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A Backup System for the Beam Rider Guided Missile when the Guidance-beam is absent or the Radar-antenna of the System is destroyed

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Abstract: In a beam rider guidance system, the guidance system is to illuminate the target by radiation of a beam of energy from a radar antenna pointed at the target. The missile is fired into this beam and thereafter gets guided over the beam till it hits the target. In the middle of the path of missile if the radar fails to produce beam or someone destroys the radar-antenna or the beam radar guidance system then due to lack of guidance signal it is nearly impossible for the missile to hit the target or may be the missile misguided. This paper will discuss about a backup system for the beam-radar guided missile which can temporarily guide the missile during the crisis period of guidance. Here, we attach a short memory and a small active homing guidance system (homing head) with the missile's inner control system. This short memory continuously stores the missile movement path and the changing position of the target just after lunching of the missile. If the missile faces any guidance crisis in its travelling path then this backup system will immediately activated and guide the missile by using its memory data record and homing head.

Keywords: Antenna, Beam rider guidance, Homing guidance, Missile, Short-memory etc.

1. INTRODUCTION:

In beam rider guidance system, equipment in the missile measures the displacement of the missile from the centre of the radar beam then appropriate action by the control system steers the missile back into the centre of the beam. If the missile is flying in the centre of the beam, no signals are sent to the control system, indicating that no corrective action is necessary. Now for any reason if the radar fails to produce beam or someone destroys the radar-antenna or the beam rider guidance system when the missile is in somewhere of its travelling path then the missile does not receive guidance signal. Then it is not possible for the missile to hit the target. To handle this crisis situation we need to develop a backup guidance system for the missile. Here, we develop an emergency backup control system where a short memory and a small active homing guidance system are attached with the missile's inner control system. This short memory continuously stores the missile movement path and the position changes of target just after lunching of the missile. If the missile faces any guidance crisis in its travelling path then this backup system will immediately activated and guide the missile by using its memory data record and homing head will help the missile to detect or hit the target accurately.

2. MISSILE AND ITS GUIDANCE:

2.1 *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.

2.2 *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.

(a) Command guidance,

(b) Homing or seeker guidance,
(c) Beam rider guidance,
(d) Inertial guidance and
(e) Stellar guidance

Here in our backup system, we are dealing only with the homing and beam-rider guidance system.

3. HOMING OR SEEKER GUIDANCE SYSTEM:

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.1 gives a schematic sketch of homing guidance system. Active, semi-active and passive homing are the main types of homing guidance systems.

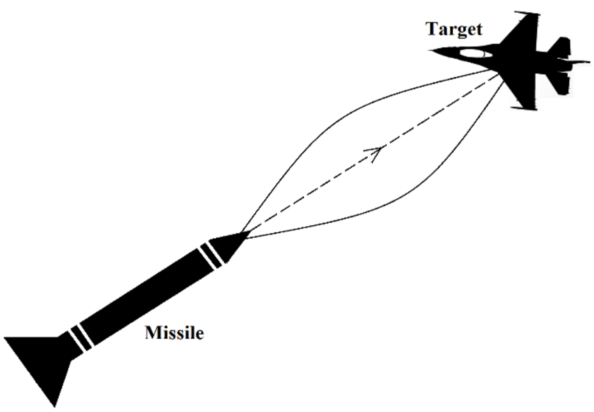

Fig.1 Schematic sketch of homing guidance system

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.

4. BEAM RIDER GUIDANCE SYSTEM:

In this method, the guidance system is to illuminate the target by radiation of a beam of energy from a radar antenna pointed at the target. The missile is fired into this beam arid thereafter gets guided over the beam till it hits the target. The sensitivity is lesser at the commencement of the flight and towards the end as the missile approaches the target. A schematic sketch of beam rider guidance shown in Fig.2 below.

