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A LITERATURE STUDY ON COMMAND TO LINE OF SIGHT MISSILE SYSTEM

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ABSTRACT
The aim of this paper is to explain the CLOS (Command to Line of Sight) Missile Systems in detail. The includes the concept behind it, the technology used and the applications in modern warfare. While the paper will largely deal with CLOS guidance, the theory behind basic functioning of a guided weapon/missile will also be discussed. The MCLOS (Manual Command to Line of Sight), SACLOS (Semi Automatic Command to Line of Sight), and ACLOS (Automatic Command to Line of Sight) are also presented along with their applications.

KEYWORDS: ACLOS, MCLOS, SACLOS

I. INTRODUCTION
A Guided weapon may be described briefly as a weapon system which the warhead is delivered by an unmanned guided vehicle. Guided missiles have only been in practical use since the advent of World War II. It is because the technology has enabled the invention of the final product has been around for a lot longer. From the oldest of discoveries, like that of gunpowder in the 1st millennium BC by the Chinese to the rapid advances in the field of science, they have all been required to the practical enabling of the concept of guided missile systems [1][2].
The Germans were the first to field guided weapons with the use of V1 guided bomb and the V2 rocket. Though they were deemed to be quite inaccurate as per the present standards, they became a major cause of concern to the Allied Forces. Following are the reasons why a guided missile/weapon system is preferred over an unguided alternative [3][4].

(a) Random Dispersion.
Even with great effort having been put into ensuring that the sighting system on a missile system is perfectly collimated, perfect alignment is not always guaranteed. Thus, there will always be imperfections which will result in the projectile not flying in exactly the desired direction [5].

(b) Projectile Deflection in Flight.
Variations in air pressure and density along the flight path, side winds and thermal layers in the air along with other factors will lead to dispersion in the flight of the missile. Thus, if the missile is unguided, there would be no way to correct for these variations as the missile encounters them [6].

(c) Target Movement.
There is a clear possibility that a non-stationary target to be struck will move between the time the missile is fired and by the time it reaches the area of the target. Guided missiles solve this problem by incorporating control systems to account for this change in position of the target, and ensuring that the missile strikes the desired target [7].

II. COMPONENTS OF A MISSILE
Based on functionality, a missile can be divided into eight sections and their description is as follows.

(a) Radome.
A housing made of ceramic material located at the front end of the missile. The radome is non-metallic to act as an EM "window" for radar or heat-seeking EM devices located inside the missile. Radar (Radio Ranging and

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Detection), transmits EM pulses that bounce off the target and return to the radar set to provide target location, direction and speed [8].

(b) Guidance.
This is the system that receives radio information from its launch controller. It is basically for directing it to launch the missile and calculate its most efficient path to the target. The Guidance system also transmits all missile functions back to its launch controller for continuous monitoring of missile subsystem performance [9].

(c) Warhead.
This system contains missile internal "homing" radar and an explosive surrounded by thousands of serrated iron pieces or other destroying material depending on the nature of the anticipated target [10][11].

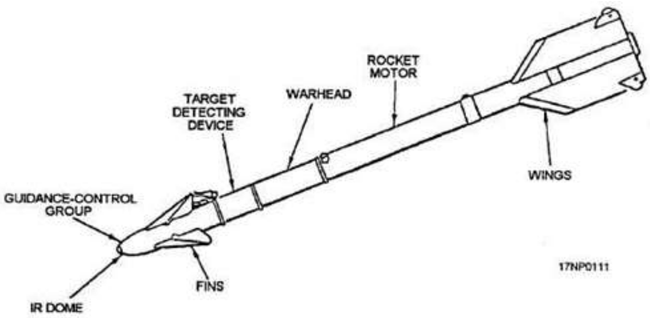
(d) Autopilot.
This system that provides missile location, direction, velocity and "attitude" (up, down, sideways, etc.). It also provides the capacity to change its motion via the Control Surfaces [12]

(e) Dorsal Fins.
The fins, along with the missile body, provide surfaces against which air exerts pressure. These dorsal surfaces are used to change the direction and attitude of the missile [13].

(f) Rocket Motor.
This system is for the mixture of solid chemical fuels. When ignited, the chemicals propel the missile from its launcher into space [14].

(g) Steering Control.
This system electrically changes the 'Control Surfaces' that change the missile motion. It reacts to information sent to it by the Autopilot [15].

