An Introduction to Guided Missile

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***Abstract* - As the world is changing drastically day by day human being become unsafe and unsafe. The unsafe factor not only stands for the individual but also for the nation. They relied on their army and defense. If the armed forces are fully provided with developed defense weapons, then the problem can be solved. In the field of army, navy and air force the most faithful weapon is missile. In this paper a focus is given on the missile. Its classification, missile parts its, aerodynamics, missile control, the various abbreviated terms are Surface to surface missile (SSM) Surface to Air missile (SAM or SAW), Surface to Underwater missile (SUM or SUW), Air to surface missile(ASM or ASW),Air to Air missile (AAM or AAW),)Air to underwater missile (AUM or AUW),Underwater to surface missile (USM or USW),Underwater to air missile(UAM or UAW),Under water to underwater missile(UUM or UUW).**

INTRODUCTION

Right from the beginning the existence of human being. The unsafe factor rises. To protect oneself from others. Human tries to keep the weapons such as stones and sticks in the stone age.AS the humanity flourished they try to live in the group and spreads their empire. There was also fear of wild animals. As the world developed there is also development. In the metallic age weapons from the metals was manufactured by human. Also they try to rule over land and sea. Before Christian era there was development of sword and shield, bows and arrows, sticks fitted with arrowheads. There are the proofs of battles between different dynasties. As the world progresses the trading starts from one group to another, one state to another, one country to another country and also from one continental to another. In eighteen centuries, The trading by sea was developed and to protect the traders the armies. The Eastern and western country take the initiative to sell their goods different countries like France and Britain. The British starts their trading and spread all over the world. They raise their army by the name East India company. There was also some invention in the European countries in the area of weapons which makes the company stronger and to spread all over the world. The concept of missile guidance originated at least as World War I, with the Idea of remotely guiding an airplane bomb onto a target. In World War II, guided missiles were first developed, as part of the German V- weapon program. Guided missiles from the cutting edge of all weapons of war today. The difference between the conventional weapons of yester year and the guided weapons is that while the conventional weapon has to be launched in the correct direction with a lead angle to intercept the target at some future position. The guided weapon can be controlled in flight till interception to achieve destruction of target. While guided missile have become more and more sophisticated and smart, the fundamentals of missile remain unchanged.[1]

Classification of Guided missiles:
Depending on the environment from which the missile is launched and the environment in which the target is to be found the guided missile (or weapon) systems are classified as

1. Surface to surface missile (SSM or SSW)
2. Surface to Air missile (SAM or SAW)
3. Surface to Underwater missile (SUM or SUW)
4. Air to surface missile (ASM or ASW)
5. Air to Air missile (AAM or AAW)
6. Air to underwater missile (AUM or AUW)
7. Underwater to surface missile (USM or USW)
8. Underwater to air missile (UAM or UAW)
9. Under water to underwater missile(UUM or UUW)

B) Guided missiles may also be classified as

1. Strategic missiles
2. Tactical missiles

Strategic missiles are large missile, often with nuclear warheads and very long range.
Tactical missiles are meant for battlefield use for the limited purpose of winning the battle or encounter. The target for strategic missile will be a fixed position

on earth such a city, troop forming up position etc. Whose are known a priori and the

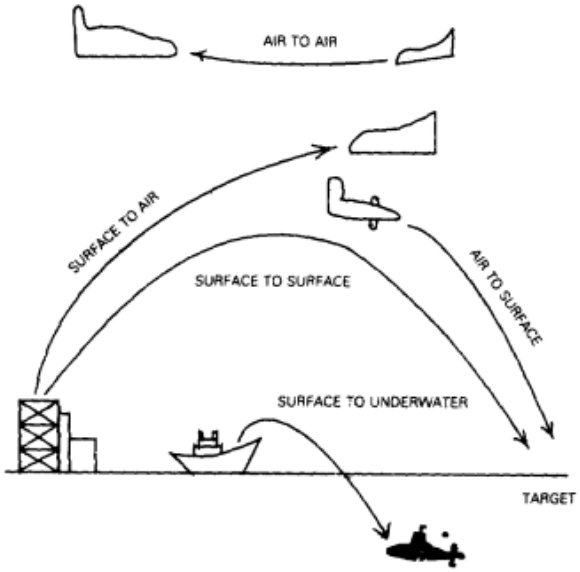

Fig 1:- Missile Classification by method of launching missile has to be programmed to fly to the geographical position. The distance from the target is noted continuously noted in the strategic missile to trace the distance the help of satellite may be taken sometimes.Strategic missiles may launch from land (or a surface ship) a submarine, or a aircraft. Ground launched missile have to protected against pre-emptive attacks or retaliatory attack. By the enemy. Ship, submarine and air launched missiles are obviously safe from this perspective.