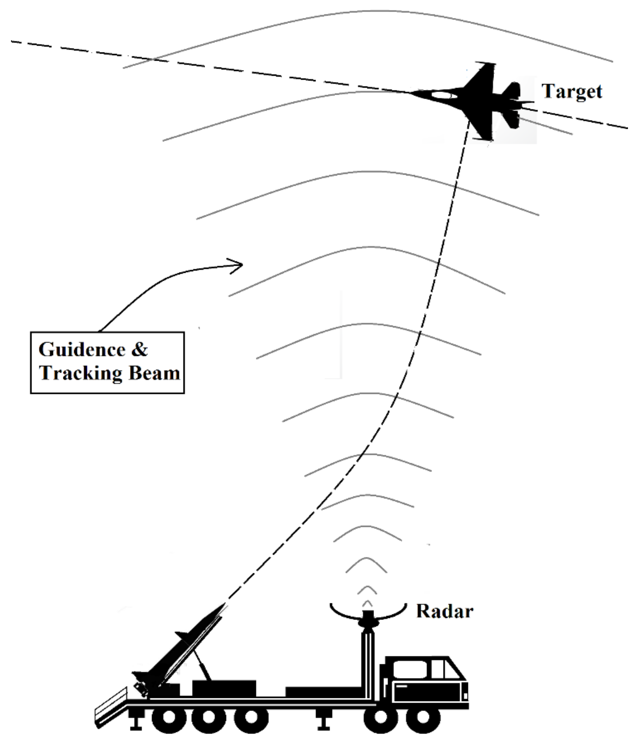

Fig.2 Schematic sketch of beam rider guidance

In a beam rider guidance system, equipment in the missile measures the displacement of the missile from the centre of the radar beam then appropriate action by the control system steers the missile back into the centre of the beam. If the missile is flying in the centre of the beam, no signals are sent to the control system, indicating that no corrective action is necessary.

The guidance beam that guides the missiles is formed by the radar antenna, which sends out electromagnetic energy in the form of lobes, as shown in Fig.3. The antenna is rotated in such a manner that the tips of the lobes describe a circle, resulting in a cone of radiation in space with its origin at the radar antenna. The missile is guided along the axis of this cone.

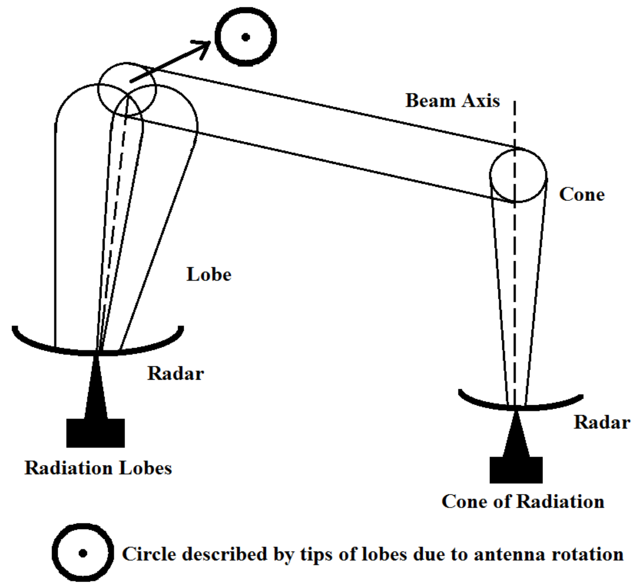

Fig.3 Movement of guidance beam

A few launching considerations are to be taken care of in this system. The missile must be launched in such a manner that it flies as nearly parallel to the beam axis as possible when it first enters the cone of radiation. Otherwise, it might fly right through the beam without being captured by its guidance signals. At this time the missile might not be up to full operational velocity, and its aerodynamic control system would not be as effective in controlling the missile as it would at the operating speed for which it is designed. Launching the missile as closely as possible to the beam axis eliminates sharp turns and sudden manoeuvres.

This type of guidance system is relatively simple, less complex with increased reliability and lower cost. The limitation is that the trajectory requires high lateral accelerations (latex) during the terminal phase.

5. WHY WE NEED BACKUP SYSTEM FOR BEAM-RIDER GUIDED MISSILE?

In beam-rider guidance, the system is to illuminate the target by radiation of a beam of energy from a radar antenna pointed at the target. The missile is fired into this beam arid thereafter gets guided over the beam till it hits the target. If the radar antenna stops to radiate the beam of energy then the missile becomes guidance-less and does not able to fulfill its job. Let a practical example of it, suppose in the war time it may be possible that the enemy sides destroy the lunching station along with guidance system but the lunching station already lunched a missile which is guided by beam rider guidance and at this situation the missile becomes guidance-less and does not able to fulfill its job.

We can handle this kind of guidance crisis if we attach a temporary backup guidance with the inner control system of the missile and in this way the missile itself capable to handle the guidance crisis situation.

6. HOW THE BACKUP GUIDANCE SYSTEM WORKS?

Suppose a beam-rider guided system lunched a missile which is guided by the radiation of beam of the radar antenna, shown in the Fig.4 below.

