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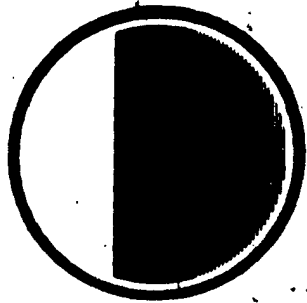
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UNITED STATES ARMY TRAINING AND DOCTRINE COMMAND

TRADOC BULLETIN 4



- WEAPONS
- TACTICS
- TRAINING

**SOVIET ZSU-23-4:
CAPABILITIES AND
COUNTERMEASURES**

JANUARY 1976

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UNITED STATES ARMY
TRAINING AND DOCTRINE COMMAND
BULLETIN NO. 4

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ON 17 Feb 83

**SOVIET ZSU-23-4:
CAPABILITIES AND
COUNTERMEASURES**

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This TRADOC Bulletin is intended to provide to commanders, and others concerned with military training, timely technical information on weapons, tactics, and training. It is not intended to supplant doctrinal publications, but to supplement material on "how to fight" with data derived from tests, recent intelligence, or other sources, which probe "why."

TRAINERS' NOTE: The format of this bulletin is designed to help trainers identify and extract needed information. Charts, illustrations, and other key data which are unclassified, are clearly marked and boxed-in by a bold line.

Comment or criticism is welcome, and should be directed to:

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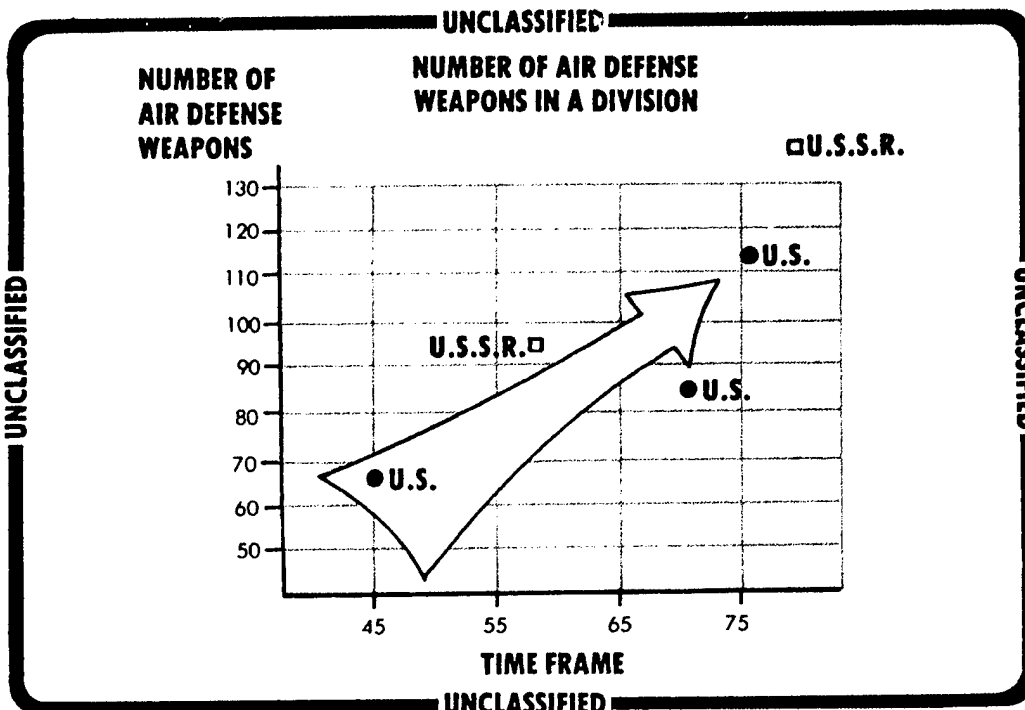
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I

AIR DEFENSE on the Modern Battlefield

Since World War II, the range, accuracy and lethality of air defense weapons have increased dramatically. The antiaircraft weapons of 1945 were guns, some radar controlled, but all limited in range to about 10 km. In contrast, today an air defense complex in a forward divisional area is made up of gun and missile systems covering the battle area forward and behind the area of contact for as much as 40 kilometers (an increase of 36 times as much volume of air space controlled). Moreover, these weapons are mobile, capable of moving with maneuver units, and providing a continuous air umbrella.

The addition of such weapons to maneuver units is one dimension of the proliferation of modern air defenses. In 1945, a US division typically had 64 air defense weapons, all inaccurate and short range. In the mid-70's, the number of weapons, with marked advances in accuracy and range, had increased to 113; Soviet-equipped divisions include an even larger number.

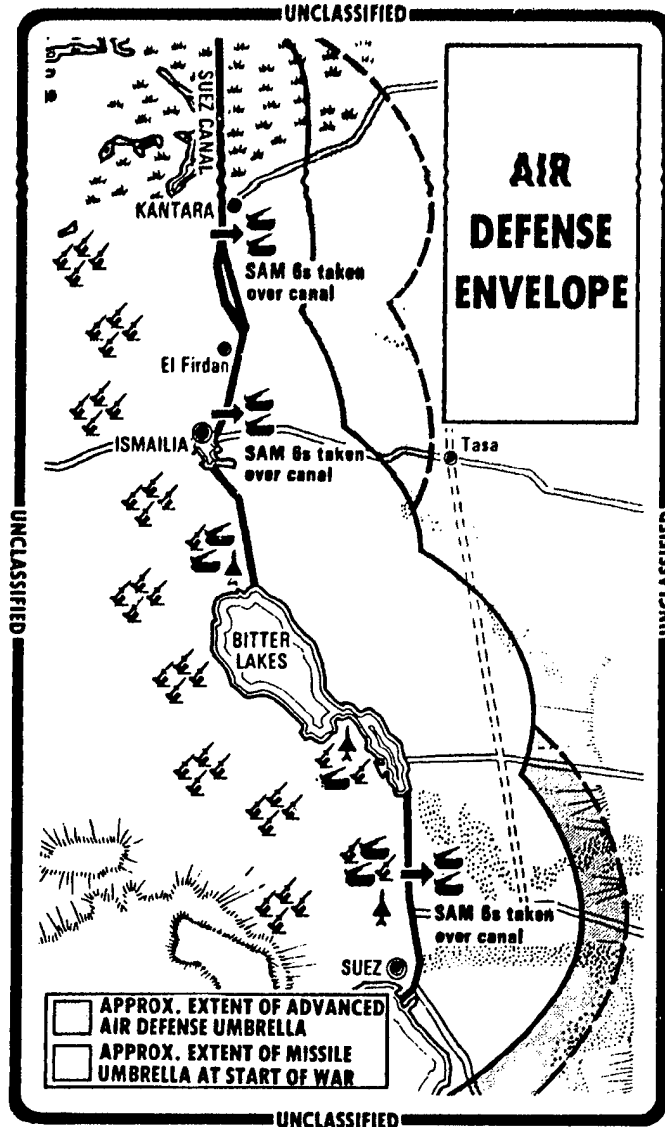


Another indication of the proliferation of air defense weapons systems to be expected on the modern battlefield was observed during the 1973 Middle East War. In this war, Arab forces alone deployed some 150 air defense artillery batteries-which is more than we have in all the active and reserve forces of the US Army. This proliferation of Soviet-built air defense weapons enabled the Arabs to provide their ground forces with a large protective "envelope." This envelope that protected the crossing of the Suez Canal and subsequent advancement by the Egyptian 2nd and 3rd Armies is shown here:

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The result of this thick and lethal air defense environment was, particularly at the beginning of the war, to deny the Israeli Army the close air support they wanted. In fact, 90% of the Israeli air sorties were flown more than 5 km behind the area of intensive air defense. That means that not more than 10% of the air sorties could have been what we would term "close air support" of ground elements in contact with the enemy. The results also showed that ground

air defenses were a far greater problem than Arab air forces. As this breakout shows, 73% of IDF air losses were attributable to ground systems:

ISRAELI AIR LOSSES

GROUND SYSTEMS

SURFACE TO AIR MISSILES	41%
GROUND GUN SYSTEMS	26%
UNDETERMINED	6%
	<hr/> 73%

AIR TO AIR COMBAT 3%

OTHER (TECHNICAL, UNKNOWN) 24%

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THE PROLIFERATION AND LETHALITY OF SOVIET-BUILT AIR DEFENSE WEAPONS SYSTEMS IS A MAJOR LESSON TO BE LEARNED FROM THE 1973 MIDDLE EAST WAR.

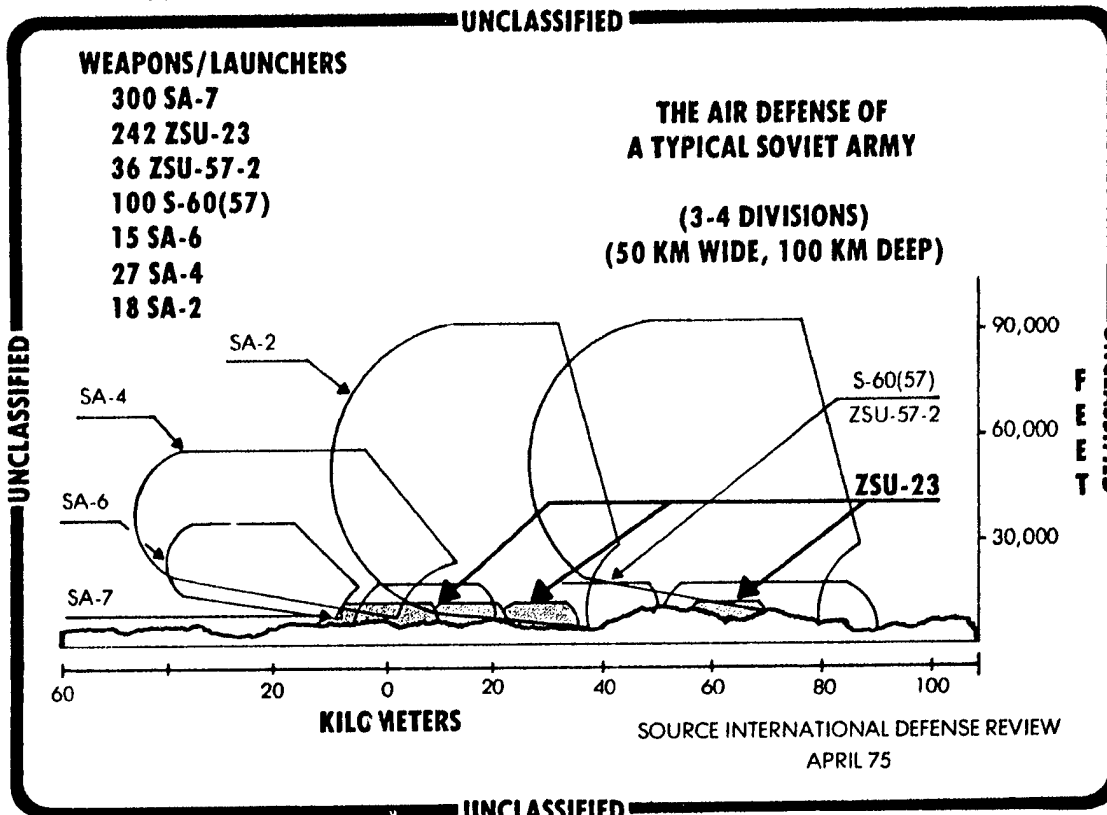
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"The equipping of the air defense troops with modern armament permits organizing an anti-aircraft defense which is capable of assuring the attacking troops freedom of maneuver and combat action and repelling enemy air strikes and thereby creating the necessary conditions for the successful conduct of the offensive."