The range of strategic missiles is very large and they follow either the ballistic trajectory.(also called the supported trajectory).

C) According to range
1) Short range Missile
2) Medium range missile
3) Intermediate range ballistic missile
4) Intercontinental ballistic missile

D) According to propulsion
1) Solid propulsion
2) Liquid propulsion
3) Hybrid propulsion
4) Ramjet propulsion
5) Cryogenic propulsion

E) According to guidance
1) Wire Guidance
2) Command Guidance
3) Terrain comparision Guidance
4) Terrestrial Guidance
5) Inertial Guidance
6) Beam Rider Guidance
7) Laser Guidance
8) RF and Gps Guidance

Missile propulsion is the means of providing power to accelerate the missile body and sustain, if necessary, to reach the required target. The basis for the working of missile propulsion system is the well Newton's law of motion. The propulsion of a missile is achieved with the help of a rocket engine. It produces thrust by ejecting very hot gaseous matter, called propellant. The hot gases are produced in the combustion chamber of the rocket engine by chemical reactions. The propellant is exhausted through a nozzle at a high speed. This exhaust causes the rocket to move in opposite direction. The rate of change of momentum causes a force to be developed. The change momentum of the missile body including rocket motor casing, the nozzle and other systems due to the ejected matter creates a force leading to the propulsive action on the missile body. The missile propelled into air, would continue to move if there were no other forces acting on it. However, resistance to its forward movement due to air (commonly called aerodynamic drag) and the force of gravity acting downwards towards center of earth are to be taken into account. By using Newton's first, law also called the law of inertia, compensative forces are imparted to the missile to overcome these negative forces. [1]

Parts of Propulsion system: All types of rocket propulsion engines contain a chamber, a nozzle and an igniter. The chemical reaction of propellant chemical takes place in the combustion chamber and produces gases. The energy due to this high-pressure reaction permits the heating of the product gases to a very high temperature (2000-3000^{0}C. These gases subsequently are expanded in the nozzle and accelerated to high velocity (2000-4500 m/s) The nozzle design, i.e. it's shape and size are critical for the efficient function of the propulsion system. The theoretical model of the thermodynamic processes inside a rocket furnishes the analytical data necessary for this. The nozzle used may a convergent, divergent or convergent and divergent nozzle. Also conical an Bell shaped nozzles may be used. The igniter through a tiny elements among the

components of the rocket engine or rocket motor, has the function of initiating the propulsion system. The propellant ignition consists of a series of complex rapid events. Commencing with the receipt of an electrical pulse and heat generation and heat transfer from the ignition products to the propellant gain surface. Flame spread is achieved to burn entire surface area to fill the free volume of the chamber. Igniters can be categorized as Pyrotechnic, Pyxogen etc. Conventional igniters are made of heat releasing compounds such as black powder, metal oxides and metal powder formulations an initiated by electrical means by passing current through an element (wire) which is imbedty in the pyrotechnic mixture. There are certain propellant combination which do not need an igniterand they are called hypergolic. These propellants burn spontaneously when they come in contact in certain proportion.

Types of propulsion systems:- Missile propulsion will be mainly of the following two types A) Air breathing B) Non air breathing. The air breathing rocket engines use the surrounding medium of air for the support of their oxidizer. Thus they can be used only within the Earth's atmosphere where in case of non-air breathing engines. The rocket engine itself carries fuel an oxidizer on board and hence can be used in space above Earth's atmosphere also and thus independent of the air medium. Depending on the physical state of matter of the propellant used. The rocket propulsion system is designed as solid rocket motor, a liquid propulsion system or a hybrid propulsion system.

