fatalities" often ascribed or imputed to them.

The Soviets, political and military leaders alike, continue to accept two of Khrushchev's theses of fifteen years ago: it may be possible to deter the capitalist attack on the USSR (i.e., "war is not totally inevitable"), and nuclear war is too dangerous to be used as a premeditated instrument of achieving political goals by military means. Thus, some of the salient tenets of Soviet military doctrine are:

- To deter a surprise attack on itself by maintaining a secure second strike force;
- To be prepared to deliver a counterforce strike designed to limit damage to the USSR by reducing the number of missile and aircraft attackers with which the USSR defenses must cope;
- To combine active (air, missile, ASW) and passive (civil defense combining urban evacuation with shelters for those remaining) defenses to limit damage to USSR population and industry, while using Soviet theatre strategic nuclear and general purpose forces to seize Western Europe as intact as possible;
- To emerge from the nuclear exchange, albeit badly battered, as a viable, recuperable national entity capable of ensuring that "socialism" rather than "capitalism" would inherit the postwar world.

Most of this is quite explicit—not only in the late Marshal Sokolovsky's widely studied book, *Military Strategy*, but also in books and articles published by the political (party) commissars.

Suggestions of Soviet willingness to enter into a mutual

suicide pact based upon overwhelming nuclear strikes designed to destroy the very fabric of the society are rare indeed, and short lived when they do appear. This sort of idea does not appeal to them as Russians or as Marxists. And, while the military continues to talk about "victory," they do not see any possibility of emerging from a nuclear war relatively unscathed. Therefore, no preventive war advocates seem to be represented among the Russian military.

On the other hand, the doctrine gives equal weight to counterforce strikes designed to limit damage to the USSR and to retaliation in the second strike mode. Accordingly, their doctrine explicitly lists the enemy's delivery systems, military industries, military facilities and forces in the field, and centers of political and military administration, rather than population per se, as the prime targets.

DEVELOPMENT & PRODUCTION OF WEAPONS SYSTEMS

As in the case of military doctrine, the development and production of advanced weapon systems and space vehicles is carried on by the USSR government in a highly integrated bureaucratic structure whose outline is relatively easy to establish but whose inner workings are not well understood.

The products of the industrial establishment often are paraded through Red Square, and further insight into what has been going on in Soviet weaponry is released periodically by the U.S. government. But, whereas there is a vast amount of information published on civilian production in the USSR, one will search in vain for a journal, or even an article, on the military industries. (If there is a counterpart of ARMED FORCES MANAGEMENT in the USSR, even its existence is highly classified.)

The czars of the Soviet industrial complex charged with developing and producing military and space hardware probably are D. F. Ustinov, who has a long history of successful management in military industry and currently is a candidate member of the Politburo and a secretary of the Central Committee, and L. V. Smirnov, who is a first deputy chairman of the Council of Ministers and a member of the Central Committee.

As was pointed out in an article in the August 1969 issue of *Fortune*, the industrial establishment supporting the military and space programs represents an "economy within an economy" enjoying perquisites, privileges and priorities denied to civilian activities.

Very little is known about the process of military planning in the USSR. Apparently, ad hoc groups consisting of industrial specialists, scientists and military officers—many of whom have advanced degrees in the sciences—often are created to solve special problems. It seems clear that much of the planning is done by some combination of the Ministry of Defense and the supporting defense industrial bureaucracy, abetted by scientists working within that bureaucracy and also drawn from external sources such as the Academy of Sciences, all subject, of course, to final approval by the party hierarchy.

Ten ministries (of a total of 54 plus 12 state committees) probably are responsible for most of the weapon development and production in the USSR. These are: general machine building, instrument manufacturing, aviation, automobile, defense, radio, medium machine building, shipbuilding, tractor and agricultural machine building and electronics. A number of other heavy industrial ministries, such as chemical, probably also are engaged in the program to some degree.

One of the primary ministries, medium machine building, is suspected to be the USSR equivalent of the AEC.

The ministers and senior officials of these ministries, and the engineers and scientists employed by them, presumably represent industry's planning cadre for Soviet advanced weapons and space technology.

Development of weapons and fabrication of the operational hardware basically is carried on in two kinds of facilities subordinate to the Ministries: the factories (zavods) and a special set of R&D facilities having a variety of designators. Slightly oversimplified, the R&D facilities do the design work and fabricate the prototype and test hardware. When the system is proved to the satisfaction of the military, the blueprints and specifications are turned over to the factories for series and mass production.

A closer look at these R&D institutes, which probably also build much of the hardware for the USSR space programs, is worthwhile.

'Strange as it may seem to many Americans, the Soviets fear a surprise attack from the United States and its NATO allies . . .'

Above, from left to right, First Secretary of the Central Committee of the Communist Party Leonid I. Brezhnev; Premier and Chairman of the Council of Ministers Alexsei N. Kosygin; and President and Chairman of the Presidium of the Supreme Soviet Nikolai V. Podgorny. Many Western observers believe that of the three, Brezhnev is the most powerful and also most closely allied with the Soviet military-industrial complex.

Over the years the USSR has evolved a rather distinct institutional structure and pattern for the performance of RDT&E activities. Essentially there are three categories of facilities performing RDT&E functions:

1) The USSR and the Republic Academies of Science, scientific research institutes (NII) subordinate thereto, the faculty of educational institutions, and scientific-technical societies. By and large, these institutions seem to concentrate on basic research, although it would be surprising if they did not occasionally build some highly specialized or prototype item of hardware. But the number of these is evidently small. Senior scientists from the academies and the universities almost certainly act as consultants and reviewers, although very little is known about the process.

2) The scientific research institutes, design-development bureaus and technological-development institutes—NII, SKB, OKB, TSKB, and NIPII. Most of these institutes are subordinate to the industrial ministries and concentrate on applied developmental activities, the "DT&E" of RDT&E, although some basic research also is carried on in these organizations. Typically, the NII and the various types of KB are large organizations with extensive laboratory and production facilities. Jurisdictionally and administratively, however, these institutions are separate and distinct from the factories, even when they report to the same minister.

3) Factory laboratories and design bureaus, and technical institutes. These are heavily oriented toward design and development work but operate on a limited and fragmented basis compared to the NII and KB facilities. Only about two percent of R&D in the USSR reportedly is performed by the factories.

According to N. O. Tyamshanski, a Soviet author who has written the best book by far on the subject, the historical evolution of the R&D institutions has been intimately connected with the military establishment, and many of the NIIs and KBs were created specifically to design military hardware.

The closest U.S. analogs are the arsenals and government laboratories and certain specialized facilities of the larger corporations. In 1962, there were some 170 "scientific research institutes" (NII) and nearly 1,500 design-development bureaus (OKB, SKB, KB) in the machine building industries (such as the ministries noted above) where the bulk of RDT&E activity is carried out. By 1965, these R&D facilities employed more engineers than all of the factories combined.

If peace should break out suddenly, the Soviet industrial establishment devoted to the development and production of advanced weapons would have some problems in converting to civilian production, although not necessarily as serious as those the United States would face.

Officially, of course, the Soviets say there would be no problem at all. To be sure, the state is the employer in the first and last resort. The USSR officially does not even acknowledge the existence of a small amount of frictional (voluntary) unemployment for which there is good evidence. Most Soviet factories, like many American corporations, produce both military and civilian products. So the Soviet Union probably could cope with a very rapid conversion to civilian products more easily than the United States, but they would have problems too.

In the meantime, it is evident that the industrial complex supporting the Soviet military and space programs has a great deal of institutional momentum. Just as each Soviet ministry and each Soviet factory is expected to turn out more and, hopefully, better products in every annual and five-year plan, the Soviet R&D facilities and factories point toward more and better weapons in each planning cycle.

This process can probably be reversed only by very major changes in defense and foreign policy, which would require some years to assimilate into the system.

According to Soviet military writers, the "revolution in military affairs" began in the late 1950s when missile technology reached the point where it could be introduced into all branches of the Soviet armed services on a large scale and when nuclear warheads began to become plentiful. This "revolution" was in large part the handiwork of Nikita Khrushchev, even though the cost of the buildup ultimately contributed to his political undoing.

The steady Soviet buildup in strategic offensive and defensive forces since 1958 seems to be consistent with, and probably derived from, the strategy and doctrine worked out by the political and military intellectuals during the early 1960s. As a result, the U.S.S.R. has achieved and continues to maintain a large margin of superiority in theatre nuclear forces. It has surpassed the U.S. in number of ICBMs and is rapidly catching up in submarine-launched ballistic missiles (SLBMs), has a vast air defense establishment which continues to be modernized and has deployed Ballistic Missile Defense (BMD) in Moscow. The U.S.S.R., however, still lags behind the U.S. in several key areas of military technology, such as development of Multiple Independently-targeted Reentry Vehicles (MIRV). Whether the Soviet political and military leaders will continue to drive for balanced offensive and defensive forces in the future depends upon a number of political and economic uncertainties.

FORCES IN THE FIELD

The scale and timing of Soviet strategic missile deployment programs, as compared to the U.S., now can be reconstructed from data in the public domain and is shown in Figures 1 through 3. Figure 1 illustrates one of the facets of Soviet policy often overlooked in this country, namely, the priority given to Eurasian strategic forces over intercontinental forces when there has been a choice between the two. While the U.S. tends to focus on the direct intercontinental relationship, to Russian political and military leaders the strategic problem begins at the border of the Soviet Union. Thus, the U.S.S.R. built medium bombers (about as many as we did) at the expense of the heavy, intercontinental models. And there was, and still is, a strategic missile gap in Eurasia.

The ICBM gap (Figure 2) turned out to be in favor of the United States for many years because the U.S.S.R. decided in the late 1950s to put first priority on acquiring some 700 intermediate- and medium-range ballistic missiles (IR/MRBMs). When that deployment was completed, they proceeded to catch up and then surpass the U.S. in the number of ICBMs, despite our confidently stated predictions of the mid-1960s that the U.S.S.R. would not do so. The Soviets are expected to have 1,250 operational ICBM launchers by the middle of this year. Allowing for normal backlog of launchers in process, this means an eventual force of about 1,500 if new construction ceased this year.

Currently, our expected upper limit of the Soviet nuclear SLBM force (Figure 3) is 800 launchers by 1974-75. The U.S., with a ceiling of 1,054 ICBMs and 656 SLBMs, can keep pace and stay ahead in the number of warheads by deploying MIRV. Evidently, however, the Soviet leaders have been following their own prescription of quantitative and qualitative superiority as the design goal of their forces.

Enough information is available to put forward the hypothesis that the Soviet force posture is consistent with, and probably derived from, their strategic concepts. This hypothesis can be illustrated by running through a checklist of known characteristics of Russian strategic offensive and defensive forces.

- In line with the Soviet doctrine to have both a retaliatory and a counterforce capability, the U.S.S.R. has bought systems designed to attack both hard and soft targets. Judging from the proportion of roughly three of the smaller, *Minuteman*-class SS-11 ICBMs to each of the huge SS-9 launchers, as reported in the press, the U.S.S.R. probably has placed about equal priority on weapons able to hit soft and hard targets. Multiple warheads are being tested on the SS-9, apparently to increase the number of hard targets these missiles can attack. The SS-9-launched Fractional Orbital Bombardment System (FOBS) could avoid U.S. Ballistic Missile Early Warning System (BMEWS) radars in attacking bomber bases. The *Yankee*-class SLBM program improves the survivability of the force and extends the options available to Soviet planners.
- In contrast with the U.S.—which has cut back its air defenses and added only a very modest degree of modernization, delayed on BMD until the *Sentinel* decision and the now much disputed (and stretched out) *Safeguard* program—the U.S.S.R. has placed heavy emphasis on expanding and modernizing its air and missile defenses. New generations of fighter aircraft have been introduced as part of a standard five-to-seven-year deployment cycle evident in the periodic Soviet air shows. The supersonic all-weather *Flagon* interceptor is the latest aircraft to enter service, and the *Foxbat*—the Soviet version of the U.S. F-12—probably will

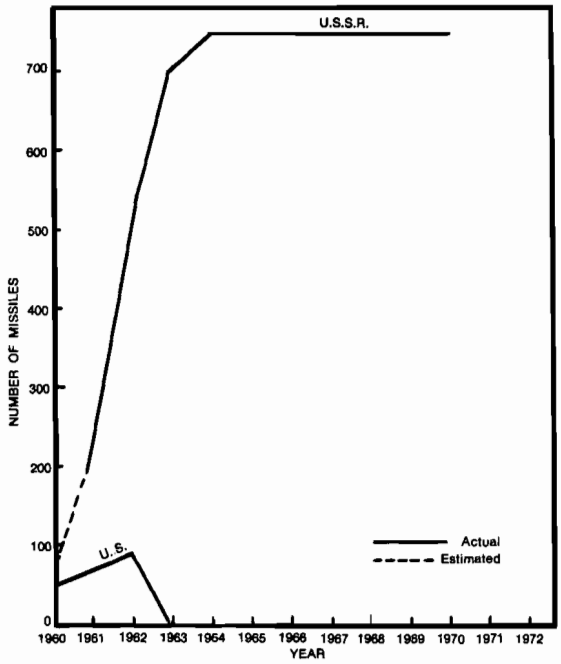


Figure 1: U. S. - U.S.S.R. IRBM/MRBM DEPLOYMENT

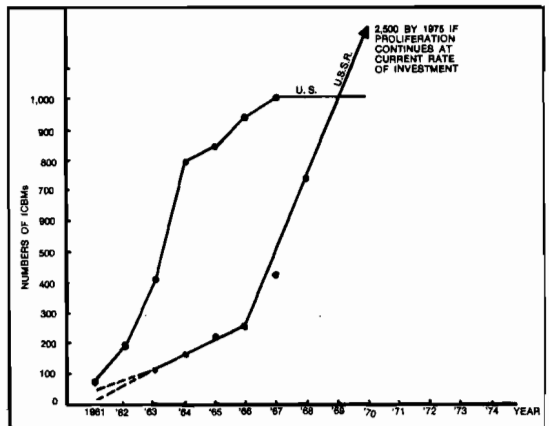


Figure 2: U. S. - U.S.S.R. ICBM DEPLOYMENT *

** The Soviet ICBM build-up curve illustrates the continuity of policy between the Khrushchev and the Brezhnev-Kosygin regimes. In order to begin the build-up in 1966, Khrushchev had to have taken the basic development decisions on the huge SS-9 ICBM and the smaller* Minuteman-*size SS-11 in 1961-62, and the initial deployment decisions prior to 1964. While the ultimate size of the deployments approved by Khrushchev is unknown, Brezhnev and Kosygin evidently did not change the rate at which Khrushchev started. Had they done so, the straight line build-up in operational launchers in this chart would have a decided change in slope. Development of the* "Yankee"*-class SLBM also dates from Khrushchev's time, as does the Fractional Orbital Bombardment System (FOBS).*

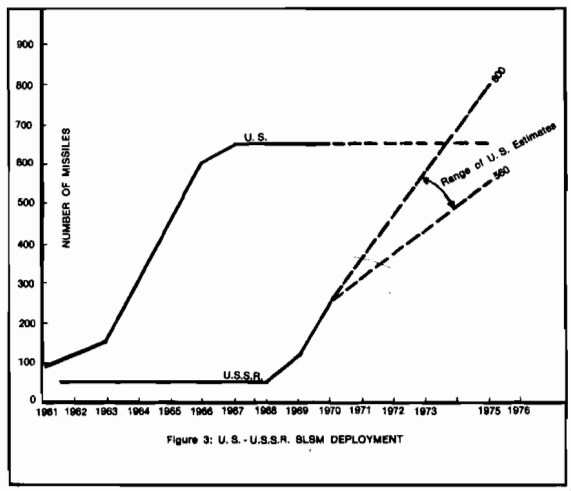


Figure 3: U. S. - U.S.S.R. SLSM DEPLOYMENT

be introduced in the near future. A Soviet airborne warning and control system (AWACS) also is being introduced, presumably to work with these and other late model air defense fighters.