(h) Control Surfaces.
These are wings that act against air resistance to change the direction of the missile.



Parts of the Missile

III. TYPES OF GUIDANCE SYSTEM

(a) Inertial Guidance.
An inertial guidance system is one that is designed to fly a predetermined path. The missile is controlled by self-contained automatic devices called accelerometers. Accelerometers are inertial devices that measure accelerations. In missile control, they measure the vertical, lateral, and longitudinal accelerations of the controlled missile. Although there may not be contact between the launching site and the missile after launch, the missile is able to make corrections to its flight path with good precision [16][17].

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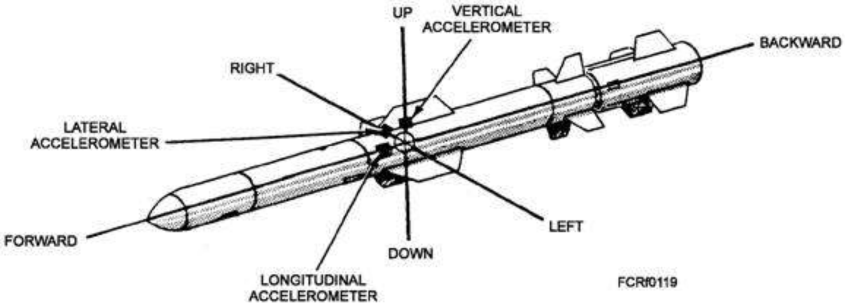
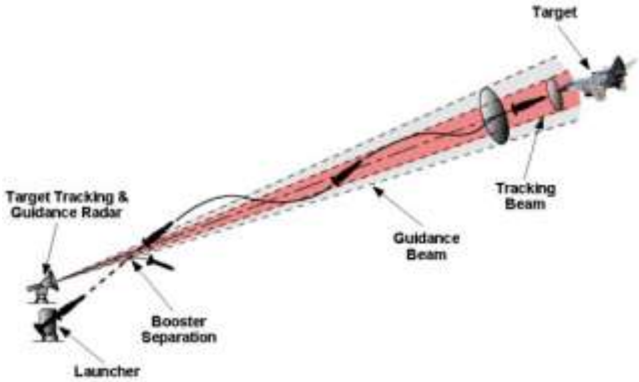


Inertial Guidance System

(b) Beam Rider Guidance.

A beam-rider guidance system is a type of command guidance in which the missile seeks out the center of a controlled directional energy beam. Normally, this is a narrow radar beam. The missile's guidance system receives information concerning the position of the missile within the beam. It interprets the information and generates its own correction signals, which keep the missile in the center of the beam [18][19].

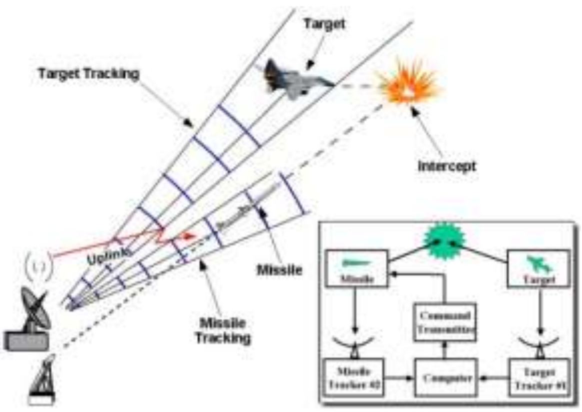


Beamer Guidance System

(c) Homing Guidance.

Homing guidance systems control the path of the missile by means of a device in the missile that detects and reacts to some distinguishing feature of (or signal from) the target. This may be in the form of light, radio, heat, sound waver, or even a magnetic field. The homing missiles use radar or RF waves to locate the target while air-to-air missiles sometimes use infrared (heat) waves. Since the system tracks a characteristic of the target or energy reflecting off the target, contact between the missile and target is established and maintained. The missile derives guidance error signals based on its position relative to the target [20].

(d) Command Guidance.



Command Guidance System

Command guidance missile are those which are guided on the basis of direct electromagnetic radiation contact with a friendly source (i.e., ship, ground, or aircraft). All guidance instructions, or commands, come from

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outside the missile. The guidance sensors detect this information and convert it to a usable form. The output of the guidance computer initiates the movement of the control surfaces and the missile responds.

(f) TERCOM.

