

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