The U.S.S.R. is continuing to deploy the surface-to-air SA-5 missile, probably to preclude any future U.S. high altitude, high-speed bomber attack options. One new low-altitude SAM has been displayed in recent years and either this or an even more advanced system now in development may be deployed in the 1970s.

Ballistic missile defense of Moscow is nearing completion, and both improvements on the missile for this system and development of components for a follow-on system that might be more suitable for national deployment have been reported.

• The naval contribution to Soviet strategic defenses already is impressive and may become more so in the future. The Soviets now have some 30 nuclear-powered submarines carrying cruise missiles (six to eight launchers each) and about an equal number of diesel-powered, cruise missile-equipped submarines. The primary mission of this force, working in conjunction with the large naval air arm, probably is to attack U.S./NATO aircraft carriers at sea. Several new classes of Soviet general purpose submarines, probably intended for both ASW and ocean interdiction missions, have also been reported. Meanwhile, the Soviets appear to be modernizing their surface fleet to emphasize the ASW role, as evidenced by new helicopter carriers and cruisers and other new classes of surface vessels. Although difficult to sort out at this time, a major ASW program, probably aimed at counteracting the U.S. *Polaris/Poseidon* fleet, evidently is under way.

• The Soviets have a large and well organized civil defense program integrated into the Ministry of Defense and commanded by Marshal V. I. Chuykov. In addition to the inherited shelters in apartment buildings constructed before 1960, the Soviets are continuing to build shelters in factories and public buildings, although no details of the scale of the program or of shelter specifications are available. The entire population receives civil defense training as they pass through the educational system and again as adults. Even allowing for the apathy that undoubtedly attends a mass program of this kind, the effort is rather impressive. Given the compactness of Soviet cities, the absence of large numbers of private cars—only about one million passenger cars currently in the hands of bureaucrats, public institutions, and private in-individuals—and Soviet capabilities to organize the population, the plan for urban evacuation carries some plausibility.

• In accordance with the doctrinal emphasis on balanced forces and the defeat in 1962 of Khrushchev's proposal to turn the Red Army into a territorial militia, the Soviets continue to maintain large ground and naval general purpose forces supported by tactical air arms. Here, the pace of modernization appears to have proceeded more slowly than in the strategic areas. Thus far, emphasis seems to have been on improving tactical nuclear capabilities using missiles and

rockets as primary delivery systems. For several years Soviet doctrine has been evolving toward allowing for some sort of conventional war—such as one between NATO and the Warsaw Pact—although the Soviets seem to expect any such conventional conflict would be very brief before escalation occurred. There is as yet, however, little evidence of changes in the Soviet general purpose forces to improve their non-nuclear capabilities. This probably will be a task primarily for the 1970s, if the Soviet budget will stand it.

In retrospect, the requirement for these programs was stated explicitly, albeit in general terms, in the major Soviet doctrinal statements of 1960-1962, and subsequently repeated many times. As was noted in Part I of this series (AFM, May 1970), the Soviets reject the notion of a preventive war at some predetermined time as an instrument of politics. But, while a nuclear war is not "inevitable," it could occur. The Soviets have thus concluded that there is a fundamental uncertainty as to who will make the first move in the event deterrence fails for any reason. They want to be able to limit damage to themselves if war appears inevitable, but they cannot confidently count on being able to do so. Hence they wish to maintain as many hedges as possible, to keep their planning as open-ended as possible.

The Soviets are also very concerned about a surprise attack on the U.S.S.R. They may overemphasize this concern in public statements, and sometimes use it in internal political polemics, but the concern seems to be sincere and durable. (After all, they lived through one surprise attack!) The Soviets think that such an attack could come out of a deep crisis, and they worry about attacks launched at the end of what would appear to be a normal U.S. training exercise. They also may have some confidence, but at the same time an irreducible uncertainty, that their intelligence net will give them adequate warning of an impending attack. In the face of such fundamental uncertainty, they want to be prepared to strike the first blow in order to destroy as many enemy weapons as possible before launch. At the same time, they must be prepared to survive and retaliate if the enemy succeeds in striking first. And they want defenses which are capable of blunting a surprise attack to some extent, and which might make the difference between the survival and the destruction of their society in the event they were able to use their offensive forces to reduce the weight of the attack. The objectives of "victory" and "defeat of the enemy," constantly stressed by the military and occasionally endorsed by civilian leaders, mean that the Soviets want to be able to fight a nuclear war if they must and to terminate it on advantageous terms. Over the years they have been acquiring what appears to be the kind of mix of deterrent and war fighting forces spelled out by this doctrine. Perhaps it is only institutional happenstance, but it could be the result of planning too.

BUDGETS AND ECONOMIC CONSEQUENCES

There is no better proof of the seriousness of Soviet military doctrine than the willingness of political leaders to pay for the weapon systems. The Soviet national defense expenditure (i.e., the equivalent of DOD, AEC and NASA in the U.S.) apparently rose more rapidly than the Gross National Product (GNP) in the early 1960s, and has grown at about the same rate as the GNP since 1964-65. The U.S.S.R. has devoted approximately 10 percent of its GNP to national security programs for some time, whereas the U.S. reached a peak of 10 percent in 1968, subsequently projected to decline to about 7.5 percent in 1971.

Whereas U.S. national defense expenditures contributed to economic growth prior to the Vietnamese war, defense outlays subsequently have been an important factor in the inflation plaguing the U.S. economy. In the U.S.S.R.. on the other hand, the cost of defense has contributed to the declining rate of economic growth observed over the last decade.

'THE SOVIETS HAVE CONCLUDED THAT THERE IS A FUNDAMENTAL UNCERTAINTY AS TO WHO WILL MAKE THE FIRST MOVE IN THE EVENT DETERRENCE FAILS.'

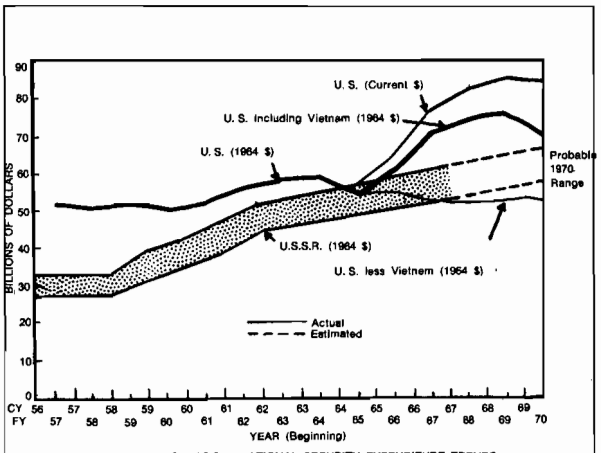


Figure 4: U. S. - U.S.S.R. NATIONAL SECURITY EXPENDITURE TRENDS (Includes DOD, AEC, and NASA Expenditures for U. S. and U.S.S.R.)

While neither of the explicit items listed for "defense" and "science" in the U.S.S.R. budget can be accepted as accurate measurements of either the trend or the magnitude of such expenditures, it is believed possible to arrive at a useful approximation of the actual national security budget by careful analysis of Soviet financial and industrial output data. The results of this analysis are shown in Figure 4, which compares U.S. and U.S.S.R. national security outlays from 1955 to date. The range of uncertainty in the U.S.S.R. data is due not only to the uncertainty of how many rubles the U.S.S.R. is spending, but also to the ratio at which one converts rubles to dollars.

The latest data available suggests that in 1970 national security probably cost the U.S.S.R. from $60-67 billion, or substantially more than the U.S. expenditures if the costs of the war in Southeast Asia are excluded.

A second comparison of interest is expenditures for research, development, test and evaluation (RDT&E) and space programs in the two countries. Figure 5 shows results of research on this subject, where the data are somewhat less reliable. Assuming that about 80 percent of U.S.S.R. RDT&E and space expenditures are devoted to military and space, the results of this independent approach again are roughly comparable to the $14-17 billion annual outlay currently estimated for Russia by the U.S. government. This compares with some $14 billion budgeted by the U.S. for FY 1971.

The economic burden of military RDT&E and space is

'THERE IS NO BETTER PROOF OF THE SERIOUSNESS OF SOVIET MILITARY DOCTRINE THAN THE WILLINGNESS OF POLITICAL LEADERS TO PAY FOR THE WEAPON SYSTEMS.'

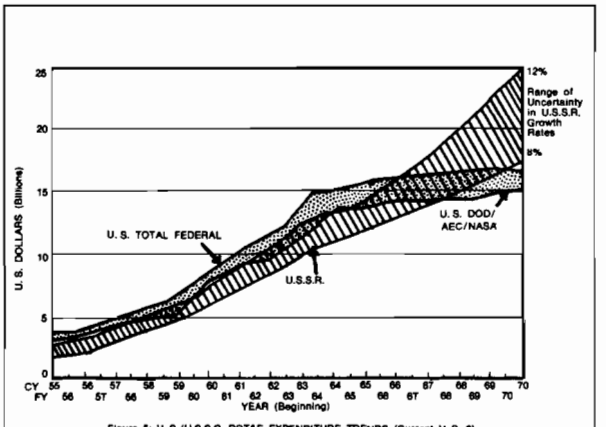


Figure 5: U. S./U.S.S.R. RDT&E EXPENDITURE TRENDS (Current U. S. $) (Includes DOD, AEC and NASA Expenditures)

much greater in the U.S.S.R. than in the U.S., however, because in this country federal spending for these purposes generally amounts to roughly 60 percent of total RDT&E outlays in the U.S. economy. The rest is accomplished by industry and other private organizations. Note also that, as in the case of total national security expenditures, the U.S.S.R. trend for RDT&E and space continues sharply upward, while the U.S. has leveled off or declined. In the case of R&D and space, U.S. federal funding since 1964 has expanded at less than the estimate of five percent per annum required for a more or less constant level of effort.

One of the most striking differences between the military establishments of the two superpowers is in their respective budgets for strategic offensive and defensive forces.

The U.S. reached a peak of about $12.6 billion (in 1966 prices) in obligational authority for strategic offensive and defensive forces in 1962, dropped steadily to a low of about $6.3 billion in 1967, rose to about $7.1 billion in 1969, and is now projected at about $6 billion for 1971, again in rough 1966 prices. Adding AEC costs probably would show some growth in 1971, but if R&D were added for the 1962-71 period, the trend might well be steadily downward. One of the few figures available for comparable U.S.S.R. outlays is the recent statement by Secretary of Defense Melvin R. Laird that the U.S.S.R. spent about $18 billion for strategic forces in 1969—well over twice the U.S. level. While nothing has been released on the distribution of the U.S.S.R. expenditures between offense and defense, the previous review of the observed forces suggests that the U.S.S.R. planners may split their budget fairly evenly between offense and defense, whereas the United States spends about 80 cents of every dollar for strategic offensive forces.

In order to support military expenditures of this magnitude over the past decade, the U.S.S.R. has had to devote about half of its durable output to the military, leaving 40 percent or more for its investment program. (The Soviet consumer gets 10 percent, or a bit less, of the durable output.) Consequently, the share of durables in the Soviet investment outlays has remained at about one-third, compared to two-thirds or more in other industrialized countries. The slow growth of producer durable output has also contributed to the declining growth of investment itself and, taken in conjunction with other secular factors, is one of the primary causes of the declining trend in the growth of the Soviet GNP.

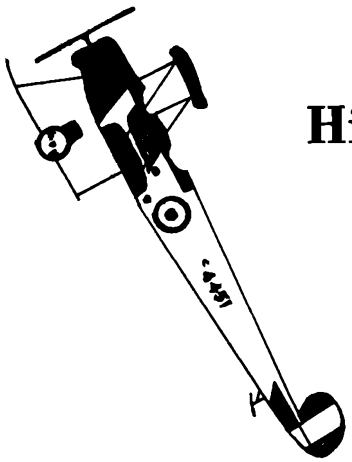
Thus, not all of the Soviet economic problems are the result of bad weather in agriculture and poor management. The evidence now available suggests that the cumulative effects of giving this kind of priority to defense (and space) over the past 12 years are particularly acute. Economic performance in 1969 was less than satisfactory. The 1970 plan goals are quite modest, and Brezhnev's December report to the Party on Soviet economic ills may never be published.