TERCOM (Terrain Contour Matching) is a navigation system used primarily by cruise missiles. In this system, a pre-recorded contour map of the terrain is used, one that is compared with measurements made during flight by an on-board radar altimeter. The accuracy of a missile, as compared with inertial navigation systems (INS), is considerably increased by a TERCOM system. The increased accuracy allows a TERCOM-equipped missile to fly closer to obstacles and generally lower altitudes, making it harder to detect by ground radar. Radar used to scan the ground/terrain that the missile is passing over. The terrain data is compared to the digital maps stored in the computer on the missile If a drift is noticed, the inertial navigation system is corrected and a course correction is made to put the missile back on path .This is repeated a number of times. Advantages are that missiles fly very low - coupled with their small size and radar cross-section, low infrared signature, they become virtually undetectable by enemy radar. GPS can be used to complement data computed by inertial system [21] [22].

IV. CLOS SYSTEM

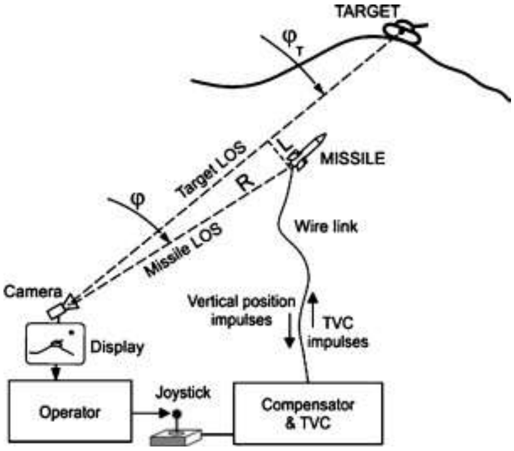
A particular type of command guidance and navigation where the missile is always commanded to lie on the line of sight (LOS) between the tracking unit and the aircraft/target is known as command to line of sight (CLOS) guidance.

The working of a CLOS missile system is described as follows:

- The CLOS form of guidance requires a target tracker and a missile tracker situated at the base or the aiming point from which the system is operational, and which is the point from which the missile is launched.
- The axis of the missile tracker is collimated with the axis of the target tracker, which is kept on the target by the target tracking process.
- When the missile is launched towards the target, the missile tracker detects any displacement of the missile from the Line of Sight (LOS) with the help of rear-facing flare or beacon on the missile.
- A computer, also located at the base, calculate the latax required to bring the missile back on the LOS. This is translated into a coded signal which is transmitted to the missile over a suitable command link (CL). The CL may be a pair of wires, an optical fibre, a laser communication link or a radio link.
- On receipt of the correcting signal, the signal is decoded by the missile and the lateral thrust is applied, either by positioning the fins or by altering the propulsive jet direction. A position gyro in the missile will usually be required to provide the reference direction.
- Both, target and missile must be tracked until impact occurs.

The types of CLOS system are explained as below:

(a) Manual CLOS (MCLOS).



Manual CLOS

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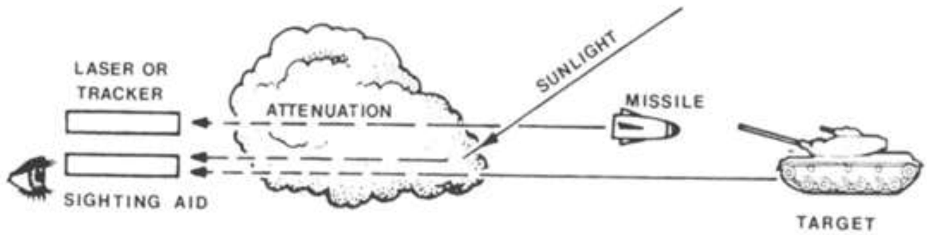
CODEN: IJESS7

In this system, both target tracking and missile tracking and control are performed manually. The operator watches the missile flight, and uses a signaling system to command the missile back into the straight line between operator and target (the "line of sight"). The operator is provided with a missile steering control, usually in the form of a small joystick or thumb pressure switch, and thus, with the missile under his direct control, he superimposes the missile between his eye and the target until impact occurs. This is typically useful only for slower targets, where significant "lead" is not required. This system worked fine against slower targets. However, against faster adversaries, it was rendered completely ineffective.

