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Protection of Cruise Missile from the Threat of Anti-Cruise Missile (ACM) by Using Small Air-to-Air Missile (AAM)

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***Abstract*—** A cruise missile is a dispensable, pilotless, self-guided, continuously powered, air-breathing vehicle that flies just like an airplane, supported by aerodynamic surfaces, and designed to deliver a conventional or nuclear device. It is a guided missile, used against terrestrial targets that remains in the atmosphere and flies the major portion of its flight path at approximately constant speed. But it may be possible that the enemy side track the cruise missile and destroy it by using anti-cruise missile (ACM). So, it is clear that to make the operation or mission of a cruise missile successful we have to eliminate the threat of anti-cruise missile (ACM). This paper will discuss about the arrangement of a small tracking system and some small air-to-air missiles attached with the main cruise missile which can destroy any anti-cruise missile (ACM), incoming towards it. So, simply this small air-to-air missiles act as anti-missiles for any incoming anti-cruise missile (ACM) which is targeting the main cruise missile.

***Keywords*—** *Anti-cruise missile (ACM), Air-to-air missile (AAM), Cruise missile, Global Positioning System (GPS), Indian Regional Navigation Satellite System (IRNSS) etc.*

I. INTRODUCTION

A cruise missile is a guided missile used against terrestrial targets that remains in the atmosphere and flies the major portion of its flight path at approximately constant speed. Cruise missiles are designed to deliver a large warhead over long distances with high accuracy, that is, small circular error probability. Modern cruise missiles are capable of travelling at supersonic or high subsonic speeds, are self-navigating, and are able to fly on a non-ballistic, extremely low-altitude trajectory. But it may be possible that the enemy side track the cruise missile and destroy it by using anti-cruise missile (ACM). So, it is clear that to make the operation or mission of a cruise missile successful we have to eliminate the threat of anti-cruise missile (ACM). If we attach a small tracking system and some small air-to-air missiles with the main cruise missile then it is possible to track an incoming anti-cruise missile (ACM) and then destroy it by using small air-to-air missiles. In this way, we are capable to provide protection to the cruise missile from the threat of an incoming anti-cruise missile (ACM) during its entire journey.

II. MISSILE AND ITS GUIDANCE

A. What is missile?

Basically any object thrown at a target with the aim of hitting it is a missile. Thus, a stone thrown at a bird is a missile. The bird, by using its power of reasoning may evade the missile (the stone) by moving either to the Left, right, top or bottom with respect to the flight path (trajectory) of the missile. Thus, the missile in this case has been ineffective in its objective of hitting the bird (the target). Now, if the stone too is imparted with some intelligence and quick response to move with respect to the bird, to overcome aiming errors and the bird's evasive actions and hit it accurately, the stone now becomes a guided missile. The incorporation of energy source in a missile to provide the required force for its movement (propulsion), intelligence to go in the correct direction (guidance) and effective manoeuvring (control) are mainly the technologies of guided missiles. They help in making a missile specific to a target, that is, they determine the size, range and state of motion of a missile.

B. Missile Guidance

Guidance is that aspect of a missile system which helps it to decide the direction in which the missile should move. Generally this decision has to be taken at very short intervals of time (1/50th of a second) during the flight of the missile. For a specific mission, particular guidance technique is used. The different types of guidance are as follows.

1. Command guidance,
2. Homing or seeker guidance,
3. Beam rider guidance,
4. Inertial guidance and
5. Stellar guidance

III. WHAT IS CRUISE MISSILE?

A cruise missile can be defined as a dispensable, pilotless, self-guided, continuously powered, air-breathing vehicle that flies just like an airplane, supported by aerodynamic surfaces, and designed to deliver a conventional or nuclear device. Cruise missiles exist in three versions:

1. Land-based or ground-launched cruise missiles (GLCM)
2. Sea-based or sea-launched cruise missiles (SLCM)
3. Air-launched cruise missiles (ALCM).