Some students of the subject allege that the Soviet "military-industrial complex" is opposed to the holding of Strategic Arms Limitations Talks (SALT). There are some signs of lack of enthusiasm evidenced in the military press treatment of the subject. On the other hand, the Soviet economy could use a respite, and the military leaders recognize that long-term economic growth is essential for a large and technologically up-to-date military establishment. The U.S.S.R. also could make good use of a slowdown in the arms competition in order to narrow the U.S. technological lead. On balance, the Soviet leaders may find continuation of the sacrifices of the past to be too high a price to pay for continued completion with the United States, and may doubt if the technological gap can be closed. On the other hand, they may view the progress of the last 25 years as being quite satisfactory, considering how far they were behind at the end of World War II. If they can stand the pace for another decade, they may be able to pull ahead. It is hard to say which way the arguments may go, and the whole problem is much complicated by the Chinese threat on the border.

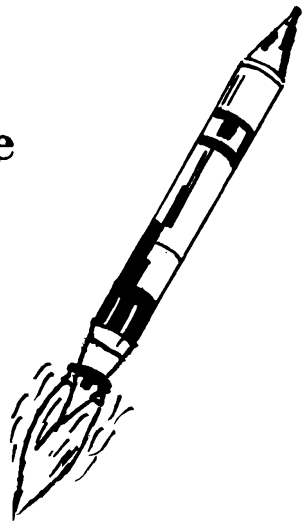
THE COMMUNICATIONS GAP

One thing does seem clear: The two military-industrial complexes have not been communicating with each other very well over the past 25 years. If one may venture a generalization, the U.S. tends to project our own "mirror image" into our perception of U.S.S.R. strategic concepts. The Soviets, for their part, tend to filter all of our ideas through the prism of Marxist-Leninism dogma. Hence, they lump together official U.S. strategic policies with the occasional preventive war theorist who has limited, if any, influence in U.S. policy-making circles. Instead of understanding the real evolution of U.S. strategies, the Soviets look upon each successive concept as being merely different words used to express what they see as the same U.S. aggressive intent under conditions in which Soviet strategic forces have caught up or exceeded those of the U.S.

Instead of assuming away the problem by imputing our own ideas to the Soviets, we might be well advised to concentrate on the communication problem as an essential first step. As long as each side has an inaccurate perception of the other's concepts, it may be difficult to reach agreements; and any agreements reached may soon come a cropper. ●



History of Air Defense



Editor's Note:

This sixth installment describes the principal allied and enemy aircraft employed early in World War II.

The British bombers operational in 1939 saw service throughout most of the war. For the most part, bombing by the British was done at night. Exceptions to this policy were missions flown by the De Havilland Mosquito (fig 1). Its performance surpassed any other aircraft available from September 1941 until early 1944. It was found that the Mosquito could outpace enemy fighters and, therefore, could be sent on long-distance daylight flights over enemy territory.

This led to roles for this plane other than as a bomber. The Mosquito proved to be highly effective as a long-range, photoreconnaissance plane, minelayer, pathfinder, high-speed military transport, long-range day and night fighter, and fighter-bomber.

In the bomber role, pinpoint targets could be hit with a high degree of accuracy. Attacks were made by combining high-speed, low-level passes with diving attacks to confuse antiaircraft defenses.

In late 1944, the B XVI emerged with a maximum speed of 408 mph at 26,000 feet, a service ceiling of 37,000 feet, and a range of 1,370 miles with a 4,000-pound bomb load. Mosquitoes attacked industrial targets and communications, and sometimes as many as 100 of these planes would bomb Berlin in one night. They were used also to lay airborne mines while flying only a few feet above the water.

The Avro Manchester I was the biggest and most powerful twin-engine bomber in the world, powered by the Rolls-Royce Vulture engine. The Vulture was two 850-hp engines placed together on a common crankcase. This gave the Manchester the weight and speed of the four-engine planes. The Manchester I first saw action in November 1940 but did not prove satisfactory because of frequent engine failure. As a result, the Manchester III was designed to use four Rolls-Royce Merlin engines. It was renamed the Lancaster.

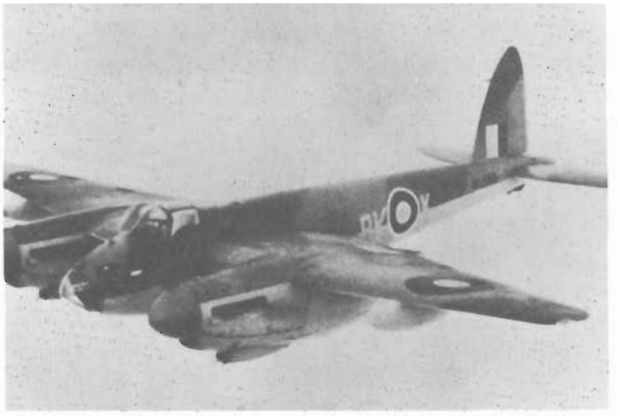


Figure 1. De Havilland Mosquito, bomber version.

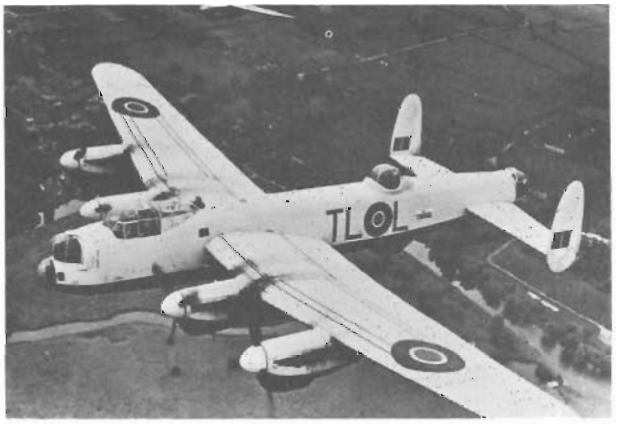


Figure 2. Avro Lancaster.

Figure 3. Short Stirling.

The Lancaster (fig 2), operational in 1942, rapidly became the major offensive weapon of the RAF. It had a maximum speed of 270 mph at 19,000 feet, a service ceiling of 21,500 feet, and a range of 2,230 miles with a 7,000-pound bomb load. Armament consisted of eight caliber .303 machineguns. Normal maximum bomb load was 4,000 pounds. With special modifications, one 22,000-pound "Grand Slam" deep-penetration bomb could be carried externally.

The spinning bomb was perhaps the most remarkable offensive weapon used by the Lancaster. It rotated as it dropped, and then would skip across the surface of a lake until it reached the dam where it would sink and explode under water. The bomb was intended for use against the Moehne, Eder, and Sarpe dams in the Ruhr. On the night of 17 May 1943 Lancasters attacked the dams, and millions of tons of water were released which forced great dislocation of German industry.

The Short Stirling four-engine bomber (fig 3) was virtually a flying battleship. It had a maximum speed of 280 mph at 14,000 feet and a range of 2,050 miles at 200 mph. It was equipped with three power turrets with eight caliber .30 machineguns and could carry 18,000 pounds of bombs. Initially, it was employed on both day and night operations, but its major role was as a night bomber. The Stirling was a weight carrier (18,000 pounds of bombs) and was referred to as the flying freight car.

The Handley Page Halifax first saw action in March 1941. It had a maximum speed of 270 mph and a range of 3,000 miles. Armament consisted of nine caliber .303 machineguns—eight in two four-gun hydraulically operated turrets (one amidships and one in the tail), and one manually operated machinegun was mounted in the nose. Maximum bomb load was 11,000 pounds.

The United States had 23 B-17's available at the start of the war. This promising aircraft became the leading strategic bomber in Europe. The B-17 (fig 4) underwent many modifications between July 1939 and July 1943 when production started on the B-17G. During this time, speed at 25,000 feet altitude increased from 268 to 287 mph; combat range increased from less than 1,500 miles with a 2,400-pound bomb load to better than 2,000 miles with a 4,000-pound load. Service ceiling increased from 30,000 to 35,000 feet. Maximum bomb load doubled from 8,800 pounds to 17,600 pounds, and armament was increased from 5 caliber .30 machineguns to 13 caliber .50 machineguns. Other changes included the addition of protective armor, bulletproof windshields, and improved equipment for communication, navigation, and flight control.

Development of the B-24 drew heavily on the experience gained with the B-17, but still many modifications were applied between 1941, when it went into production, and the end of the war.

The B-24J had a maximum speed of 300 mph at 30,000 feet, a service ceiling of 28,000 feet, and a range of 1,700 miles with a 5,000-pound bomb load. Major changes between the first B-24's and the B-24J's were as follows: Bomb load increased from 8,800 pounds to 12,800 pounds; armament increased from three caliber .50 and four caliber .30 machineguns to 10 caliber .50 machineguns; and more armor, self-sealing fuel tanks, power gun turrets, and improved flight equipment were added.

Except for modifications to increase range or bomb capacity, most changes were made to counter tactical or technical advantages of the enemy. Enemy fighters shot down B-17's by attacking from the rear until tail guns were installed. The earlier B-17's and B-24's were vulnerable to a head-on attack because the fields of fire of the forward-firing guns left a blind spot in front of the aircraft. On 23 November 1942, the German fighters changed their tactics from the rear attack, against tail guns and heavy armor, to a frontal attack. Frontal attacks accounted for most of VIII Bomber Command's losses. The need for protection was so great that authorization was given for field modifications. Most heavy bombers in Europe were equipped with some type of forward-firing armament by mid-January 1943. B-17's and B-24's that arrived, starting in August 1943, were equipped with a power turret in the nose.

Large, tight formations, stacked so that mutual fire support was provided by several aircraft, afforded the best protection against enemy fighters. However, large formations increased vulnerability to flak and decreased bombing accuracy by enlarging the bomb pattern.

The North American B-25 Mitchell was manufactured in larger quantites than any other twin-engine bomber. It saw service on every major front during the war and was used for day and night bombing and ground attack.

Produced in many variants, the principal changes were in armament and bomb-carrying capability. Speed and service ceiling remained relatively unchanged. Armament increased from two caliber .50 and three caliber .30 machineguns to as many as 18 caliber .50 machineguns. Some models were armed with a 75-mm cannon and 14 caliber .50 machineguns. Bomb load increased from 2,500 to 4,000 pounds. Maximum speed was 275 mph at 15,000 feet, service ceiling was 25,000 feet, and range was 1,275 miles with 3,200 pounds of bombs.

The Martin B-26 Marauder (fig 5) was employed in Europe and Africa as a long-range fighter and as a day and night bomber. (The B-26 Marauder is not to be confused with the current Douglas B-26 Invader. The latter, an outgrowth of the Douglas A-20, was operational in 1944 as the A-26 and was redesignated B-26 in 1948.) It achieved some success at the close of the Tunisian campaign as a fighter. Because of its heavy armament, long range, and relatively high speed, the Marauder was able to intercept German transports far out over the Mediterranean as they attempted to evacuate the German forces.

Operation as a low-altitude day bomber over the Continent was not successful because of the high loss rate. In November 1943, B-26's were employed by the Ninth Air Force in an intensive night interdiction campaign in France. In this role, the Marauder enjoyed almost immediate success. With the Ninth Air Force, the B-26 had the lowest loss rate of any American aircraft in Europe. The loss rate reached a point below one-half of 1 percent on missions against heavily defended French and German targets.

Of the many variants produced, the major change was in armament. Armament increased from four to 12 caliber .50 machineguns. Maximum speed was 274 mph at 15,000 feet, service ceiling was 19,800 feet, and range was 1,100 miles. Bomb load was 4,000 pounds. One model could carry two 1,600-pound bombs and one 2,000-pound torpedo.

The Douglas A-20 Boston (fig 6) was operational in 1940. Until 1944, when it was replaced by the A-26, it was used by the Americans, British, and Russians. It achieved

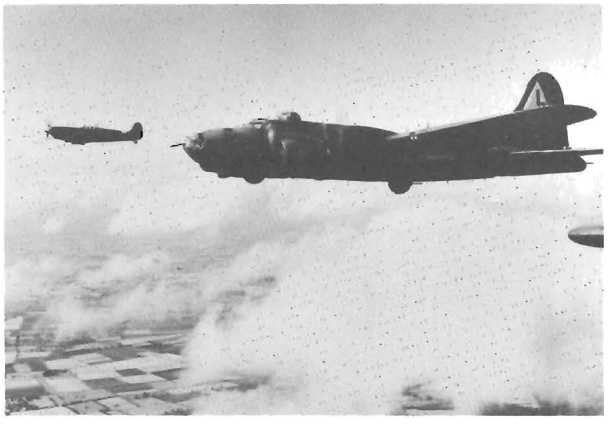


Figure 4. Boeing B-17F, shown here escorted by a Spitfire V.

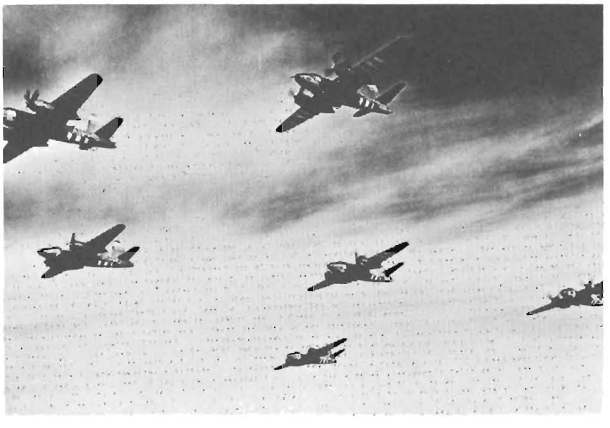


Figure 5. Martin B-26 Marauders, shown here with the special identification stripes worn by all Allied tactical aircraft during early stages of the invasion of Europe.

Figure 6. Douglas A-20. The night intruder version was called the Havoc.

success in the tactical and intruder role in Europe and North Africa. (In the Pacific, it was used in low-altitude attacks, dropping parachute fragmentation bombs with instantaneous fuzes.)

There were eight major models of the A-20. Between 1940 and 1944, the armament was increased from seven caliber .30 machineguns to as many as nine caliber .50 machineguns; some carried five caliber .50 guns and up to 12 5-inch rockets. The bomb load increased from 2,400 pounds to 4,000 pounds. The maximum speed of 325 mph and the normal tactical radius of 250 miles with a 2,000-pound bomb load remained about the same on all models.