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

In this system, while the target is tracked manually, the missile tracking and control is automatic. It is similar to MCLOS but an automatic system is designed into place to position the missile in the line of sight while the operator simply tracks the target. 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. The automatic missile tracking system is generally slaved to the bore sight of the target tracker by some form of a servo system. When the missile is launched, as nearly as possible to the along the LOS, the automatic missile tracker detects any departure of the missile from the LOS. This error is passed to the guidance computer which is built into the tracking system. The computer determines the correct command to be sent to the missile, encodes it, and this is passed to the missile over the CL.



Semi-Automated CLOS

(c) Automatic Command to Line-Of-Sight (ACLOS).

In this form of guidance, both target and missile are tracked automatically. The target and missile position data are passed to the guidance computer by their respective trackers and the calculated and coded are sent automatically to the missile via the CL. In some systems, the target tracker and missile tracker may operate quite separately; for example, the target may be tracked using radar and the missile using IR. In such a case, the collimation must be maintained between the target and missile trackers. In other systems, a single tracker perhaps a differential tracking radar, may track both missile and target, using a single antenna or lens system. In this case, there must be some signal processing technique in the tracker to separate the target and missile signals. To achieve this, we use range gating or doppler shift velocity filtering.

V. CLOS IN MODERN WARFARE

(a) AT - 3 SAGGER (9K11 MALYUTKA) ATGM.

The 9M14 Malyutkais a manual command to line of sight (MCLOS) wire-guided anti-tank guided missile (ATGM) system developed in the Soviet Union. The Malyutka is recognizable for its distinctive 9M14 missile, which has a pointed nose containing a HEAT warhead and oversized fins, that is stored inside the 9K11 portable fiberglass launcher. The Malyutka's best attribute compared to other anti-tank missiles is its ease of use. While earlier systems deserved their reputation as crude and unwieldy the arrival of the Malyutka marked a serious breakthrough for the Soviet Army. Carried in its suitcase, the Malyutka is assembled and ready to fire in under a minute. A proper Sagger unit, however, required a three-man team of two soldiers for carrying the missiles and a third "senior operator" carrying the 9S415 control panel and its monocular sight/periscope. When fired the missile's course is guided from a control panel with a joystick and a periscope sight for accurate navigating beyond 1 000 meters. A red tail light emitted from the rocket motor serves as a visual guide to the operator before the missile impacts.

(b) MILAN.

MILAN is a portable medium-range, anti-tank weapon manufactured by Euromissile, based in Fontenay-aux-Roses in France. It is a wire guided SACLOS (semi automatic command to line-of-sight) missile, which means the sight of the launch unit has to be aimed at the target to guide the missile. The MILAN can be equipped with

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a MIRA or MILIS thermal sight to give it night firing ability. MILAN ADT has an integrated thermal imager with a video output which allows remote operation.

(c) RAPIER SAM.

Rapier is a British surface-to-air missile developed for the British Army. The Rapier missile is capable of engaging supersonic, low-level, highm anoeuvrability aircraft and can be towed behind medium size vehicles and armoured personnel carriers. It is air-portable by transport aircraft or helicopters.The search radar was of the pulsed Doppler type with a range of about 15 km. The aerial, located at the top of the launcher, rotated about once a second, looking for moving targets through their doppler shift. When one was located, a lamp would light up on the Selector Engagement Zone (SEZ), a box containing 32 orange lamps arranged in a circle about the size of an automobile steering wheel. The radar operator could also blank out returns from other directions, providing jamming resistance. Upon detection, the optical tracking system would then be slewed to target azimuth and the operator would then search for the target in elevation. The operator's field of view would depend on the target range: "wide" at about 20 degrees or "track" at about 4.8 degrees. When the target was found the operator switches to "track" and uses a joystick to keep the target centred in the telescope. Once a steady track was established the missile was fired. The TV camera on the tracker was tuned to track the four flares on the missile's tail. Like the operator's telescope, the TV system had two views, one about 11 degrees wide for the initial "capture", and another at 0.55 degrees for midcourse tracking

VI. CONCLUSION

CLOS missile systems have played an instrumental role in warfare for many decades. As the world we live in continues to make technological progress with each passing day, the domain of missile systems remains no exception. Consequently, CLOS missile systems have also come a long way.

This progress can easily be noticed from how the tracking devices/methodology of the missiles has changed over the years. Moreover, this technology is not one that is going to stop with its advancements anywhere in the near future, and we can expect much more sophisticated weaponry being developed as time goes by.

VII. ACKNOWLEDGEMENTS

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