*A. A. Sidorenko
Moscow 1970*

The above quotation from **THE OFFENSIVE** typifies Soviet military thought and indicates their determination to provide an effective air defense which, in turn, will insure their freedom of maneuver on the battlefield. Soviet air defense forces are equipped with a sophisticated array of missile and gun systems. They not only provide extensive coverage; but are highly mobile and are deployed with maneuver units to provide continuous protection for attacking troops. A

typical Soviet air defense system would include the following weapons, which would provide these overlapping envelopes:



From the vast array of sophisticated air defense weaponry available to Soviet forces and from the demonstrated performance of these weapons systems in the October 1973 War, we can conclude that in the air above the battlefield, as on the battlefield itself...



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While air defense radar can detect at distances well beyond the capability of the human eye, within eye-range, most gun systems are lethal.

One of the most numerous air defense weapons found in the forward echelons, and therefore most likely to be encountered by US Army aviation units, is the ZSU-23-4 Self-Propelled Antiaircraft Gun. The purpose of this bulletin, therefore, is to examine this system to show how it operates, how it is employed, how effective it is, and, perhaps most importantly, to point out some important tactical implications for US Army aviation units.

Data in this bulletin is from the Defense Intelligence Agency, various reports on the 1973 Middle East War, tests conducted by CDEC and MASSTER, and from US Army Material Systems Analysis Activity. Effectiveness data presented in the following charts are derived either from actual tests conducted or from computer model simulations conducted by USALDA, based on actual tests and accepted data. The US Army Aviation School and US Army Air Defense School also made valuable contribution in the preparation of this bulletin.

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II

THE SOVIET ZSU-23-4 SELF-PROPELLED ANTIAIRCRAFT GUN

The ZSU-23-4 AA weapons system consists of four 23mm automatic weapons and fire control radar mounted on a lightly armored, full tracked vehicle. The weapons are mounted parallel, in two pairs, in an enclosed turret with the barrels protruding from a cutaway portion to allow for gun elevation. Both turret traverse and gun elevation are accomplished by power, with a manual control for emergency. The gun barrels are liquid cooled and expended cartridge cases are ejected outside the turret by chutes. Fire control is provided by the on-carriage radar or by optical sights.



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CHARACTERISTICS

VEHICLE		WEAPON	
Weight	13-15 tons	Elevation	-10 to +85 deg
Length	21 ft	Traverse	360 deg
Width	8.9 ft	Rate of fire, cyclic	800-1000rpm (per gun)
Height	7.5 ft	Rate of fire, practical	300-350rpm (per gun)
Armor protection	0.5 to 1 in	Max vert range	5100 m
Max speed	25 mph	Max horiz range	7000 m
Cruising range	150 miles	Tact AA range, optical	2500 m
Crew	4	Muzzle velocity	930 m/s
* Ammo load	2000 rds		

* Normally 3 HE incendiary-tracer rounds to 1 Armor piercing-incendiary-tracer round.

US COUNTERPART: 20MM Vulcan Air Defense System XM-163

It is important to note that:

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- The ZSU-23-4 CAN SHOOT WITH EITHER RADAR OR VISUAL FIRE CONTROL.
- IT IS TRACKED AND LIGHTLY ARMORED; SO IT CAN KEEP UP WITH TANKS.

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This antiaircraft gun was first displayed in November 1965 and it soon appeared in virtually all of the Warsaw Pact armies. It saw combat in the 1973 Middle East War and proved to be the most effective antiaircraft gun employed. It is still the best available in the Warsaw Pact today.

METHOD OF OPERATION

The system incorporates a fire control radar (i.e. the GUN DISH radar mounted on top of the vehicle) that enables it to acquire targets at a line of sight range of 20 km. It can track targets out to 10 km and provides good range data for low altitude targets. For low altitude targets, the radar is backed up by 2x and 6x optics. Optics are relied upon heavily in an environment of high electronic countermeasure usage and/or during periods of emission control.

Target information is provided to a computer, which receives corrections from its three plane stabilization system, calculates the intercept point and lead angle, and points the guns. This gives the system this important capability:

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The ZSU-23-4 can fire...

- ...while stationary
- ...on the move (up to 25 km/hr)
- ...on a 10° degree slope

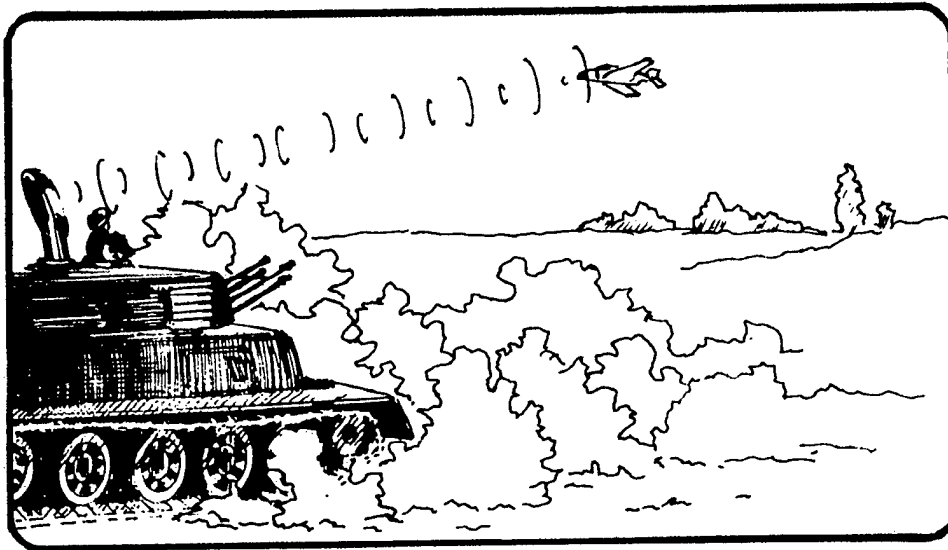
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FIRING MODES

There are five options or modes for firing the ZSU-23-4:

1. RADAR ONLY

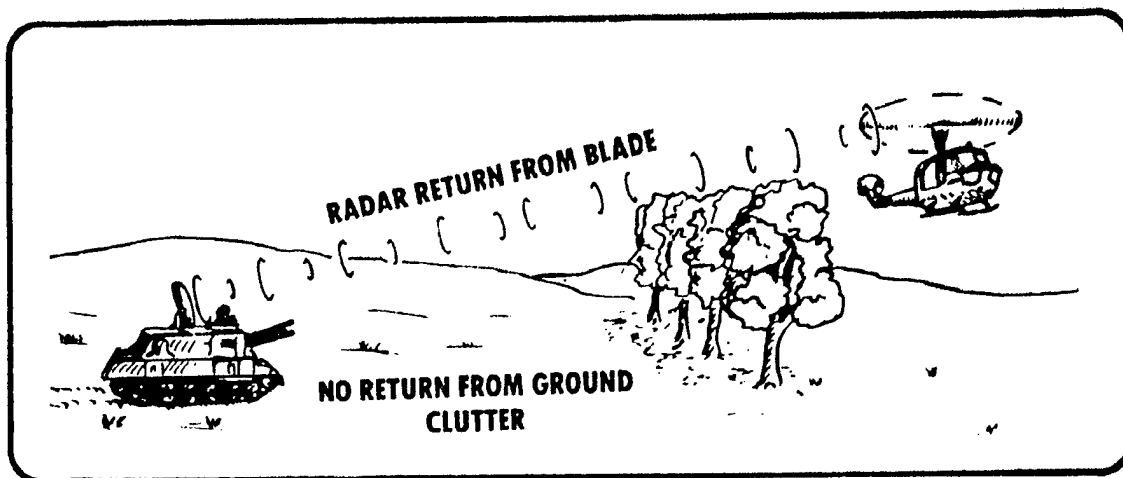
In this mode the radar provides target azimuth, elevation and range, thus enabling automatic full solution to the gunnery problem. This mode is preferred when engaging high performance aircraft on targets above ground clutter.



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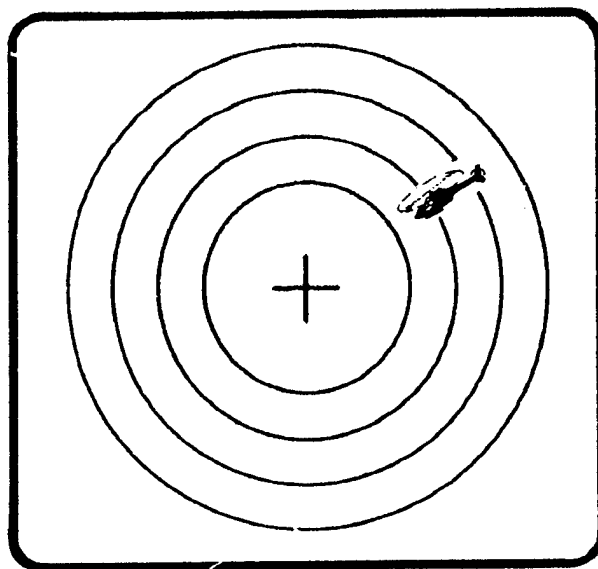
2. RADAR PLUS OPTICS

Radar plus optics provides range only. The operators' two power or six power optics are used to track in azimuth and elevation. The computer automatically controls the guns. This mode is used against low altitude targets and ground targets, as the reduced sensitivity of the radar highlights the moving target, against background.



