

Radio Altimeter Spectrum



Scope

- Radio altimeter operations and requirements
- Spectrum used
- Equipage and performance
- Assessment of radio altimeter performance during interference
- Protection of the radio altimeter
- Questions

Radio Altimeters

- Radio altimeter a critical avionics systems
 - Developed to prevent Controlled Flight Into Terrain (CFIT)
 - Major source of accidents before 1970's implementation
 - Part of the Ground Proximity Warning System (GPWS)
 - Modern systems combined with GPS to enhance safety (eGPWS)
- Current usage
 - Core aircraft sensor system during the critical phases of flight (landing and takeoff in low/zero visibility weather)
 - Provides readings from -10 to 15000+ feet
 - Accuracy to 3 feet or less
 - Used by autopilot system to control altitude



ICAO Requirements

- ICAO Annex 6 Part 1 Chapter 6 states:

'All turbine-engine aeroplanes of a maximum certificated take-off mass in excess of 15 000 kg or authorized to carry more than 30 passengers shall be equipped with a ground proximity warning system which has a forward looking terrain avoidance function.'

(other paragraphs have similar provisions for different weight categories of aircraft.)

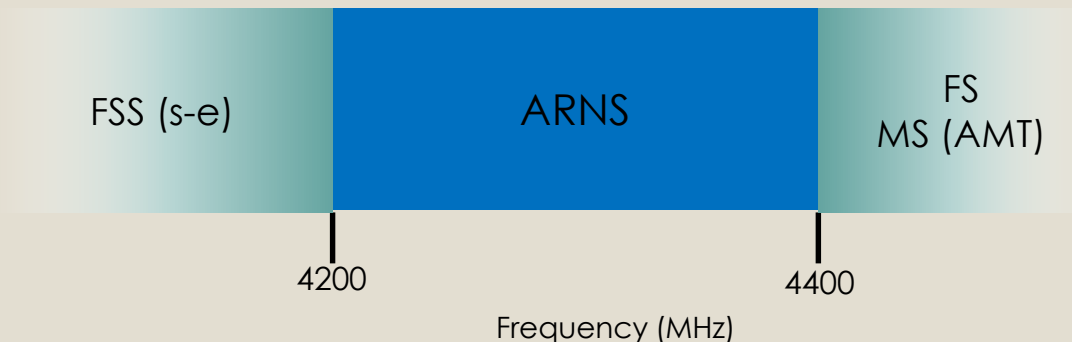
Equipage and operation US National Example

- All FAA Part 135 helicopters are now required to have an operational radio altimeter
 - Approx. 22,000 operational civil rotorcraft*
- Some FAA Part 91 aircraft require altimeters for certain operations such as Cat II ILS, etc.
 - Approx. 34,000 general aviation/private aircraft
- All large passenger aircraft
 - Approx. 7000 US based civil aircraft*
 - Plus international carriers



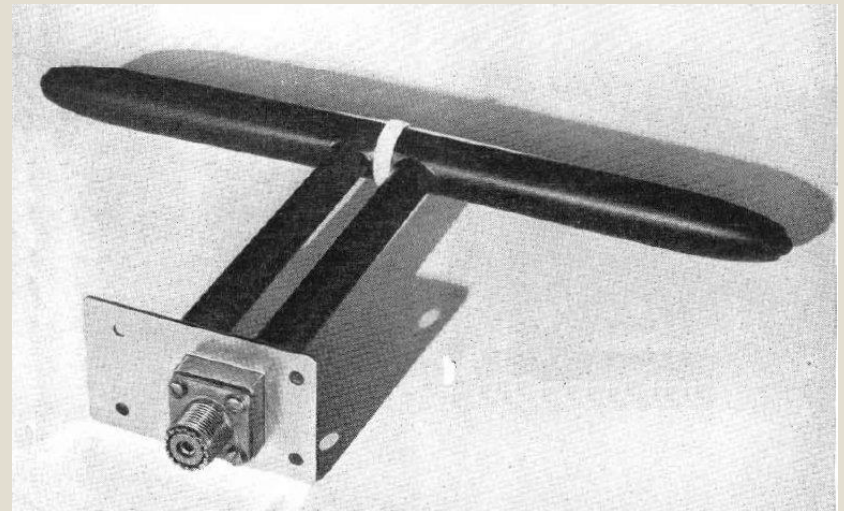
Radio Altimeter Spectrum

- Altimeters operate within the 4200-4400 MHz ARNS allocation
 - Worldwide allocation
 - Traditionally almost no other users within the band
- WAIC system recently allocated to the same band as an AM(R)S
 - Wireless Aircraft Intra Communications
 - WRC-15 primary allocation across whole band
 - Radio altimeters have primary status over WAIC systems