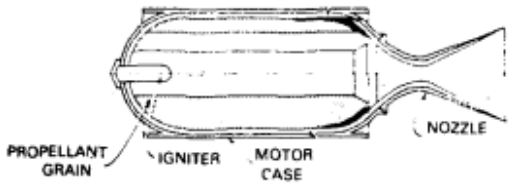

Fig2: Sketch of Solid rocket motor

Solid Rocket Motor (SRM):- In a solid propellant rocket, the propellant to be burnt is contained with combustion chamber FIG 2 shows a typical solid rocket motor. The propellant charge or the grain contains the chemical elements for complete burning. Once ignited, it burns at a designed rate till the propellant is completely consumed. Solid rockets are relatively simple as compared to the other systems.

B) Liquid propulsion system:- Most of the liquid propulsion rockets are used where long duration of the operation is required. Here the oxidizer and fuel (both liquid) propellants are stored in separate tanks in the missile. There are basically two types of liquid propellants deployed: Cryogenic (with boiling temperature below 120k like liquid hydrogen, liquid oxygen etc)and non-cryogenic or storable type (like kerosene, hydrazine, nitrogen tetra oxide, hydrogen peroxide etc.). In space mission usually both propellants (oxidizer and fuel) used are cryogenic, whereas in missile the propellants used are storable or non cryogenic. Sometimes in space mission a combination is used where are the propellant is used cryogenic the other is storable. The engine here is relatively small in size and is designed to with stand hot gases. The engine has an injector through which the propellants are injected at high speed in the form of fire jets impinging on each other. Thrust chamber where the propellant react and produces hot gaseous products and a nozzle.

Hybrid Propulsion:- In this system one of the propellants is solid while the other is liquid. Usually the oxidizer is in the liquid state. This system is very rarely used though it has certain advantages. These types of propulsion system are not generally used.

Air breathing propulsion:- In this case the advantage is taken of the atmosphere is taken of . The atmosphere oxygen for burning the fuel thereby reducing the quantity of propellants to be carried by a missile. This lowers the weight of the rocket greatly as 75% of the total propellant weight is due to the oxidizer. This can be used either by using small turbojet engines power the missile or ramjets. Unlike turbojets which have extreme rotary machinery and therefore costly. There is no such system in ramjets. Here the speed of the incoming air is utilized i.e. when we slow it down using the geometry to intake passage its pressure rises. Then we add fuel to this and through nozzle obtain the thrust force. Here rocket motor is used .

Ramjets cannot operate without atmosphere and also at extremely high speeds. They also produce high thrust for a given size. They are used in long range, low manoeurs steady and flying missile[1]

Tactical guidance intercept techniques:- The expression homing guidance is used to describe a missile system that can itself to the target by some

means, and then guide own control surfaces. Homing is useful in tactical missiles where consideration such as autonomous (or fire and forgot) operation usually require sensing target motion to be done from the interceptor missile (or pursuer) itself. Consequently in such cases the sensor limitations generally restricts the sensed target motion parameters to the set consisting of direction of the line of sight and its rates of various orders. Homing is used not only for the terminal guidance of the missiles, but also for the entire flight in some cases particularly for short range missiles. Homing guidance is a term used to describe a guidance process that can be determine the target (or certain position parameters) of the target.(e. g. an aircraft, ship or tank) with respect to the purser and can formulate its own commands to guide itself to the target. More specifically, a homing system is a specialized form of guidance. Which entails selecting, identifying and following (chasing) a target through some distinguishing characteristics of the target. Such identifying characteristics as heat or sound from a factory, light from a city , or reflections of radar waves from a ship or air craft are used as the source of intelligence to direct the missile to the target. Homing systems may be classified in three general groups as follows a) Active b) Semi active c) Passive. In an active homing system, the target is illuminated and tracked by equipment on board of the missile itself (Fig 3). That is the missile carries the source of radiation on board is addition to the radiation sensor. In an active homing system, for example, both the radar transmitter and the receiver are contained within the missile. Actively guided missiles have the advantages of launch and leave. i.e. they can be launched and forgotten. Disadvantages of the active homing system are additional weight, higher cost and susceptibility to jamming, since the radiation it emits can reveal its presence. An example of an active homing system is the European Meteor active radar guide AAM.