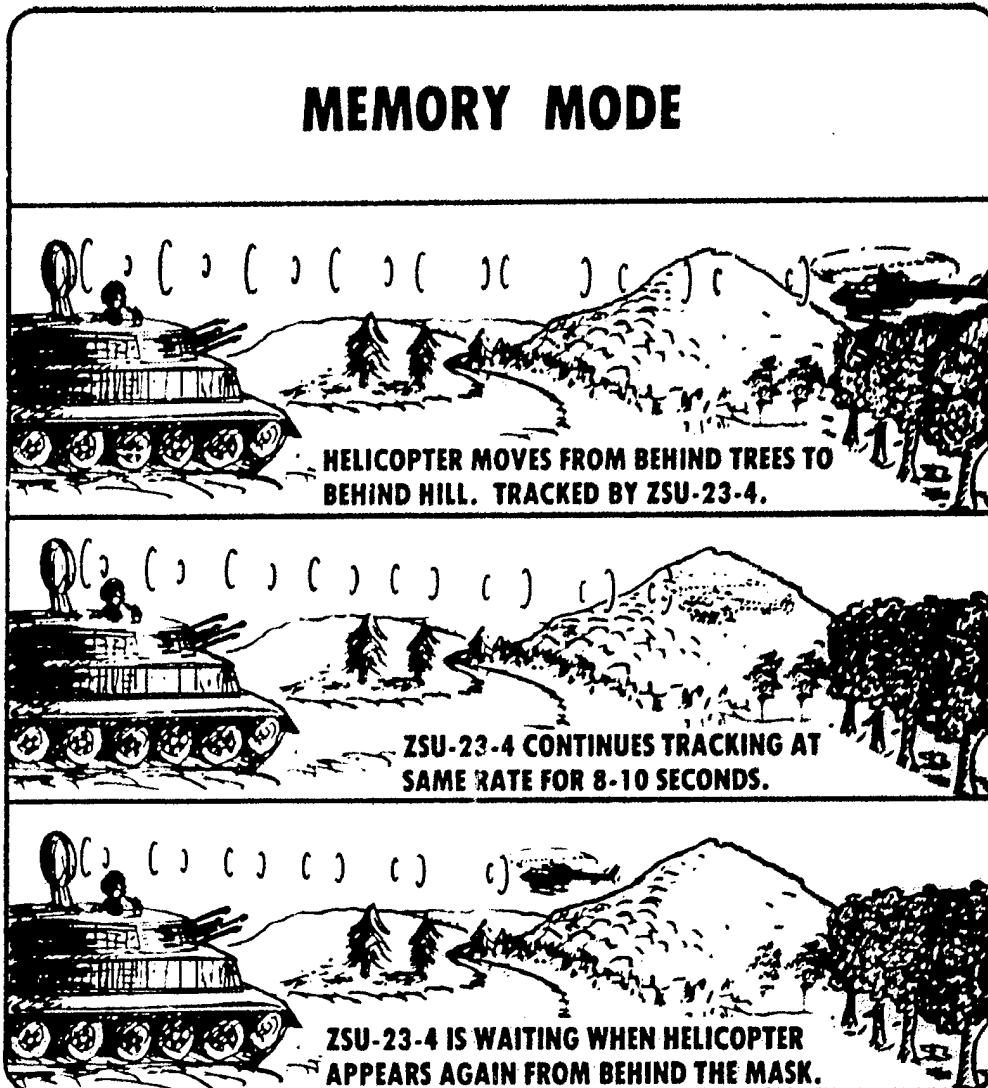
3. OPTICS ONLY.

Optics are used when the radar is denied range data. In this mode the operator inputs the range information based on his own estimates or data provided by another gun in the platoon. Guns are pointed by manually tracking the target with the aspect ring sights.



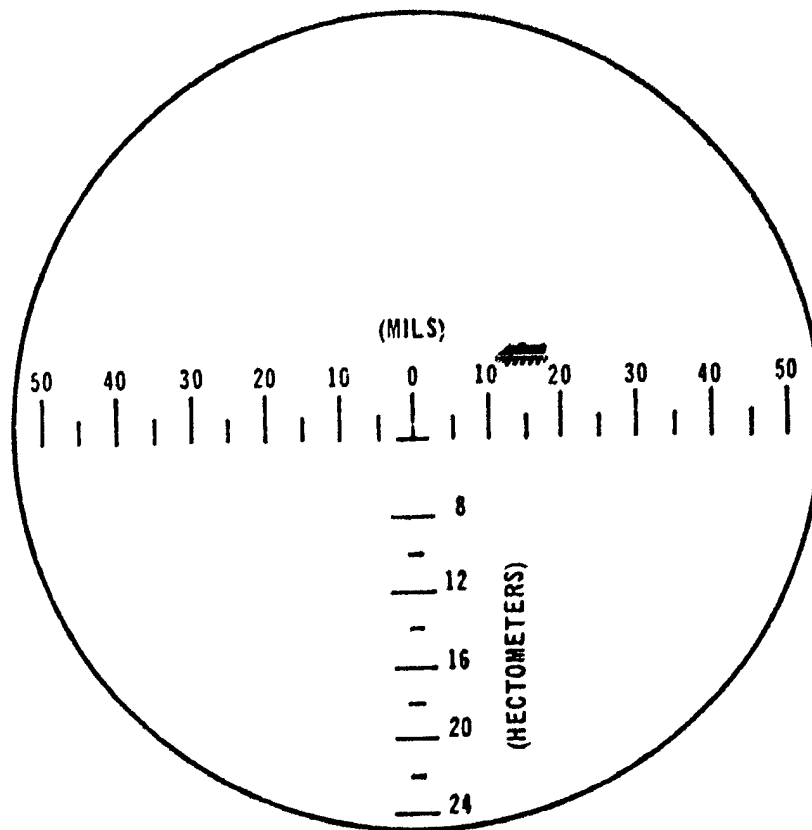
4. MEMORY

Memory provides steering data to the guns for 8-10 seconds based on the last computed tracking rate. Memory is used with modes 1 and 2 and is used when targets fly behind some mask.



5. GROUND FIRE

Ground fire is normally used for self-defense only. Fire control is normally optical.



EFFECTIVENESS OF ZSU-23-4

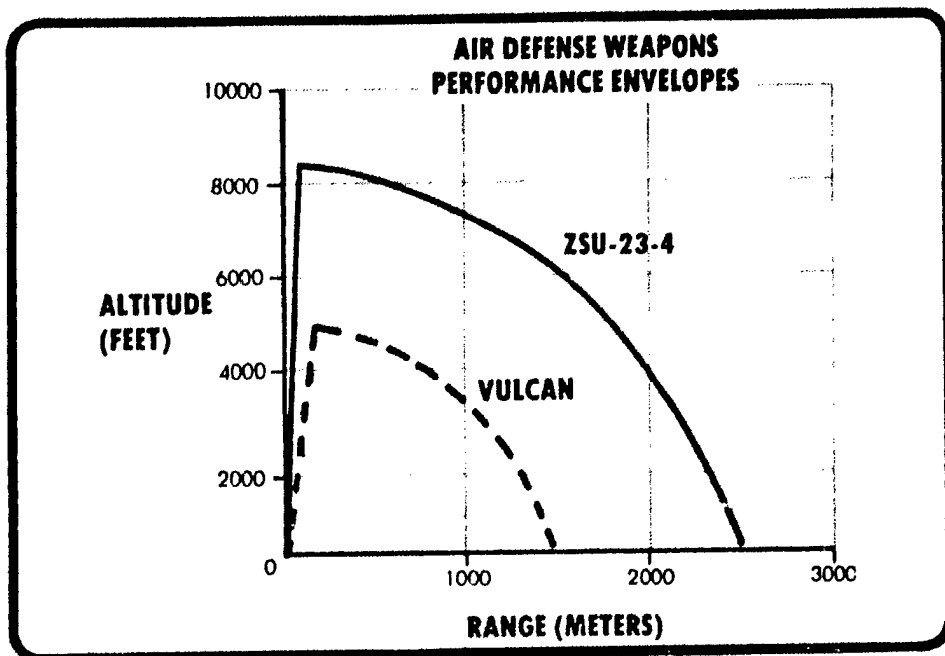
RANGE

The ZSU-23-4 must be regarded a highly effective antiaircraft gun weapons system. To illustrate this effectiveness let us compare it with its US counterpart, the 20mm VULCAN.

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The chart below shows the maximum altitude and range of VULCAN engagements compared to the ZSU-23-4.



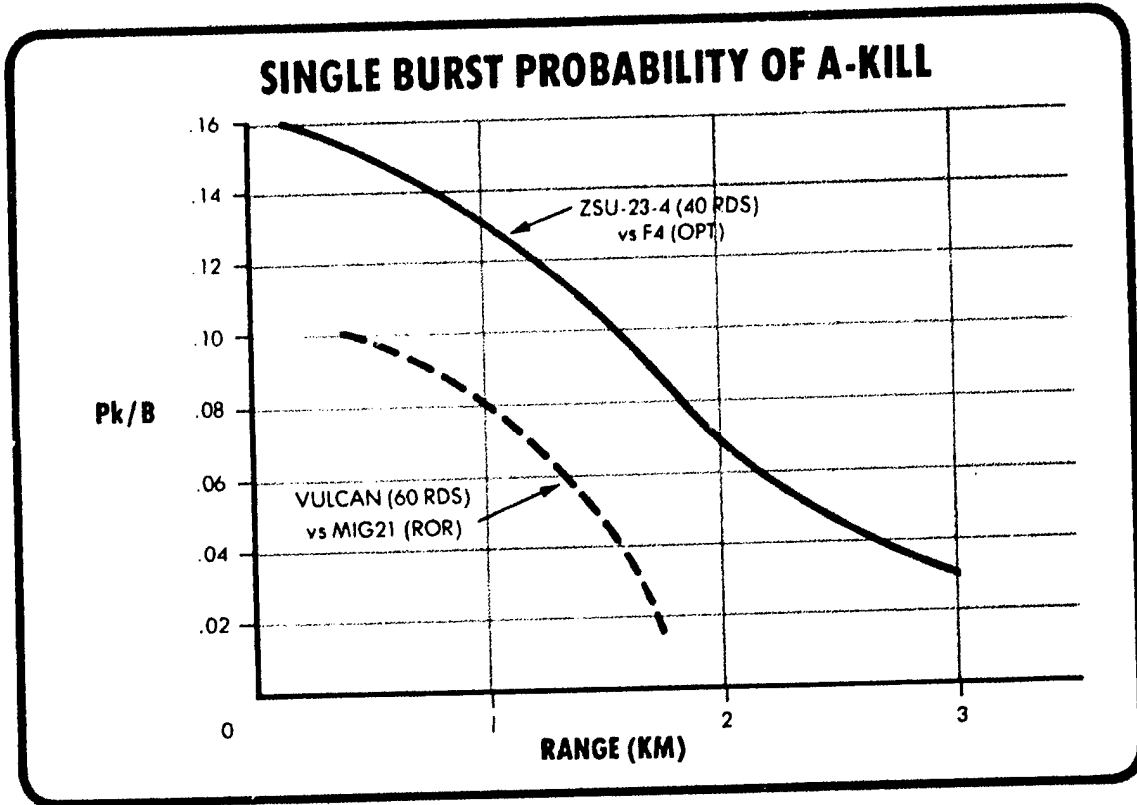
This chart shows the "horizontal" range of the ZSU-23-4 out to 2500m. The Soviets feel that accuracy drops off so sharply beyond 2500 meters that the gunner should not engage beyond that range except in self defense.

LETHALITY

The next chart compares the lethality of the ZSU-23-4 to that of the VULCAN. It shows the probability of an "A-Kill" given a burst (Shown as Pk/B and meaning that the aircraft will be a loss within five minutes). In this example, an F-4 jet aircraft is flying straight and level at 500 meters altitude; at 400 kts and does not maneuver. Thus, if the ZSU-23-4 fires a 40 round burst from its four automatic cannons, and if it fired at the F-4 at a range of 1 km using optics only.

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the ZSU-23-4 has a probability of kill per burst of approximately .13; whereas, the VULCAN firing at a MIG-21 with a 60 round burst under the same conditions and using its range only radar has a probability of kill per burst of only .08.



Thus, by way of comparison, we can say that

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COMPARED TO THE VULCAN...

THE ZSU-23-4 has...

