Threat Evasion & Management

Lesson 1: Missile Flight and Guidance

476th vFighter Group Weapons School

Threat Evasion and Management

Welcome to the 476th vFighter Group Weapons School threat evasion training course. Upon completion of this presentation the student will:

- Understand the basics of Surface to missile flight and guidance mechanics.

Lesson Contents

- Part 1: Missile Propulsion
- Part 2: Missile Control
- Part 3 Missile Guidance

Missile Propulsion and Control

Missile Propulsion

Both air-to-air and surface-to-air missiles are typically powered by rocket motors, with some newer missiles utilizing ram jet engines or a combination of rocket and ram jet. Solid rocket motors are generally preferred as they have a high thrust to weight ratio and do not require any form of throttle control, which further reduces weight, cost and complexity. Short range missiles normally use a single solid rocket motor with a short burn time and high thrust output which accelerate the missile to a high speed in a very short time (a few seconds), ideal for missiles with a short flight duration.

As range requirements for a missile increase, so will the complexity of the motor design. Simply increasing the size of the rocket to provide endurance would cause the missile size and weight to increase, so rather than simply increasing size, it is necessary to improve efficiency. For medium range missiles this is often accomplished by using a solid rocket engine designed to produce two levels of thrust, a high thrust booster stage, followed by a lower thrust sustainer.

As missile, and engine size, increase liquid fuelled rockets start to become a viable option. But due to their limitations, such as not being able to store and/or transport them in a fuelled “ready for launch” state the are not often used in surface-to-air, and never in air-to-air missiles. In cases where a missile is designed to remain in the atmosphere, ram jet propulsion can be used in long range missiles, often the ram jet sustainer is combined with a solid rocket booster to accelerate the missile to ram jet operating speed.

The important thing to remember about missiles, regardless of their propulsion type, is that due to their relatively small size they only carry a very limited fuel supply. This means that in most cases the majority of a missile’s flight is unpowered.

Missile Propulsion

Key Points:

- Rocket motors are the most common method
- High thrust, short burn time
- Many medium and long range systems use two stage boost/sustain motors
- Smoke plume offers visual identification
- Finite energy

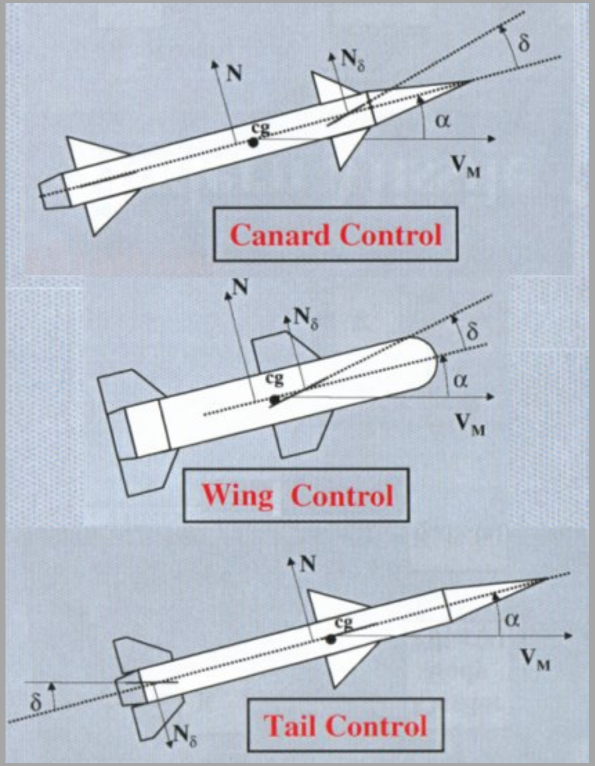
Missile Flight & Guidance

Missile Control

The control system is responsible for manoeuvring the missile in response to commands from the missile's guidance system. Missiles normally use aerodynamic control, just like conventional aircraft, but some may also use thrust vector control or an arrangement of fixed control jets. Missiles are subject to the same forces and principles of flight as any aircraft, the major difference is that missiles are rarely restricted to a limiting structural load factor, i.e., they generally operate at speeds below their corner velocity.

Aerodynamically controlled missiles, therefore, often have their best turn performance at their highest speeds. As many rocket powered missiles have a short period of high thrust followed by "gliding" unpowered flight, maximum speed, and therefore maximum turn performance occurs at the point of motor burnout. As soon as a missile begins its unpowered flight, its turn capability begins to diminish.

Thrust vector control is provided by altering the direction of the motor exhaust gases to change the thrust vector. This may be accomplished by swivelling the nozzle(s) or by using deflector vanes in the exhaust. The thrust is vectored to cause a severe side slip, and then re-centred to send the missile off in the new direction. Such a system is highly unstable and requires and extremely fast and sophisticated autopilot system, but it has the potential for great manoeuvrability, especially at low speeds, such as the ability to turn near square corners. Of course the big downside with thrust vector control is that the motor must be burning in order for it to operate. This means it must either be teamed with normal aerodynamic controls or limited to use on short range missiles

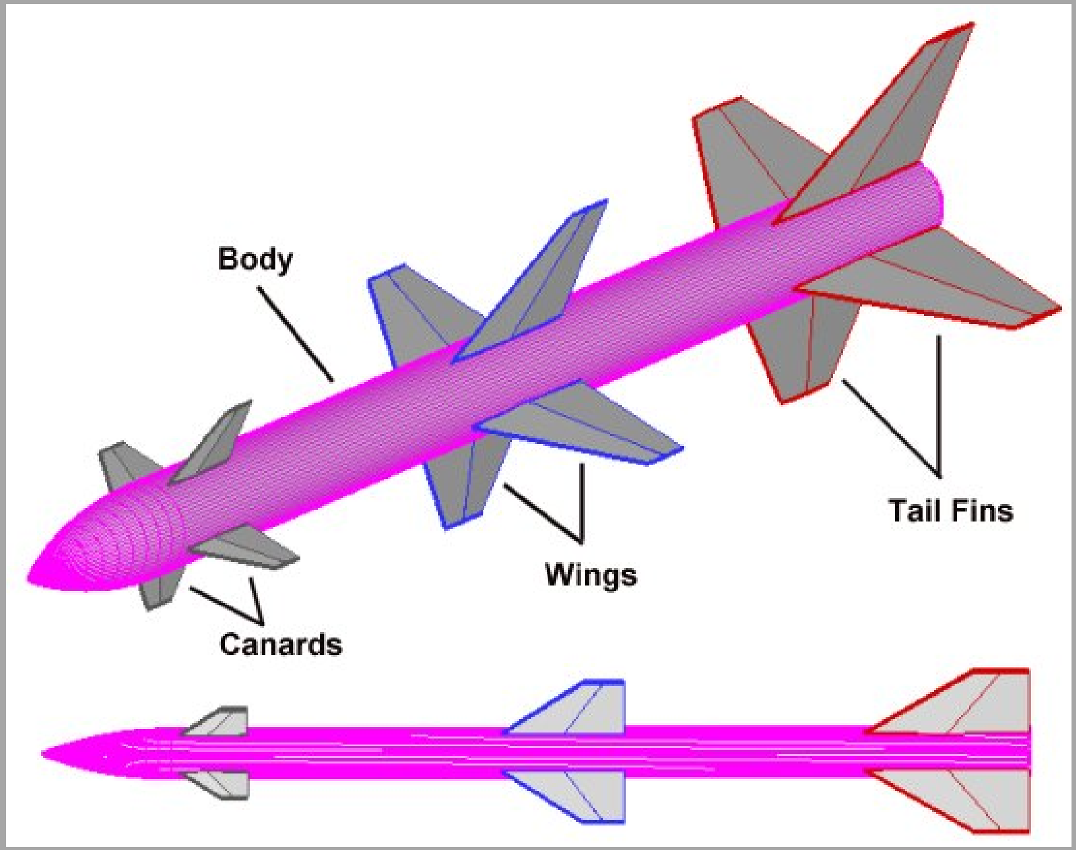


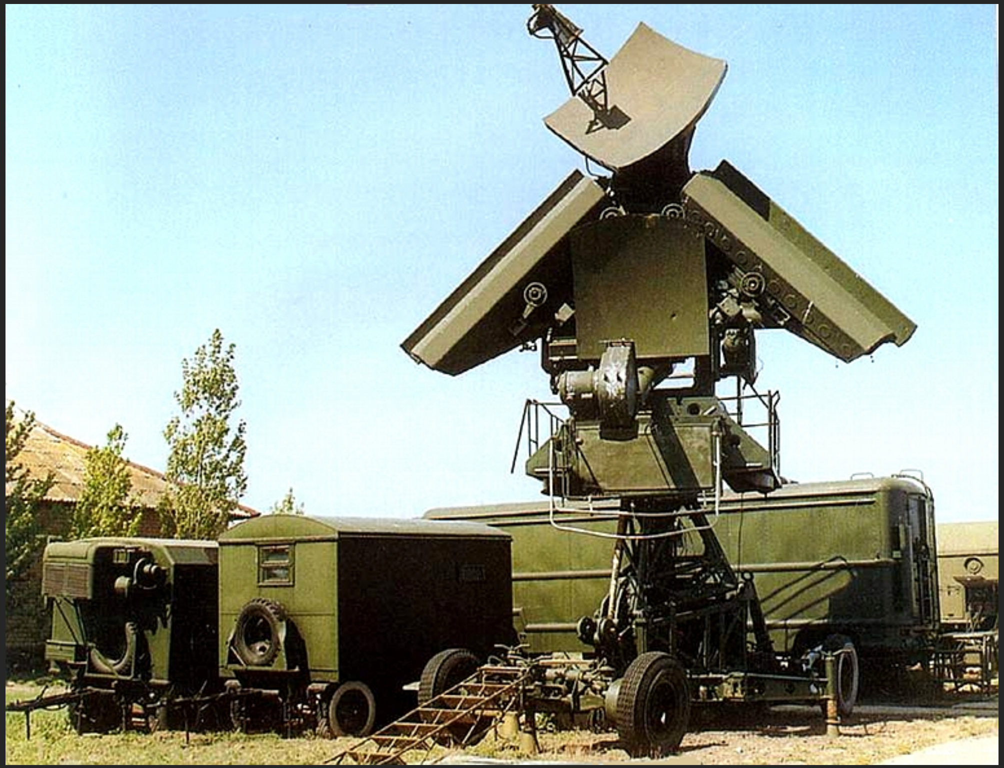
Missile Flight & Guidance

Missile Control

Key Points:

- Primarily aerodynamic control
- Higher speed = better control performance
- Practically no G limit
- TVC used on short range systems only
- Turning bleeds energy
- Limited control power source





Missile Guidance

Missile Guidance

Once a target has been designated, acquired, and tracked by a threat radar system, the final stage in target engagement is to guide a missile or projectile to destroy the target. There are three basic requirements for successful missile guidance:

1. Precise target tracking by a target tracking radar (TTR) to provide target parameters (range, azimuth, elevation, velocity, etc.)
2. A method to track the position of the missile compared with the target
3. A fire control computer to generate missile guidance commands based on target and missile position.