A semiactive homing is one that selects and chases the target by following the energy from an external source, such as tracking radar, reflecting from target (Fig3). The illuminating radar may be ground based, ship borne or airborne. Semiactive homing requires

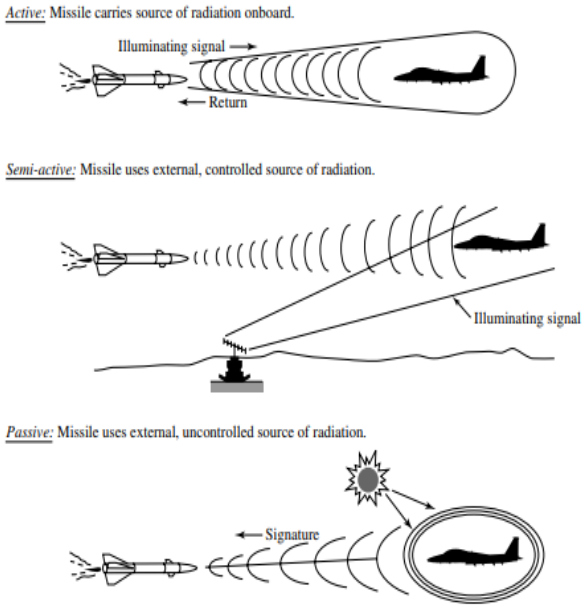

Fig3 : Active, semiactive and passive guidance system

the target to be continuously illuminated by external radar at all times during the flight the missile. The illuminating energy may be supplied by the target tracking radar itself or by a separate transmitter collimated with it. The radar energy reflected by the target is picked by a receiver (the seeker) in the nose of the missile and is used by the missile's guidance. Equipment used in the semiactive homing system is more complex and bulky than that used in passive system. It provides homing guidance over much greater ranges and with fewer external limitations in its application. Supersonic Sparrow III(model AIM_7f) is semiactive homing guidance missile. A passive homing system, one that is designed to detect the target by means of natural emanations or radiation. Such as heat waves, light waves and sound waves. The passive homing guidance systems are based on the use of the characteristic radiation from the target itself as a means attracting the missile for example, as in infrared homing systems. In other words the target acts as a lure. Missile guidance is generally divided into three distinct phase (i) boost or launch (ii) midcourse and (iii) terminal. The boost phase lasts from the time the missile leaves the launcher until the booster burns all of its fuel. The missile may or may not be actively guided during this phase. The midcourse phase, when it has a distinct existence, is usually longest term of both distance and time. The terminal phase is the last

phase guidance and must have high accuracy and fast reaction in order to ensure intercept with the target. [3]

Command guidance:- Command guided missiles are those missiles whose guidance instructions or commands come from sources outside the missile. In this type of guidance a tracking system that is separated from the missile is used to track both missile and target. The tracking can be accomplished using radar, optical, laser or infrared. [2]

Missile control:- In missiles the control function is to ensure stability of the missile and implement the guidance signals received from external sources or onboard. The control after processing guidance signals actuates the aerodynamics surfaces on thrust vector to generate turn of the missile speed and direction as required. The guidance system is to detect whether the missile is flying above or below, to the left or right of the required path. It obtains these deviations or errors and send the signals to the control system to reduce these errors to zero. The task of the control system therefore is to maneuver the missile quickly and efficiently making use of signals. To understand the controls one may be define the body in six degrees. Like X,Y,Z axis direction and three rotary movements about these axis. The other directions are pitch yaw and roll. Pitch is the turn of missile when it climbs up or down. Yaw is its turn to left or right. The roll is when the missile rotates about its longitudinal axis which is also called roll axis. The longitudinal axis is the one running from nose to tail. If a missile is resting horizontally then, the pitch axis is one which is normal to longitudinal axes and parallel to horizontal axis and pitch axis. Missile can roll when in motion due to various reasons. There are missiles in which roll is controlled. Roll can be sensed onboard using a free gyro sensor and eliminated through actuation of controls. Some missiles have roll induced by design to use it for stability. The other axis which are controlled for motion are pitch and yaw axis.[1]