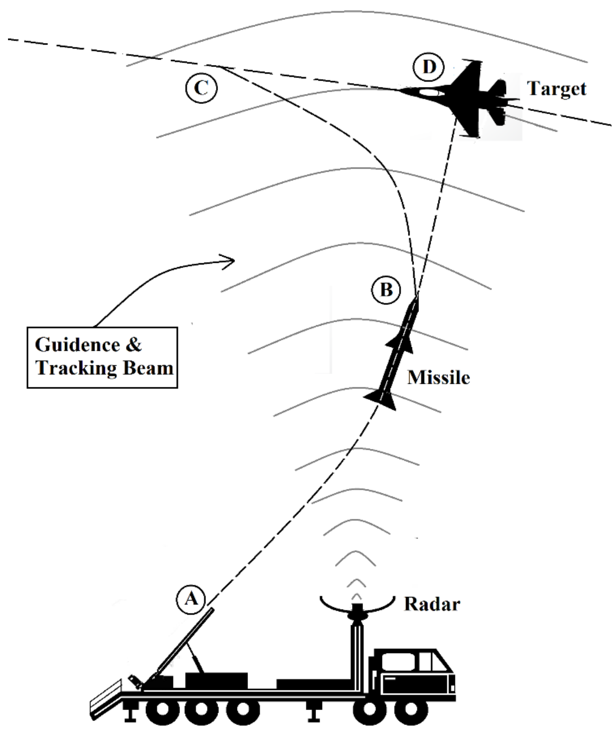

Fig.4 Beam-rider guided system lunched a missile

Here, we attach a short memory with the missile's inner control system. This short memory continuously stores the missile movement path just after lunching of the missile. In the above figure (Fig.4) the missile travelled 'AB' path and the direction of missile movement according to the command or control signal of beam-rider guidance was stored. The beam-rider guidance generates control signal accordingly with the change of target position. As the target position is continuously changing then the guidance system also generates control signals continuously. Here in the inner control system of the missile we also attach a calculating system. The system calculates the probable point and the probable path which the missile has to follow to reach the target by observing and analyzing mainly two factors: [a] the change of path direction of missile from lunching station to missile's current position (In Fig.4 it is from point A to B) and [b] the change of target position (In Fig.4 the current target position is D).

By using these two factors the system calculates the probable point where the missile will hit the target and the probable path which the missile has to follow to reach the target. Here, in Fig.4 the probable hitting point is 'C' and the probable path is 'BC'. The block diagram of the backup control system's calculation procedure is shown in the Fig.5 below.

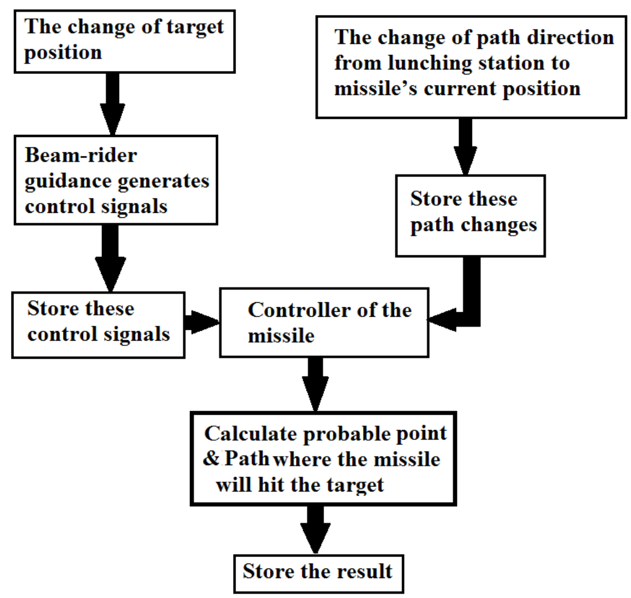

Fig.5 Block diagram of the backup control system's calculation procedure

Now, suppose an enemy missile hits the lunching station and destroys it completely shown in the Fig.6 below.