The missile guidance techniques employed by modern surface-to-air missile (SAM) systems will be covered in this chapter. There are three distinct phases in any missile intercept: boost, mid-course, and terminal.

Missile Guidance

Boost Phase

Most surface to air, and some air to air, missiles are unguided during the initial boost phase. During the boost phase, the missile's electrical and hydraulic systems are activated and are coming up to operating parameters. The missile is gathering speed and normally will be in an unguided mode of flight.

Missile Guidance

Mid-Course Phase

During the mid-course phase, the missile is actively being guided to the target using some type of guidance. Guidance signals deflect the control vanes of the missile to change its direction. These vanes change the roll, pitch, and yaw, in some combination, to control the missile flight path. Normally a gas grain generator powers a small hydraulic pump that deflects the control vanes in response to guidance signals. Each missile carries a limited supply of hydraulic fluid for manoeuvring. The fluid is expended through vents with every control surface activation. The limited quantity of hydraulic fluid can be a significant factor during a long-range missile intercept.

Introduction

Missile Guidance

Terminal Phase

The final phase of an intercept is the terminal phase. During this phase, the missile attempts to pass close enough to the target to detonate the fuse while the target is within the lethal radius of the warhead. Modern missiles employ both a contact fuse and some type of proximity fuse. Proximity fuses range from command detonation for command-guided missiles, fractional Doppler gates for semi-active guided missiles, to active laser fuses for IR-guided missiles.

Missile Guidance

The guidance system provides commands to the missile's control system, which in turn makes the necessary control movements to manoeuvre the missile to intercept the target.

There are many variations of guidance system but all of them can be put in to the following classifications.

- Pre-set
- Command
- Beam Riding
- Homing

Over the next few pages we will look at each of these types in detail.

SA-11 Gadfly Guidance Section

Missile Flight & Guidance

Pre-set Guidance

Pre-set guidance means that a pre-launch determination is made of the missile-target intercept point in space. Prior to launch the guidance system is provided with this information, and a trajectory to be followed using either dead reckoning, or inertial guidance to reach the pre-set point.

As the pre-set point cannot be changed after the missile is fired, any inherent system inaccuracy or post launch target manoeuvre may result in a wide miss.

Pre-set guidance is therefore closely related to unguided rockets and it is applicable to the air to-air and surface-to-air mission only in conjunction with large warheads (nuclear) or as an initial guidance mode used in conjunction with more accurate terminal guidance techniques.

Today, pre-set guidance alone is only used for surface-to-surface or air-to-surface missiles.

German V2 Surface-Surface Ballistic Missile

Command Guidance

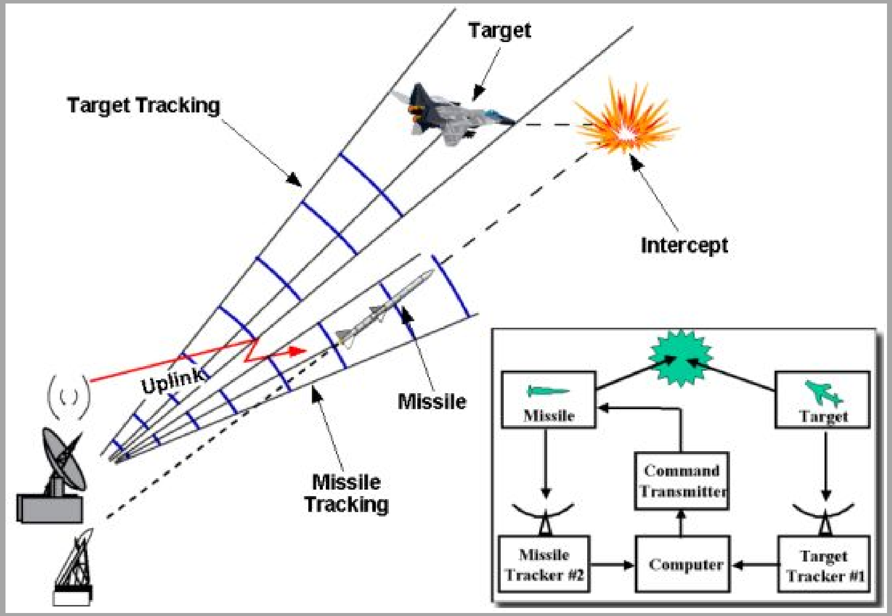
Command guidance can be likened to classic remote control. During missile flight, the positions of both the missile and the target are monitored at the launch platform, and commands are sent to the missile instructing it to fly a course that will lead to target interception.

Tacking of the target and missile is usually accomplished by either RADAR, electro-optical or visual. Of these three methods, only RADAR generally provides target/missile range information sufficiently accurate to allow computing of a lead-intercept trajectory for the missile (versus high speed or long range airborne targets).

Command Off Line-Of-Sight (COLOS)/Radio Command

This guidance system was one of the first to be used and still is in service, mainly in anti-aircraft missiles. In this system, the target tracker and the missile tracker can be oriented in different directions.

The guidance system ensures the interception of the target by the missile by locating both in space. This means that they will not rely on the angular coordinates like in CLOS systems. They will need another coordinate which is distance. To make it possible, both target and missile trackers have to be active. They are always automatic and use RADAR as their source of guidance data. Some COLOS surface to air missiles system employ INS navigation during their mid course phase and then switch to COLOS guidance during the terminal phase of flight. This enables them to fly a more energy efficient flight path, and also helps ensure the target is not alerted to the inbound missile(s) until the last minute.

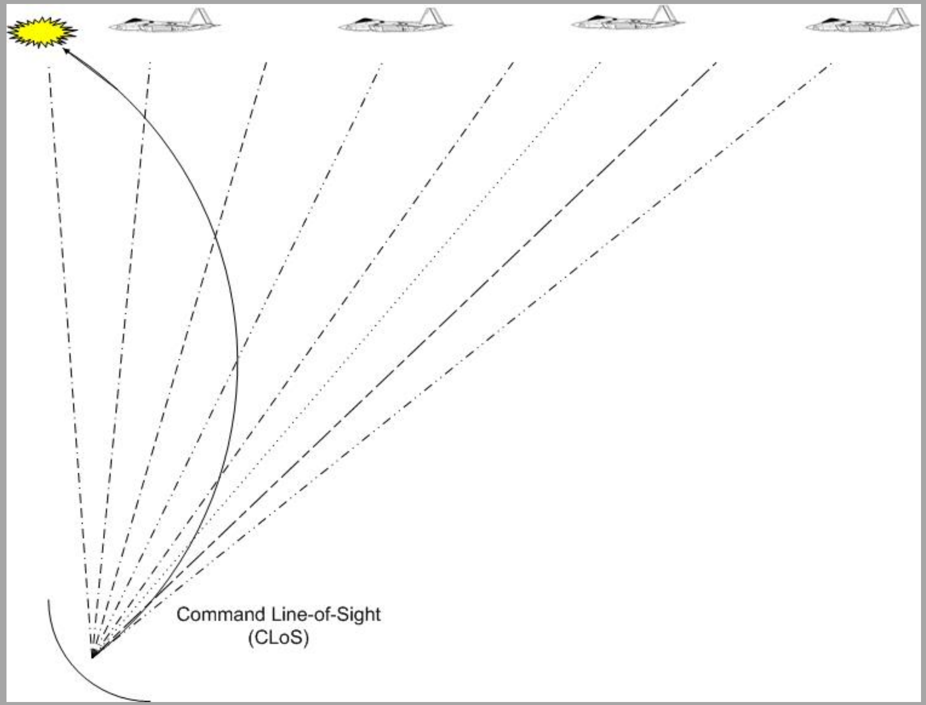


Command Guidance

Command to Line of Sight (CLOS) Guidance

Without range data the missile is ordinarily guided along the line of sight (LOS) between the target and launcher. This technique, known as command-to-LOS, can be accomplished by with no range information at all and is applicable to visual and electro-optical systems as well as to RADAR combination systems. Although due to the less efficient flight path of the missile (pure pursuit), such guidance is generally limited to short range systems. The guidance instructions to the missile are generally transmitted by radio data-link, which is susceptible to jamming, as are most RADAR trackers.

The CLOS system uses the angular coordinates between the missile and the target to ensure the collision. The missile will have to be in the line of sight between the launcher and the target (LOS), correcting any deviation of the missile in relation to this line. CLOS guidance has 4 variations, which are described in this section.



Manual Command to Line-Of-Sight (MCLOS)

The target tracking and the missile tracking and control is performed manually. The operator watches the missile flight and uses some sort of signalling system to command the missile back into the straight line between the operator and the target (the "line of sight"). MCLOS guidance is essentially nothing more than “radio control” of the missile, and is just like flying a radio controlled aircraft. As such it is typically useful only for slower targets where significant "lead" is not required. It is almost useless as a guidance method for A/A or S/A missile systems.

Missile Flight & Guidance

Command Guidance

Command to Line of Sight (CLOS) Guidance

Semi-Automatic Command to Line-Of-Sight (SACLOS)

The target tracking is manual and the missile tracking and control is automatic. SACLOS is similar to MCLOS but the missile's position is tracked electronically by the launch vehicle. The guidance system sends commands to the missile (normally by using the system's RADAR antenna) in order to keep it in the centre of the operators crosshairs. The operator simply tracks the target by keeping it in the crosshairs of the system's optical sight. This systems greatly reduces operator workload and is more effective than MCLOS, although it does have significant weaknesses.

