Chapter 4

Fundamentals of Guidance

Module 3: Lecture 7
Guidance Phases; Categories of Homing Guidance

**Keywords.** Command Guidance, Three-point Guidance, Homing Guidance, Two-point Guidance, Active Homing, Passive Homing, Semi-active Homing

4.1 Guidance Phases During Missile Flight

The basic difference between an unguided projectile and a guided missile is the generation of guidance commands which attempts to change the missile’s flight direction. This guidance command is in the form of a lateral acceleration command which the autopilot translates into the amount of lift necessary to produce the desired turn rate (or maneuver).

Portions of missile trajectory for SAMs and AAMs can be classified into several guidance phases based either on their function or on the mode of guidance employed. For example, in an air-to-air missile, the first part of the trajectory is called a programmed maneuver phase, which is independent of target information and is executed solely to ensure that the missile clears the launch aircraft. At the completion of this maneuver, midcourse guidance phase is initiated. The function of the midcourse guidance phase is to place the missile within the terminal acquisition range of its seeker with the missile
The last few seconds of the engagement constitutes the *terminal guidance phase*, which is the most crucial since its success or failure determines the success or failure of the entire mission. In the terminal phase the missile locks on to the target and attempts to close the distance to the target as quickly as possible under the constraints of energy availability and maneuver limitations. The intercept seldom takes place by the missile directly hitting the target. Usually the missile passes close to the target and the proximity fuze explodes the warhead. Hence, the effectiveness of the terminal guidance phase is solely judged on how close the missile can get to the target (i.e., the *miss-distance*). These phases are shown in Figure 4.1.

The missile trajectory for SAMs is almost the same except the initial phase which is called the *boost phase*. In this phase the missile’s booster provides the required velocity to the missile. Since this phase occurs for a very short time during which the missile is marginally stable and has high longitudinal acceleration, no guidance commands are normally given to the missile. However, some modern missiles under development consider the incorporation of a *boost phase guidance scheme* to improve overall performance. Figure 4.2 shows these phases in the trajectory of a SAM.

Missile trajectories can also be classified according to the nature of the guidance scheme. This will be discussed in the context of surface-to-air missiles.
mand guidance scheme the target and missile positions and velocities are measured by a tracking radar situated at the ground station. This information is processed and given to the guidance computer which generates the steering or guidance commands using some guidance law. The guidance computer is also situated at the ground station. The guidance commands are then communicated to the missile via a data uplink. Based on these inputs the missile flight control system takes action. Thus, the computers and other equipment at the ground station command the missile to behave in a certain fashion. This kind of guidance is also known as three-point guidance since there are three major points of reference: the missile, the target, and the ground station. The part of the trajectory in which the missile is command guided is called the command guided phase. Usually in purely command guided missiles there are three phases: boost phase, command guidance phase, and the terminal phase. The last phase is for a short duration in which the missile is very close to the target and hence normally it either does not maneuver or uses some constant maneuver level obtained from previous guidance commands. The reason for this is that the missile during this phase is so close to the target that there is little time to generate new guidance commands and consequently update the maneuver level. This kind of trajectory is shown in Figure 4.3(a). Homing guidance scheme does not depend on any ground station for the generation of guidance commands. This is also called two-point guidance. Though some homing guidance
schemes need assistance from a ground station, the guidance commands themselves are generated inside the missile itself. Here too we have a boost phase, a homing guidance phase, and a terminal phase. This is shown in Figure 4.3(b). One can also have a mixed guidance scheme in which after the boost phase the missile is command guided from a ground station till the target comes within the acquisition range of the missile seeker antenna. Then the missile uses homing guidance till the terminal phase. This is shown in Figure 4.3(c).

4.2 Different Categories of Homing Guidance

Homing guidance schemes are desirable from the point of view that they require less control from a ground station and once launched, could be more or less autonomous in guiding themselves. These are also called fire-and-forget missiles. However, there are many categories of homing guidance which invest varying degrees of autonomy to the missile. Some of these categories are discussed below.

4.2.1 Active Homing

An active homing guidance system is one in which both the source of energy to illuminate the target and the receiver of the energy reflected from the target are carried in the missile. Hence, the missile contains a transmitting antenna, a receiving antenna, and a re-
**Missile Signal**

Figure 4.4: Active homing guidance

receiver. It also carries within it the signal processor and the guidance computer. Missiles employing active homing are **fully autonomous**. Such a system is shown in Figure 4.4.

**4.2.2 Semi-Active Homing**

A system wherein the transmitter of the energy is at a point external to the missile, but the receiver is inside the missile is called a semi-active homing system. The energy is reflected from the target and is received by the missile. The missile contains a *receiving antenna*, a *signal processor*, and a *guidance computer*. Since the transmitting antenna is located externally (either land-based or ship-based), it has **less autonomy** than active homing guidance. This system is shown in Figure 4.5.

**4.2.3 Passive Homing**

A system in which the receiver, placed inside the missile, utilizes the energy emanating from the target is called a passive homing system. It does not require a transmitter. A *heat seeking missile* uses such a system. The missile contains the *receiver* appropriate for the kind of energy that the target emanates, a *signal processor*, and a *guidance computer*. These missiles may appear to be as autonomous as missiles using active homing but are actually less autonomous, since they have to depend on the target to emanate the necessary energy. If the target stops emanating this energy, the missile stops functioning.
Figure 4.5: *Semi-active homing guidance*

Passive homing system is shown in Figure 4.6.

**Questions**

1. What are the guidance phases of a (a) Surface-to-air-missile (b) Air-to-Air missile? Sketch figures to explain.

2. What are two point and three point guidance schemes?

3. Define command guidance and homing guidance.

4. Describe the following phases of the missile trajectory (a) Programmed maneuver phase (b) boost phase (c) midcourse phase (d) terminal phase.

5. What are the different category of homing guidance schemes?

6. Sketch figures and describe the following (a) Active homing (b) Semi-active homing (c) passive homing.
Figure 4.6: Passive homing guidance