...2/3 more range

...greater than 50% more accuracy

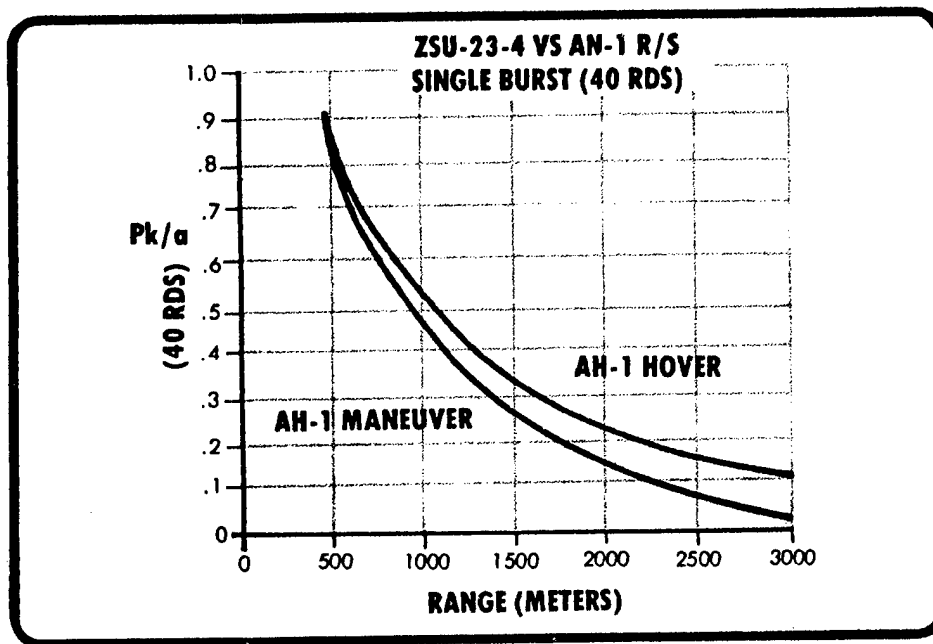
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LETHALITY AGAINST THE HELICOPTER

The following chart depicts the probability of kill (Pk) vs. range of a single 40 round burst of a ZSU-23-4 firing at an AH-1 helicopter shooting a TOW, both while it is at hover, and while it is maneuvering laterally. Maneuver is that limited to the maximum "G" force (.35) the helicopter can use and still control the TOW missile.

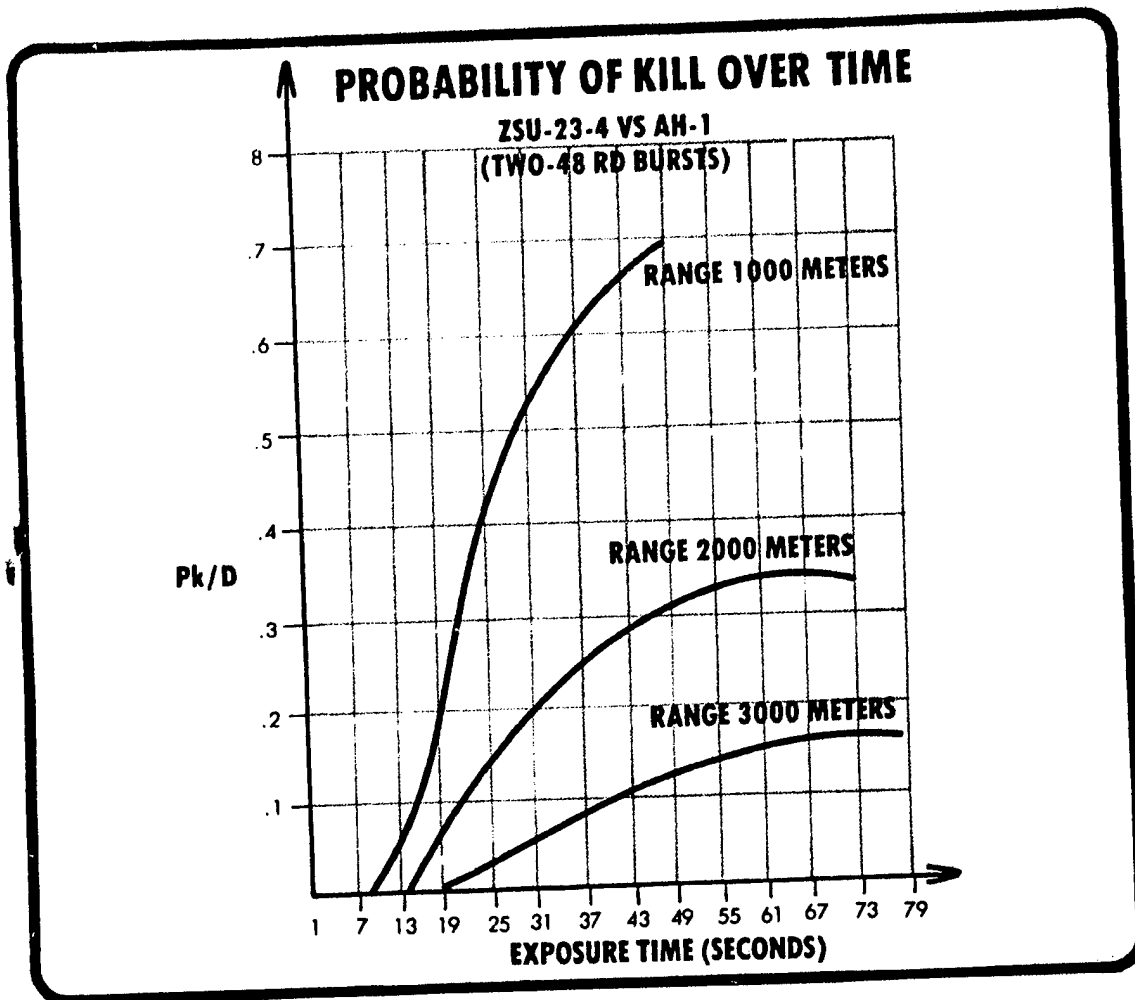
The chart shows a high probability of kill at the shorter ranges but dropping off for a hovering AH-1 to .1 at 3,000 meters. However, if the helicopter is maneuvering laterally, it improves its chance of survival. At 2000m the Pk is .25 while hovering, but when maneuvering Pk falls to .15—a 40% increase in the chances of survival at that range.



LETHALITY AS A FUNCTION OF RANGE AND EXPOSURE TIME

This next chart displays the probability of kill vs exposure time at three selected ranges—1000, 2000, and 3000 meters. In this case, a ZSU-23-4 fires two 48 round bursts against a hovering AH-1 COBRA, frontal aspect. This data is restricted by the use of two 48 round bursts because the analysis is based on the practical consideration that two bursts would alert a pilot in an attack helicopter, and he would attempt to break away before the arrival of the projectiles from a third firing. This chart shows that cutting exposure time reduces the lethality of the ZSU-23-4 and that it also decreases rapidly as the range increases.

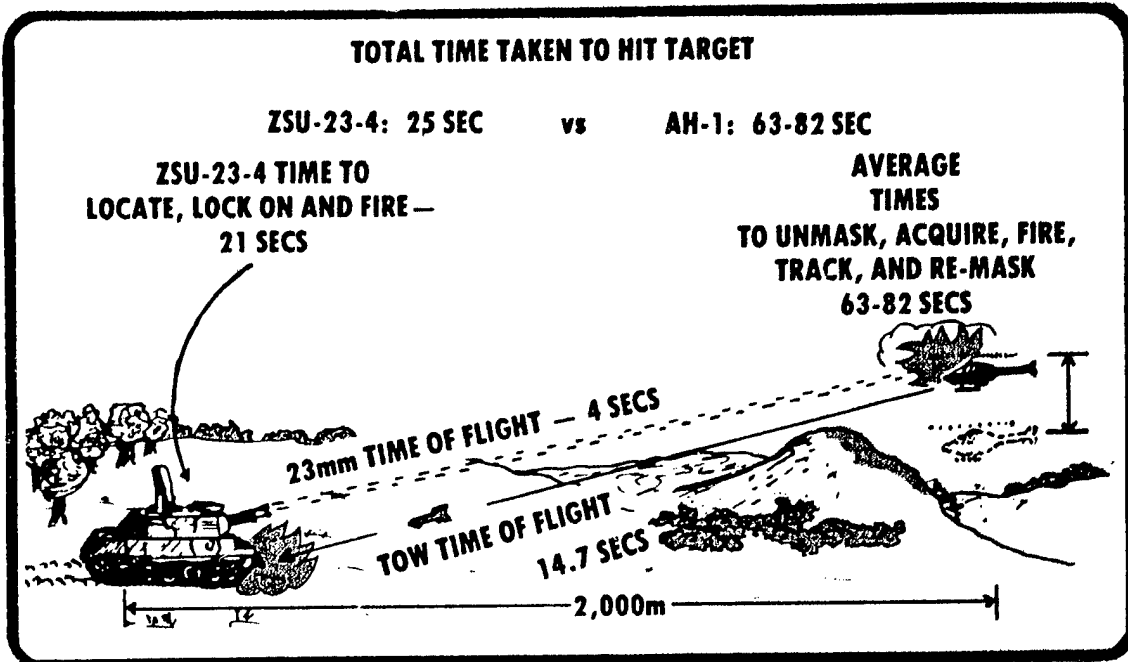
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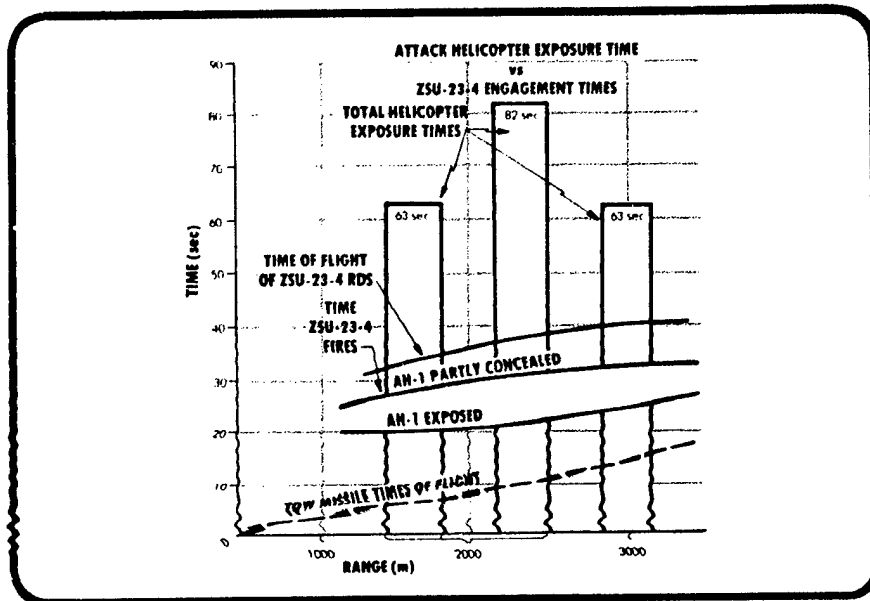
ZSU-23-4 ENGAGEMENT TIME

To further illustrate the interrelationship between the probability of kill of the ZSU-23-4, and the range and exposure time of the target aircraft, the following sketch and chart depict the dynamics of an attack helicopter vs. ZSU-23-4 engagement on the battlefield. The sketch depicts the situation in which the helicopter unmarks, acquires his target ZSU-23-4, prepares to fire, fires, tracks his TOW missile to the target, and remarks. Recent tests have shown that some pilots took 63 to 82 seconds for these actions. At the same time, the ZSU-23-4 can locate the attacking helicopter lock on, fire, and rounds can travel to the target, in as little as 25

seconds. The sketch below shows this sequence for an engagement range of 2000 meters. Note: These are some actual performance times based on tests.