SACLOS has the advantage of allowing the missile to start in a position invisible to the user, as well as generally being considerably easier to operate. SACLOS is the most common form of missile guidance against ground targets such as tanks and bunkers and is used in several surface to air systems, most notably the SA-19/SA-N-11 Grison.

As SACLOS systems require an operator to keep the target in sight, they are realistically limited to low and slow flying aircraft or ground targets. While it is possible for a SACLOS system to engage high performance aircraft, the chances of a kill are greatly reduced as the operator will have difficultly keeping a high speed, manoeuvring target in his LOS.

SA-19 Grison

Command Guidance

Command to Line of Sight (CLOS) Guidance

Automatic Command to Line-Of-Sight (ACLOS)

Both the target tracking and the missile tracking and control is automatic. ACLOS is similar to SACLOS but the target's position is tracked electronically by the launch vehicle. There is no human operator input beyond selecting the target and launching the missile. To the operator, there is no difference in workload between ACLOS and COLOS systems, although ACLOS systems still suffer the same limitations, especially against high speed and high altitude targets.

ACLOS guidance is not widely used, but is employed by both surface to surface and surface to air systems. The Swedish BAMSE SAM system employs ACLOS guidance as do several surface to surface systems such as Sea Wolf.

SAAB BAMSE SAM

Command to LOS Guided SAM Systems

- **SA-19 Grison** (2S6 Tunguska) – Optical SACLOS
- **Roland II** – RF SACLOS/Optical CLOS

Missile Flight & Guidance

Radio Command Guided SAM Systems

- ***SA-1 Guild*** *(S-25 Berkut) - COLOS*
- ***SA-2 Guideline*** *(S-75 Dvina) - COLOS*
- **SA-3 Goa** (S-125 Neva) - *COLOS*
- ***SA-4 Ganef*** *(2K11 Kpyr) - COLOS/Terminal SARH*
- **SA-6 Gainful** (2K12 Kub) - *COLOS*/Terminal SARH
- **SA-8 Geko** (9K33 Osa) - *COLOS*
- **SA-15 Gauntlet** (9K331 Tor) - *COLOS*
- ***SA-22 Greyhound*** *(Pantsir S-1) - COLOS*

Missile Flight & Guidance

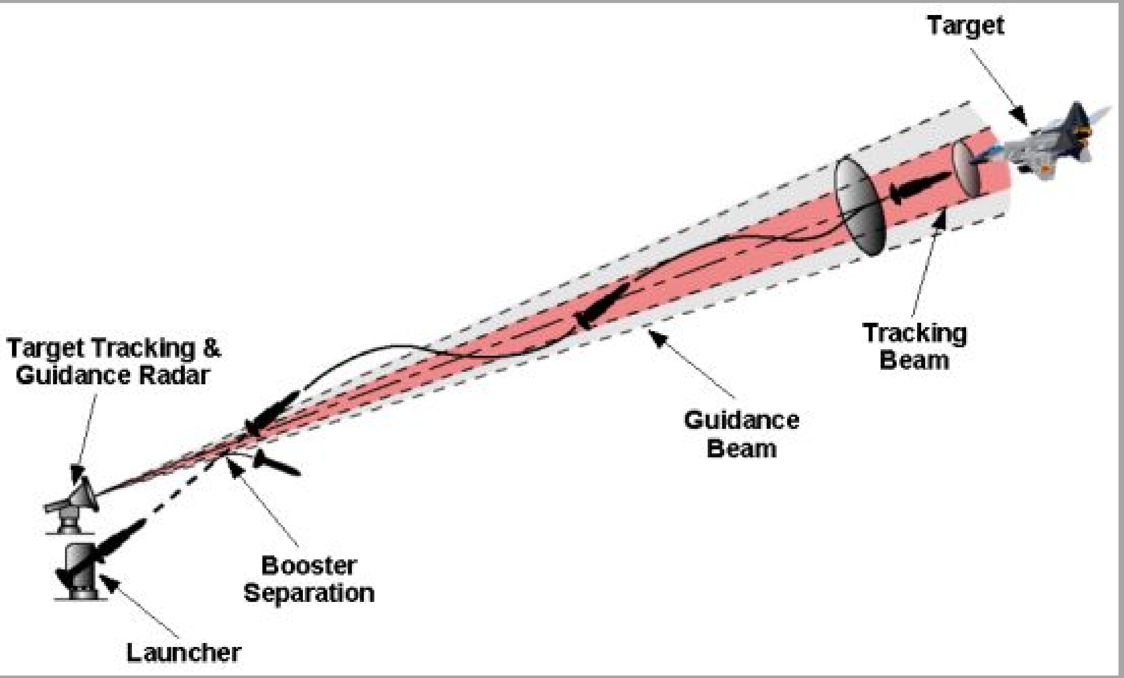
Line-Of-Sight Beam Riding Guidance (LOSBR)

Beam riding guidance is somewhat similar to command-to-LOS guidance, except that the missile guidance system is designed to "seek" and follow the guidance beam automatically, without specific corrections from the launch platform. The guidance beam may be provided by a target-tracking RADAR or by visual or electro-optical systems, using either RADAR or LASER.

Like RADAR-enhanced command guidance systems, RADAR beam rider systems are not limited to daylight and/or good weather conditions, but they are more susceptible to electronic countermeasures then electro-optical or visual systems.

One problem with beam-rider systems, as with command-to-LOS, is that the missile must have high manoeuvrability in order to intercept an evasive target. As they approach the target, beam-rider missiles must often tighten their turns continually to keep up. At high speeds tight turns may exceed the missiles capabilities.

Using two RADARs, one for target tracking and a second for missile tracking and guidance, can reduce this problem somewhat by providing a more efficient lead trajectory, but such systems are more complex and their use is generally limited to SAMs.



Beam-riding guidance, however, is usually more accurate and faster reacting than command guidance systems, and it can be quite effective against even evasive aircraft targets.

Beam riding guidance is not used in modern surface-to-air or air-to-air systems, although it was used in early systems it fell out of favour by the mid 1960's. It is however still used by some surface-to-surface and air-to- surface systems.

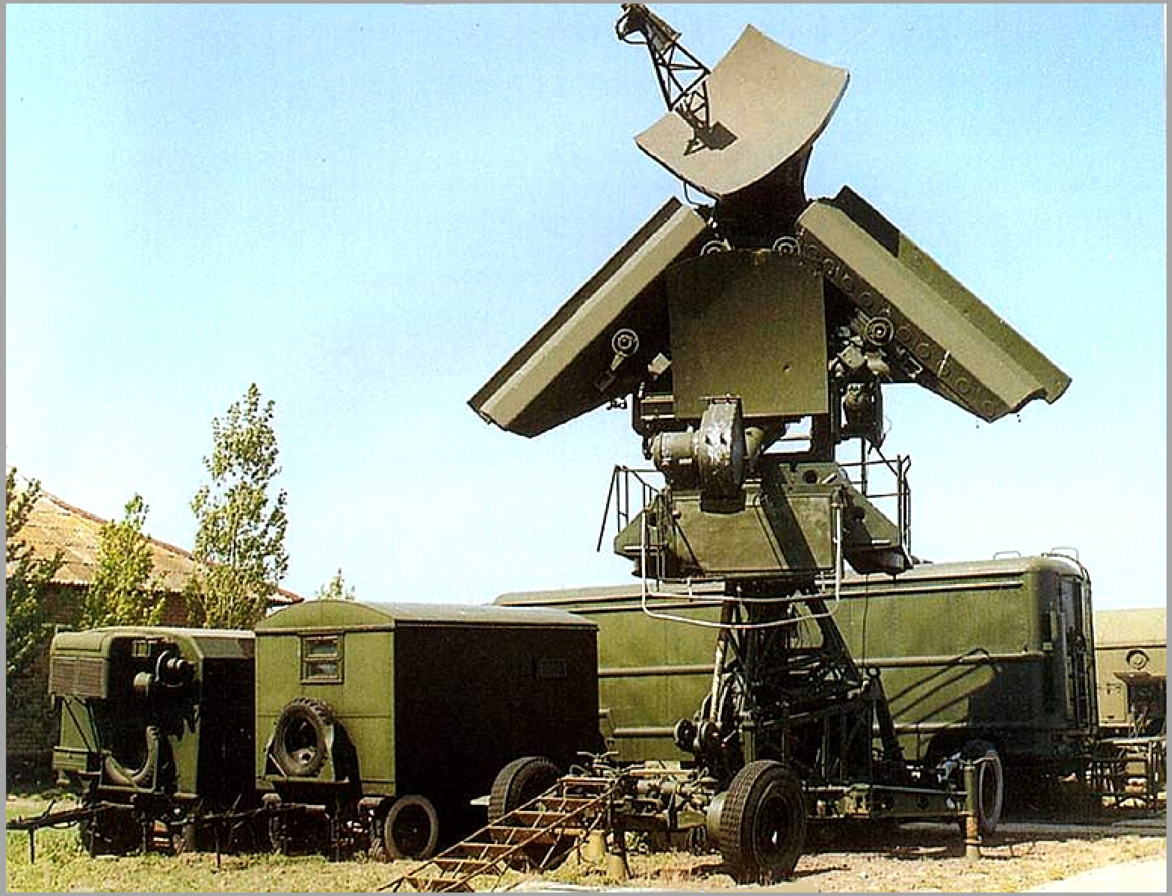
Missile Flight & Guidance

Homing Guidance

Homing guidance systems control the flight path by employing a device in the weapon that reacts to some distinguishing feature of the target. Homing devices can be made sensitive to a variety of energy forms including RADAR, infrared, reflected LASER, and visible light. In order to home on the target, the missile must determine at least the azimuth and elevation of the target by a means of angle tracking.

Homing guidance is split into four categories.

