MISSILE GUIDANCE

Missiles are generally classified into two types.

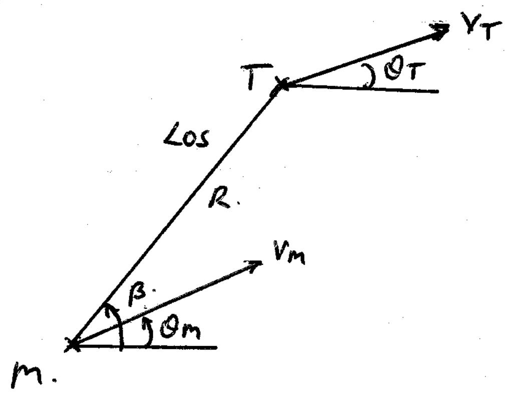
Tactical missiles

- Short range (<100 km), relatively low speed, moving target
  eg. SAMs, ground to air, air to air
- purpose is to influence the outcome of a battle/combat

Strategic missile

- long range (> 1000 km), near orbital speed, stationary targets.
  eg. Ballistic missiles (ICBMs)
- Can influence the outcome of war; serve as a strategic deterrent.

Tactical guidance:



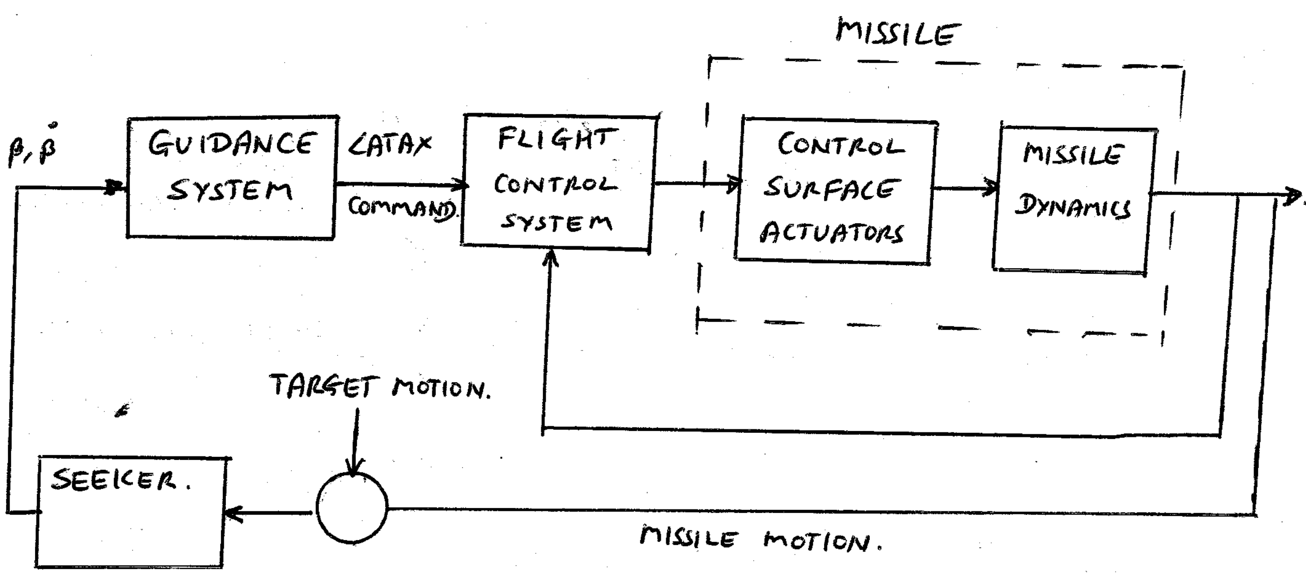
2D tactical engagement geometry

R - range
V_m - missile vel. vector
θ_m - missile heading.
V_T - target vel. vector
θ_T - target heading
R - range.
β - LOS orientation
$\dot{\beta}$ - LOS rate

The magnitude of V_m (that is, missile speed) depends on the variation of thrust, weight & altitude with time.

For simplicity, we will assume the magnitude of V_m to be constant. Then, θ_m has to be varied to achieve an intercept. This can only be done by generating lateral acceleration, or LATAX in guidance parlance.