The chart below illustrates the above situation at ranges of 2000 and 3000 meters. You can see that it takes slightly longer for the ZSU-23-4 to acquire his target when the AH-1 is partially concealed by having terrain, or foliage, in the background.



The important point to note from the above chart is that in some tests our helicopters remained unmasked too long! If you add 6 seconds time of flight for the 23mm round at 3000 meters, you can see that, even when partially concealed, the maximum time available to the attack helicopter pilot is about 35-40 seconds. Fortunately, a later test showed that some crews were able to complete the engagement within 37 seconds!

From the foregoing data we should begin to conclude the following important facts about the ZSU-23-4:

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ZSU-23-4 EFFECTIVENESS

- THE ZSU-23-4 IS A HIGHLY LETHAL WEAPON
- ITS EFFECTIVENESS FALLS OFF SHARPLY BEYOND 2500 METERS
- THE ZSU-23-4 CAN ACQUIRE, LOCK ON, AND FIRE AT A TARGET IN APPROXIMATELY 20-30 SECONDS
- THE ZSU-23-4 IS LESS EFFECTIVE AGAINST A MANEUVERING HELICOPTER THAN A HOVERING ONE
- THE ZSU-23-4 EFFECTIVENESS IS REDUCED AS THE TARGET'S EXPOSURE TIME IS DECREASED

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These facts suggest the following training standards for US Army aviators:

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- KNOW THE CAPABILITIES OF THE ZSU-23-4 IN ORDER TO SURVIVE ON THE BATTLEFIELD
- REMAIN UNMASKED NO LONGER THAN 30-35 SECONDS
- ENGAGE WITH TOW - BEYOND 2500 METERS

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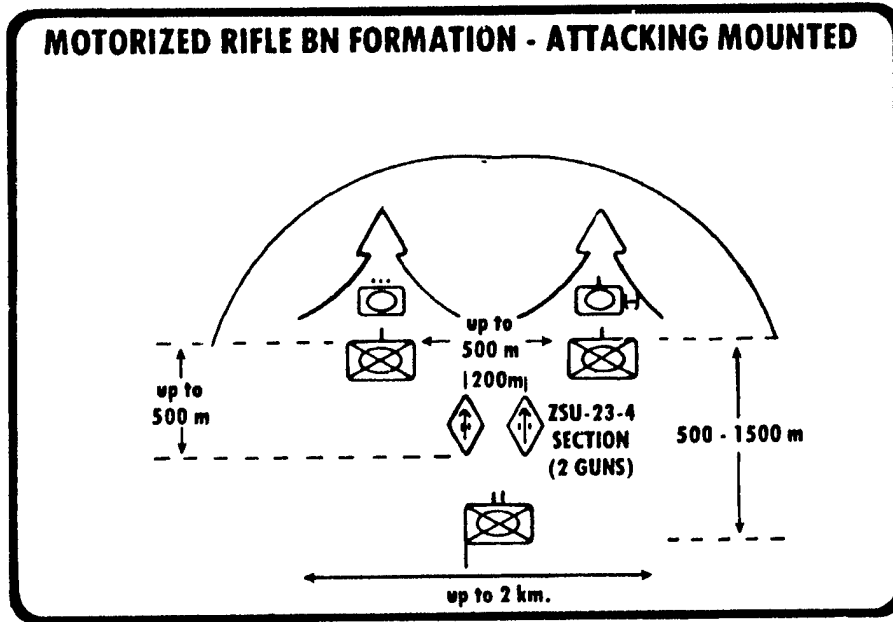
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TACTICAL DEPLOYMENT

ATTACK

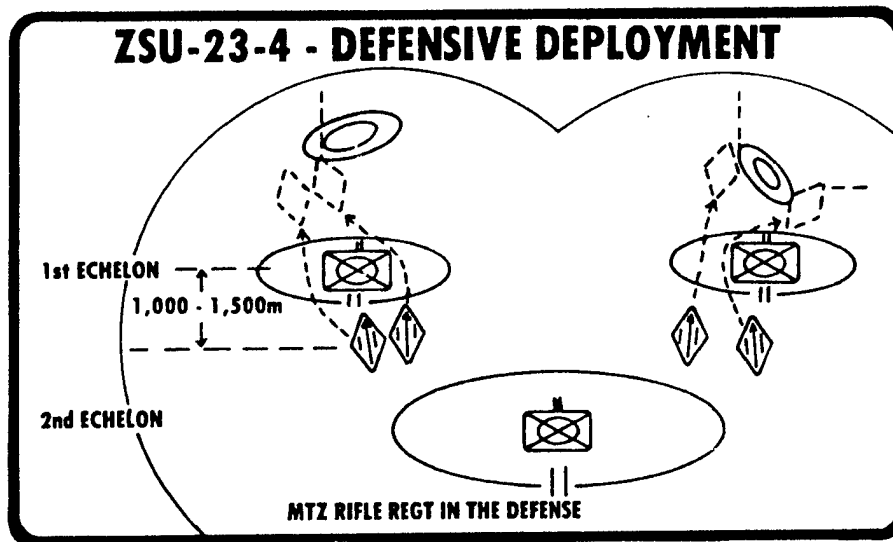
The ZSU-23-4 is found at regimental level. The regimental air defense battery consists of one platoon of four ZSU-23-4 self-propelled guns and one platoon of four BRDM-2A's mounting the SA-9 SAM missile. The ZSU-23-4's normally operate in pairs within the combat formations of tank or motorized rifle units. One section of two guns is usually attached to each first echelon attacking battalion. Thus, in the attacking first echelon of the regiment, look for four guns operating in two pairs.

When a battalion deploys for combat the ZSU-23-4's will follow the assaulting tanks or BMP's at a distance of 400-500 meters. They normally keep 200 meters between guns and fire either on the move or from the short halt. Their location within an attacking battalion's formation would look something like this:



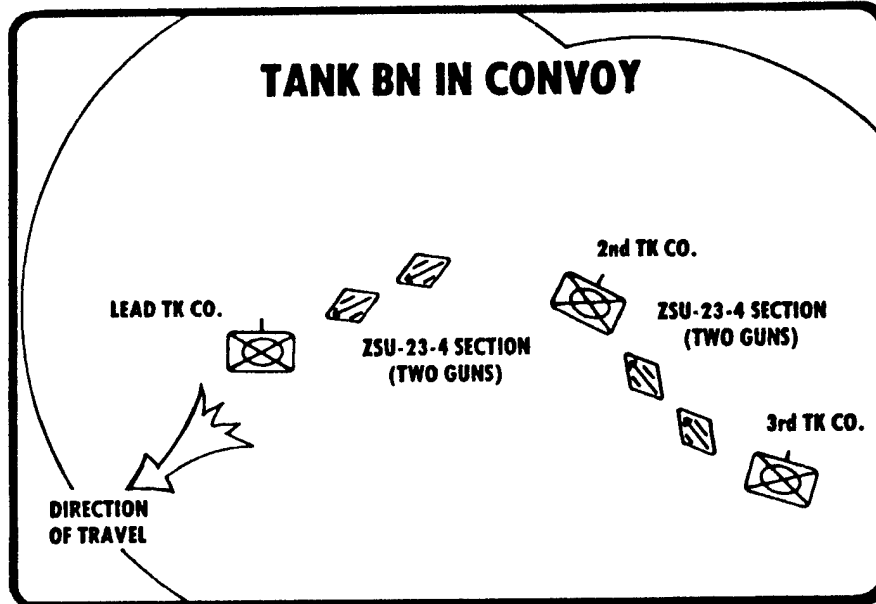
DEFENSE

In the defense the ZSU-23-4 platoon will establish primary defensive positions some 1000-1500 meters behind the supported battalions main defensive positions. Prior to the expected attack, the gun sections will occupy positions forward of prepared defenses from which they will attempt to ambush helicopters and conceal their primary defensive positions.



ROAD MARCH

In convoy the ZSU-23-4's normally move with their supported battalion. In order to provide adequate fields of fire, an interval of 30-50 meters is maintained between the guns and other vehicles. In the example below, the platoon of four guns is moving with one tank battalion.



From the normal tactical deployment of ZSU-23-4 we should remember several important points:

- ZSU-23-4s ARE FOUND IN PAIRS ABOUT 200 METERS APART.
- LOOK FOR TWO PAIRS. THERE ARE FOUR TO A REGIMENT. LOOK FOR TWO PAIR OVER A 2-4 Km SECTOR.
- THEY ARE DEPLOYED CLOSE BEHIND TANKS AND BMPs. THEY WILL BE IN THE FIRST ECHELON.
- IN THE ATTACK, THEY ARE FOUND 400-500 M TO THE REAR OF ATTACKING TANKS AND BMPs.
- IN THE DEFENSE, THEY ARE USUALLY 1-1.5 KM BEHIND THE MAIN DEFENSIVE POSITIONS; BUT, THEY MAY COME FORWARD OF THE MAIN DEFENSIVE POSITIONS TO AMBUSH ATTACKING AIRCRAFT.

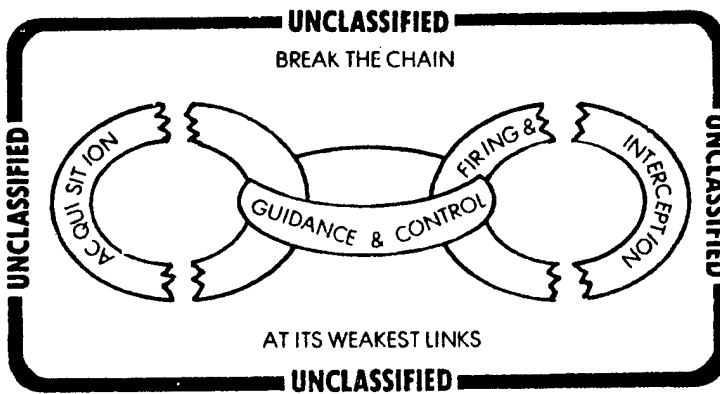
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III
COUNTERMEASURES:
TACTICAL AND TRAINING IMPLICATIONS

Let's examine the ZSU-23-4 antiaircraft weapons system to determine its vulnerabilities. There are three essential functions that must be performed in order to complete a successful engagement. First is acquisition—the target aircraft is acquired either visually or by radar. Next is the internal guidance and control—the range, deflection, and altitude data for the target aircraft is fed to the computer, which then correctly aims the guns. Finally, there is the firing and interception—the guns are fired and the rounds intercept the target.

Since there is no practical method of interfering with the ZSU-23-4's guidance and control system, we must break this chain of events by destroying the other two links. We must prevent the ZSU-23-4 from effectively acquiring targets and we must degrade the effectiveness of his fire.