- Passive Homing
- Semi-Active Homing
- Active Homing
- Retransmission Homing (Track via Missile)



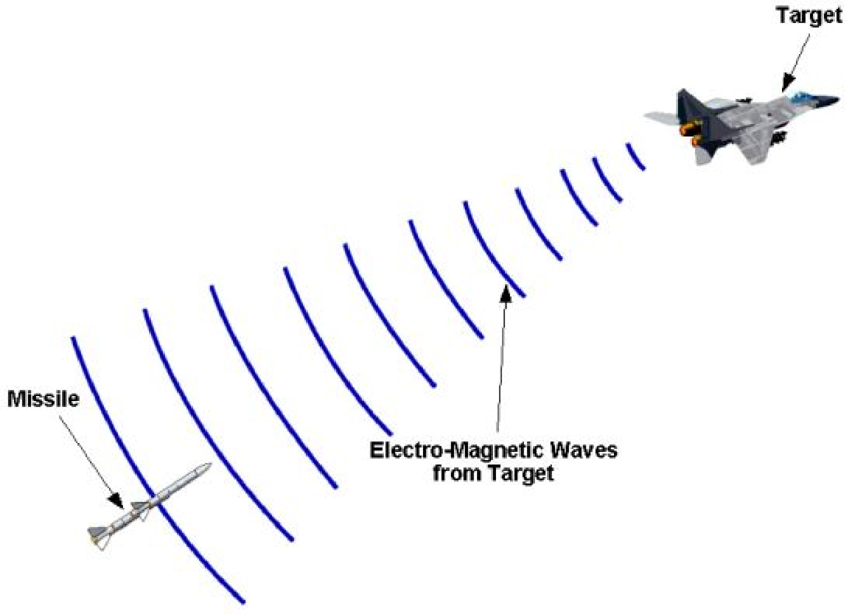
Missile Flight & Guidance

Homing Guidance

Passive Homing

Passive homing depends only on the target as a source of tracking energy. This energy takes the form of emitted RF radiation from the target's own sensors in the case of an anti-radiation (ARM) weapon, heat sources such as aircraft engine exhaust, contrast with the temperature or visible light environment, or even the radiation all objects emit in the microwave region. As in the other homing methods, the missile generates its own correction signals on the basis of energy received from the target rather than from a control point. The advantage of passive homing is that the counter detection problem is reduced, and a wide range of energy forms and frequencies are available. Its disadvantages are its susceptibility to decoy or deception and its dependence on a certain amount of cooperation from the enemy.

Passive homing in anti-aircraft weaponry is most commonly used in the form of infra-red homing (commonly known as heat seeking).



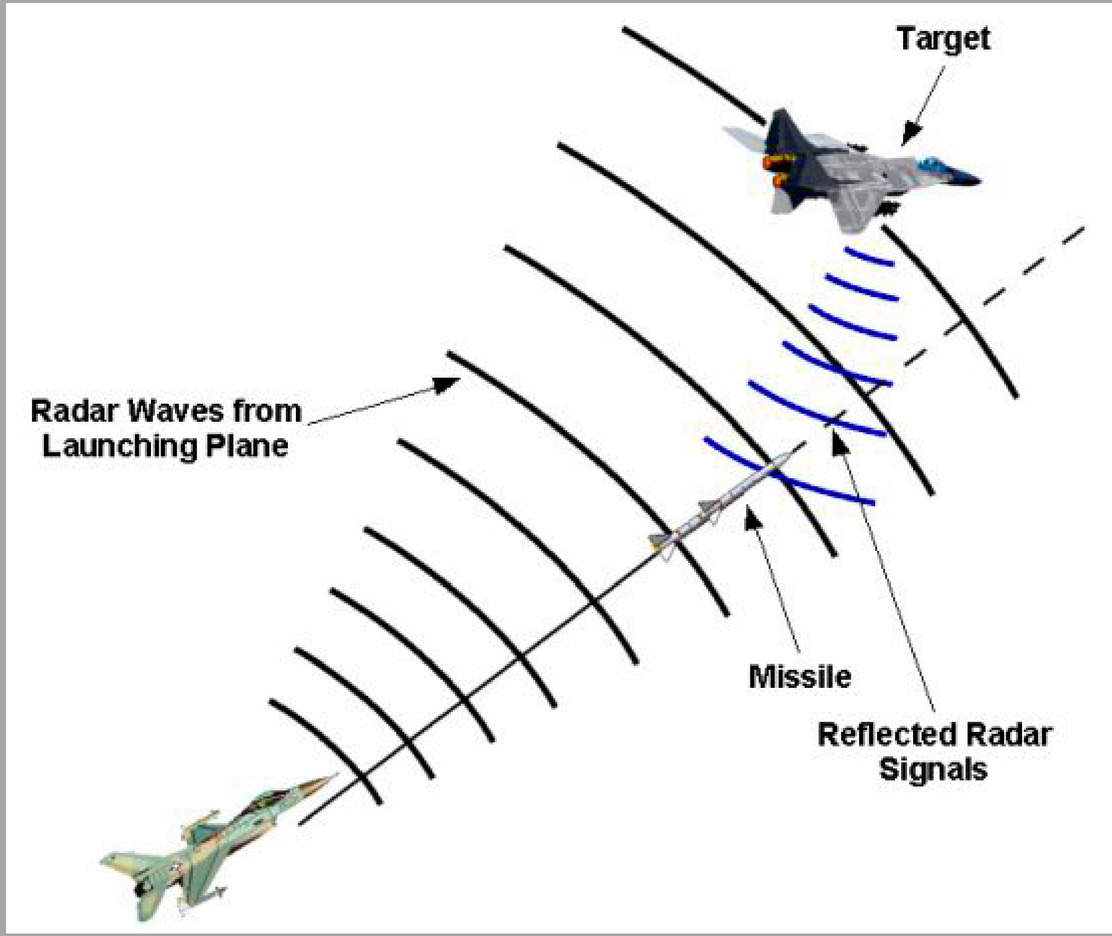
Missile Flight & Guidance

Homing Guidance

Semi-Active Homing

In semi-active homing, the target is illuminated by a tracking radar at the launching site or other control point. The missile is equipped with a radar receiver (no transmitter) and by means of the reflected radar energy from the target, formulates its own correction signals as in the active method. However, semi-active homing uses bistatic reflection from the target, meaning that because the illuminator platform and weapon receiver are not co-located, the returning echo follows a different path than the energy incident to the target. Due to its shape and composition, the target may not reflect energy efficiently in the direction of the weapon. In extreme cases the weapon may lose the target entirely, resulting in a missed intercept. This disadvantage is compensated for by the ability to use greater power and more diverse frequency ranges in an illumination device in a ship, aircraft, or ground station.

Semi-active homing is more often seen in air to air missiles, especially earlier second and third generation systems such as the AIM-7 Sparrow. Semi-active homing has seen use in SAM systems, however its use is less widespread than other guidance types.



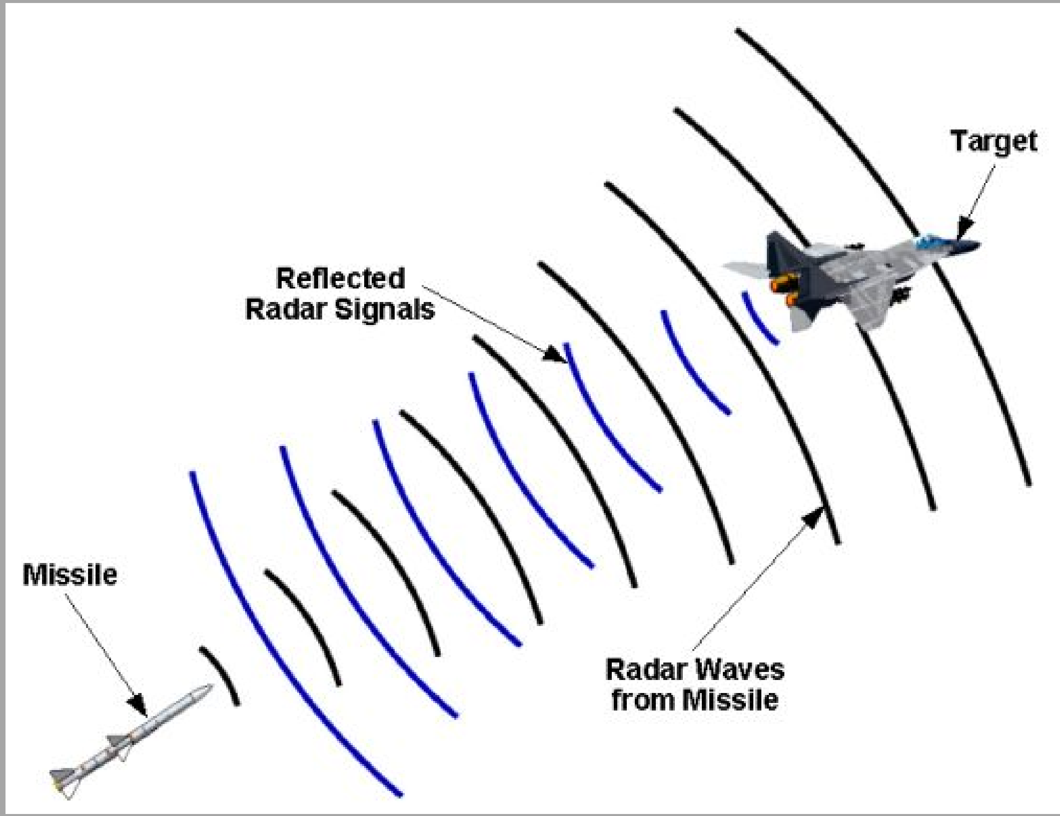
Missile Flight & Guidance

Homing Guidance

Active Homing

In active homing, the weapon contains both the RADAR transmitter and receiver. Search and acquisition are conducted as with any tracking sensor. The target is tracked employing monostatic geometry in which the returning echo from the target travels the same path as the transmitted energy. An on-board computer calculates a course to intercept the target and sends steering commands to the weapon's autopilot. The monostatic geometry allows the most efficient reflection of energy from the target, but the small size of the missile restricts the designer to high frequencies and low power output from the transmitter, resulting in comparatively short seeker acquisition range.

Active homing in most often seen in air to air weapons, however it is employed in some SAM systems, often as a terminal guidance phase combined with either command or semi-active homing during the initial phase of flight.