A diagram of cruise missile shown in the figure (Fig.1) below.

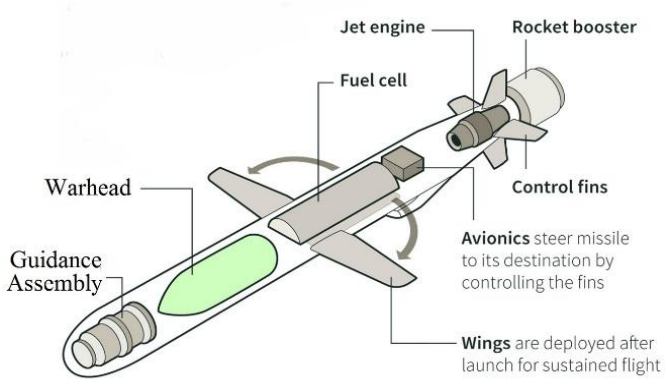

Figure 1: Diagram of a cruise missile

Unlike a ballistic missile, which is powered and hence usually guided for only a brief initial part of its flight, after which it follows a free-fall trajectory governed only by the local gravitational field, a cruise missile generally requires continuous guidance, since both the velocity and the direction of its flight can be unpredictably altered, for example, by local

weather conditions. In modern time cruise missiles are developed with automatic guidance system along with manual or command guidance system. The purpose of a guidance system is to direct the missile to target. Guidance systems vary greatly. Use of an automatic target recognition (ATR) algorithm/device in the guidance system increases accuracy of the missile. Different types of guidance systems used to guide cruise missiles are as follows:

1. Inertial navigation system
2. TERCOM (Terrain Contour Matching)
3. DSMAC (Digital Scene-Mapping Area Correlator)
4. Satellite navigation.

Now let us discuss these guidance systems used in cruise missile briefly one by one.

A. Inertial navigation system

An inertial navigation system includes at least a computer and a platform containing accelerometers, gyroscopes, or other motion-sensing devices. Accelerometers measure the vertical, lateral, and longitudinal accelerations of the controlled missile. Gyroscopes measure the angular velocity of the system.

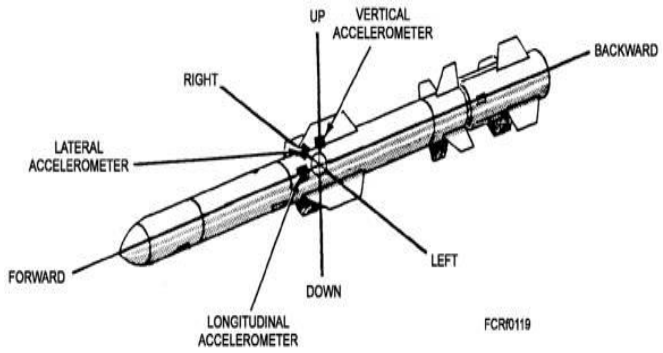

Fig.2 Inertial navigation system

B. TERCOM (Terrain Contour Matching)

It uses a pre-recorded contour map of the terrain that is compared to measurements made during flight by an on-board radar altimeter. The missile's radar altimeter feeds measurements into a smaller buffer and averages them out to produce a single measurement. The series of such numbers a strip of measurements similar to those held in the maps. The two are compared to overlay the strip on the known map, and the positioning of the strip within the map produces a location and direction. The guidance system then uses this information to correct the flight path of the missile.