The Douglas A-26 Invader was operational in Europe in 1944. Although an attack plane, it was the most advanced medium bomber used by the USAAF during the war. It was faster and carried a heavier bomb load than any of the medium bombers. The A-26 had a maximum speed of 360 mph, a service ceiling 22,100 feet, and a combat range of 1,000 miles with a 4,000-pound bomb load. Armament consisted of 18 caliber .50 machineguns and 14 5-inch rockets. Maximum bomb load was 6,000 pounds.

The German Junkers Ju-87 attained greater notoriety initially than any other weapon in the arsenal with which Germany launched World War II. It aroused greater controversy and was more widely discussed than many more worthy aircraft. With virtually no air opposition, the Ju-87 was able to exploit the accuracy of dive bombing. The use of the Ju-87 presumed control of the air, but the issue was settled in the Battle of Britain when their formations were decimated by Hurricanes and Spitfires. The dive bombers were withdrawn from the Cherbourg area. They did achieve some success against shipping in the Mediterranean and on the Arctic route to Russian ports. The Ju-87D had a maximum speed of 255 mph at 13,500 feet, a service ceiling of 23,950 feet, and a maximum range of 1,200 miles.

The Junkers Ju-88 was the true backbone of the Luftwaffe. It was produced in greater numbers than all other German bombers combined and appeared in many different models. The major variants were designed as dive bombers, torpedo bombers, and medium- and high-altitude bombers and for ground attack.

The first real test of the Ju-88A was the Battle of Britain. Even though it fared better than the other German bombers, it had some serious shortcomings. Modifications resulted in the Ju-88A-4. Defensive armament was increased and rocket-assisted-takeoff units were added which raised the bomb load to 6,614 pounds. A heavily armored ground attack version carried 16 7.9-mm machineguns and two antipersonnel bomb containers, each containing 72 small bombs; later versions were equipped with one 75-mm, two 37-mm, or one 50-mm cannon; the torpedo bomber could carry two 2,200-pound torpedoes and 3,300 pounds of bombs.

The Ju-88 (fig 7) was used as the lower component of the composite aircraft known as the Mistel (or termed "father and son" by the Germans). The upper component, which served as the control aircraft, was either an FW-190 or Me-109. The Ju-88 airframe contained a large hollow-charge warhead, and the pilot of the upper component operated all of the controls by radio. The Mistel was operational during the Allied invasion. It was intended primarily for use against capital ships and heavily protected land targets. Some successes were recorded for the Mistel. (In figure 7, the fighter pilot controlled both planes and guided the Ju-88 by radio after release. A B-17 over the Channel once investigated the combination and found itself being chased by the guided missile. Escape was made by dodging around a water tower over land, a maneuver the fighter pilot could not follow with his missile.)

Figure 7. Piggyback Ju-88/FW-190 combination.

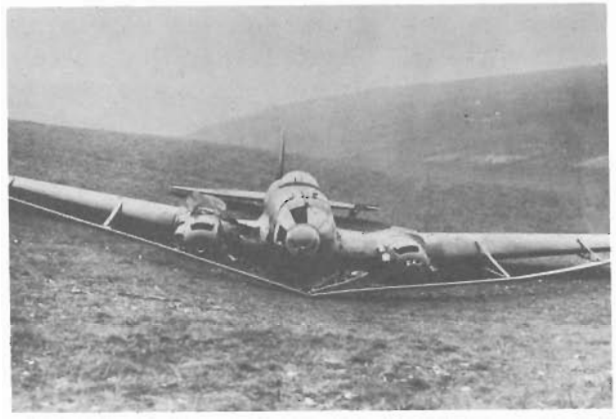


Figure 8. Heinkel He-111 with cable-cutting attachment.

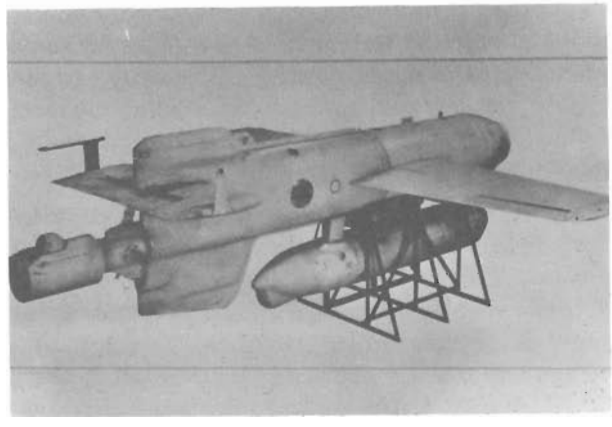


Figure 9. Hs-293 radio-controlled glide bomb.

The Ju-88A series proved too slow for day operations without a fighter escort. As a result, the Ju-188 was developed. It could carry 6,600 pounds of bombs and two 2,200-pound torpedoes. Armament consisted of two 20-mm cannon and two 13-mm machineguns. Maximum speed was 325 mph with a 3,000-pound bomb load. The high-altitude version had a pressurized cabin, a maximum speed of 429 mph, and a service ceiling of 38,400 feet and carried no defensive armament.

The Heinkel He-111 (fig 8) medium bomber bore the major burden of the German bombing offensive during the Battle of Britain. The He-111, with its armament of only three 7.9-mm machineguns, was no match for Hurricanes and Spitfires. Desperate measures were taken to add guns and armor, but loss rates remained high. After the Battle of Britain, the He-111 was switched from day to night bombing.

The H-series was the most important variant of the Heinkel. It appeared in a variety of subtypes. Employed in the antishipping role, the He-111H suffered heavy losses because of its limited armor protection, although it was highly suitable for torpedo dropping. The 111H-6 torpedo bomber could carry two torpedoes or 5,510 pounds of bombs. It had a maximum speed of 258 mph at 16,400 feet, a service ceiling of 25,500 feet, and a range with maximum bomb load of 760 miles. Armament consisted of one 20-mm cannon and six 7.9-mm machineguns.

The He-111H-8 was fitted with a combined balloon cable fender and cutter, an immense framework that extended from a point in front of the nose to both wingtips, and weighed 550 pounds. The He-111H-12 was modified to launch the Henschel Hs-293 bomb (fig 9), an air-to-surface radio-controlled missile. It could be launched from far outside effective antiaircraft range. The He-111H-12, carrying two Hs-293 bombs, was used with some success against shipping in the Mediterranean.

The He-111H-20 was fitted with larger engines and a three-speed, two-stage supercharger. It had a maximum speed of 295 mph and a service ceiling of 32,800 feet. Armament consisted of four 7.9-mm and three 13-mm machineguns.

The Dornier Do-17 was unsatisfactory as a day bomber during the Battle of Britain. Losses to British fighters were high because of the inadequate defensive armament. Attempts were made to increase the armament, but losses were still so heavy that the Do-17 was withdrawn from daylight operations.

The next stage in development of the Do-17 design resulted in the Do-217. The Do-217M-1 had a maximum speed of 348 mph at 18,700 feet, a service ceiling of 31,168 feet, and a range of 1,550 miles. Armament was six 7.9-mm and two 13-mm machineguns and one 20-mm cannon. Maximum bomb load was 8,820 pounds. The M-11 could carry either the Hs-293 or the FX-1400 (radio-controlled, armor-piercing bomb) under the fuselage. Some of the M models were converted to 217 IV's as night fighters, these being equipped with radar and armed with four 20-mm cannon and four 7.9-mm machineguns.

The primary four-engine bombers were the Heinkel He-177 and the Focke-Wulf FW-200 Kurier. The Heinkel He-177 had two double-engine units, each unit driving one four-bladed propeller. It had a maximum speed of 300 mph at 19,000 feet, a service ceiling of 25,000 feet, and a range of 1,000 miles. Maximum bomb load was 17,000 pounds.

The Focke-Wulf 200C Kurier was used for long-range oversea reconnaissance, mine-laying, and convoy attack. It had a maximum speed of 250 mph at 13,120 feet, a service ceiling of 28,850 feet, and a range of 2,300 miles. Normal bomb load was 3,300 pounds.

As the war progressed, the German Air Force became less capable of defending against air attack. Toward the end of the conflict a significant factor in their air defense was deadly antiaircraft fire, called "flak" after the Fliegerabwehrkanone antiaircraft gun.

Tow Banner Bullet Scoring System

The standard 2- by 12-foot tow banner is widely used as a training target for Army air defense automatic weapon systems. In normal training, gunner performance is measured by an experienced observer during firing. After the flight, the banner is dropped from the MQM-34D drone tractor vehicle and retrieved and the hits are counted. Real-time precision measurement of trainee performance is not available, and near miss information cannot be determined. Furthermore, the accuracy of the measurement is subject to considerable error through damage to the banner, multiple hits at the same spot, and similar causes.

To determine the accuracy of the 20-mm Vulcan and other automatic weapon systems, an electromagnetic bullet counting system has been developed. The system functions in real-time, providing firing results directly to the gunner, cadre personnel, range control, and spectators and observers. Firing results can be recorded to provide a permanent record for establishment of comparative performance baselines.

Bullets are counted by sensing the number of individual rounds penetrating a specially shaped antenna pattern surrounding the aiming point. The bullet counting system, developed by Babcock Electronics and Cartwright Engineering Industries working in close cooperation with the US Army Missile Command (MICOM), uses step-keyed RF radiation to create a specially shaped, electromagnetic zone-of-influence around the tow banner (fig 1). When a projectile enters this zone-of-influence, a signal is reflected from the projectile. The reflected signal is compared to the transmitted signal, and the resulting doppler signal is detected, processed, and transmitted over a self-contained telemetry unit to the ground station. At the ground station each doppler burst is counted cumulatively. The bullet counting system provides a highly reliable, low-cost projectile sensing system for use in training. It fulfills the need for a simple, rugged device to improve the effectiveness of gunnery training.

The system consists of a small, solid-state radar sensor and its associated battery and antennas, all of which are mounted in a small pod carried below the yoke of the tow banner (fig 2). The units are currently being flown at White Sands Missile Range to demonstrate feasibility. The photographs of these units illustrate their simplicity (fig 3). A telemetry transmitter is included in the basic package to relay the round count information to the firing point and to other bullet counters. The unit contains a miniature receiver and three-digit counter that accumulates a total of 999 hits. It can be manually reset for each firing pass. The unit is small and compact and fits easily into the gunner's station. The read-out unit (fig 4), inexpensive, self-contained, and battery operated, can be operated from external power sources for permanent installations or from the prime movers batteries. An external magnetic tape recorder can be plugged into the unit to obtain a permanent record of the data.

To permit the bullet counter to be easily and inexpensively used with existing tow banner systems, aerodynamic and mechanical considerations were critical. The sensor in the bullet counter system is a rugged, simple device, but the installation must protect it from adverse effects of snatch loading, flight associated forces, and recovery. Reuse of the sensor for more than one presentation significantly improves the cost effectiveness of the system since

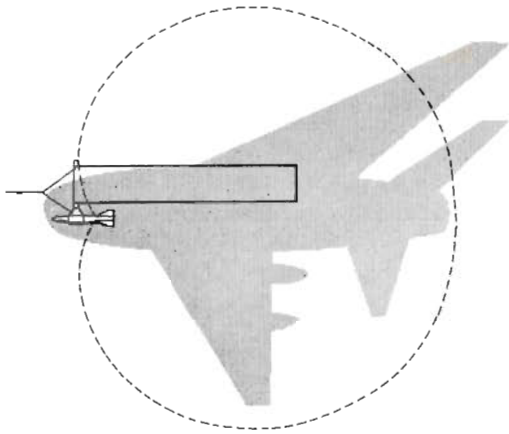
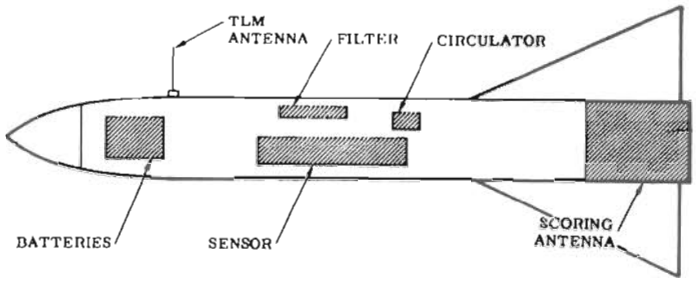


Figure 1. Antenna pattern of tow banner bullet counter with a typical threat silhouette overlaid.



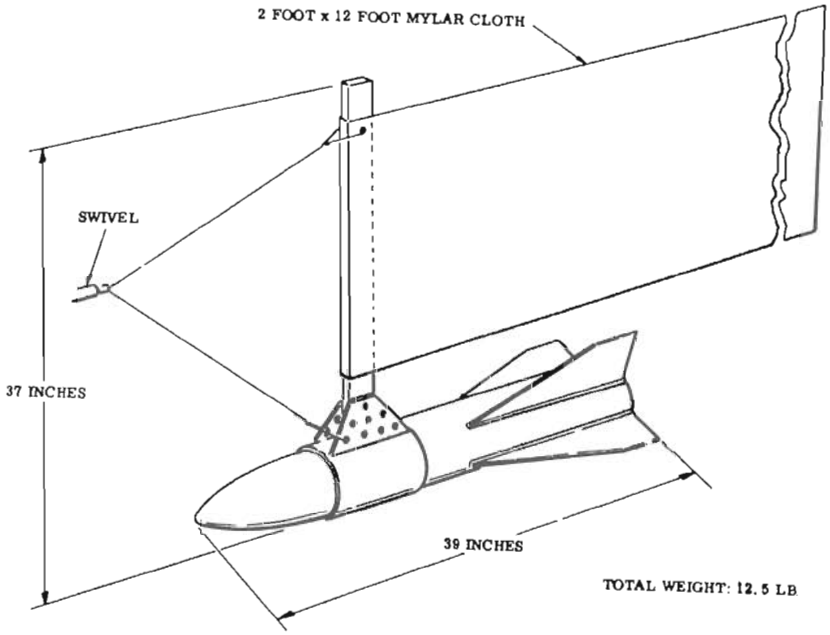


Figure 2. Bullet counter airborne components on tow banner target.