Altimeter Technical Requirements

- Technical operation
 - Frequency Modulated Continuous Wave (FMCW) radar system for most civilian altimeters
 - Pulsed system used by state aircraft and helicopters
- Both systems measure time from transmission of a radio signal from the aircraft to reception of the reflected signal
 - For FMCW, difference in transmitted signal and received generated a beat frequency that corresponds to a distance
- Few standards that define altimeter system performance
 - ITU-R Rec M.2059 - Operational and technical characteristics and protection criteria of radio altimeters utilizing the band 4 200-4 400 MHz
 - RTCA DO-155 – MOPS for Airborne Low Range Radar Altimeters

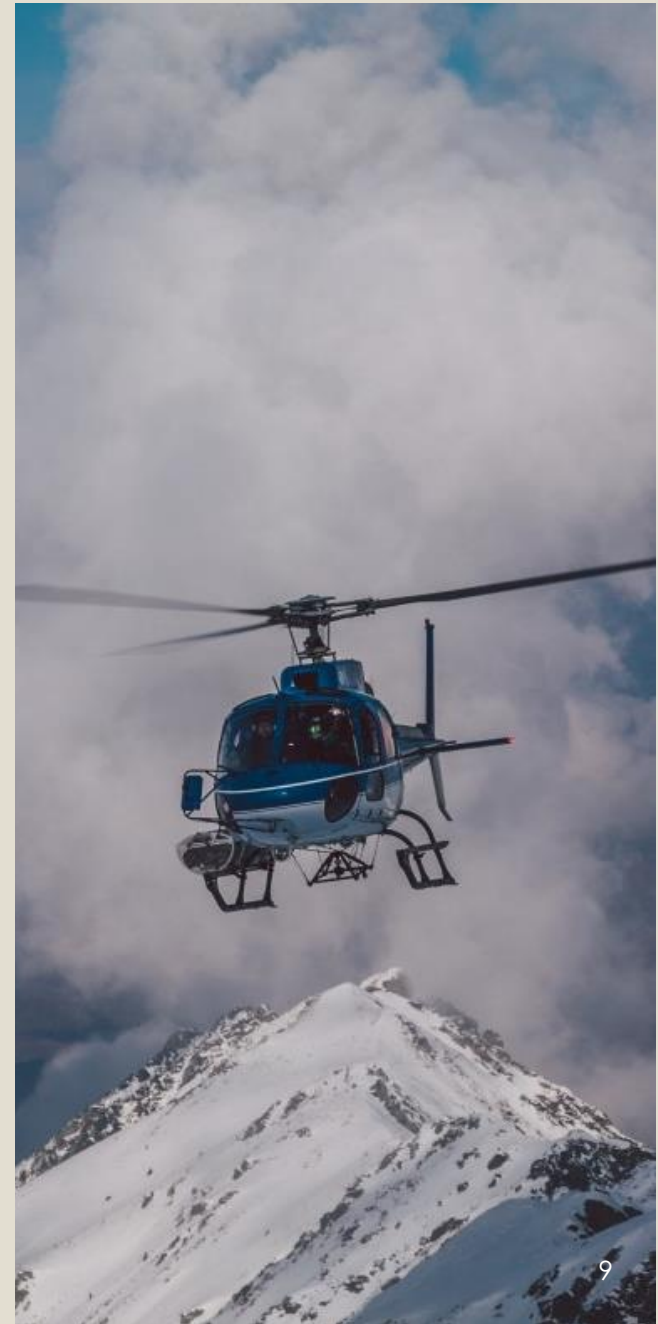


Altimeter Technical Requirements

- FMCW altimeter sweeps most of the 200 MHz
 - Largest known bandwidth is 196 MHz (40dB)
 - Transmit power between 0.1 and 100 watts
- Protection criteria (as per ITU standard)
 - Desensitization: $I/N = -6$ dB
 - Front End Overload: $I_{RF} \leq P_{T,RF}$ as defined in Tables 1 and 2
 - False Altitudes (for FMCW Altimeters only): $ID < IT,FA$, where $IT,FA = -143$ dBm/100 Hz following the instantaneous altimeter local oscillator
 - 6 dB safety margin applicability
- Any interference that compromises the reported information can immediately affect aircraft safety systems
 - Autopilot function, GPWS, and HTAWS
 - Receiver adjacent channel isolation rolloff starts at band edge