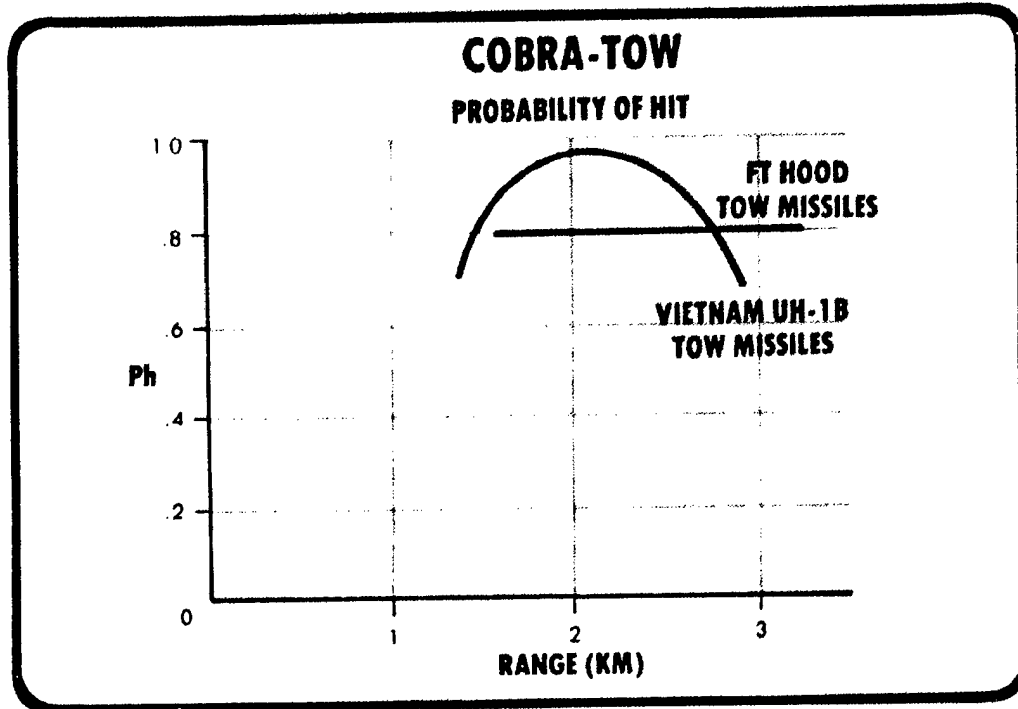
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- We do this in two important ways:
- REDUCING EXPOSURE TIME
 - STAYING OUT OF EFFECTIVE ZSU-23-4 RANGE
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RANGE

Because of the attack helicopter's mobility and firepower, it is a valuable antitank asset available to the commander. It must, therefore, be employed primarily to destroy enemy armor; however, it must first survive to do that. Often it will be necessary to destroy or suppress enemy antiaircraft weapons before being able to do its primary job of killing tanks. In its battle with the ZSU-23-4, the attack helicopter has one enormous advantage—a greater effective range!

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To illustrate, the chart below depicts the probability of hit of the COBRA-TOW and the UH-1B TOW vs. range. In tests conducted at Fort Hood, 103 TOW missiles were launched at an M-48 target moving 3-14 mph. Firings were conducted at ranges between 1744 — 3030 and also at 3500 and 3600 meters. In Vietnam, 133 missiles were fired and the targets were almost all stationary. Pilots were considered well trained and fired from a forward flight tactic on a descending angle toward the targets.



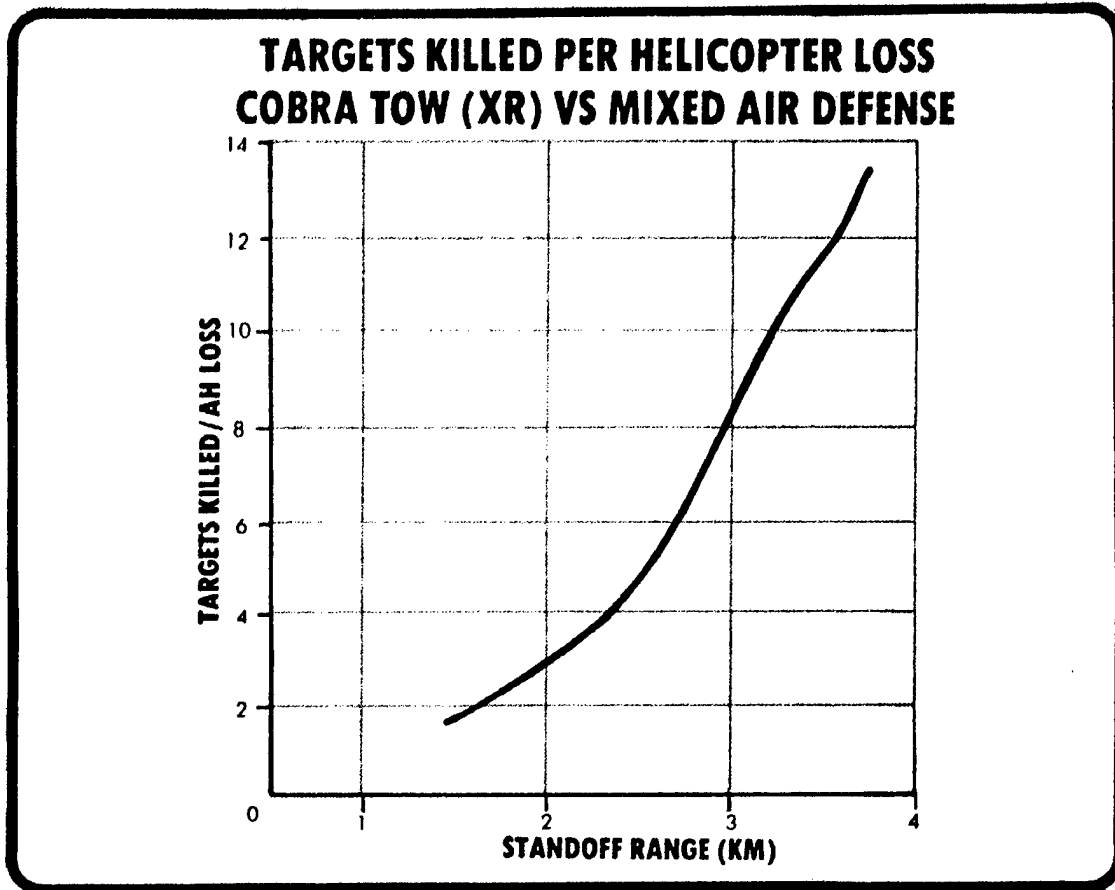
As this chart indicates, the TOW has a high probability of hit, nearly 80% and it does not decrease with range. Thus, the attack helicopter with an 80% probability of hit at 3000 meters has an enormous advantage over the ZSU-23-4 with a probability of kill of only 10% at that same range.

We should remember to

TAKE ADVANTAGE OF STAND-OFF RANGE WITH THE COBRA-TOW. ENGAGE BETWEEN 3000 AND 3750 METERS (MAX RANGE).

Since the attack helicopter will face more than just the ZSU-23-4 on the battlefield, the next chart further illustrates the advantage of employing standoff range. This graph shows the targets killed per helicopter loss as a function of range against a mixed air defense of SA-7, SA-8, and ZSU-23-4.

This example shows an exchange ratio curve of slightly more than 2:1 at 2000 meters, increasing to 7:1 at 3000, further increasing to 12.5:1 at 3750 meters (max range).



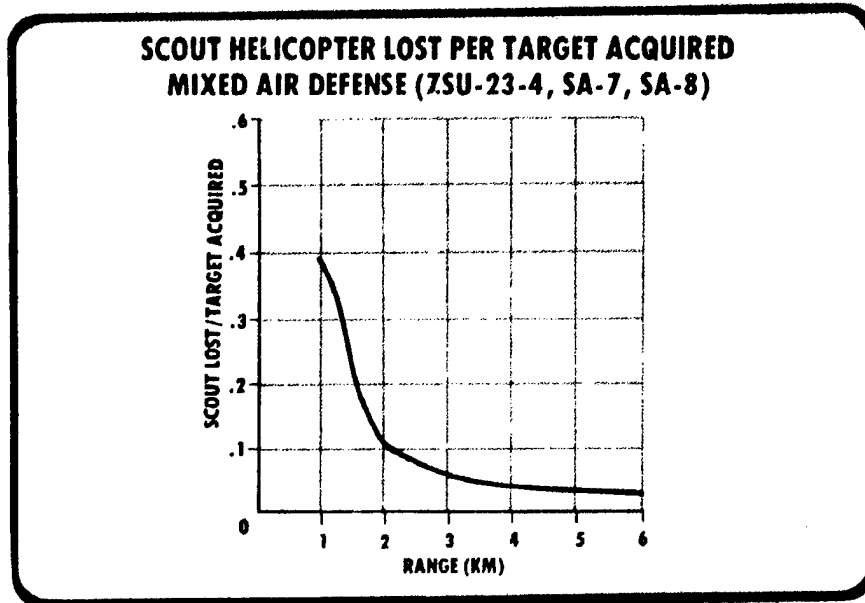
This chart reinforces the idea that

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UNCLAS THE FURTHER AWAY THE ATTACK HELICOPTER IS ABLE TO ENGAGE, THE HIGHER HIS EXCHANGE RATIO WILL BE. UNCLAS

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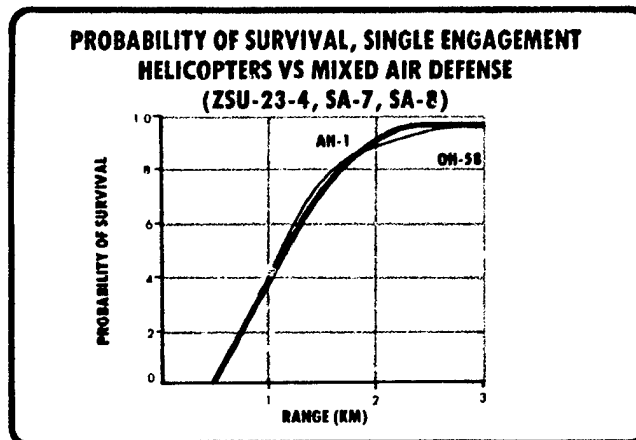
Scouts must also pay attention to the ranges at which they operate from enemy air defense weapons. This simulation demonstrates the survivability of aero scouts while attempting to acquire targets against a mixed air defense of ZSU-23-4, SA-7, and SA-8. This suggests to us that survivability while scouting, like survivability while engaging, it also dependent on range.



Thus, we should teach our scout pilots the following:

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 - Do your scouting beyond 2500m, if possible
 - The closer you get, the HIGHER your chances of being hitUNCLAS
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This next chart indicates that the type of aircraft being flown has very little effect on the probability of surviving a single engagement against a mixed air defense. The AH-1 and the OH-58 are relatively equal in survivability. Once again, the most significant factor is range. Beyond 2500 meters, you have almost a 100% chance of surviving a single engagement.