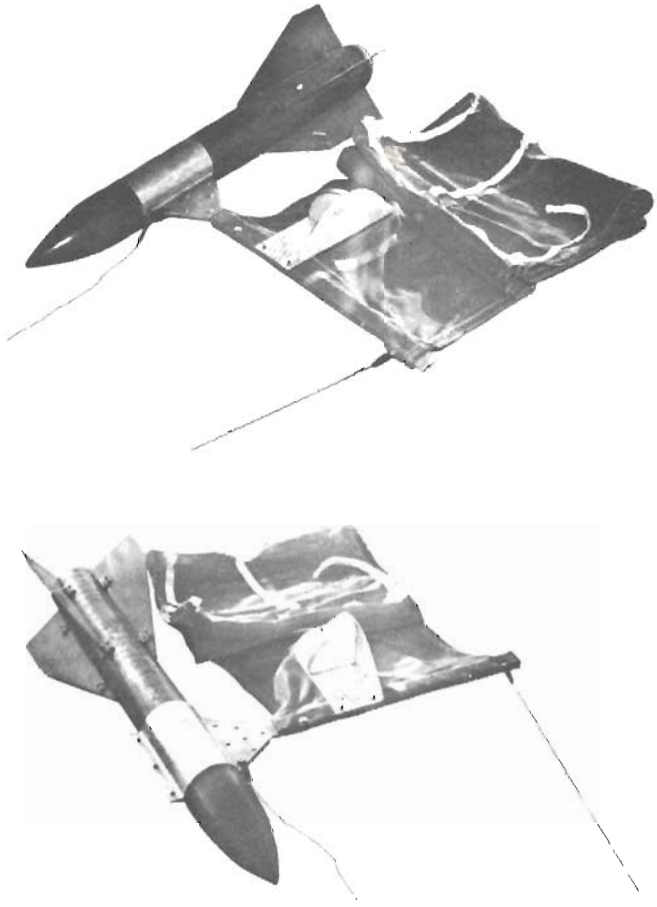


Figure 3. Bullet counting system for tow banner gunnery training.

Figure 4. Read-out unit.

the sensor is the most costly item. Repeated tests have demonstrated only minor impairment of tow banner aerodynamic and mechanical characteristics. The sensor is recoverable after the banner is cut loose and strikes the soft ground. The present battery pack, having a relatively high mass, is normally not recoverable. Studies are underway to make the battery pack both rechargeable and reusable for several presentations. The inexpensive antenna assembly is attached to the sensor by a coaxial cable and is expendable.

The bullet counter system uses the basic miss-distance indicator now in operational use, scoring missiles such as the Redeye and Chaparral. Both the indicator and bullet counter have a working range of 17 or 20 feet.

The 20-mm projectile has a radar cross-section of about 0.1 square feet, which is significantly lower than the radar cross-section of missiles such as the Redeye. To obtain comparable performance with the 20-mm projectile, a 10-decibel minimum increase in loop gain is used to compensate for the smaller target cross-section. This is accomplished by a new antenna configuration using a reflector. This increases the antenna gain and thus the loop gain. The reflector, at the same time, shapes the scoring pattern to generally follow the banner contour.

The sensor is used to detect projectiles that enter the scoring zone. Each doppler burst is detected and integrated and fires a threshold detector. A special circuit is used for signal processing and detection that advances a visual counter one count for each doppler burst. All these steps occur in real-time.

Separate bullet counters are employed at various other convenient points in the area. The simplicity, reliability, and convenience of the bullet counter greatly increase the training and demonstration effectiveness of firing passes.

To provide an accurate bullet count, it is desirable that only one projectile at a time enter the scoring zone. Because this zone has a thickness of about 10 feet, the projectile spacing must be somewhat greater than 10 feet. To be safe, 20 feet was used as a design criteria. If the projectile velocity is 1,000 feet per second, the projectiles are spaced a minimum of 20/1000 or 20 milliseconds apart in time, at the banner, yielding a maximum allowable fire rate of 3,000 rounds per minute. This is well within the normal rate of fire for most air defense weapons. If two projectiles enter the zone simultaneously, they would score as a single round. Analysis performed during the design phase indicated that this was a relatively remote possibility.

To verify the aerodynamic stability of the tow banner with the bullet counter attached to the tow bar, several test flights were conducted in July 1970. The technique for "snatching" the banner from the ground by the Firebee drone was developed and the mechanical configuration found capable of withstanding the rapid acceleration at launch.

Live firing tests were conducted on 18 September 1970 at the White Sands Missile Range. Several batteries of the Vulcan gun were used to fire at the banner. The guns were operated by training personnel from Fort Bliss, Texas.

Two drones were utilized to tow the two banners equipped with the bullet counting system. Fifteen passes were flown by the first drone, and 13 rounds were recorded as being in the

antenna pattern. The second drone flew 14 passes in the reverse direction at a higher speed, and 17 rounds were counted. The tow banners, which are cut loose by radio command in flight, were recovered. Damage from the landing impact was very minor. Additional flights are being scheduled for these two systems.

The tests were witnessed by United States and several foreign Army representatives who expressed a high interest in using the bullet counting system in support of the Vulcan training program.

The initial low cost and the high recovery provides an extremely low "cost per presentation" for this target system.

Air Defense System Effectiveness and Kill Definitions

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Effective communications among individuals is accomplished by them only if a common language has been established. Presently, no single language exists for analysis of air defense weapon systems. There are, instead, many variations of the definitions of terms used—all of which present formidable barriers to understanding. In an effort to reduce this confusion, the Joint Technical Coordinating Group for Munitions Effectiveness (JTCG/ME) set as a goal the standardization of the definitions associated with air defense weapon system analysis. The JTCG/ME is a Department of Defense directed interservice activity designed to evaluate the effectiveness of munitions and their associated weaponry.

Both the US Army Air Defense School and US Army Combat Developments Command Air Defense Agency have contributed to the efforts of the JTCG/ME. In March 1969 a joint USAADS/USACDCADA position paper on system effectiveness and kill definitions was presented to the Aerial Target Sub-Group of JTCG/ME. This paper described system effectiveness (E_S) as the probability that a weapon system will accomplish its mission against a single target vehicle operating within the engagement envelope of the weapon system. It is a measurement of the capability of the system. System effectiveness can thus be expressed as either inherent or operational effectiveness, the principal differences between these being attributed to human and logistics factors which are included in the concept of operational effectiveness.

1. Inherent system effectiveness (E_{SI}):

$$E_{SI} = A_I \cdot P_{ENG} \cdot P_{SSK}$$

This equation, while not of immediate importance to air defense artillery operational planners, is considered a useful tool for logistics and maintenance planners.

2. Operational system effectiveness (E_{SO}):

$$E_{SO} = A_O \cdot R_O \cdot P_{ENG} \cdot P_{SSK} \quad \text{(fig 1)}$$

where A_I is the inherent availability of the system, P_{ENG} is the probability of engaging a target, P_{SSK} is the single-shot kill probability, A_O is the operational availability of the system, and R_O is the reliability of the human operator. These terms are defined and discussed below.

System availability (A) is the probability that a system or equipment shall operate satisfactorily at any given time when employed under design tactical and environmental influences. In the case of an air defense weapon system, it is the probability that the system will be

available to fire at least one missile, projectile, or burst of projectiles when any random target enters the system engagement envelope. Availability is expressed as either inherent or operational.

$$E_{SO} = A_O + R_O + P_{ENG} + P_{SSK}$$

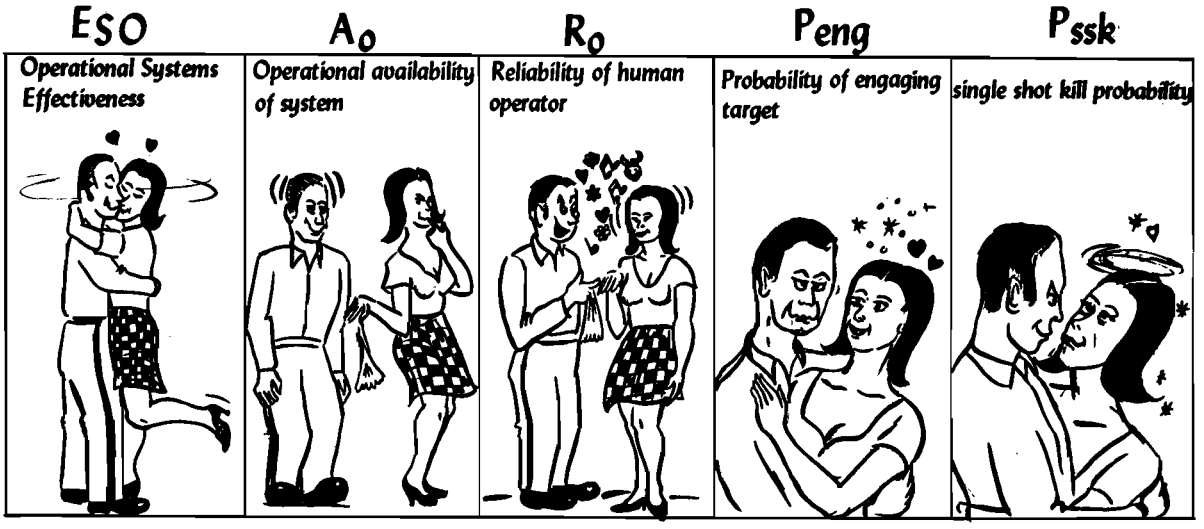

Figure 1. Operational systems effectiveness.

Inherent availability (A_I) assumes an ideal support environment; i.e., repair parts, manpower, tools, and manuals are available at the equipment. It excludes nonoperational time resulting from preventive maintenance, scheduled maintenance, supply, and administrative downtime. Inherent availability (fig 2) is defined by the equation

$$A_I = \frac{MTBF}{MTBF + MTTR}$$

where MTBF is mean time between failure. The MTBF for a given equipment is obtained by dividing a particular interval of the total functioning time by the number of failures during this interval of time. MTTR is mean time to repair and is obtained by dividing the total repair time during the specific time interval by the total number of failures during this same period.

Operational availability (A_O) differs from A_I in that A_O includes nonoperational time resulting from preventive maintenance, scheduled maintenance, and administrative and supply downtime. Operational availability is given by the equation

$$A_O = \frac{MTBM}{MTBM + MDT}$$

where MTBM is the mean time between maintenance. The MTBM for a given piece of equipment is obtained by dividing a particular interval of the total functioning time by the number

$$A_I = \frac{MTBF}{MTBF+MTTR}$$

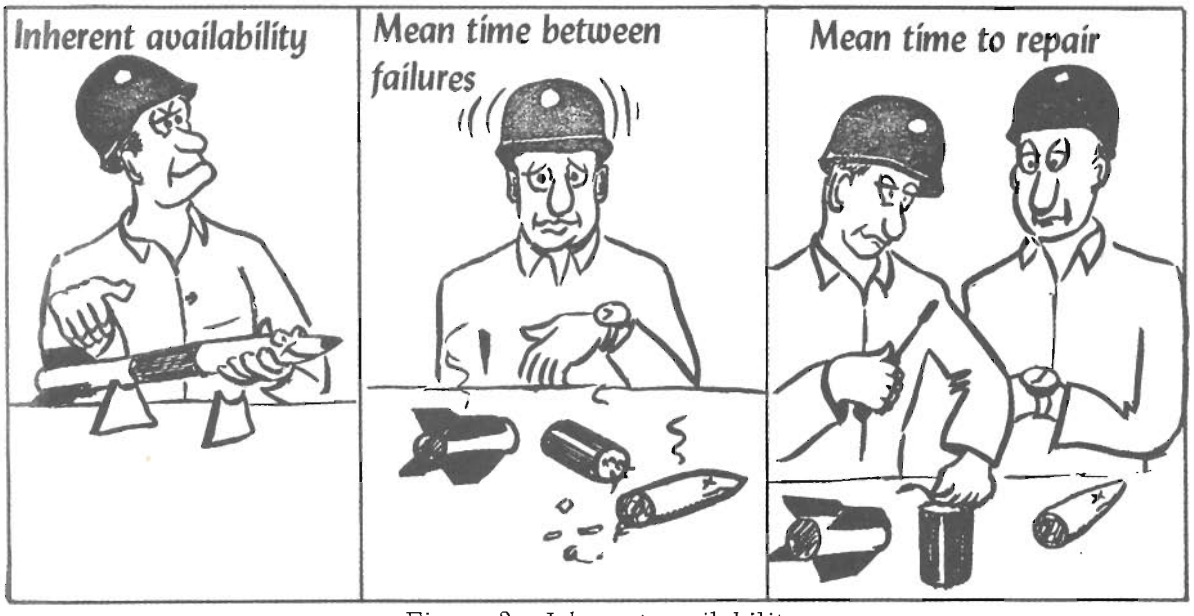

Figure 2. Inherent availability.

$$P_{SSK} = R_L \cdot R_F \cdot L$$

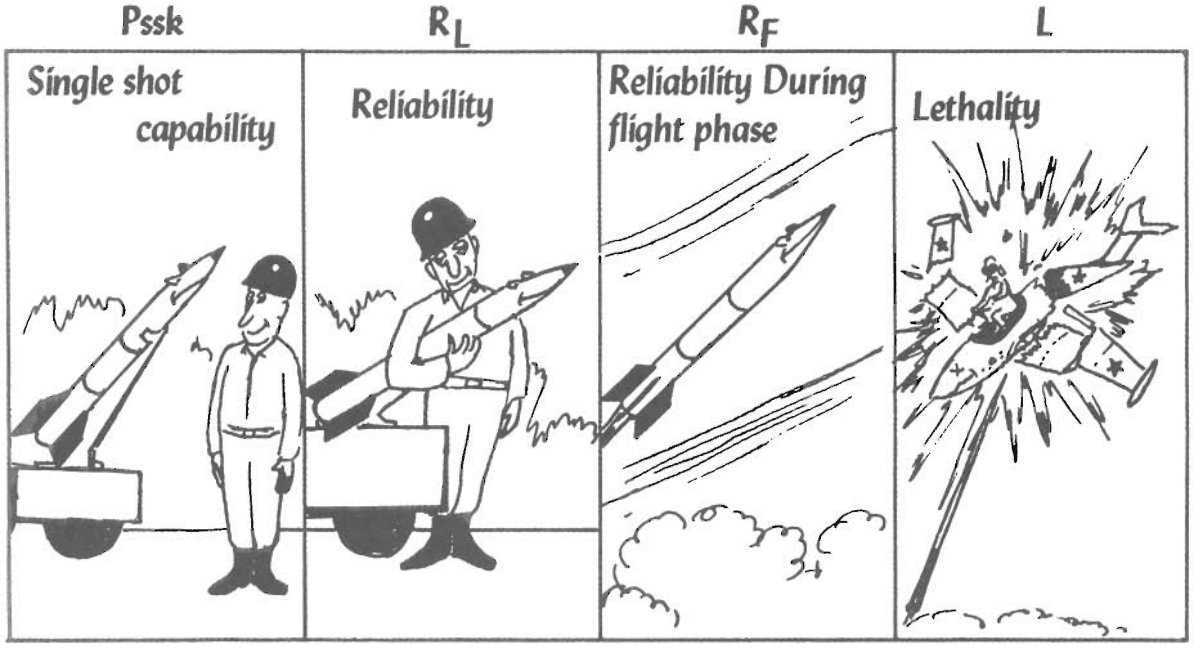

Figure 3. Single-shot kill probability.

of maintenance periods (scheduled, preventive, or repair) during this interval of time. When scheduled and preventive maintenance are not performed, or are not considered, MTBM becomes MTBF. MDT is mean downtime and is the sum of MTTR, mean administrative time, and mean supply time during the time interval.