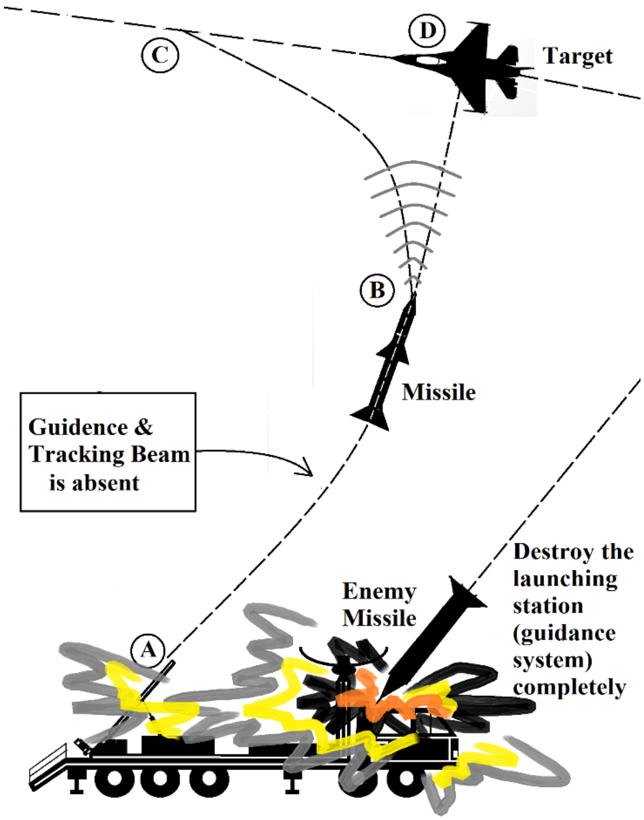

Fig.6 Enemy missile destroys the lunching station (guidance system) completely

Now, the guidance system is destroyed and the radar fails to produce beam. At this guidance crisis situation the backup system come into work. Here, the short memory of the missile continuously records and analyses the mainly two variables: [a] the change of path direction of missile from lunching station to missile's current position and [b] the change of target position. By using these two variables the system calculates the probable point where the missile will hit the target and the probable path which the missile has to follow to reach the target. The control system continuously update the probable point and path in accordance with the changing position of missile and target. The missile also consists an active homing guidance system with its inner control system. In active homing system the range of the homing head which is used to detect a target is comparatively lower (with <4 km range). So, an active homing is used here for detecting the target accurately. Now, the missile short memory stores the last calculated probable point and path. Here, from the Fig.6 we can assume that the probable point is 'C' and probable path is 'BC'. The missile will first follow the probable path 'BC' and at the same time its homing head continuously search the target's accurate position. As the range of homing head is small then it can only detects the target when it comes nearer (<4 Km.) to its homing head. Let, when the missile was in point 'B' the beam-rider guidance was destroyed and the missile's backup guidance system follows the probable calculated path 'BF'. When the missile comes from point 'B' to point 'F' it detects the target and during this period the target position is also changed form point 'D' to point 'E' shown in the Fig.7 below.

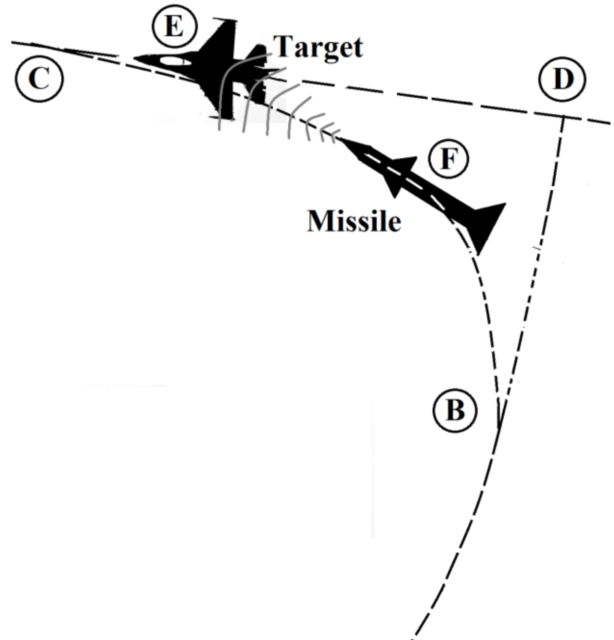

Fig.7 Homing head detects the target

Once the homing head detects the target it immediately stops following the probable path which was calculated by missile's backup control system and then the guidance for hitting target will completely provide by homing guidance system (homing head) of the missile. So, here the missile travels the 'BF' path accordance to the probable calculated path. After point 'F' the missile will travel the remaining path according to the guidance signal generated by the homing guidance system which is also a part of backup control system. The whole working procedure of the missile's control system can be explained by the following flow-chart diagram (Fig.8).

