Distance Measuring Equipment (DME)

- VOR receiver determines radial bearing
- DME determines: distance to VOR, ground speed, and time to station
- Rho-theta navigation
DME indicating 97.9 NM from VORTAC, ground speed equal to 120 kt, and 48 minutes to the station
• The airborne component of a DME contains an interrogator, which transmits and encoded signal to a ground station’s “transponder.”
• A “radar mile” is the time required for a radar signal to travel a distance of one nautical mile and back.
• Nautical mile equals 1852 meters
• Radar mile equals: \( T = \frac{(1852 \times 2)}{c} = \frac{3704}{3 \times 10^8} = 12.35 \mu s/\text{NM} \)
• DMEs are of various modes. The X channel ground station imposes a 50\( \mu \)s delay on the received interrogation before replying back to the aircraft. This delay prevents the false secondary interrogation from a multi-path signal.
• X channel distance is calculated as: \( D_{\text{NM}} = \frac{\Delta t - 50 \mu s}{T} \)
  = \( \frac{\Delta t - 50 \mu s}{12.35 \mu s/\text{NM}} \), where \( \Delta t \) is the total elapsed time
• Generalized distance: \( D = \frac{\Delta t - T_0}{T} \), since other modes use different delay values.
• Note: slant range and map distance are approximately equal for greater distances and lower altitudes. E.g. “5.15, DME”
• Although a rectangular pulse is the easiest waveform to permit accurate timing, their bandwidth requirement is excessive.

\[ V(t) = V e^{(-\pi at^2)} \]
• DME uses amplitude modulation:
  \[ V(t) = V \cos(2\pi f_c t) e^{(-\pi(at)^2)} \]
• DME uses a double-pulse encoding, which provides some noise immunity, since the probability of noise corrupting to successive pulses separated by a known time period is low.
• X channel interrogation and reply timing
• X channel example:
  • VOR frequency: 108.000 MHz is paired with
  • DME interrogation: 1041 MHz
  • Station reply: 978 MHz
• Question: Why do the interrogation and reply channels use different frequencies?
• Y channel uses a 36μs pulse separation for the interrogation pair and 30 μs for the reply pair.
• Interrogation pulse pairs are sent out at different time separations to prevent synchronization between DME navaids on different aircraft.
• Question: What problem(s) would result for synchronizing DMEs?
• DME example:
  Example: assume that a DME interrogator transmits a pulse pair 16 times per second (on average) and has a ground speed of 500 kts. How far does the aircraft move between interrogations?

16 pulse pairs per second yields 1/16 seconds per pulse pair, which is 62.5ms. 500 kts x 1852m/NM x hr/3600s x 0.0625s = 16m

• Replies from other aircraft is referred to as FRUIT, which stands for “friendly replies unsynchronized in time.” The military term “friendly” originated by the use of radar.
• DME uses a Morse Code sequence to identify each station.
• http://tinyurl.com/pygp8vc

![Image of TACAN Antenna, VOR Antenna, and Counterpoise]
Regulatory and Advisory Agencies

• International Civil Advisory Organization (ICAO): Aeronautical advisory branch of the UN located in Montreal, Canada
  • ICAO was created as the result of an aviation conference in Chicago on December 7, 1944
  • Most countries are ICAO members
  • ICAO recommendations are widely adopted and cover all aspects of aviation. For instance ICAO Annex 10 regulates radio navigation aids and communication, whereas Annex 14 describes airport characteristics, such as the size, length, markings, and lights of runways.
  • ICAO recommendations are referred to as SARPS “Standards and Recommended Practices”

• Federal Aviation Administration (FAA): Federal agency under the DOT, that is responsible for regulating aviation safety and practices within the US.
  • The FAA Administrator reports to the Secretary of Transportation
  • FAA regulations and standards:
    • FAR: Federal Aviation Regulations cover Title 14 of the Code of Federal Regulations (CFR), which cover aircraft design and manufacture, testing and licensing of pilots, mechanics and air traffic controllers, etc.
    • [http://www.faa.gov/regulations_policies/faa_regulations/](http://www.faa.gov/regulations_policies/faa_regulations/)
• FAA regulars and standards:
  • AIM: Aeronautical Aviation Manual AIM covers basic flight information and ATC procedures

• Federal Communications Commission (FCC): Federal agency “responsible for the orderly operation of communications within the US.”
  • FCC is under the Department of Commerce
  • FCC Commissioner reports directly to the Secretary of Commerce

• Radio Technical Commission for Aeronautics (RTCA): Avionics advisory group to the FAA, which was first established in 1935.
  • The current definition of RTCA is “Requirements and Technical Concepts for Aviation”
  • RTCA is a not-for-profit, privately owned entity comprised of “avionics manufacturers, airlines, military, universities, and individuals.”
  • RTCA conducts work via Special Committees
  • RTCA generate MOPS (“Minimum Operational Performance Standards”), which specify design and test specifications for aircraft equipment, such as avionics. MOPS form the basis of FAA TSOs, “Technical Standard Order.”
• Aeronautical Radio Incorporated (ARINC ~ “air-ink”): Is a publicly traded company, which provides communications-related services to airlines. Such services usually include: arrival and departure times, crew and passenger information, gate assignments, etc.
• ARINC also generates avionics standards, known as “Characteristics,” which pertaining to “form, fit, and function.” Most ARINC standards apply to LRUs, Line Replaceable Units.
• European Aviation Safety Agency (EASA): EU organization based in Cologne, Germany, tasks with airline safety.
• The agency was created in 2003 and has 27 EU and 4 non-EU members
• Agency responsibilities include: “rule making for members to insure standardized requirements for aircrafts, pilots, and mechanics.”