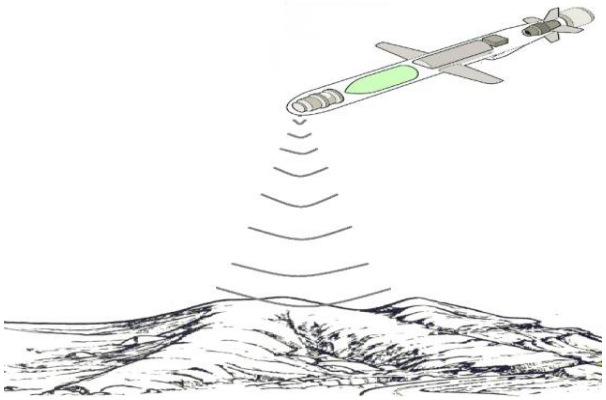

Fig.3 Terrain Contour Matching (TERCOM) navigation system

C. DSMAC (Digital Scene-Mapping Area Correlator)

A series of photographs are taken from surveillance aircraft and are put into a carousel in the missile. Another camera takes pictures out of the bottom of the missile. A computer compares the two images and attempts to line up areas of high contrast. This system is very slow and its role is being taken up by TERCOM.

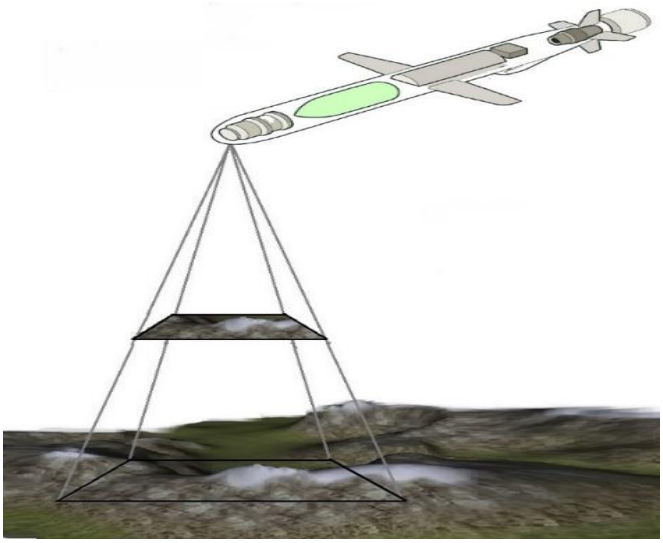

Figure 4: Digital Scene-Mapping Area Correlator (DSMAC) navigation system

D. Satellite navigation

Another way to navigate a cruise missile is by using a satellite positioning system, such as GPS or IRNSS. Satellite navigation systems are precise and cheap. If the satellites are interfered with (e.g. destroyed) or if the satellite signal is interfered with (e.g. jammed), the satellite navigation system becomes inoperable. The GPS or IRNSS-based navigation is useful in a conflict with a technologically unsophisticated adversary.

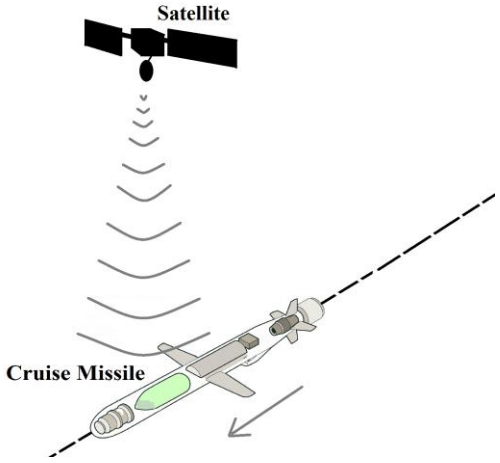

Figure 5: Satellite navigation system

IV. WHAT IS ANTI-CRUISE MISSILE?

Here, I considered that any incoming missile towards the cruise missile with the aim to destroy it is an anti-cruise missile. Now let us see a diagram (Fig.6) how a ground tracking system detect a cruise missile.