The guidance system uses measurements/estimates of β & $\dot{\beta}$ to generate a LATAX command. The LATAX command is intended to achieve an intercept if faithfully followed by the missile. The flight control system attempts to generate the LATAX commanded by the guidance system, by using aerodynamic ~~lifting~~ control surfaces or thrust vectoring to manipulate aerodynamic forces.



Aerodynamic tactical missiles ~~may generate the necessary lift force by banking~~ are classified into two categories depending on ~~the~~ how the lateral force is generated.

<u>Bank-to-turn missiles:</u> The missile generates the lateral aerodynamic force by first banking to set the lift vector to ~~along &~~ have a component along the commanded LATAX,

& then increasing the AOA to increase the lift force.

Skid-to-turn missiles: This is typical of a missile without "wings". The missile ~~turns~~ rotates ~~into~~ the direction in which ~~later~~ LATAX is required. The resulting increase in α result in increased aerodynamic force ~~in the ve~~ along the commanded LATAX.

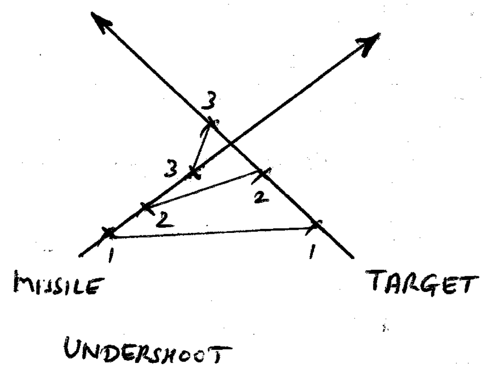
Tactical guidance can be of two types.

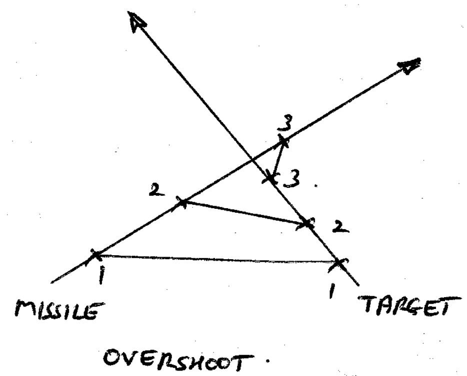
A) Homing guidance: Missile carries a seeker that generates β & $\dot{\beta}$ without any external support. Seekers may be IR seekers or radar seekers, & consist of a passive IR sensor array or ~~an radar~~ active radar mounted on gimbals which are actuated by motors. Once the seeker "acquires" the target, the gimbal control system uses the IR or radar signal to maintain "lock". In the process the gimbal angles directly give the LOS orientation in the seeker frame. The ~~signal~~ β signal is filtered to obtain an estimate of $\dot{\beta}$. A missile seeker is a crucial & therefore closely guarded piece of technology.

B). Command guidance: The missile depends on a ground station or the parent aircraft ~~to~~ either for $\beta, \dot{\beta}$, or for the LATAX command itself.

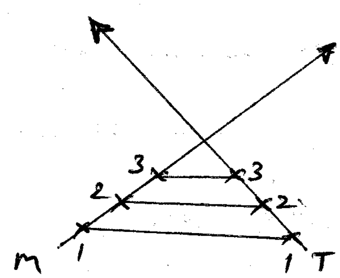
Why is it sufficient to just know β & $\dot{\beta}$ to determine if the missile & target are on a collision course?

eg.





In both cases, the line of sight rotates. Hence to achieve an intercept, the LOS rate should be made zero.

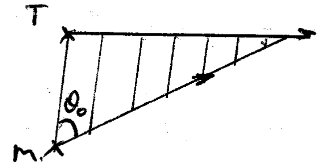


Hence, it is sufficient to use β & $\dot{\beta}$ to try & reduce $\dot{\beta}$ to zero.

Types of homing guidance

1) Pursuit guidance: missile velocity is ~~dir~~ always directed towards the target. i.e, $\theta_M = \beta$.
2) Fixed lead: missile always directed ahead of the target by a fixed amount

$$\theta_M = \beta - \theta_0.$$



3). Constant bearing: θ_T is ~~such~~ such that $\dot{\beta} = 0$.
4) Proportional guidance: $\dot{\theta}_T = \lambda \dot{\beta}$ (feedback $\dot{\beta}$ to reduce $\dot{\beta}$ to zero)