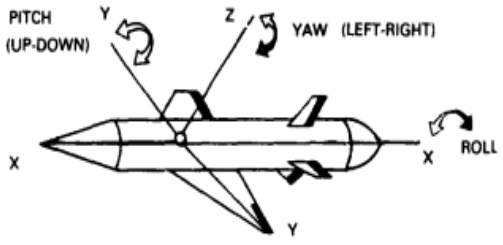

Fig 4: Missile control

Missile Aerodynamics:- Study of the movement of a body in the presence of air is called aerodynamics. This is important in the design of aircraft, missiles and rockets. The atmosphere as we know is densest closed to earth's surface at sea level. As we go higher it becomes thinner (i.e. the pressure and density are lower). The sensible atmosphere is up to a height of 80 kilometers. The temperature also varies with heights. The layer of atmosphere nearest to earth is called troposphere. Above that stratosphere which is further subdivided into lower stratosphere and upper stratosphere. Beyond that is ionosphere or ozonosphere and the last is exosphere. The very high speed fighter aircraft fly up to altitudes of about 30km, while transport jets fly up to about 10-11 km. The aircraft missiles are bodies that are heavier then air and so can support the weights only if they produce a force counter it. This force can be either lift force generated by the flow of air over the winged body or generated by means of an engine in the form of thrust. This is done by helicopter or by aircraft with swing engines. (Vertical takeoff type) where mere engines can be swiveled . In missiles (most are launched vertically or with an inclination) apart of the weight is countered by rocket engine thrust. If anybody moving in air without wing or with wing it observes a force called drag it is also countered by the engine thrust. It depens on fineness or bluntness of size. To minimize the drag force one has to choose the aerodynamic shape such that functional requirement also met. In the missile aerodynamic surfaces called wings fly and control surfaces and body called fuselage are designed to provide the necessary lateral maneuverability. This is achieved by deflecting control surfaces through actuation mechanism and there by altering the balance of forces and generally turning movements. This happens at very rapid rate. In cruise missile wings are provided to generate lift force while the missile flies in the horizontal level mode. Most of the aerodynamics is studied by mathematical analysis of flows and then further validated by tests on scaled down models in wind tunnel where forces are measured and correlations generated. The principle of aerodynamic is similar for airplane and a missile. Also there is requirement of mechanical and electrical system engineer in overall missile design.

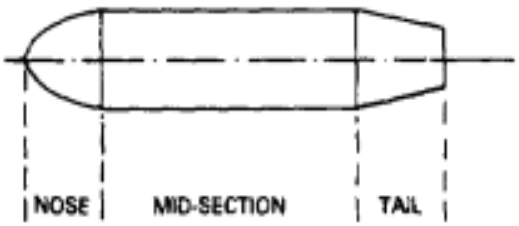

Fig 5: Missile component

The following are major consideration while optimization of missile.[1]

1. Simplicity in external configuration to reduce development time and cost.
2. Efficient aerodynamic control surfaces to simplify control and guidance system circuits and to minimize servo power requirements.
3. Missile range, speed and other performance characteristics the mission requirements.
4. Simple, efficient and highly reliable power plant.
5. Low cost predictability and light weight airframe constructions.
6. Accuracy of the control and guidance system to accomplish the desired mission.
7. Reliability of the complete weapon system as well as its individual components.
8. Efficiency in packaging the various major components to facilitate check out and replacement.

9)Degree of complexity in the preparation and delivery of the missile to accomplish its mission.

Warheads and Fuses :- The only purpose of the missile is to deliver the warhead to the target. The function of warhead is to damage the target. The warhead is located in the missile. In tactical missile the warhead is based on conventional chemical explosive called high explosive. The nuclear based warheads are deployed in only strategic and some tactical missile by nuclear based club nations like USA, USSR, UK,France and China. They are meant for the large scale destruction area. The smaller one carries the nuclear based material equivalent to 10-15000 tones TNT (a high explosive). While the larger one is in the equivalent of tens of millions of thousands of TNT. Most of the advanced ballistic missile carry multiple nuclear bomb called MIRVs (Multiple independently targeted Re-entry vehicles)

Fuzes:- Every warhead must have a fuze. Fuzes are the devices which sense the right moment to detonate the warhead. There are numerous kinds of fuzes which are based on different kinds of the principles for different kinds of missile, warhead and environment of operation. The most important type of fuzes are impact fuze, altitude fuze and proximity fuze.

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