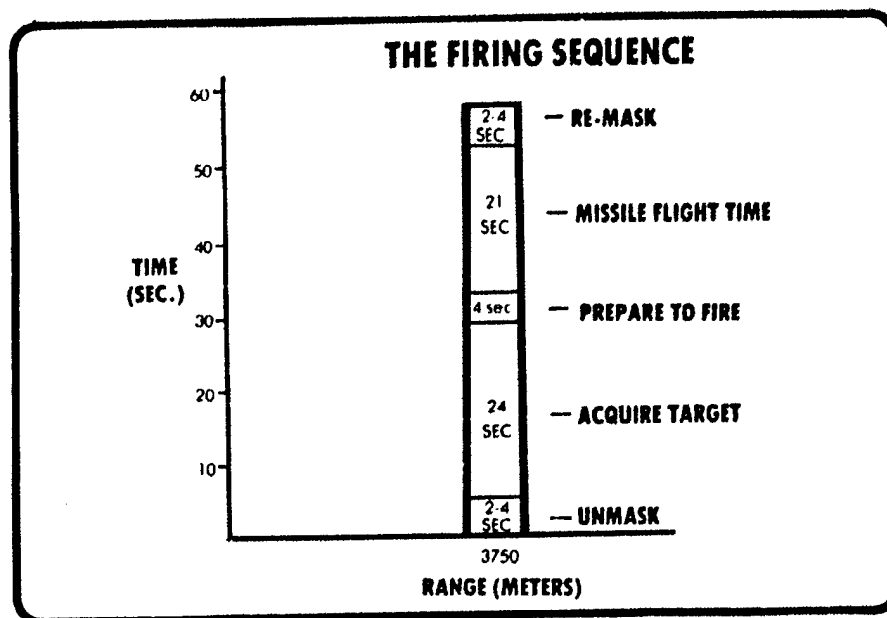


EXPOSURE

The second general category of countermeasures is designed to break the chain of events before they really begin. The objective is to disrupt the enemy's ability to acquire you. You can accomplish this by having someone else fire suppression—for example, artillery—or you can, reduce your exposure to the enemy.

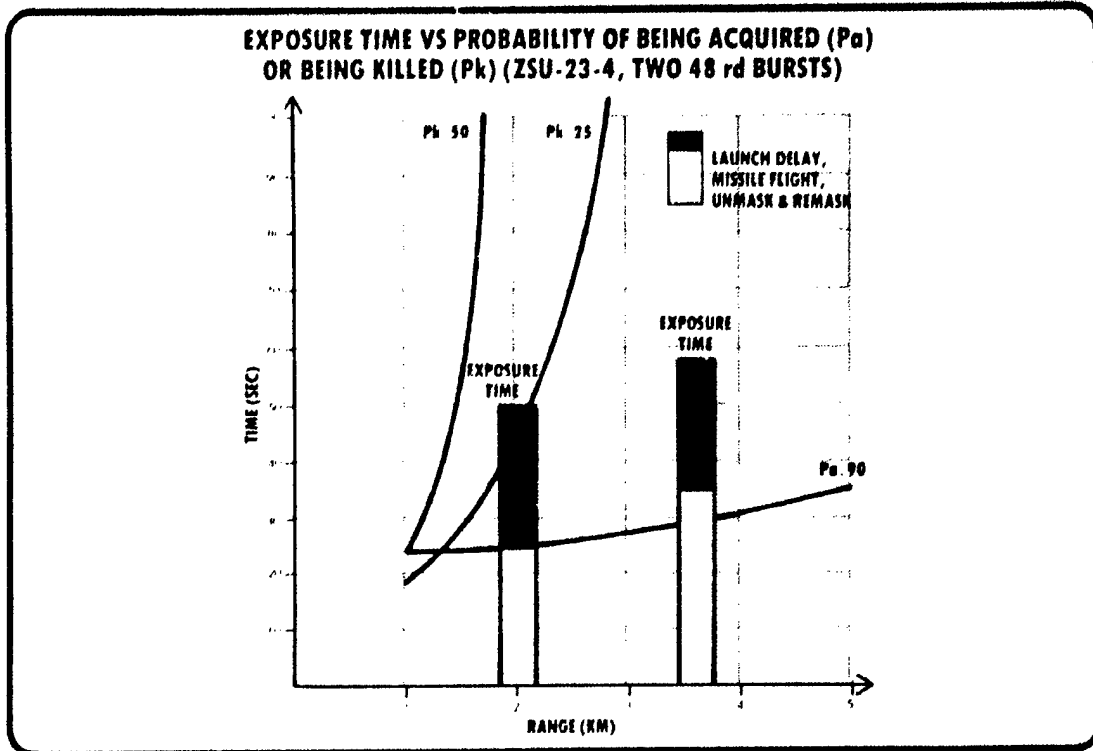
Despite all attempts to remain covered and concealed, there are occasions when you must be exposed (e.g. when firing). As noted earlier, actual tests have shown that pilots remained exposed at median times of 63 to 82 seconds while engaging targets. Remembering the ZSU-23-4 can engage and the rounds arrive at 3000 meters within 28 seconds, pilots with those exposure times run unnecessarily high risks. Therefore, every effort must be made to reduce our exposure time!

Let us examine what happens during a firing sequence to determine where we can best cut our time. The chart below illustrates a chronological sequence of events and the average times required to perform them as determined during an actual test.



From this chart we can see that the only function that can be significantly reduced is that of target acquisition. All other functions require a relatively fixed amount of time.

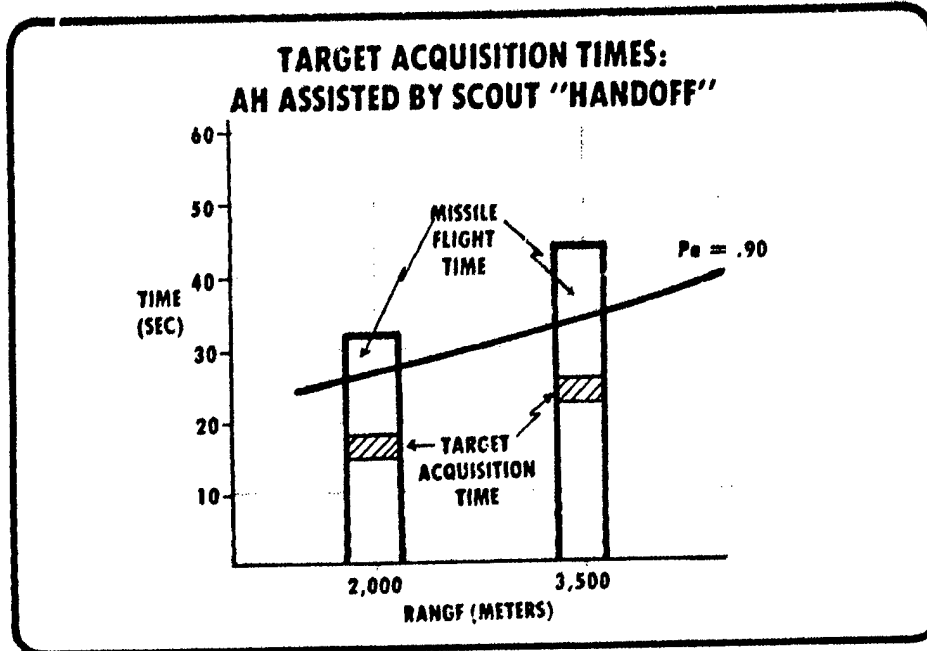
This next graph illustrates total exposure times from two different tests at ranges of 2000 and 3750 meters. As the curved line Pa (probability of being acquired) indicates, it is highly likely that an engaging aircraft will be acquired by the ZSU-23-4. On the other hand, as the two Pk (probability of being killed) lines indicate, at ranges beyond 3000 meters the probability of being killed with two 48 round bursts is small. We must remember, though, that although the ZSU-23-4 loses accuracy, the rounds can still travel out past three and four thousand meters. So on occasion, we should expect some incoming fire even at extended ranges.



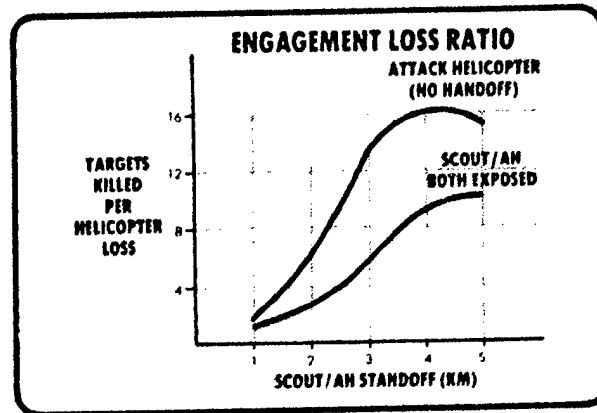
Thus, we ought to expect that:

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- Even at 3500 meters the attack helicopter will most likely be acquired.
 - At that range it can receive incoming 23mm fire
 - The probability of being killed is small
 - Even at extended ranges, a longer exposure time increases the probability of being hit.
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Since we must reduce our total exposure time even at extended ranges and since the only way to significantly reduce it is by reducing target acquisition time, let us look at some test results that do show reduced exposure. The two examples below show test results in which the attack helicopters were assisted by scouts in acquiring their targets. Each scout found the target and then while unmasked, "talked" the attack helicopter into acquiring it. As a result of this "hand off", target acquisition times were cut to an average of 3 seconds. But even with this reduction, the ZSU-23-4 still has enough time for a 90% probability of acquiring the attack helicopter before the AH can kill the ZSU-23-4.



Thus there is great value for the attack helicopter in the "hand off" technique for reducing target exposure times. If possible, the scout should remask during "hand-off" or quickly thereafter. Generally, a scout at 3000 meters should consider that he has about 20 seconds of observation time before being acquired by the ZSU-23-4.



The problem arises from the manner in which the "hand off" is performed. The ZSU-23 system alerts to the first detected aircraft. With radar and optics attentive for targets in a given direction, a second helicopter appearing near the first is easily detected. In these tests, the scout unmasked, acquired the target, remained unmasked while the attack helicopter "popped up", and talked the AH onto the target before remasking. This method results in unnecessary exposure for both aircraft and in terms of overall losses, it is worse than if the AH had no assistance at all. In the chart below the top curve depicts the targets killed per helicopter loss when the attack helicopter acquires his own target. The bottom curve shows that when both the scout and attack helicopters are exposed to execute the "hand off", the result is significantly fewer targets killed for each helicopter lost.

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3. • ATTACK HELICOPTERS ARRIVE AT POSITIONS A & C, AND REMAIN MASKED.

• SCOUT CONTINUES SEARCH AND LOCATES 2nd ZSU-23-4, PASSES TARGET LOCATION (COORDINATES, AZIMUTH, & RANGE) AND DESCRIPTION OF TARGET POSITION TO THE ATTACK HELICOPTERS, WHICH ARE STILL MASKED.

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4. • SCOUT REMARKS AND WITHDRAWS

• ATTACK HELICOPTERS UNMASK AND ENGAGE THE ZSU-23-4, AND TANKS SIMULTANEOUSLY.

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• ATTACK HELICOPTERS UNMASK AND ENGAGE THE ZSU-23-4, AND TANKS SIMULTANEOUSLY.