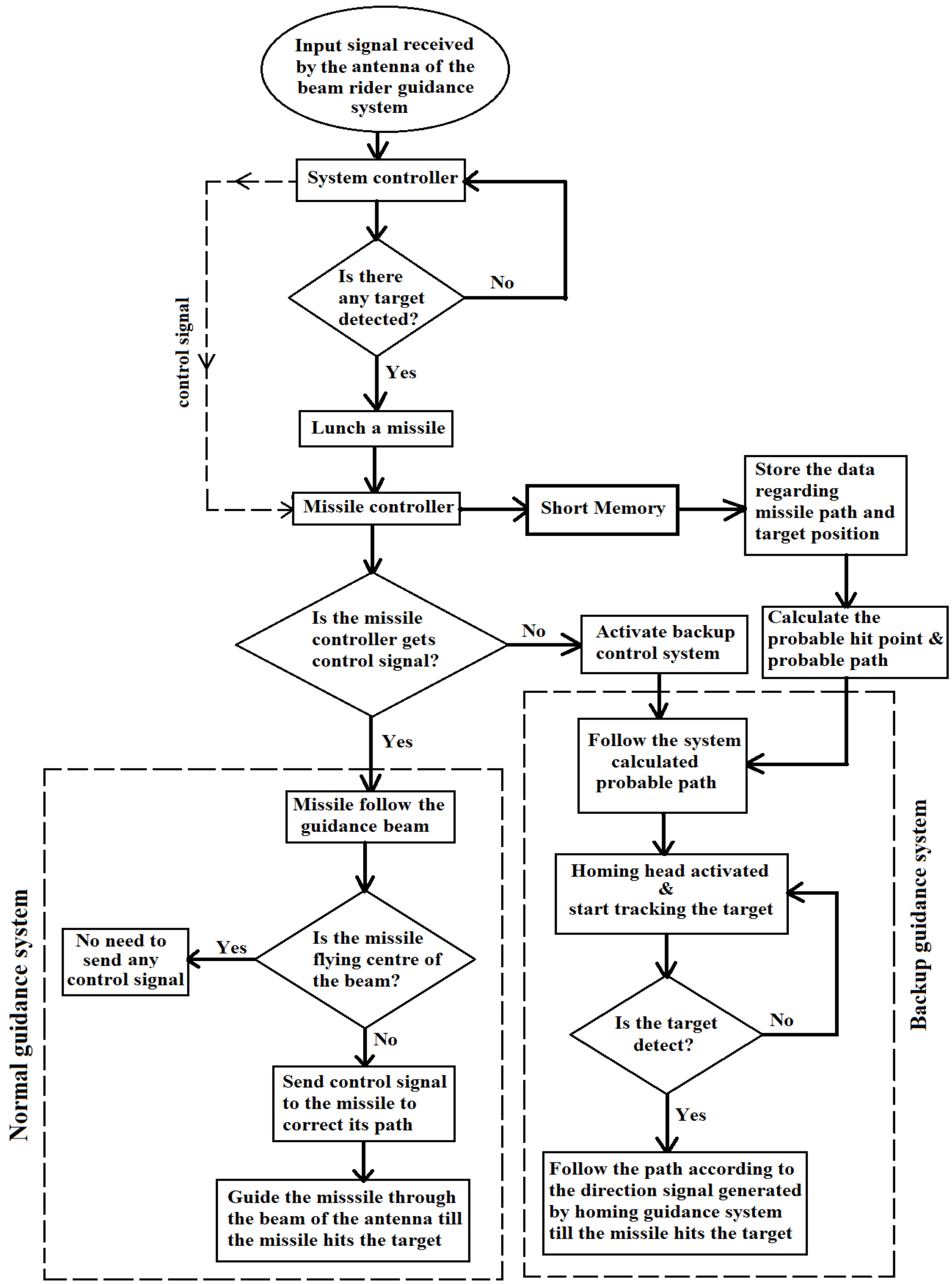

Fig.8 Flow-chart of the whole missile’s control system

7. CONCLUSION:

So, here we develop a model of backup guidance system for the beam-rider guided missile when the guidance-beam is absent or the radar-antenna of the system is destroyed. The advantages of this system are that it enables the missile to convert it into a self-guided missile during crisis period, it is comparatively less complex and this system can be developed with a small cost. The disadvantage of the system is that after activation of backup control system the missile has to follow the probable path until its homing head detects the target. The probable path is a system calculated path and the system calculates it by observing the continuous change of target position and the missile's travelling path after lunching. The probable path may not be cent-percent accurate because the target may follow a completely different path and it becomes difficult for the homing head either to detect the target or if detected then the missile has to make path-correction of the missile according to the target's present position. But if we considered the cost and complexity then it may be a good backup guidance system for a beam rider guided missile. We can increase accuracy of the backup guidance system by introducing more guidance devices with missile's inner control system like GPS or IRNSS-aided device, satellite-aided device etc. We can also developed this kind of backup control system for other type of missile's guidance system like command guidance system, stellar guidance etc. So, in near future this kind of backup system can be used with more advance software and hardware combinations.

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