Aircraft Systems – Radio systems

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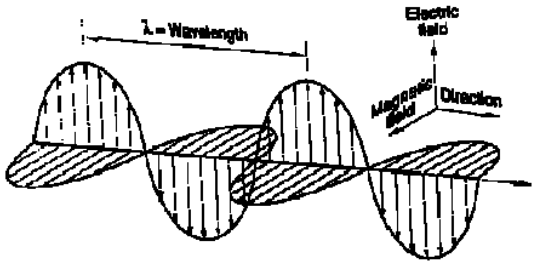
Communications

- Radio Frequency (RF) systems are used to provide communications between the aircraft and the ground or between two aircraft.
- They are also used for navigation systems.

- Early systems were developed to provide voice communications
- More recent systems were developed to provide a data link with operational and safety information as well as provide services for the passengers.

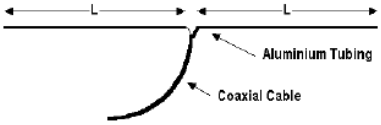
Radio waves

- Electro-magnetic radiation – travelling waves of orthogonal electric and magnetic fields

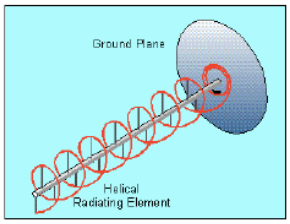


Radio transducers

- The transducer between the electrical conduction (i.e. in the wires and cables of our avionic systems) and the broadcast EM radiation domains is an 'antenna' or 'aerial'.
- Antennas work by having an electrical length of similar dimensions to the wavelength of the EM wave in air.



Half Wave Dipole



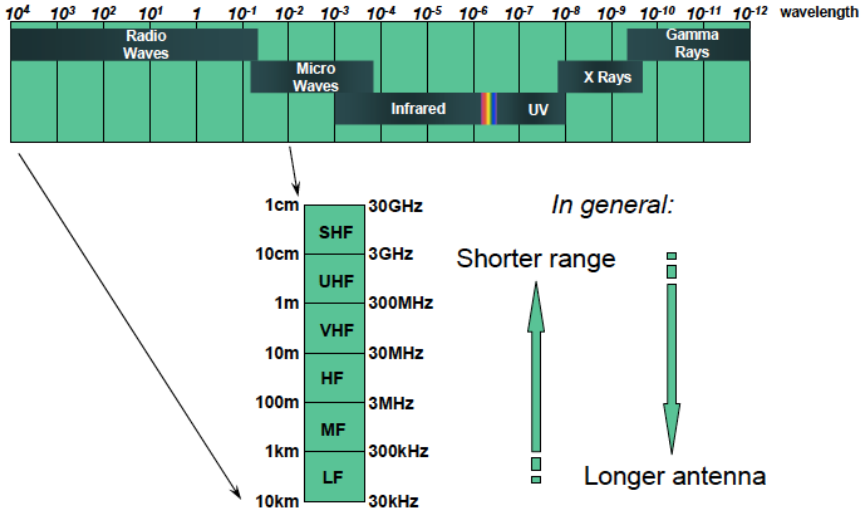
helical antenna

Radio propagation

- Differing frequencies of EM radiation propagate in differing ways.
- Long wavelengths tend travel further and 'bend' around obstructions.
- Shorter wavelengths tend to line of sight.
- Some frequencies can bounce off layers in the atmosphere.

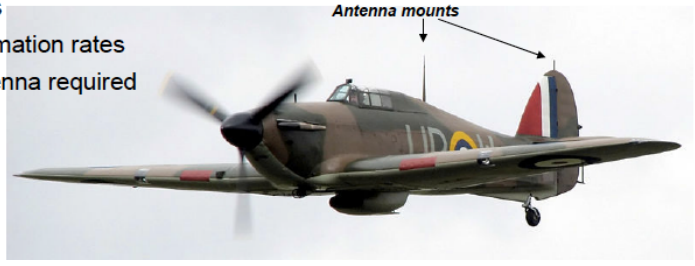
- The 'wavefront' of a transmitted signal spreads out over time – RF transmission distances are often long so the received power is usually many, many orders of magnitude below that transmitted.
  - e.g. a sensitive receiver may pick up signals ~ 1x 10^{-10} mW

RF spectrum

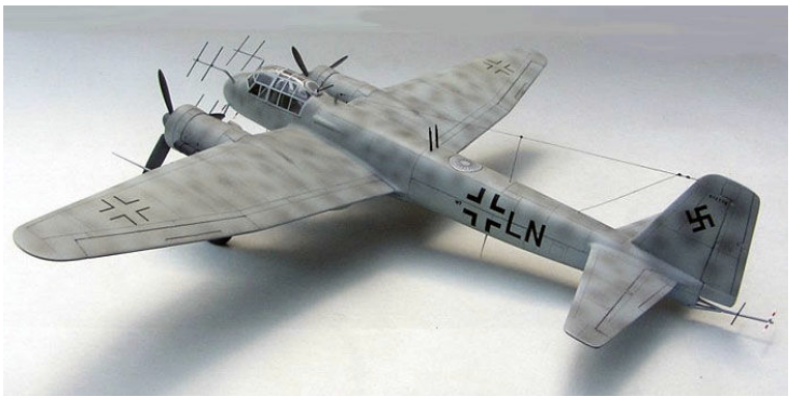


HF communications

- The first aircraft used the HF part of the spectrum. This provided long range associated with the long wavelength radio waves (over the horizon as they are reflected by the atmosphere)
- Still used for long range civil data and comms links
- But they have drawbacks
  - Susceptible to interference and fading – affected by atmospheric conditions
  - Low information rates
  - Long antenna required