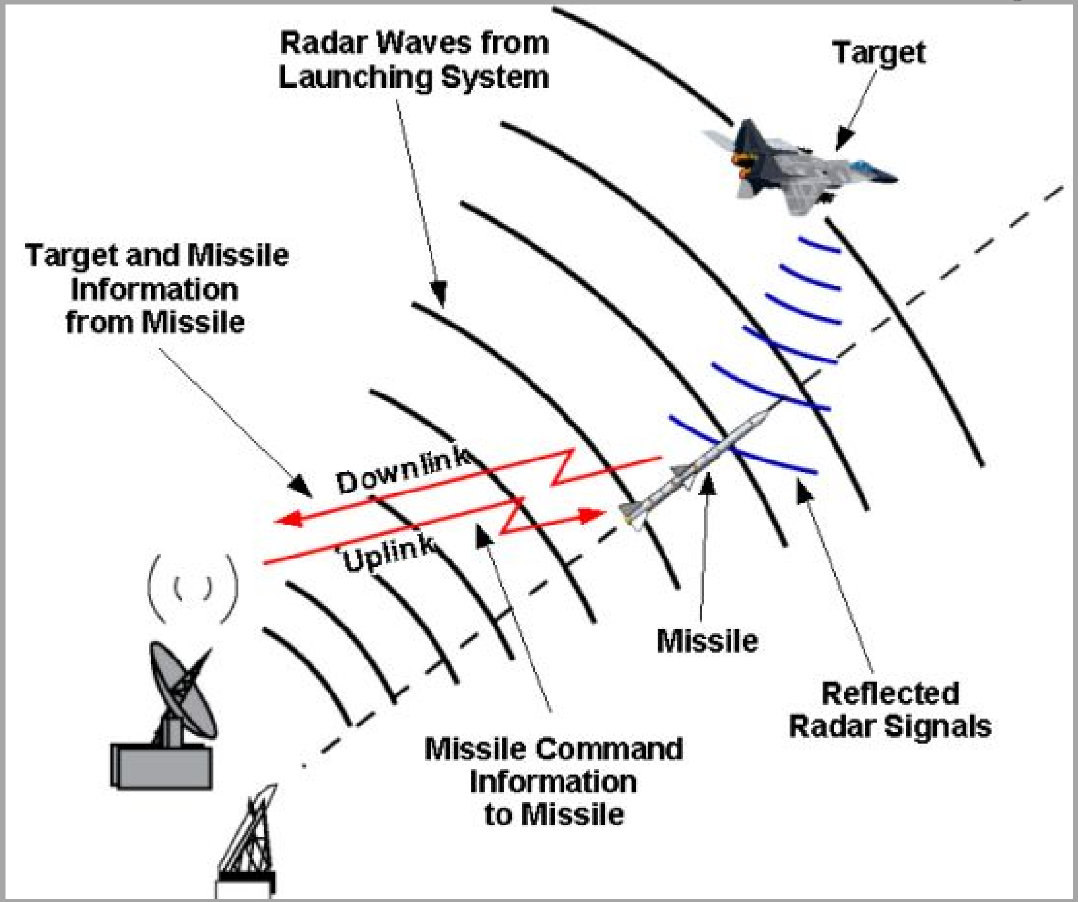
Missile Flight & Guidance

Homing Guidance

Re-transmission Homing (TVM)

Also known as Track Via Missile (TVM). Re-transmission homing is a blending of the characteristics of both command and semi-active homing guidance. In command guidance, missile steering commands are computed at the launch point using target position and missile position data derived from launch point sensors. In retransmission homing, the missile contains a semi-active seeker that determines the azimuth and elevation angle from the missile to the target, which is then coded and transmitted to the launch platform via data link (down link). The fire control system within the launch system can use its own target tracking data, that of the missile (or both), and missile position data to compute steering commands, which are then transmitted to the missile via an uplink. This technique is used in some new surface to air missile systems, including the U.S. Patriot system and the Russian SA-10 Grumble. Specific retransmission or TVM systems may vary somewhat from this ideal; however, they all will in some way use target angle data from the missile to compute steering commands at the launch point that are then transmitted to the missile.

TVM homing is exclusively employed by MERAD/LORAD SAM systems.



Missile Flight & Guidance

Semi Active RADAR Homing Guided SAM Systems

- ***SA-4 Ganef*** *(2K11 Kpyr) - Radio Command/Terminal SARH*
- ***SA-5 Gammon*** *(S-200 Angara) - SARH/Terminal ARH*
- **SA-6 Gainful** (2K12 Kub) - Radio Command/Terminal SARH
- **SA-11 Gadfly** (Buk-M1) - SARH
- ***SA-17 Grizzly*** *(Buk-M2) – SARH*
- ***MIM-23 Hawk*** *- SARH*

Missile Flight & Guidance

Track via Missile Guided SAM Systems

- ***SA-10 Grumble*** *(S-300P/PS/PT) – TVM*
- ***SA-12 Gladiator*** *(S-300V) – TVM*
- ***SA-20 Gargoyle*** *(S-300PM/PMU) - TVM*
- ***SA-21 Growler*** *(S-400) - TVM*
- ***SA-23 Giant*** *(S-300VM) – TVM*
- ***MIM-104 Patriot*** *- TVM*

Threat Evasion and Management

Lesson 2: SAM Systems

476th vFighter Group Weapons School

Threat Evasion and Management

Welcome to the 476th vFighter Group Weapons School surface to air missile evasion training course. Upon completion of this course the student will:

- Be familiar with the various SAM systems in DCS.
- Understand the basic characteristics of each threat system featured in DCS.
- Be familiar with the basic techniques to defeat/counter each system.

Lesson Contents

- Part 1: Radio Command Systems
- Part 2: Command to Line of Sight Systems
- Part 3: Semi Active Homing Systems
- Part 4: Track Via Missile Systems
- Part 5: IR Homing Missile Systems

Radio Command Guided Systems

Threat Evasion and Management

Radio Command Guided SAM Systems

- ***SA-1 Guild*** *(S-25 Berkut)*
- ***SA-2 Guideline*** *(S-75 Dvina)*
- **SA-3 Goa** (S-125 Neva)
- ***SA-4 Ganef*** *(2K11 Kpyr) - Radio Command/Terminal SARH*
- **SA-6 Gainful** (2K12 Kub) - Radio Command/Terminal SARH
- **SA-8 Geko** (9K33 Osa)
- **SA-15 Gauntlet** (9K331 Tor)
- ***SA-22 Greyhound*** *(Pantsir S-1)*

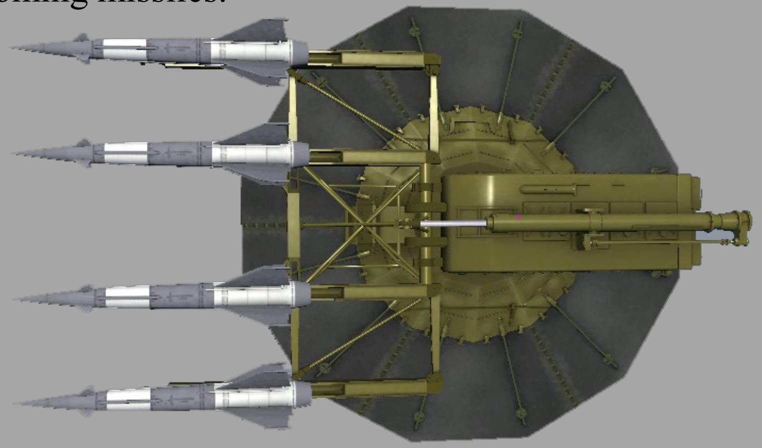
SA-3 Goa (S-125 Neva)

The GOAs relatively limited altitude envelope and especially its high minimum engagement altitude make it a low to moderate thereat for aircraft in the low level environment. Its 700 foot AGL limitation allows aircraft to easily fly beneath its MEZ, even well within its range envelope. However extreme caution must be employed when doing so as should the MEZ be entered unexpectedly the GOAs reasonable chaff rejection will make it difficult to evade, especially at low airspeed and close range.

In the medium altitude environment, the GOA presents a moderate threat, it is highly lethal to any aircraft with low energy and any descending evasive manoeuvre is likely to force the defending aircraft in to the WEZ of SHOARD/AAA systems. It is highly recommended to plan to fly around any SA-3 MEZ at medium altitude, or where possible transit at high altitude above its ceiling which is comparatively low for the MERAD system.

The GOA countermeasures rejection is surprisingly high given its age and as such is must be respected when it is encountered. A rapidly dispensing high volume chaff program, combined with beaming/dragging turns will be required to decoy any incoming missiles.

Ammunition Qty:	4 Missiles per launcher
Reloading Time	N/A
Acquisition Time:	
Minimum Effective Range:	TBC
Maximum Effective Range:	11.2 nautical miles
Minimum Effective Altitude:	700 feet
Maximum Effective Altitude:	20,500 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Break turn to place missile on beam Terrain Mask High Speed Split-S into extending S-Turns



SA-6 Gainful (2K12 Kub)

The SA-6 has comparatively good capability vs a low-level aircraft with a minimum engagement altitude of approximately 100 feet AGL, however the SA-6 has a chaff rejection rate in the region of 50% which makes it only a moderate threat to low level aircraft. A combination of terrain masking and swift reaction to any RWR warning will in most cases prevent the system engaging.

At medium level the SA-6 presents a greater threat especially for aircraft with limited energy. The typical launch range of the system combined with advance warning of pending engagement provided by early TTR lock-on should be sufficient to allow successful evasion. Should a missile be fired a long salvo chaff dispensing program with a .5 – 1 sec burst delay should be sufficient to decoy any incoming missiles.

The SA-6 will engage only a single target, however, it will fire a salvo of two missiles per engagement with up to a 5 second delay between each. The high smoke motor and large size of the missile aids in visual acquisition, especially at medium altitudes and further enhances evasion probability.