Operator reliability (R_O) is the probability that the operator(s) will successfully perform all required functions from the time any random target enters the system engagement envelope to the time of kill mechanism activation. Required functions include any operation including operator training proficiency that could influence the overall system effectiveness.

The probability of engagement (P_{ENG}) is the probability of successful equipment operation from the time the target comes within detection range until the firing circuit is activated. Further, it is the probability that any random target will be detected, acquired, identified, assigned to a target tracking radar or gun mount, tracked, and assigned to a missile/launcher.

The single-shot kill probability (P_{SSK}) of a system is the probability of achieving a kill with a single round once the firing circuit has been activated. The P_{SSK} value is the product of launch reliability (R_L), flight reliability (R_F), and lethality (L) and is given by the equation

$$P_{SSK} = R_L \cdot R_F \cdot L \quad \text{(fig 3)}$$

where R_L is the reliability of the system during the launch phase. The launch phase is initiated when the firing circuit is activated and ends with missile or projectile propellant ignition. Included in R_L is the probability that all ground equipment required for a successful engagement will operate satisfactorily during the launch phase.

R_F is the reliability of the system during the flight phase. The flight phase begins when the launch phase terminates and ends at the time of kill mechanism activation. Included in R_F is the probability that all ground equipment required for a successful engagement will operate satisfactorily during the flight phase.

L is the lethality of the missile or projectile and is the probability that a reliable missile or projectile will achieve the level of kill specified against a specific target. In general, the values of L are a function of miss distance, warhead effects, and target vulnerability.

For the case where more than one missile or more than one burst of projectiles is fired at a target, P_{SSK} has to be replaced by a multiple-shot kill probability. This kill probability can be defined as P_{MSK}, the probability of achieving a kill with "n" number of missiles or "n" bursts of projectiles once the firing circuit has been activated.

In an effort to get away from the current plethora of kill definitions (e.g., k - kill, KK - kill; B - kill . . . . .) this paper proposed the following:

1. Carrier kill (fig 4). The carrier is either a weapon delivery means or a platform from which other threat devices are operated. Carrier kill is the disablement of an aerial

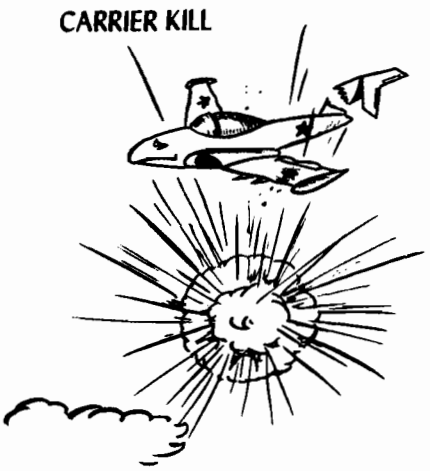

Figure 4. Carrier kill.

Figure 5. Weapon kill.

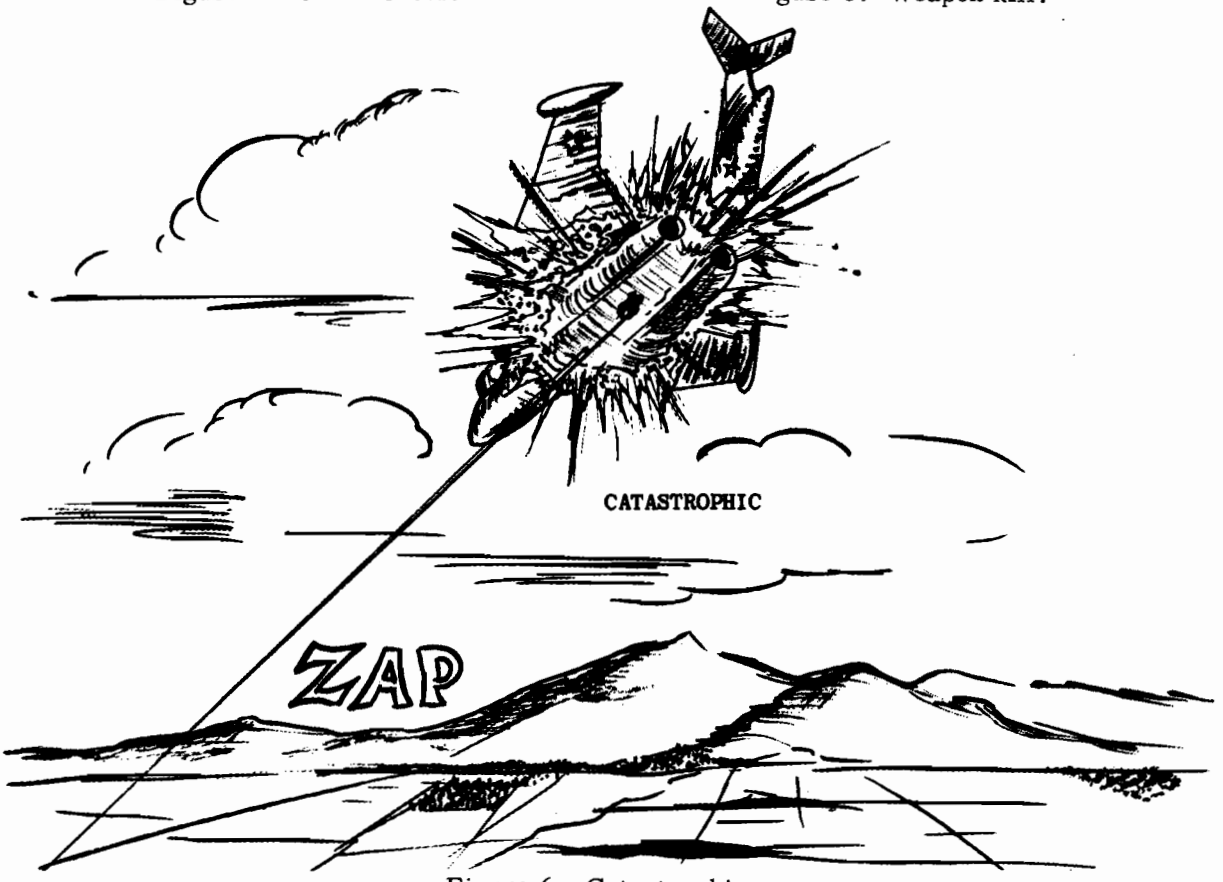

Figure 6. Catastrophic.

vehicle. The damage inflicted will cause the target to disintegrate or to become permanently incapable of maintaining directed flight or trajectory. These events should occur within time "t" of kill mechanism activation.

2. Weapon kill (fig 5). Weapon kill is defined as destruction or incapacitation of munitions carried by aerial vehicles. The munition, nuclear or nonnuclear, is completely destroyed within time "t" of kill mechanism activation. For a nuclear weapon, the damage inflicted destroys that portion of the weapon designed to produce the nuclear yield. A nonnuclear weapon is either detonated or fragmented. In either case, nuclear or nonnuclear, detonation of the weapon subsequent to time "t" is precluded.

Subsequent discussion by the Aerial Target Sub-Group reduced the USAADS/USACDCADA kill definitions to one; namely, catastrophic (fig 6). This means immediate structural breakup of an aerial target when successfully taken under fire. Added to this definition were two other "kill" types:

1. Mission - Aerial target cannot complete its assigned mission.

2. Attrition - Subsequent loss to the user of the aerial target.

These three are intended for general triservice use. They in no way constrain a particular service from using definitions peculiar to itself and necessary to its own internal activities.

No action has yet been taken concerning acceptance of the system effectiveness definition. Nevertheless, efforts are now underway to have the aforementioned "kill" definitions incorporated within the dictionaries and technical glossaries of the defense establishment.

This in itself represents a significant step forward in the formation of a badly needed common language for weapon systems analysis.

System Engineering Air Defense School Courses

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The United States Army Air Defense Artillery branch is a vast and complicated organization. One of its most important functions, both in peace and war, is training personnel to do jobs. Training programs are designed to prepare personnel to perform a multitude of specific jobs involved in the varied highly technical and demanding activities of modern air defense.

With each modification of equipment and with each additional responsibility, additional training is required. Hence, the overall training commitment is subject to continuous change.

Systems engineering responds to these changes by presenting a new methodology which can open new vistas to the educational, vocational, and training management functions. Development of a skilled manpower base for air defense weapon systems is assured.

AUTHORIZATION

Early in 1968 Headquarters, United States Continental Army Command, published a regulation which established uniform procedures for designing courses. Career and functional courses, as well as Army subject schedules conducted or prepared by Army service schools and training centers, were included in the systems approach.

Systems engineering of training was organized and implemented at the US Army Air Defense School by midyear. The technology of the program was presented to all departments through several workshops and publication of guidelines for development of course design.

Department directors meticulously selected system engineering personnel who (1) were subject matter specialists with broad experience both in the work environment and the training system, (2) were interested in instructional and educational techniques, and (3) had demonstrated ability to write technical material.

PURPOSE

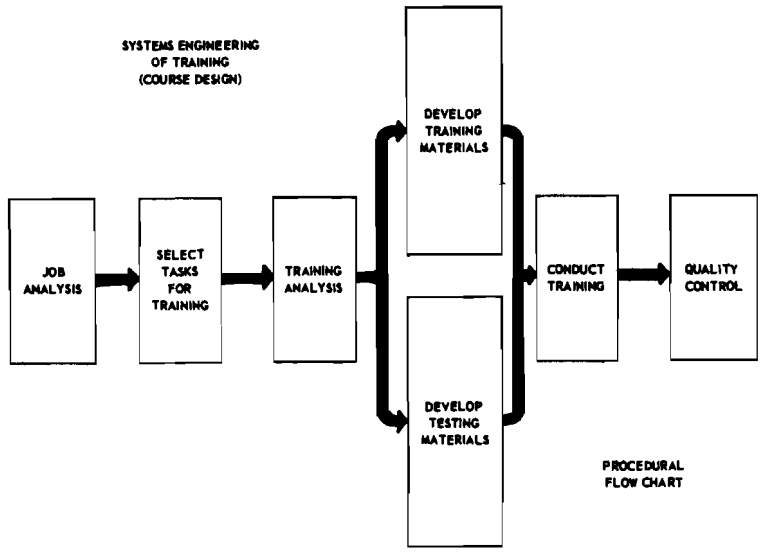
The objective of systems engineering of training is to make management scientific. Scientific management is the substitution of measurable yardsticks systematically applied to reasoning for training decisions in terms of documented facts and principles. When a training manager turns to intuition, speculation, and the "way he feels about it," he's not managing—he's guessing. He's hoping for a favor from Lady Luck so that maybe he'll be right half of the time.

The systems engineering concept requires detailed documentation of all course design actions. A master record of each decision made with respect to a particular course is immediately available for a training manager to respond to changes in the training program

necessitated by new equipment, modified equipment, field command requirements, training plans, and special requirements. This process will insure that the training program is tailored to reach the specific goal of training the student to perform all jobs in an MOS at beginning level. It will specify those knowledges and skills essential for job performance. It will insure that we teach what is necessary.

In the final analysis this systematic documented approach will enable the US Army Air Defense School to serve the needs of user agencies better and sooner.

THE SYSTEM CYCLE



The first step in the system cycle is to analyze the operational system and the training system; identify and describe the characteristics of the operational system; determine whether special education/training is necessary to operate the system; determine, based on present state-of-the-art, what type of manpower is needed; and complete a job analysis. The job analysis identifies the field performance requirements. The completed job analysis sets the framework from which all subsequent steps of the systems engineering process occur. It consists of two elements: identifying the job and developing the task inventory.

The second step in the system cycle is to select those measurable tasks which need school training. Those tasks not selected for school training are either prerequisites for the job or are selected for training elsewhere.

Training analysis is the third step. It bridges the gap between job requirements and the classroom. This is the critical phase. The subject matter specialist must determine for each task:

1. What must be done, how accurate, and how fast?

2. What cues indicate an action must be taken?

3. What feedback indicates when the action is complete and achieves the desired standard?

4. What alternate action is required in case of emergency or when incorrect results are obtained from a correct response?

5. What knowledge is needed for guidance (i.e., nomenclature, location, purpose, components, rules, etc.)?

6. Does this knowledge make any difference in what the incumbent does? If it doesn't, it is excessive.

7. What are the physical and environmental working conditions?

8. What tools, test equipment, or job aids are to be used?

When this analysis is complete, the writer must structure measurable training objectives which encompass all of the facts. Then, for the first time, the constraints which limit the training will be identified. Several alternate systems should be structured which could achieve the training objective. The best alternatives are recommended to the training manager. Finally, the training objectives are sorted into a sequence most efficient for student learning.

Developing training and testing materials, the next two steps, may be performed concurrently. This is the production phase of the process. All instructional and administrative materials are developed, including programs of instruction, lesson plans, examinations, handouts, TV tapes, films, and other training media to support learning.

The sixth step of the systems cycle is the conduct of training. Here, the courage to try something new is an important asset for progress in the education/training environment.