Attempts to Change the Spectrum Neighborhood

- US NTIA assessment in 2011
 - Mistook lack of US licenses for unused spectrum
 - US aviation industry and manufacturers required several years of pressure to drop proceeding
- WRC-15 under AI 1.1
 - Several nations sought repurpose 3.7-4.2 and 4.4-4.9 GHz while at WRC
 - Required coordinated effort with ICAO, IATA and other aviation attendees to prevent changes
- European CEPT work on Ultra Wide Band (UWB)
 - Would be implemented across whole 200 MHz
- US considering new broadband in 3.7-4.2 GHz
 - Options for fixed/mobile broadband



Assessment of Radio Altimeter Performance During Interference

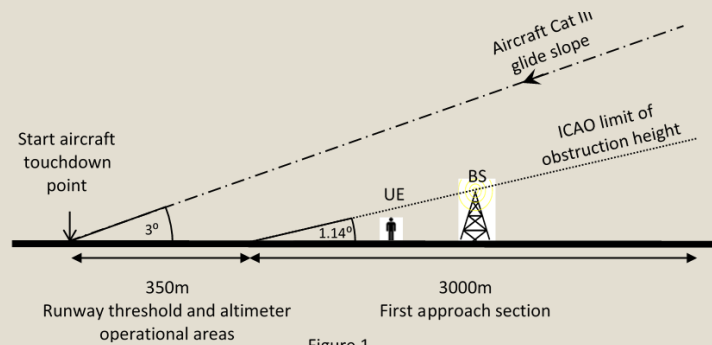
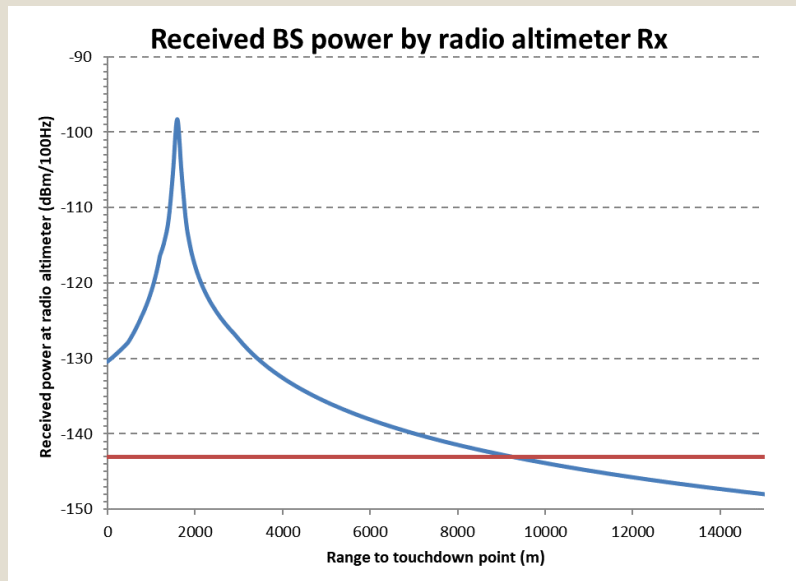


Figure 1



- Preliminary ICAO studies provide best known impact at this time
 - Used parameters from ITU-R recommendation
 - Altimeters highly vulnerable to interference
 - Revealed current data is not fully coherent
- Additional performance testing required
 - IATA has agreed to fund study
 - Will use equipment from the WAIC development process
 - Awaiting response from manufacturers

Radio Altimeter Protections

- Need to consider both in and out of band effects
 - In band protection has been strengthened by WAIC
 - Adjacent band repurposing being considered by several nations
- Operational scenarios critical
 - Helicopter ops most likely to be impacted
- Close proximity to ground provides a higher power reflected signal
 - False altitude protection limits appear to be the dominating factor



Summary

- Radio altimeter spectrum critical to almost all classes of aviation
- New demand for 'mid-band' spectrum places altimeters in a desirable location
- There will continue to be attempts on the frequency band and to those adjacent
- Aviation needs all the information available to ensure a robust defense of the system

Questions?