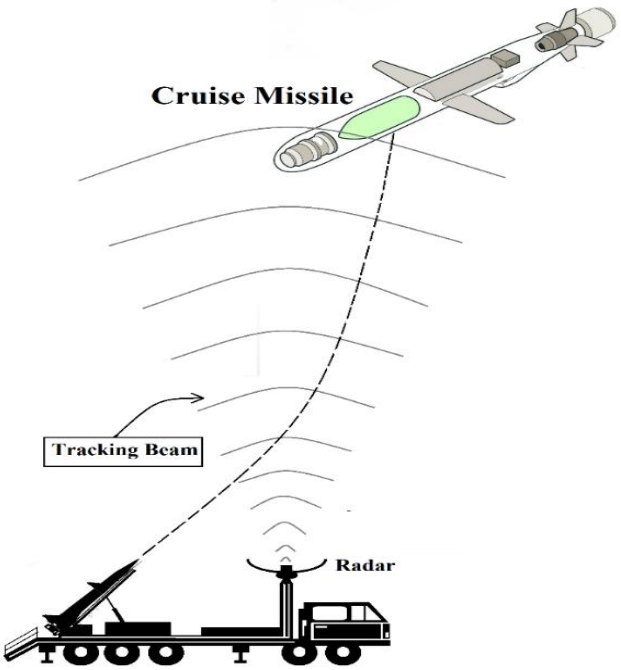

Figure 6: Ground tracking system detect a cruise missile

After successfully detection of a cruise missile the ground tracking system immediately launch a anti-cruise missile to destroy it. Let us see the situation in the figure below (Fig.7) when an anti-cruise missile coming towards the cruise missile to destroy it.

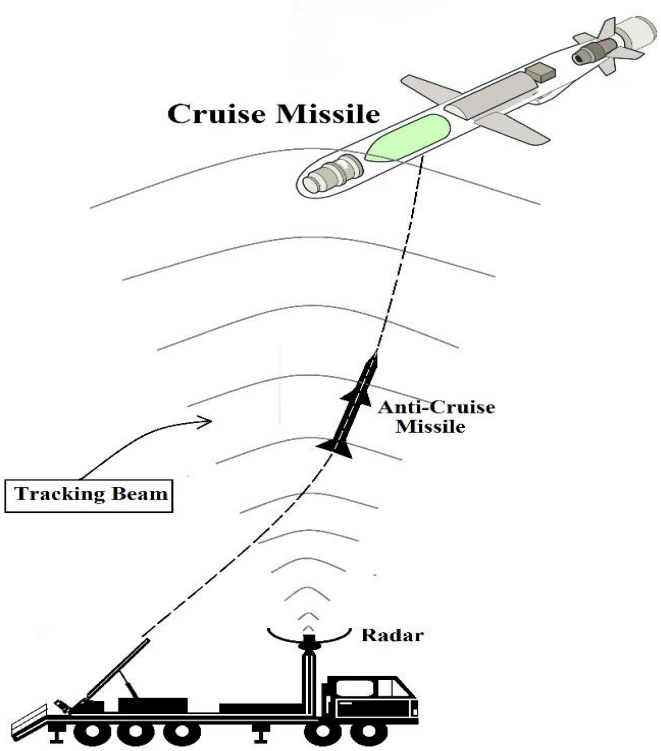

Fig.7 An anti-cruise missile coming towards the cruise missile to destroy it

If we do not provide protection to the cruise missile then the incoming anti-cruise missile will destroy it. Now we will see the protection system of cruise missile from the threat of anti-cruise missile.

V. HOW THIS PROTECTION SYSTEM WORKS?

In this system a homing or seeker head is attached with the missile's guidance system and small missiles are attached with the main cruise missile shown in the figure (Fig.8) below.

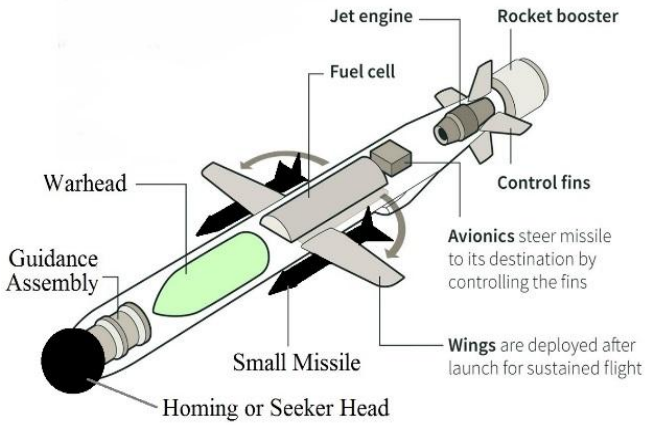

Figure 8 cruise missile with homing or seeker head and small air-to-air missiles

So, first we have to understand what is homing guidance?