The final and continuing step is quality control, the process whereby a vigorous evaluation of the training program is made and adjusted for optimum success of maximum numbers of graduates of air defense courses.

EXPERIENCE

Even though the process for systems engineering is a good one, the experiences of the US Army Air Defense School thus far indicate latent sources of error exist in implementing this concept.

Scientific management requires systematic application of the general truths or laws which govern the building of one fact onto another for a functioning, efficient system. Systems engineering requires rigid discipline to apply the exacting yardsticks to carry a task from step one to step seven without slipping into the world of "I feel" or "I think."

Some of the more common discrepancies which have developed during the implementation of the steps in the systems cycle are (1) tendency of writers to use the outline form of task

inventory rather than the matrix form which results in incomplete inventories, and (2) reluctance of systems engineers to structure objectives to the subtask level which will provide greater flexibility in applying accepted principles of learning to the program of instruction.

CONCLUSION

National security demands that training be reduced to essentials. Each analysis of the subject matter will aggressively interrogate the subproblems to insure efficient realistic training. The analysis will separate facts from assumptions, limitations from variables, intuition from bias, need from pressures, and "pet solutions" from analytical methods. Air defense men will be trained in depth, and battery control and tactical control officers will be better educated to perform within the disciplines of complex air defense situations.

Early Warning for Forward Area Weapons

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Editor's Note:

The suggested interim early warning system described in this article was developed by instructors in the Command and Staff Department of the US Army Air Defense School. The concepts mentioned are being taught by the School in Chaparral, Vulcan, and Redeye courses. Other agencies at Fort Bliss and units in the field have also contributed ideas and observations, and many of the ideas originated in the 4th Battalion, Chaparral/Vulcan, 61st Air Defense Artillery, at Fort Carson, Colorado.

DETECT—IDENTIFY—INTERCEPT—DESTROY: The four steps in accomplishing the air defense mission all depend on early warning. This is especially true for the SHORAD weapons—Chaparral, Vulcan, and Redeye—because of the very brief time that an enemy aircraft would be within the firing envelope of these weapons. The only problem with early warning for SHORAD weapons, then, is how to get it. Current field manuals and TOE's indicate two solutions: Wait for the forward area alerting radar (FAAR) to be issued or forget about early warning! This article suggests techniques for a third (and better) alternative: Provide early warning to the fire units today using existing equipment. The solution presented is designed for a division with Redeye and a Chaparral/Vulcan (C/V) battalion. The same concepts can be used, with slight modification, for nondivisional SHORAD weapons.

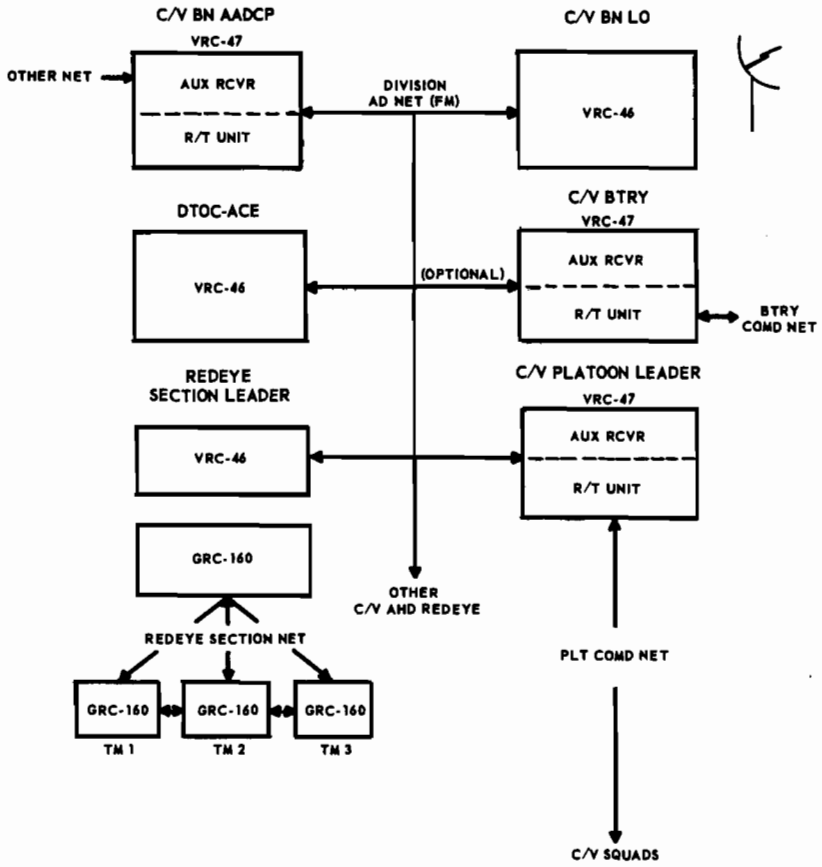
BACKGROUND

First let's review the assets available for an interim early warning (EW) system. Within a typical division will be 48 C/V squads and approximately 60 Redeye teams. All personnel in these 100-plus fire units are trained in search-and-scan procedures and visual aircraft recognition, and all fire units are equipped with radios. By netting C/V and Redeye with two-way communications and by training the squads/teams on common procedures we can establish an effective ground aircraft observer system. Another available asset not to be overlooked is radar. It is probable that in any combat situation, and often in training exercises, there will be some radar coverage of the division by Hawk or Air Force forward air control post (FACP) radars or by the GCA (ground controlled approach) radar at the division main airfield. If radar coverage does exist, we can place the C/V battalion liaison officer at the radar and tie him into the radio net with C/V and Redeye.

CONCEPT IN BRIEF

Key features of the interim EW system are described below. A detailed discussion follows.

1. A division air defense net (FM) is established. Stations on the net include the C/V AADCP (net control station (NCS)), DTOC-ACE (division tactical operations center-Allied Command Europe) (alt NCS), C/V liaison officer (LO), C/V platoon leaders, Redeye section leaders, and C/V battery headquarters (optional) (fig 1).



Example of Radar EW:

1. LO (on div AD net): (NET CALL), THIS IS (LO) BANDIT IN DELTA GOLF, HEADING SOUTH, OUT.

2. Redeye sec ldr (on sec net): (NET CALL), THIS IS (SEC LDR), BANDIT IN DELTA GOLF, HEADING SOUTH, OVER.

3. Redeye tms (on sec net): THIS IS (TEAM 1), ROGER, OUT, etc.

Example of Visual EW:

1. Vulcan sqd (on plt cmd net): (NET CALL), THIS IS (SQD NO.), BANDIT IN ECHO LIMA, HEADING WEST, OVER.

2. Plt ldr (reads back on plt net): THIS IS (PLT LDR), BANDIT IN ECHO LIMA, HEADING WEST, OUT.

3. Plt ldr (enters div AD net): (NET CALL), THIS IS (PLT NO.), BANDIT IN ECHO LIMA, HEADING WEST, OVER.

4. AADCP (readback).

5. Redeye sec ldr (hears either 3 or 4 or both and broadcasts on his sec net): (NET CALL) THIS IS (SEC LDR), BANDIT IN ECHO LIMA, HEADING WEST, OVER.

6. Redeye tms: (acknowledge).

Figure 1. The division air defense net (FM).

2. Radar EW is broadcast by the LO, monitored by C/V platoon leaders/Redeye section leaders, and immediately rebroadcast by platoon/section leaders to their fire units on platoon/section nets.

3. Visual EW reports are initiated by C/V squads or Redeye teams sighting unknown or hostile aircraft. The fire unit transmits a warning on the platoon/section net (simultaneous back-tell to the platoon/section leader and lateral-tell to sister fire units). The platoon/section leader then enters the division AD net (FM) and retransmits the warning (simultaneous back-tell to the AADCP and lateral tell to adjacent platoon/section leaders). The AADCP acknowledges by giving an immediate readback (this is done to insure better dissemination of the EW). Adjacent platoon/section leaders monitor the EW and retransmit (forward-tell) to their own fire units on their platoon/section nets.

4. Communications procedures are simplified and abbreviated.

5. A gridded map overlay (matrix) is used to tell aircraft locations. The matrix consists of 4 km by 4 km squares, lettered to read "right and up" so that each square is identified by two letters.

6. The recommended telling sequence contains three elements: a proword to identify the message as EW and to tentatively identify the aircraft (e.g., "bandit"), the matrix location of the aircraft, and the aircraft heading.

Note. Examples of EW messages are shown in figure 1.

DISCUSSION

Within this interim EW system, the most difficult problems (and the most controversial "solutions") are in the area of communications. Why do we need the division AD net? Where does the LO get an FM radio? How can FM range and masking problems be overcome? And how can the platoon/section leaders meet all communications requirements plus that new net?

We need the new net for two reasons. First, the old concept of an AM net for EW has been shot down by TOE changes—the AN/GRR-5 receivers have been deleted from TOE and not replaced. Second, existing FM nets follow chain-of-command patterns and would not be available or suitable for EW. Retransmission at every headquarters in the chain of command would cause "early warning" to become "late warning." The new net uses current radios and jumps command channels to minimize time lost through retransmissions.

Next let's solve the LO's problem. He does not have an FM radio according to TOE 44-326G. He could transmit radar EW on AM to the AADCP where it could be retransmitted on FM, but that compromise would degrade the effectiveness due to time loss. From an EW standpoint it would be better to give him an FM set and degrade some other function. It is recommended that he use one of the two AN/VRC-46's assigned to the ACE, or the battalion motor officer's radio. Or, the LO may use a radio belonging to the Hawk unit or FACP where he is observing the radar. Divisional assets might be raided as another source for scrounging a radio.

Now that everyone has an FM radio, how can FM broadcast cover the entire division area? A combination of fixes may be required to make the net work. The LO and AADCP should use RC-292 antennas (or field expedient substitutes; e.g., home-made 292-type antenna or the whip antenna and matching unit mounted on top of a pole). In static situations the platoon/section leaders can enhance their reception by using directional field expedient antennas (long wire or half rhombic), or they, too, might use the techniques recommended for the LO and AADCP. If retransmissions are still needed, one or more relay stations could be set up for automatic retransmission. Of course, this last step requires AN/VRC-49 radios and extra frequencies. The C/V battalion has one AN/VRC-49. Others may be available from division assets. As a final suggestion, perhaps a radio relay aircraft could be used for a temporary solution. The simplest fixes should be exhausted before resorting to radio relay, and all personnel should consider terrain effects on communications when selecting positions.

The final major communications problem concerns the C/V platoon leaders and Redeye section leaders. Their EW functions are identical, but their communications problems are different and must be discussed separately.

At present, there are some contradictions among different TOE's concerning Redeye. In designing this EW system, it was assumed that all Redeye section leaders have one AN/GRC-160 and one AN/VRC-46 (source: TOE 7-28G, Combat Support Company, Infantry Battalion, 3 Nov 69). The AN/VRC-47 radio authorized by earlier TOE's would also suffice. In any event, it is possible for the Redeye section leader to be augmented with radios from the assets of his battalion if required. The section leader has three basic communications requirements. He must talk to his teams and his battalion headquarters and participate in the division AD net (continuous monitoring and occasional transmissions). It is recommended that he use the AN/GRC-160 on the Redeye section net with his teams and the AN/VRC-46 on the division AD net. His communication with the battalion headquarters is accomplished by collocation or telephone during static operations. During headquarters movements he can periodically check in with the battalion operations or command net. Also, the battalion headquarters could talk to him at any time by entering the Redeye section net.

Chaparral and Vulcan platoon leaders must talk to their squads on the platoon command net, monitor their battery command net, participate in the division AD net, and perhaps monitor a supported unit net. These three or four requirements put a severe strain on the two-channel capability of the platoon leader's VRC-47. The recommended solution (fig 2) is to have two designated squads monitor the battery command and supported unit nets for the platoon leader. When traffic for the platoon leader comes in on one of these external nets, the responsible squad leader will inform the platoon leader on the platoon command net. The platoon leader then changes frequency on his R/T unit to the external net and answers the call. A third squad is designated as alternate NCS for the platoon command net and backup on the division AD net to cover for the platoon leader while he is talking on an external net. This arrangement will work equally well for static or moving situations, no extra equipment is needed, and only the platoon leader will have to change freuqencies. In static situations an alternative solution might also work. The platoon leader could position his vehicle near one of the squads, establish wire communications with that squad, and then use that squad's radio himself by remounting the radio in his vehicle or by using a remote set. Vulcan platoons defending small vital areas could also use wire for their primary platoon command net.

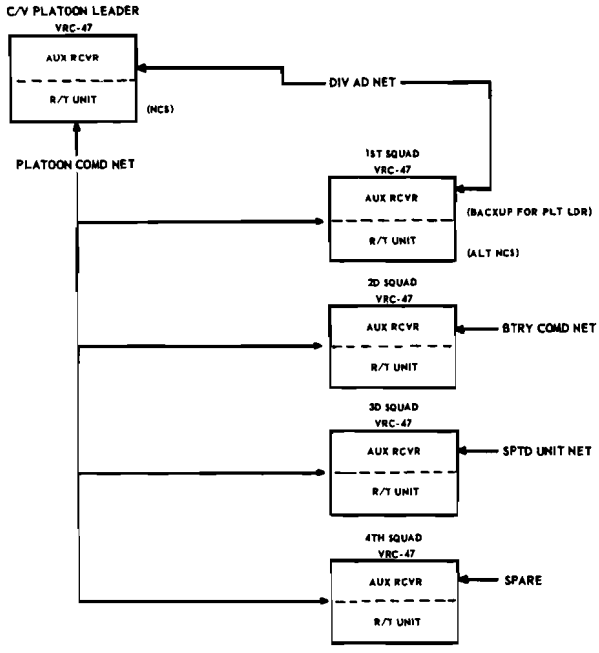


Figure 2. Chaparral/Vulcan platoon communications.

Another area of contention in this interim EW system is the selection of a matrix system for aircraft position reporting. Other grid and directional systems were considered and rejected. GEOREF is too gross. A single GEOREF square (1° square) can cover 16 full division areas (25 x 30 km each). Also, GEOREF is not printed on Army maps and requires highly trained and proficient personnel to use it. The standard military grid system, UTM, becomes difficult to use in converging grid-zone areas. Too, the high degree of accuracy inherent in UTM is not feasible for estimating the position of fast-moving aircraft. The matrix concept is one way of overcoming the problems of UTM, and it facilitates quick and simple EW. Directional systems, such as "clock-azimuth," would work well within tightly grouped platoons or sections, but wouldn't work at all for exchanging visual EW between dispersed platoons and sections spread over the division area.