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In training, therefore, we must remember:

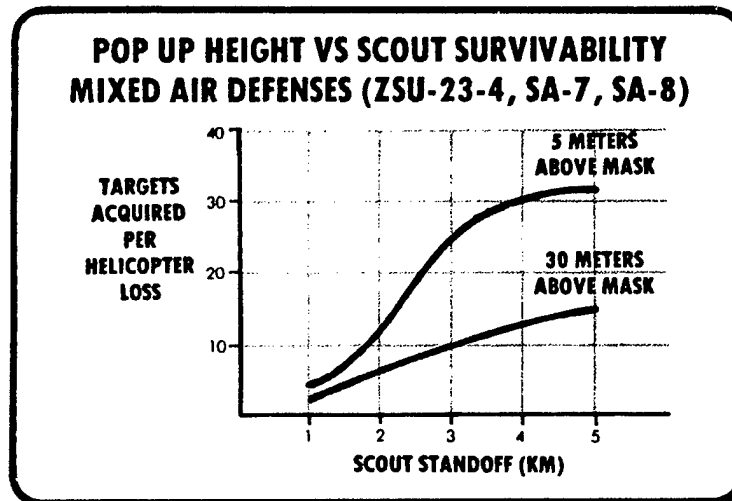
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- Cut exposure of scouts during target "hand-off" to AH. Put as much separation between scout and AH as you can.
- Use techniques that reduce overall exposure
 - (1) Train using efficient visual search techniques
 - (2) Use scouts to find the enemy force
 - Pass target information to the AH by coordinates or azimuth and range
 - Add verbal description of the target location
 - (4) Request assistance in target designation from ground troops

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EXPOSURE HEIGHT

In addition to reducing vulnerability by reducing the amount of time an aircraft remains exposed, vulnerability can also be reduced by keeping to the minimum the height to which an aircraft "pops up". The following example shows the exchange ratio for targets acquired by scouts per helicopter loss as it relates to the pop-up height. The situation depicts a mixed air defense of two ZSU-23-4's, five SA-7's, and one SA-8. Search time is restricted to 30 seconds. Note: at 3000 meters a pop-up height of 5 meters is about 2.5% times more effective than a 20 meters pop-up height.



RADAR DETECTION

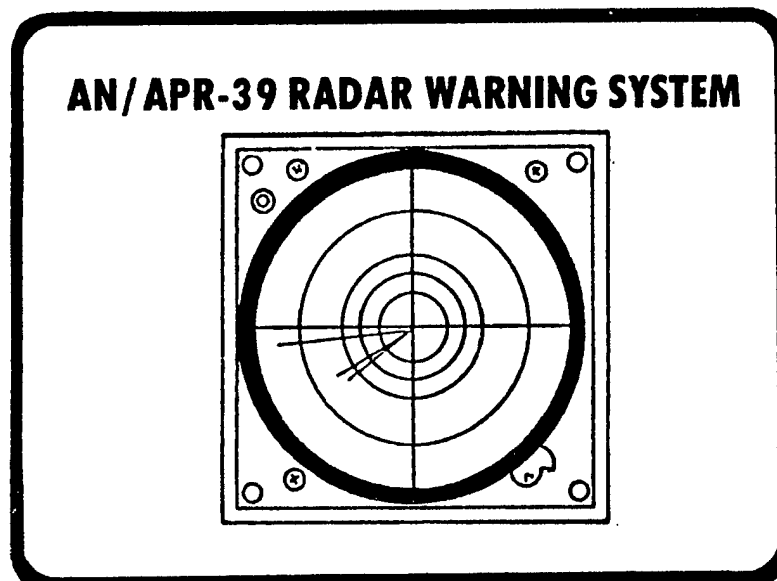
Another important counter measure is a quick evasive maneuver or a rapid move to cover. Before we know to do this, we must first know that we have been found and locked on by enemy radar. The AN/APR-39 Radar Warning System tells us this.

The display head, which has a diameter of three inches, is mounted in the cockpit. The system gives both audio and visual warnings when the helicopter is receiving radar signals.

A visual warning is displayed on the Radar Signal Indicator in the form of a strobe line whose length and intensity is proportional to the intensity of the radar signal and extending in the general direction from which the signal is being emitted. For the following modes of enemy radar operation, it gives the following indications:

MODE	VISUAL	AUDIO
Scanning	Flashing line corresponding to the speed of the passing beam.	Occasional high-pitched tone.
Lock-on	A steady line.	A steady tone.
Lock-on and fire	A rapid flashing strobe and flashing amber light.	A rapid warbling tone.

Below is a typical display on the AN/APR-39. The threat is only identified as being in the general direction of the 225° - 270° sector. Range to the radar source cannot be accurately determined.



GENERAL TACTICS & TECHNIQUES

In addition to the specific techniques to counter the ZSU-23-4 already discussed, there are certain general tactics that increase the survivability of Army aviation in this highly lethal enemy air defense environment.

SUPPRESSION

Army aviation is not alone in its battle against the enemy air defense. The US Air Force is waging the same battle. Additionally, the actions of ground elements of the combined arms team can also degrade the effectiveness of enemy air defenses. To obtain close air support from the Air Force, we must be able to suppress enemy air defenses. To do this will require a high order of intelligence, reconnaissance and surveillance. Both the Army and the Air Force possess various means to suppress enemy air defenses. For example, the following means are, or will be, available to assist in our suppression effort.

SUPPRESSORS

AIR FORCE

A-7
F-4
F-111
Munitions
 Electro/Optical
 Laser Guided
 General Purpose
 Anti-radiation missiles
Wild Weasel (F4C, F105)

A-10
Wild Weasel (F4E)
EF 111

F-16
Improved Munitions
 Guidance
 Fuzing
ECM

ARMY

Tanks (M-60/A1/A2)
Anti-Tank Guided Missiles
Field Artillery
Attack Helicopter (AH-1G)

Improved Conventional
Munitions
ECM

AH-1Q/

Obviously, to employ these suppressors effectively will require careful Army-Air Force coordination and cooperation, particularly at the corps/division level.

Assistance in suppressing enemy air defenses can and must come from our ground forces. Teamwork and correct employment of the combined arms team is the key. For example, artillery can be used to suppress the ZSU-23-4. By knowing where the ZSU-23-4's are normally found, that area can be suppressed with high explosives (to destroy or damage his GUN DISH radar) while his optical capability can be degraded by the use of smoke.

TERRAIN FLYING

Battlefield survivability for the aviator depends to a large extent on how he flies around the battlefield. While it is generally true that reasonable altitude is desired for flight safety considerations, for operational considerations, flight at altitude may well be lethal. Enemy detection and engagement capabilities may dictate combinations of low level, contour, and nap-of-the-earth flight as well as hover, pop-up, sideslip, dash, quick-stop and land. Regardless of whether the aviator is performing NOE, contour, or low level flight, he must use the terrain to his advantage if he is to survive and complete his mission. This is the concept of terrain flying. This is what the aviator must learn and practice.

(See FM 1-1, Terrain Flying, for a full discussion.)

NIGHT OPERATIONS

With the introduction of the "cav nav" goggles our helicopters will soon have the capability to engage targets at night. In night operations the ZSU-23-4's optical capability is degraded, offering the goggle-equipped AH some advantage.

DESTRUCTION

Obviously, the best countermeasure to any air defense weapon is simply to destroy it. Destruction of enemy air defense requires many skills of the Army aviator but one skill is absolutely essential- **good gunnery**. Good gunnery, with the TOW missile, for example, requires practice. Even with practice, there will still probably be some people who simply lack the necessary psycho-motor aptitude to be a good gunner. Flying ability does not necessarily equate to gunnery ability!

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UNCLAS ACCURACY DEPENDS ON TRACKING ABILITY UNCLAS
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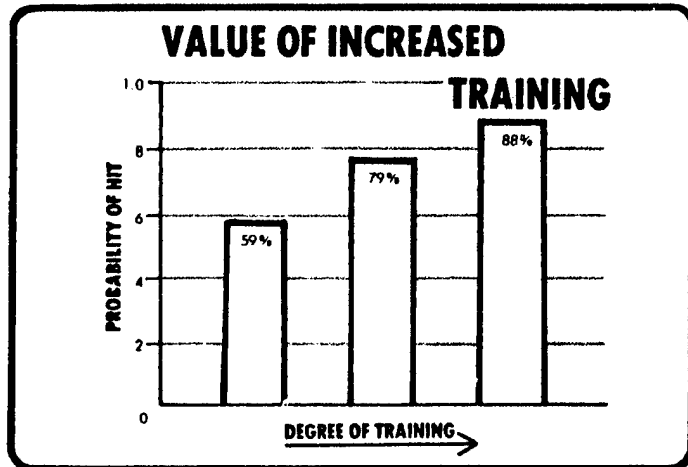
We must improve the tracking ability of poor gunners. This improvement can only result from training and practice. Aerial TOW gunners should improve their missile tracking skills on the M70 TOW trainer.

Those who simply cannot demonstrate the necessary hand-eye coordination to consistently maintain at least an 80% probability of hitting the target at 3000 meters should not be selected as a COBRA TOW gunner. To survive in battle, we need our best gunners firing the missile.

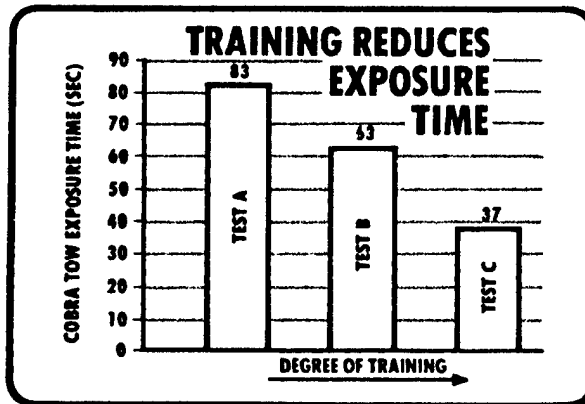
In short, we must:

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- Train to improve and maintain gunnery skills
 - Select only the best qualified to be TOW gunners
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To illustrate the value of training in order to increase our ability to destroy the enemy, the graph below portrays three tests conducted by TOE aviation units. All three tests were conducted under similar conditions and the bar graphs represent the aggregate scores of each unit firing the COBRA TOW at moving targets at ranges of 1700-3000 meters. The unit on the left had received little training; the two tests on the right were conducted by the same unit. The improved score on the right is the result of more tracking practice and more time devoted to all aspects of training.



Tests have also shown that with training, helicopter units can reduce their average exposure time for target engagements. The chart below shows that. Test A, in which the average exposure times were 83 seconds, was done by a unit that had received little training. Later, after more practice, a better awareness of the nature of the threat, and by using improved search techniques to reduce target acquisition time, the same unit in Test C has an average exposure time of only 37 seconds! The unit in Test B had received more training than the unit conducting Test A.



Thus, we must conclude that

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TRAINING MAKES THE DIFFERENCE
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CONCLUSION

In summary we can state the following:

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 - The air defense environment of the modern battlefields is highly lethal.
 - The ZSU-23-4 has proven to be an effective killer.
 - We have good aircraft with excellent weapons that give us a range advantage.
 - We must use techniques that reduce our exposure.
 - Training makes the difference.

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Specifically with respect to our attack helicopter units, we ought to remember that:

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ATTACK HELICOPTER UNITS

HAVE:

 - High mobility to influence a decisive battle
 - High armor kill potential for decisive effect

MUST:

 - Know enemy air defense capabilities
 - Use terrain to minimize exposure
 - Operate at maximum standoff where
 - Own weapons have high probability of kill
 - Enemy weapons probability of kill is reduced

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