A. Homing guidance

Homing guidance is generally used for short-range missiles. In this system the missile receives the signals reflected or emanating from the target and generates the command signals to direct its motion between the missile and the target. Fig.9 gives a schematic sketch of homing guidance system. Active, semi-active and passive homings are the main types of homing guidance systems.

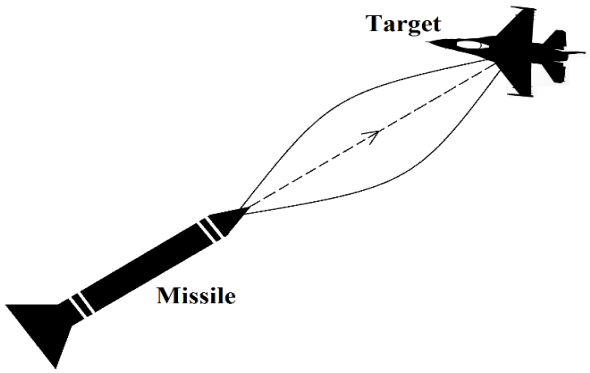

Figure 9: Schematic sketch of homing guidance system

In the active homing guidance system, the missile itself carries the transmitter and the receiver. The signal, generally electromagnetic radiation, is transmitted at the target and the reflected signal is received. In this system, the missile is not dependent on the ground launcher. Active homing can be used for guidance in all phases, from launch upto target interception. It can also be used in terminal guidance in conjunction with other modes of guidance for the initial phases.

Where homing guidance is used alone, the range is limited because the system is bulky and needs a lot of force. It has instruments called homing head, also called seeker head, which are locked on to the target in tracking mode before launch. Such a system is also called the 'fire and forget' type of guidance. When used in terminal guidance, the homing head is provided with search capability to locate the target and then lock on to it till interception.

Active homing is used for short-range anti-tank missiles (with <4 km range). It is, however, extensively used as terminal guidance in long range surface-to-air, air-to-air and anti-ship missiles. In such cases, command or inertial guidance is used to bring the missile close to target, say within 15-20 km. Then the homing head is switched on and the search commenced.

Once it locates the target, the searcher starts tracking the target and homing guidance commences. In homing guidance, the final accuracy is superior to command guidance.

In semi-active guidance, the source for target illumination is located in the launcher and the missile has only the receiver. The rest of the process is identical to active type. This type helps to have a simple onboard system and can be used for longer ranges (upto 50 to 60 km). Examples of this are the missiles Sea-hawk, Sea-dart and Sea-sparrow etc.

In passive homing type, the missile has only a receiver and detects signals emanating (not reflected) from the target. The signals could be electromagnetic or infrared or both. The missile has in its homing head detectors sensitive to infrared or electromagnetic radiation. The missile where infrared homing is used are also called heat-seeking missiles. This system can also be used in conjunction with other modes of guidance in the same way as the active system. When it is used as stand-alone method, the range is limited to a maximum of about 7-8 km in case of electromagnetic radiation.

Here we use active homing guidance (consists both the transmitter and the receiver) for detecting the target and once the target is detected then the cruise missile launch a small missile this small missile is guided by semi-active homing guidance (consists only receiver). Suppose the cruise missile's head detect an incoming anti-cruise missile shown in the figure (Fig.10) below.