The system described in this article is not the only possible solution to the EW problem. It was designed to optimize EW, within the constraints of available equipment and at the expense of less urgent functions. It is recognized that personnel will require extensive training in the system if EW is to be timely and duplications of EW are to be minimized. Other anticipated weaknesses include a low-saturation level on the division AD net, susceptibility to communications jamming or deception, and inability to cover a mountainous division area with FM communications despite the numerous fixes attempted. Weaknesses notwithstanding, this approach to the SHORAD EW problem is better than simply waiting for the FAAR to be fielded.

No longer can it be said that "there's nothing in writing" on EW for the SHORAD weapons. It is still true that no tested and proven software interim EW systems are in print. How about testing this system in your battalion, colonel?

Lessons Learned in Vietnam

TACTICAL EXPERIENCES OF DEPLOYED UNITS

(Introductory comments by the Editor)

●In this issue, several units provide useful information. Task Force South reports on enemy use of dummy positions, enemy locations in stream beds, ground followup of secondary exploxions, and enemy use of camouflaged punji stakes●

The VC often build poorly camouflaged dummy bunker positions to draw unwary allied units into prepared killing zones. These dummy positions are usually complete with fresh trail activity leading to the bunkers. Well-camouflaged enemy positions are located nearby with good observation and fields of fire covering the dummy positions. When a careless allied unit approaches the dummy positions, it is taken under fire by enemy forces in the well-concealed bunkers. Awareness of this enemy tactic and caution in approaching obvious enemy positions may reveal the true location of the enemy force and negate this tactic.

When conducting operations, allied units should be especially cautious when approaching stream and riverbeds. The VC and NVA often choose a water source as a location for their base camps. Bunkers and fighting positions may be found along the stream or even inside the bank, staggered from side to side to insure good fields of fire. When walking parallel to the stream, fighting positions inside the bank may be difficult to observe. The enemy has used this technique in Binh Thuan Province during the dry season.

During recent operations, it has been the experience of this command that immediate and aggressive followup of secondary explosions, caused by placing the artillery fire into suspected enemy locations, produces rewarding results. An example of such an operation is the 3d Battalion, 503d Airborne Infantry, followup of three secondary explosions caused by artillery fire in western Lam Dong Province. In the general vicinity of the explosions the unit discovered several important munitions caches, training areas, and trails, in addition to making contacts with small enemy forces.

During the dry season, grass fields and harvested rice fields are easily set afire by artillery, airstrikes, etc. The enemy uses a special type of punji stake in burned-out areas. This stake is a nonflexible black metal rod with a barbed tip. The punji stake is stuck into the ground at an angle in the midst of the charred grasses. It is extremely difficult to detect because of its color. Caution should be exercised in crossing such areas. An awareness of the above technique may reduce casualties.

●Sometimes very simple expedients can overcome the most stubborn obstacles. Here is a prime example from the Deputy Senior Advisor of the 2d Ranger Group, II Corps●

During several recent operations in the highlands, normal identification of unit locations by smoke grenades was often prevented by ground fog and close overhanging jungle foliage. A simple means to mark positions by smoke under such circumstances is to tie two bamboo poles together and attach the smoke grenade to one end. Once identification is requested, the grenade is "popped" and the pole is raised, thus permitting the smoke to penetrate through the ground fog and ground foliage.

●If there is any area where US troops are in need of improvement, it is in night operations. Our enemy always seems better at this game than we do. This is a report on a system that proved effective in combat for one battalion●

The 2d Battalion, 503d Infantry (Airborne), 173d Airborne Brigade, recently instituted a program of effective night operations utilizing one platoon at a time from each of the rifle companies of the battalion. Each platoon designated for night operations is cycled through night operations consisting of the following three phases (one phase each night).

1. Phase I: Entire platoon is utilized for conduct of night operations.

2. Phase II: 50 percent of platoon is utilized for night operations and 50 percent get maximum rest in a platoon laager site.

3. Phase III: Entire platoon rests in a laager site with the company CP and acts as company reaction force.

During daylight hours those personnel utilized for night operations get maximum rest. Personnel who get normal rest at night conduct daylight patrols and reconnoiter night ambush sites prior to noon. Occupation of laager sites during the afternoon takes advantage of a relatively secure area to prepare the night operations. This is usually the period of least VC activity. Night operations are conducted by squad and smaller elements in static ambushes and roving ambush patrols.

Parallel Circuit Characteristics

Across

1. The voltage is the same across parallel _____.

5. An open in the main line results in no current in _____ branches.

7. The equivalent resistance of 10 and 15 ohms in parallel is _____ ohms.

8. The ohm meter reading across an open resistance is _____.

11. Dividing millivolts by milliamperes gives an answer in _____.

13. $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n}$ is known as the _____ resistance formula.

14. The total power of the source equals the sum of the _____ values of power dissipated.

Down

2. Each branch current equals the voltage divided by the _____.

3. The _____ is the same in both sides of the main line that connects the voltage source to the parallel branches.

4. The line current equals the _____ of the branch currents.

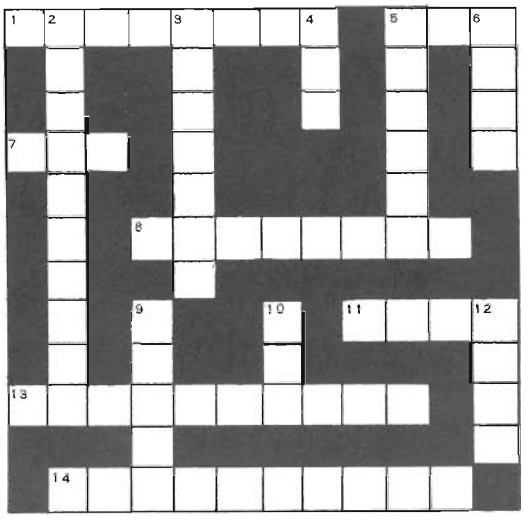
5. An identical _____ of voltage appears across all branches.

6. With resistance of 100, 200, and 300 ohms in parallel, R_t is _____ than 100 ohms.

9. The equivalent resistance of three 1K resistors in parallel is one- _____ K.

10. With 100 volts across ten 50-ohm resistances in parallel, the current through each equals _____ amps.

12. With two resistances connected in parallel, the voltage across each will be the _____.



Answers on page 95.

Reader's Corner

CURRENT BOOKS AND ARTICLES OF MILITARY INTEREST

This list is published to draw attention to worthwhile and informative books and articles in other publications. We realize that not all items will be available to all readers. Our motive is to be helpful to as many readers as possible.

The content of these publications does not necessarily represent the opinion of the US Army Air Defense School.

—Editor

BOOKS

Escalation and the Nuclear Option by Bernard Brodie. Princeton University Press.
"Dr. Brodie, whose writings on strategy over the past twenty-five years have won him an international reputation, here stresses the importance, in choosing strategies for the future, of avoiding exclusion of the option to threaten use of tactical nuclear weapons."

The ABC of Color TV by Harry G. Cisin. Amagansett, New York.
This pamphlet covers basic color principles, the ABC's of color transmission, color television reception, and color picture tubes.

In Case of Emergency by Bry Benjamin. Doubleday, Garden City, New York.
"This is a basic and indispensable book that every family should keep within handy reach - for the accident or illness that could never happen, but sometimes does."

Research and Report Writing by Francesco Cordasco and Elliott S. M. Gatner. Barnes and Noble, New York.
"This book presents complete, step-by-step guidance to the correct techniques of gathering and preparing material for research papers."

Truth Is the First Casualty by Joseph C. Goulden. Rand McNally, New York.
"Here for the first time is a complete reconstruction of the Tonkin Incident - and its far-reaching aftermath - which marked the point of no return in the political and military conduct of the Vietnam War."

Area Handbook for Burundi by American University. U.S. Government Printing Office, Washington, D. C.
"This volume is one of a series of handbooks prepared by Foreign Area Studies (FAS) of the American University, designed to be useful to military and other personnel who need a convenient compilation of basic facts about the social, economic, political, and military institutions and practices of various countries."

Anatomy of a Crisis by Bernard B. Fall. Doubleday, Garden City, New York.
"Bernard Fall acutely reconstructs the origins, major actions, and probable consequences - for Asia, the United States, and the rest of the world - of this still precarious situation."

The Concise Dictionary of 26 Languages in Simultaneous Translation by Peter M. Bergman. Polyglot Library, New York.
"A new concept in multi-language dictionaries. The only comprehensive book of its kind that translates 26 modern languages instantaneously."

ABM; An Evaluation of the Decision to Deploy an Antiballistic Missile System. Harper and Row, New York.
This report is the result of the studies of an independent evaluation group, made at the time that Congress was considering the decision to employ the ABM.

The Sex Education Racket by Phoebe Courtney. Free Men Speak, Inc., New Orleans.
"If you have children or grandchildren in school, this book vitally concerns you because it contains documented information regarding the real implications and meaning of the so-called sex-education courses now being taught in an increasing number of elementary and secondary schools throughout this nation."

"Che" Guevara on Revolution by Jay Mallin. University of Miami Press.
"Jay Mallin's fascinating, readably documented study separates the man from the myth and for the first time gives us the whole - and real - 'Che' Guevara."

Army Registry of Special Educational Materials by U.S. Dept. of Army. DA Pamphlet No. 350-16.
"In order to identify, collect, record, and make easily accessible the materials produced by the various Army schools and colleges, the Army Library has established the Army Registry of Special Educational Materials (ARSEM)—a central records facility."

ARTICLES

"Chemical and Biological Weapons," Matthew S. Meselson, Scientific American (May 1970), pp. 15-25.
"The U.S. has renounced all forms of biological weapons and the first use of most chemical weapons. The issue of whether or not to include irritant gases and antiplant agents in the prohibition remains open."

"Rise of Soviet Sea Power," Thomas H. Moorer, Ordnance (January-February 1970), pp. 394-398.
"With their fleet of modern combat vessels the Reds are gaining experience in operating farther from their home bases and already have become a potent military presence in the Mediterranean Sea."

"The Giant Harvest from Space - Today and Tomorrow," James J. Haggerty, Air Force/Space Digest (February 1970), pp. 30-43.
"The US space investment to date is already paying handsome dividends, not only 'hard' benefits of practical value but also a broad spectrum of little-understood advances in science and technology that include new techniques, processes, products, and ways of managing enterprises."

"Morale and Mental Health," Edward M. Colbach, Army Digest (May 1970), pp. 9-11.
"U.S. soldiers in the Republic of Vietnam are holding up better than in any previous conflict. It's partially due to the qualified medical personnel, NCOs, and commanders - all working hand-in-hand to improve morale and stiffen upper lips."

"Why American Troops Should Remain in Europe," William E. Griffith, Reader's Digest (May 1970), pp. 121-125.
"It is not just a matter of close ties with people who share our cultural heritage; the defense of Western Europe is every bit as important to us as it is to the people who live there."

"Start Planning Your Retirement Right Now," Changing Times (May 1970), pp. 33-35.
"In the last analysis, retirement is like any other stage of your life - just what you make of it. That is why it makes sense to devote all the time that is needed to planning for it, beginning right now."

"Man Vs. Machines in Space - What the Future Holds," U.S. News & World Report (May 11, 1970), pp. 78-79.
"Apollo 13's troubles have re-ignited the debate over space priorities. One result may be a larger role for unmanned satellites in the years ahead."

"Second-Guessing Tomorrow," Craig Powell, Armed Forces Management (April 1970), pp. 26-29.
This article attempts to determine the current and projected threat to the United States from foreign powers and how we plan to counter the threat.

"An Entire City Under Glass," Jim Davis, Popular Science (March 1970), pp. 74-75.
"An Alaskan metropolis, will begin to take shape this summer to provide offices and homes for 40,000 live-ins who will enjoy a year-round ideal climate."

"This Far, No Farther," Theodore C. Mataxis, Military Review (March 1970), pp. 74-82.
"Our oath as officers and our responsibilities under the Uniform Code of Military Justice to defend our country against 'all enemies foreign and domestic' demand that we take well-reasoned and considered action now to counter these attempts to destroy the morale."

"Tiny Computers May Use Magnetic Bubbles," Electronics Digest (January-February 1970), pp. 8-9.
"Minute magnetic bubbles may provide compact and inexpensive data storage and processing for tomorrow's computer and switching systems. The bubbles, locally magnetized areas moving in thin plates of magnetic material, are being explored by scientists."

"Semiconductor Injection Lasers," Ronald L. Carroll, Electronics World (March 1970), pp. 45-47.
"These solid-state diodes, which emit coherent light, are much smaller than the more common gas or pumped ruby-rod lasers. When mounted in arrays, they can produce substantial output power."

ANSWERS TO CROSSWORD PUZZLE:

Across		Down	
1.	branches	2.	resistance
5.	all	3.	current
7.	six	4.	sum
8.	infinite	5.	amount
11.	ohms	6.	less
13.	reciprocal	9.	third
14.	individual	10.	two
		12.	same

Are You FA or ADA?

There still are a few officers who are not sure whether they are assigned to the Field Artillery (FA) or Air Defense Artillery (ADA) Branch.

Transfers to ADA were announced in paragraph 311, DA Special Orders (DASO) 233, 29 November 1968; paragraphs 316 through 325, DASO 64, 3 April 1969; and paragraphs 115 and 116, DASO 84, 1 May 1969. DASO 84 also announced transfer of certain ADA officers back to FA. Artillery officers not switched to ADA by these orders were assigned automatically to FA.

Individuals who are in doubt about their status should check these orders. In addition, all Artillery officers should insure that item 12, DA Form 66 (Officer Qualification Record), reflects their transfer from Artillery to FA or ADA as appropriate.

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AIR DEFENSE TRENDS

An index of all issues of Air Defense Trends for the previous year will be published in the first issue annually. This index covers the year 1970.

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Here is the second increment of 24 aircraft identification figures for your flash card deck.

Army, Fort Bliss, Texas