Ammunition Qty:	3 Missiles per TEL
Reloading Time	N/A
Acquisition Time:	28 seconds
Minimum Effective Range:	0.5 nautical miles
Maximum Effective Range:	19.2 nautical miles
Minimum Effective Altitude:	100 feet
Maximum Effective Altitude:	26,000 feet
Missile Max Speed:	M2.2
Countermeasures:	Chaff
Defensive Manoeuvre:	Break turn to place missile on beam Terrain Mask High Speed Split-S into extending S-Turns

SA-8 Geko (9K33 Osa)

The GEKO represents a moderate threat to fixed wing aircraft operating at low altitude, the short-range nature of the system combined with its relatively long acquisition time allow aircraft employing terrain masking techniques to approach and engage any targets within the GEKO’s MEZ while avoiding the threat providing standard TTPs are adhered to.

For aircraft at medium altitude the GEKO represents a moderate threat. The MEZ can be easily avoided and provided any RWR indication is swiftly reacted to, however if fired upon terrain masking will not be available therefore sufficient airspeed/altitude to allow rapid manoeuvring is essential.

Chaff is highly effective against the GEKO when combined with beam aspect manoeuvring.

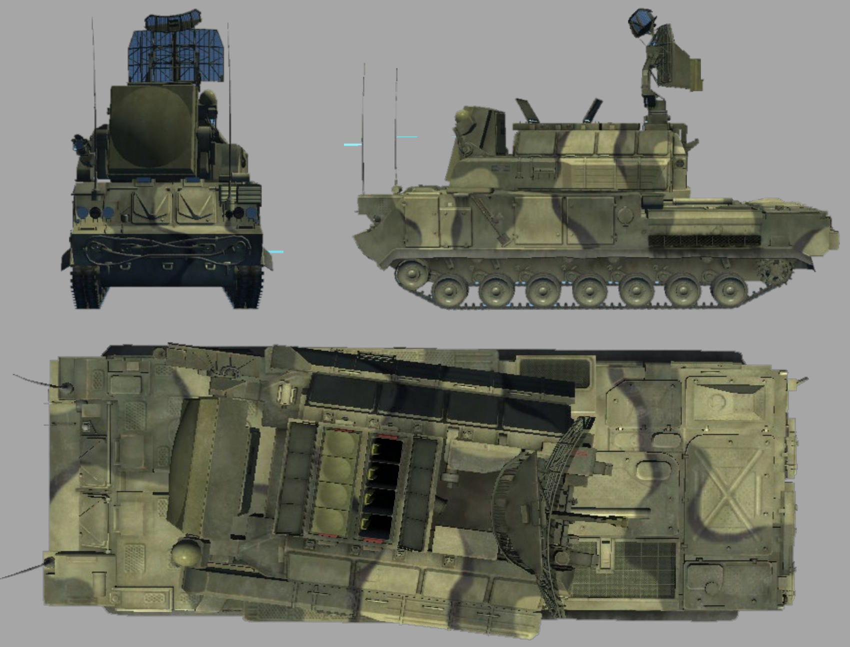
Ammunition Qty:	**6 Missiles per TELAR**
Reloading Time	N/A (3 seconds between each missile launch)
Acquisition Time:	26 seconds
Minimum Effective Range:	0.8 nautical miles
Maximum Effective Range:	7.5 nautical miles
Minimum Effective Altitude:	50 feet
Maximum Effective Altitude:	21,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	High speed break turn to hold on beam Orthogonal roll over missile

SA-15 Gauntlet (9K331 Tor)

The GAUNTLET represents a significant threat to all aircraft operating at low and medium altitudes. It is highly resistant to chaff (greater than 90% rejection) and the SA-15 missile is highly manoeuvrable and able to deal with most kinetic defensive manoeuvring. The SA-15 system will typically employ salvos of two missiles per target to further enhance its Pk and, due to its 8 ready to fire missile capacity, is able to quickly launch follow on salvos should the first salvo be defeated.

Further enhancing the GAUNLET's lethality is its ability to engage low RADAR cross section targets, including cruise missiles and air to surface missiles such as AGM-88 and AGM-65, giving it the ability to defend itself against attack.

The standard battery size of 4-6 TELARs leave the GAUNTLET a significant tactical challenge for any SEAD/DEAD package tasked against it, and a major threat for any strike package having to negotiate its MEZ.



Ammunition Qty:	8 Missiles per TELAR
Reloading Time	4 seconds between missile launches
Acquisition Time:	9 Seconds
Minimum Effective Range:	0.8 nautical miles
Maximum Effective Range:	6.5 nautical miles
Minimum Effective Altitude:	60 feet
Maximum Effective Altitude:	26,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Terrain Mask Break turn to place missile on beam High Speed Split-S (>M0.9) into extending S-Turns

Command to LOS Guided Systems

Command to LOS Guided SAM Systems

- ***SA-19 Grison*** *(2S6 Tunguska) – Optical SACLOS*
- ***Roland II*** *– RF SACLOS/Optical CLOS*

SA-19 Grison *(2S6 Tunguska)*

The Grison represents a moderate/high threat to all fixed wing aircraft operating at low level, the combination of missiles and high calibre guns gives the SA-19 the ability to effectively engage targets at ranges from zero to 5.5 nautical miles. Within 2 nautical miles, guns are the preferred weapon system, outside of 2 nautical miles the missiles are used. While the guns are highly effective with their calibre allowing a small number of hits to cause significant damage to their target, the SACLOS guidance used by the missiles makes them only moderately effective against fixed wing aircraft as their maximum LOSR and ability to manoeuvre is quickly reached by a crossing/manoeuvring target.

The system represents a very high threat to rotary wing aircraft operating in close proximity to hostile forces and can be deadly if not detected early, the SA-19 missiles are highly effective against slow moving targets at up to 4 nautical miles while at closer ranges the 30mm cannons high RoF and large calibre make them extremely deadly.

The Grison is typically employed in batteries of 4-6 units embedded with armoured forces. And will advance with them in close proximity to provide effective defence against air attack. It has largely replaced the ZSU-23-4 in Russian service.

Ammunition Qty:	968 Rounds per Gun + 8 SA-19 Missiles
Reloading Time	N/A
Acquisition Time:	4 seconds
Minimum Effective Range:	Zero (Guns) / 1 nautical mile (Missiles) - Typical (varies by LOSR).
Maximum Effective Range:	2 nautical miles (Guns) / 4 nautical miles (Missiles)
Minimum Effective Altitude:	Zero (Guns) / 100 feet (Missiles)
Maximum Effective Altitude:	10000 ft. (Guns) / 16000 ft. (Missiles)
Countermeasures:	None Effective in DCS
Defensive Manoeuvre:	Missiles - Break turn placing launcher on 3/9 line + maximise LOSR Guns - “ZSU” Break or Vertical Jink

Threat Evasion and Management

Roland II

The Roland is a moderate threat to aircraft at both low and medium altitude. The missile is both moderately manoeuvrable and has a countermeasures resistance of approximately 60%. The Roland system is only able to support a single missile in flight at one time which does improve the chances of evasion father provided defensive action is taken shortly after launch.

The high smoke motor of the Roland missile makes visual detection of a launch highly likely, this combined with the target tracking RADAR providing clear RWR track and launch warnings further enhances survivability of aircraft equipped with modern defensive aids when faced with the Roland.

Ammunition Qty:	10 Missiles
Reloading Time	
Acquisition Time:	11 seconds
Minimum Effective Range:	0.5 nautical miles
Maximum Effective Range:	5.1 nautical miles
Minimum Effective Altitude:	<500 feet
Maximum Effective Altitude:	19,500 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Terrain Mask Break turn to place missile on beam

Semi Active Homing Guided Systems

Threat Evasion and Management

Semi Active RADAR Homing Guided SAM Systems

- ***SA-4 Ganef*** *(2K11 Kpyr) - COLOS /Terminal SARH*
- ***SA-5 Gammon*** *(S-200 Angara) - SARH/Terminal ARH*
- **SA-6 Gainful** (2K12 Kub) - *COLOS* /Terminal SARH
- **SA-11 Gadfly** (Buk-M1) - SARH
- ***SA-17 Grizzly*** *(Buk-M2) – SARH*
- ***MIM-23 Hawk*** *- SARH*

Threat Evasion and Management

SA-11 Gadfly (Buk-M1)

The SA-11 presents a moderate to high threat to aircraft at low level, with each TELAR carrying its own TTR and being able to engage even without a supporting search RADAR low flying aircraft must ensure they mask from all units within a threat battery. The large, high speed missile, is highly manoeuvrable especially at speed and therefore any kinetic defence in the inner portion of the Gadfly's MEZ will prove difficult, especially if low on energy.

At medium and high altitudes, the Gadfly is a very high threat system, its ability to close to lethal range with a manoeuvring aircraft and high chaff rejection (greater than 90%) will leave any aircraft unable to execute a high-energy escape manoeuvre in a limited survivability situation.

The most effective method of evasion to be employed against the Gadfly is rapid terrain masking or high energy extending turn to drag the missile and cause it to lose energy. At the far limit of the Gadfly's MEZ beaming manoeuvres can be successful however are only advised if other threats and/or aircraft capability prevent a high-energy escape manoeuvre.

Ammunition Qty:	4 Missiles per TELAR
Reloading Time	N/A
Acquisition Time:	TBC
Minimum Effective Range:	TBC
Maximum Effective Range:	20.2 nautical miles
Minimum Effective Altitude:	<500 feet
Maximum Effective Altitude:	>45,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Terrain Mask High Speed Split-S into extending S-Turns Break turn to place missile on beam

MIM-23 Hawk

The HAWK presents a moderate threat to aircraft at low and medium altitudes, its chaff rejection is in the mid-range at around 60% which requires a high burst/salvo quantity dispensing program. Combined with effective manoeuvring however chaff is effective at decoying fired missiles. Evasion by manoeuvring alone is also effective against incoming HAWK missiles, especially following motor burnout as the missile will rapidly decelerate and once subsonic loses effective manoeuvring capability.

The MIM-23B will accelerate to max speed (1200 KTAS) in approx. 5 seconds from launch with motor burnout occurring after 26 seconds. An unpowered non-manoeuvring MIM-23B will lose approx. 200 KTAS every 5 seconds.

The HAWK is only able to support a single missile per TTR further increasing survivability, especially towards the outer limits of its MEZ, however it should be noted that a typical HAWK battery will have two TTRs therefore allow it to support two missiles and/or engage two targets simultaneously.

