Navigation system

System performance requirements

* Accuracy
* Integrity
* Availability
* Continuity of service

Categories

* **Sole means:** For a given phase of flight meets all system performance requirements
* **Supplemental means:** used in conjunction with a sole means system
* **Primary means**: For a given phase of flight needs to meet first two requirements. 🡪 Don’t need full availability and continuity of service requirements 🡪 Safety achieved by limiting flights to specific time periods or through procedural restrictions and operational requirements

Types of navigation systems

* **Dead reckoning systems:** Derive the state vector from continuous series of measurements relative to initial position
  + *Classic DR:* air data magnetic heading and wind velocities
  + *Inertial navigation systems:*accelerations and angular rates are measured and integrated
* ***Positioning systems:*** *Measures state vector without regard to the path travelled by the vehicle in the past*
  + *Celestial navigation*: based on stars
  + *Mapping navigation systems:* based on observed visual images of Earth’s surface
  + *Radio navigation systems:* basis of radio signals transmitted by ground beacons, stallites or other aircraft

INS

**Advantages**

* Continuous availability of position, velocity and attitude information
* Self-contained: IN is based on measurements on-board
* Autonomous: IN does not depend on other systems
* Passive: IN does not radiate, is not jammable
* High accuracy

**Disadvantages**

* Expensive ($ 50,000-150,000)
* DR system, so position and velocity information degrades in time
* Initial alignment is necessary
* Accuracy depends somewhat on the vehicle manoeuvres

**Positioning systems**

Theta systems

Rho systems

Hyperbolic systems

GDOP 🡪 Geometric dilution of precision

Distance Measuring Equipment (DME )

* Based on the measured time interval between pulse transmitted by the airborne DME interrogator and the reception sent back by the ground-based DME transponder.
* DME channel consist of two carrier wave frequencies always 63 MHZ apart

Interrogator has two modes

* **Search mode:** 140 pulse pairs per second; has to recognize its own replies and ignore the replies to the DME interrogators of other aircraft
* **Tracking mode:**  5 to 8 pulse-pairs a second ; recognized its own replies

Every aircraft interrogator has his own rhythm or jitter. (small time difference). It looks for replies with a constant time difference with respect to the interrogator transmission

Future trends

Satellite navigation but not in near future because

* widespread use of equipment and cost of replacement;
* lack of available air traffic management operational procedures compatible with satellite-based systems
* the absence of full sole means of navigation status of GPS (and GLONASS); GALILEO ...
* issues involving system accuracy, integrity, availability and continuity of service of the satellite systems have not been resolved