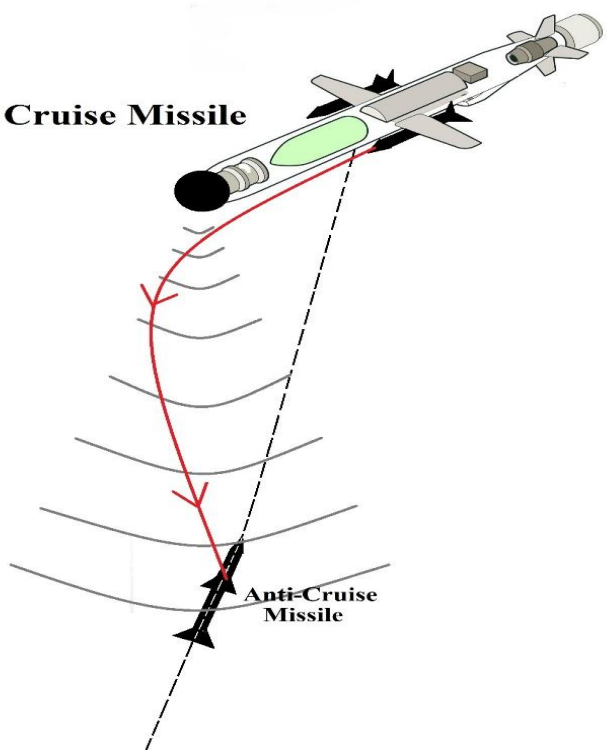

Fig.10 Cruise missile's head detect an incoming anti-cruise missile

After detecting the anti-cruise missile the guidance system of the missile continuously tracking the incoming anti-cruise missile until it come within a certain pre-set range or distance (say within 3 to 4 Km.) from the cruise missile. Once the anti-cruise missile come within the range then the cruise missile immediately launch a small missile and the small missile is guided by semi-active homing guidance. Then this small missile will destroy the incoming anti-cruise missile. The whole working procedure of the cruise missile's protection system can be explained by the following flow-chart diagram (Fig.11).

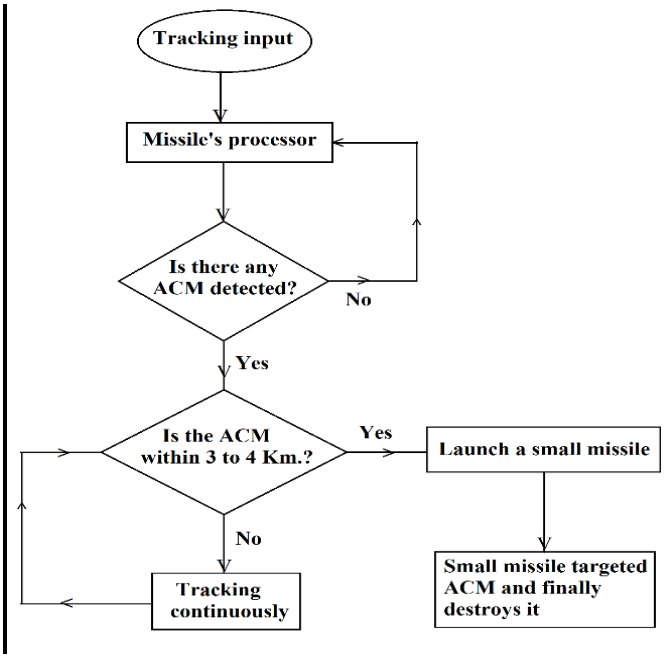

Figure 11: Flow-chart of the whole working procedure of the cruise missile's protection system

CONCLUSION

So, here we develop a protection system which can protect the cruise missile from the threat of anti-cruise missiles (ACM). The advantage of this system is that the whole thing can be done with a small cost. Here we do not need to develop any external tracking system, the cruise missile itself carry the tracking system and itself able to take decision. But we can also make arrangement for giving manual command or directions in this regard. This system provide protection during its whole journey period of the cruise missile, this is from launching to attack. This kind of protection system can also be developed for other type of missiles. In future with the more advanced devices we are able to design more reliable and accurate protection system for the cruise missile.

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