Ammunition Qty:	3 Missiles per launcher
Reloading Time	N/A
Acquisition Time:	12 seconds
Minimum Effective Range:	TBC
Maximum Effective Range:	25.6 nautical miles
Minimum Effective Altitude:	<500 feet
Maximum Effective Altitude:	>45,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Break turn to place missile on beam Terrain Mask High energy out of plane break turn High Speed Split-S into extending S-Turns

Track via Missile Guided Systems

Threat Evasion and Management

Track via Missile Guided SAM Systems

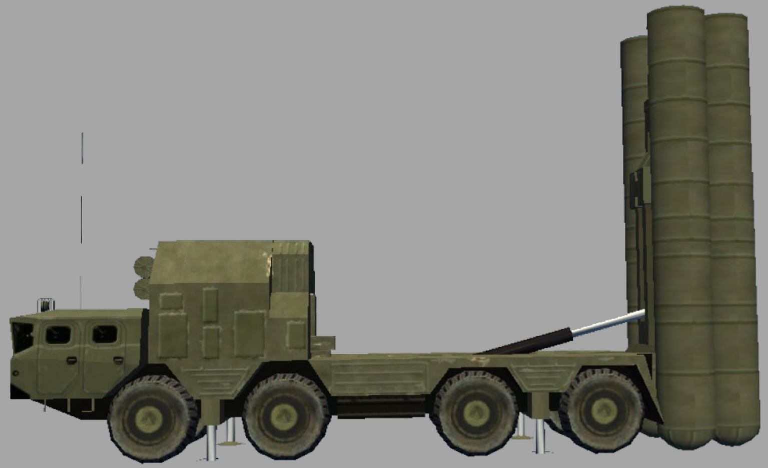
- **SA-10 Grumble** (S-300P/PS/PT) – TVM
- ***SA-12 Gladiator*** *(S-300V) – TVM*
- ***SA-20 Gargoyle*** *(S-300PM/PMU) - TVM*
- ***SA-21 Growler*** *(S-400) - TVM*
- ***SA-23 Giant*** *(S-300VM) – TVM*
- **MIM-104 Patriot** - TVM

SA-10D Grumble D (S-300PS)

The SA-10 Grumble is representing and extremely high threat to all aircraft operating within its MEZ. The system has both a long range and is able to effectively engage low flying aircraft down to very low level, only lack of line of sight due to terrain masking is effective in preventing low level engagements. The fast acquisition time of the system also means that aircraft employing pop-up tactics will find themselves being engaged shortly after unmasking.

The SA-10 also has excellent chaff rejection (>90%) meaning that once fired upon, evading incoming missiles is very challenging and may be impossible for aircraft flying at low energy states. The SA-10 system can engage 6 separate targets and support 12 missiles simultaneously

Ammunition Qty:	4 Missiles per launcher
Reloading Time	N/A
Acquisition Time:	3 seconds
Minimum Effective Range:	3 Nautical Miles
Maximum Effective Range:	40 Nautical Miles
Minimum Effective Altitude:	50 feet
Maximum Effective Altitude:	100,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Terrain Mask High Energy Split-S into extending S-Turns Break turn to place missile on beam (very low success chance if subsonic) High energy out of plane break turns

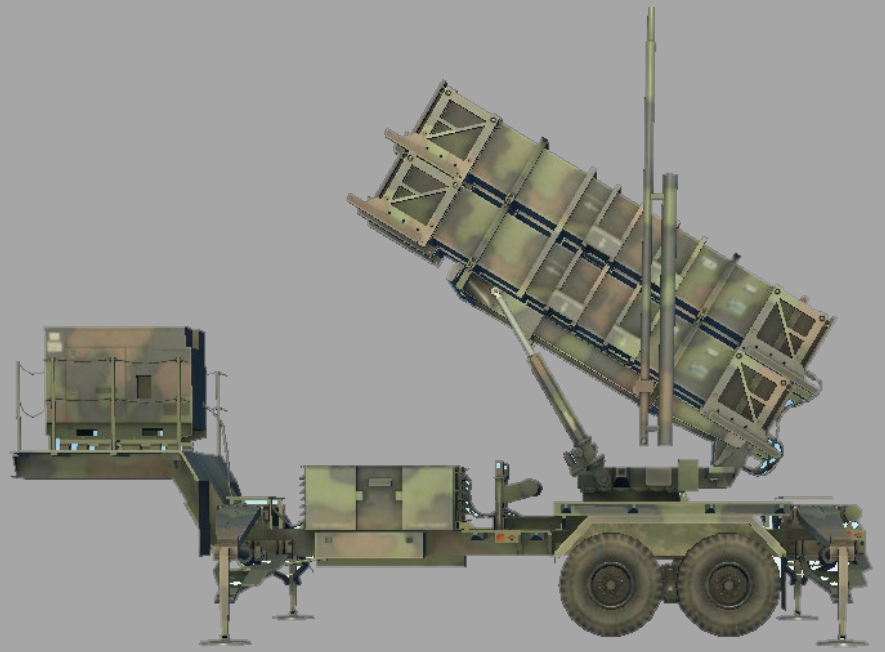


MIM-104 Patriot

The Patriot represents an extremely high threat to all aircraft operating within its MEZ. The Patriot has both a long range and is able to effectively engage aircraft down to very low level, only lack of line of sight due to terrain masking is effective in preventing low level engagements. The fast acquisition time of the system also means that aircraft employing pop-up tactics will find themselves being engaged shortly after unmasking.

The Patriot's excellent chaff rejection (greater than 90%) also enhances its lethality, once fired upon evading incoming missiles is very challenging and may be impossible for aircraft flying at low energy states.

Ammunition Qty:	4 Missiles per launcher
Reloading Time	N/A
Acquisition Time:	
Minimum Effective Range:	
Maximum Effective Range:	58 nautical miles
Minimum Effective Altitude:	<500 feet
Maximum Effective Altitude:	>45,000 feet
Countermeasures:	Chaff
Defensive Manoeuvre:	Terrain Mask High Energy Split-S into extending S-Turns Break turn to place missile on beam



IR Homing Missile Systems

Threat Evasion and Management

IR Homing Missile Systems

- **FIM-92C Stinger**
- **MIM-72G Chaparral**
- **SA-18 Grouse**
- **SA-24 Grinch**
- **SA-9 Gaskin**
- **SA-13 Grouse**

FIM-92C Stinger

Stinger presents a low threat to low flying fixed wing aircraft due to its high susceptibility to flare and other IRCM systems, the missiles high smoke motor permits fast visual acquisition of a launch and early defensive reaction provide standard visual lookout contracts are adhered to. The short range of the system combined with the acquisition time allows low flying aircraft to fly through the MEZ of a single system before a shot can be taken.

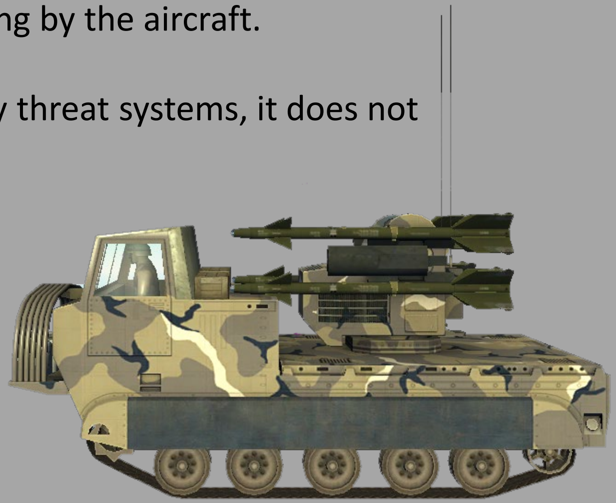
Rotary wing aircraft should consider the Stinger a moderate threat due to their lower speed allowing a higher chance for a shot to be taken against them however given the high effectiveness of IRCM early detection of a launch should allow successful evasion

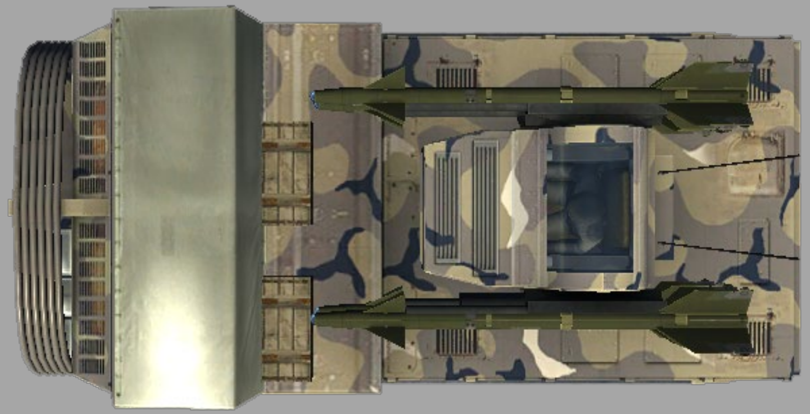
Ammunition Qty:	3 per single operator
Reloading Time	12 seconds
Acquisition Time:	6 seconds
Minimum Effective Range:	0.25 Nautical Miles
Maximum Effective Range:	2.5 Nautical Miles
Minimum Effective Altitude:	Zero
Maximum Effective Altitude:	12,000 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	High speed break turn to hold on beam Out of plane break turn Orthogonal roll over missile

MIM-72G Chaparral

The M48 Chaparral system presents only a low-level threat to low flying aircraft due to its very low countermeasures rejection. Flare and other IRCM systems are highly effective at decoying the MIM-72G missile even at close range and without significant manoeuvring by the aircraft.

Although its presence on the battlefield cannot be ignored and it can be used to drag aircraft into other, more deadly threat systems, it does not present a significant challenge to any aircraft with modern defensive aids operating under standard TTPs.





Ammunition Qty:	4 Missiles
Reloading Time	N/A
Acquisition Time:	2.5 seconds
Minimum Effective Range:	0.1 nautical miles
Maximum Effective Range:	3.0 nautical miles
Minimum Effective Altitude:	<500 feet
Maximum Effective Altitude:	9,500 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	IRCM Dispense Aggressive out of plane break turn

SA-18 Grouse

The Grouse is a moderate threat for all aircraft at low altitude and has reasonably high countermeasures rejection of approximately 75%. The CM rejection rate means that early detection of and reaction to a launch is critical, a long salvo duration low release interval single flare string CM pattern is most effective (1/0.25/8).

The Grouse has a high smoke output motor with a 6 second burn time allowing a launch to be quickly detected and reacted to providing visual lookout contracts are in place. Should a hit be suffered the comparatively low yield warhead means that a single missile impact is unlikely to cause catastrophic cascading system failures, however and damage suffered may leave the aircraft more susceptible to follow on launches.

The SA-16 Gimlet, SA-18 Grouse, and SA-24 Grinch appear to be somewhat merged and confused within DCS and therefore values for each system is difficult to derive with acceptable accuracy. The SA-24 GRINCH should therefore be treated as the assumed threat for all IGLA series MANPADS within DCS.

Ammunition Qty:	**3 per single operator**
Reloading Time	12 seconds
Acquisition Time:	6 seconds
Minimum Effective Range:	0.25 Nautical Miles
Maximum Effective Range:	2.5 Nautical Miles
Minimum Effective Altitude:	Zero
Maximum Effective Altitude:	12,000 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	High speed break turn to hold on beam Out of plane break turn Orthogonal roll over missile

SA-24 Grinch

The Grinch is a high threat for all aircraft at low altitude and has reasonably high countermeasures rejection of approximately 85%. The CM rejection rate means that early detection of and reaction to a launch is critical, a long salvo duration low release interval single flare string CM pattern is most effective (1/0.25/8).

The Grinch has a high smoke output motor with a 6 second burn time allowing a launch to be quickly detected and reacted to providing visual lookout contracts are in place. Should a hit be suffered the comparatively low yield warhead means that a single missile impact is unlikely to cause catastrophic cascading system failures, however and damage suffered may leave the aircraft more susceptible to follow on launches.

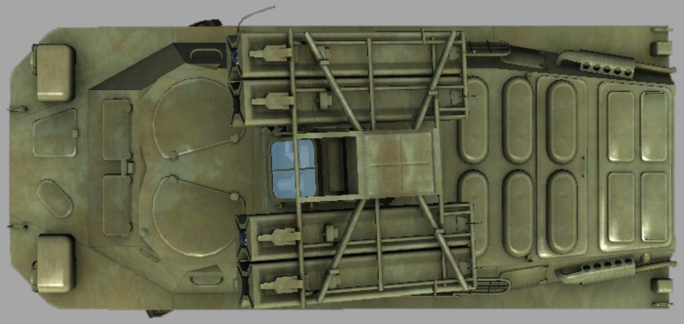
The SA-16 Gimlet, SA-18 Grouse, and SA-24 Grinch appear to be somewhat merged and confused within DCS and therefore values for each system are difficult to derive with acceptable accuracy. The SA-24 GRINCH should therefore be treated as the assumed threat for all IGLA series MANPADS within DCS.

Ammunition Qty:	3 per single operator
Reloading Time	12 seconds
Acquisition Time:	6 seconds
Minimum Effective Range:	0.25 Nautical Miles
Maximum Effective Range:	2.5 Nautical Miles
Minimum Effective Altitude:	Zero
Maximum Effective Altitude:	12,000 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	High speed break turn to hold on beam Out of plane break turn Orthogonal roll over missile

SA-9 Gaskin

The GASKIN can be categorised as a low threat to fixed wing aircraft operating at low altitudes due to its short range and high (les than 20% rejection) susceptibility to IRCM. The missile's comparatively low maximum speed and very short range further limit its ability to effectively engage fixed wing aircraft. Its high smoke motor and 10 second burn time provide clear visual indication of a launch allowing timely defensive action providing standard TTPs are employed to ensure detection.

The GASKIN represents no notable threat to aircraft at medium altitude.

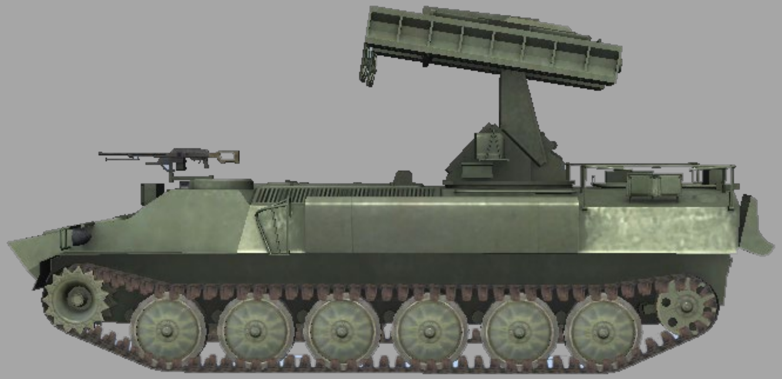


Ammunition Qty:	4 Missiles per TEL
Reloading Time	N/A
Acquisition Time:	2.5 seconds
Minimum Effective Range:	0.4 nautical miles
Maximum Effective Range:	2.5 nautical miles
Minimum Effective Altitude:	100 feet
Maximum Effective Altitude:	12,000 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	Break turn to place missile on beam Orthogonal roll into and over missile

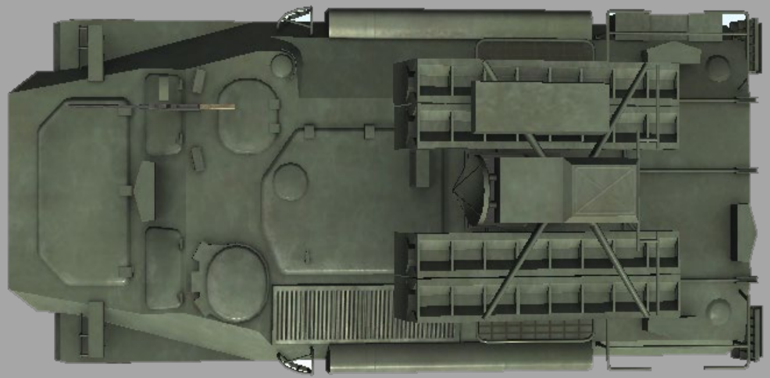
SA-13 Gopher

The GOPHER represents a moderate threat to fixed wing aircraft operating at low altitudes due to its short range and medium susceptibility to IRCM. The missile's comparatively low maximum speed and very short range further limit its ability to effectively engage fixed wing aircraft. Its high smoke motor provides clear visual indication of a launch allowing timely defensive action providing standard TTPs are employed to ensure detection.

The GOPHER represents a low threat to aircraft at medium altitude, while its ceiling allows it to engage aircraft in the low portion of the medium altitude block, its low IRCM rejection leaves it capable of little more than harassing fire at such altitudes. Although caution should still be employed to ensure the Gopher does not cause aircraft to trespass higher threat systems while evading and shots that are taken.



Ammunition Qty:	4 Missiles per TEL
Reloading Time	N/A (2.5 seconds between missile firings)
Acquisition Time:	2.5 seconds
Minimum Effective Range:	0.4 nautical miles
Maximum Effective Range:	2.8 nautical miles
Minimum Effective Altitude:	75 feet
Maximum Effective Altitude:	15,000 feet
Countermeasures:	Flare/AIRCM
Defensive Manoeuvre:	Break turn to place missile on beam Orthogonal roll into and over missile



Threat Evasion and Management

Lesson 3: Defensive Manoeuvres

476th vFighter Group Weapons School

Threat Evasion and Management

Welcome to the 476th vFighter Group Weapons School surface to air missile evasion training course. Upon completion of this course the student will:

- Be familiar with the basic techniques necessary to counter Surface-Air missile systems.

Surface to Air Missile Defence

Threat Evasion and Management

Missile Defence

- Out of Plane Break Turn
- Orthogonal Roll
- Doppler Notch/Beaming
- Dragging

Threat Evasion and Management

Out of Plane Break Turn

- Roll out of missile flight plane followed by high G pull.
- Chance of success increases with higher starting airspeed and more available G.
- Works by creating turn rate (G) problems for missile.
- Tally of threat missile required for manoeuvre to be most effective.
- Combination of manoeuvre and countermeasures required for best effect.
- Descending break turn preferable for energy sustainment.

Execution

- Roll to place lift vector at 90° to missile > target plane (line drawn from missile to your aircraft).
- Pull maximum available G.
- Deploy chaff/flare.

[Demo Video]

Threat Evasion and Management

Orthogonal Roll

- Energy bleeding manoeuvre (will leave a/c at low energy state).
- Chance of success increases with higher starting airspeed.
- Most effective against older missiles with 2 axis control systems.
- Works by creating angle problems in all 3 dimensions that the threat missile cannot solve causing it to drop in to lag.
- Tally of threat missile required for manoeuvre to be effective.
- Last ditch manoeuvre against all threat missile types.

Execution

- Evolution of a barrel roll.
- Initiate with 4-5G pull and blend in aileron.
- Aim to keep threat missile “fixed” in the canopy and roll over and around it.

Demo Video

Threat Evasion and Management

Beaming

- Most effective against medium/long range threats
- Chance of success increases with higher starting airspeed.
- Most effective against older generation systems with limited Clutter/CM rejection.
- Works by reducing closure to target RADAR and/or increasing LOS rate, generating angle both tracking and angle problems for the threat system.
- Tally of threat missile greatly increases effectiveness.
- Increases effectiveness of chaff.
- CM must be employed.*

Execution

- Max performance turn to place threat on 3/9 line.
- Descend if possible to regain energy
- Turn to keep threat held on 3/9 line
- Dispense Chaff/Flare

[Demo Video]

*N/A for SA-19 or other optical SACLOS systems

Threat Evasion and Management

Dragging

- High energy kinetic manoeuvre.
- Chance of success increases with higher airspeed.
- Most effective in outer half of threat system MEZ (beyond motor burnout range).
- Works by both increasing range to intercept and bleeding missile energy.
- Rear aspect increases chaff effectiveness

Execution

- Initiate with Split-S (over banked descending turn can be used at low altitude, but less effective).
- Follow with 3-4G 30° turns, alternating left/right.
- Manoeuvre complete once missiles defeated or lock dropped.

Demo Video