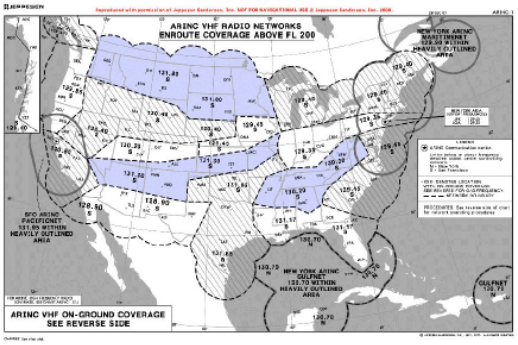


HF antenna



VHF communications

- VHF is the most commonly used radio communications link for data and voice on aircraft.
- The shorter range of VHF means that it is generally used for domestic communications.



ARINC (US standards for Aircraft systems) VHF US domestic coverage map

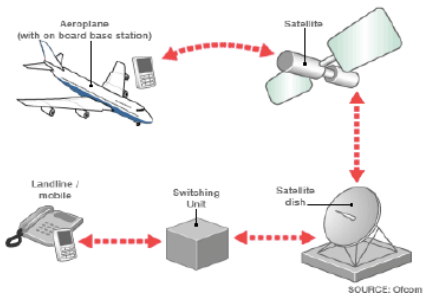
ARINC = Aeronautical Radio INC.

VHF antennas

AVDASI 1
AENG 10001

Satellite communications

- Satellite communications provide the highest data rates and widest coverage.
  - Used for voice, data and passenger services
- Aerospace operators use the IMMARSAT constellation of geo-stationary satellites.



SATCOM can be used for advanced services, such as to provide mobile phone service in addition to operational data for the flight

SATCOM antennas

High gain antenna – fixed wing, pod mounted

High gain antenna – Rotary wing

Electronically steered, low gain

AVDASI 1
AENG 10001

SATCOM antennas

High gain antenna – fixed wing, pod mounted

High gain antenna – Rotary wing

Electronically steered, low gain

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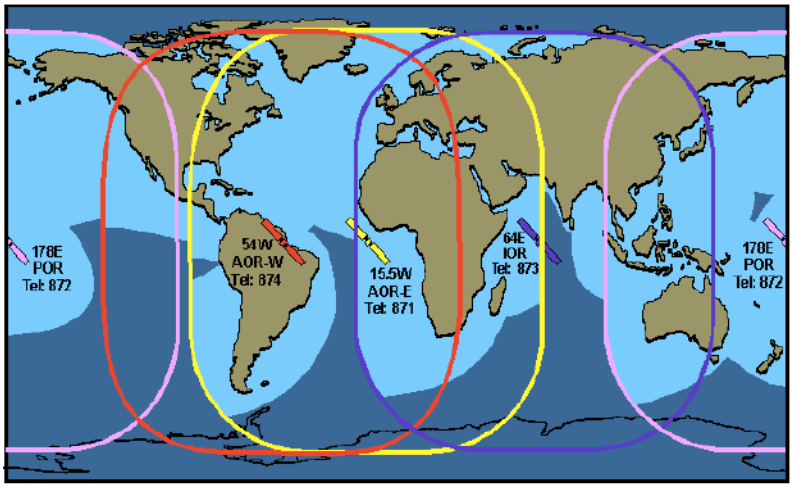
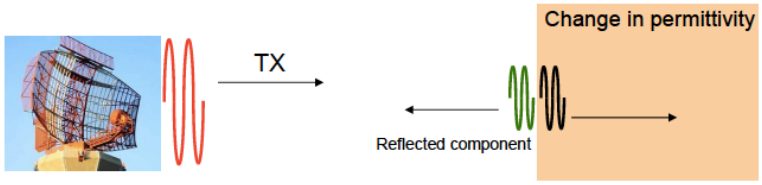
INMARSAT coverage



Radar

- Originally RAdio Detection And Range – now a 'proper' word
- Radar systems transmit RF energy and listen for a reflection.
- By directing the transmission, and from the characteristics of the received reflection, relative position, motion and size of an object can be determined.
- Obviously use for military in defensive/offensive roles.
- Also used in civil aircraft for weather detection and as a means of measuring altitude .

Radar – how it works



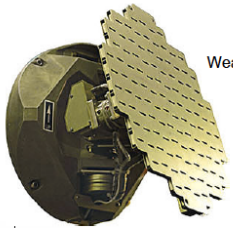
- Where there is a change in permittivity in the transmission medium, some EM energy is reflected back.
- Metallic surfaces are particularly good at reflecting.
- The timing of the return pulse can determine range.
- The signal is attenuated as its wave front expands – results in received power proportional to $1/R^4$. Radars transmit high powers and receive low powers.

Weather radar

- Weather radar lives under the 'radome' – the nose of the aircraft. The radome is always made of a non-conductive material so that it is transparent to RF radar pulses.
- The radar scans the forward flight path for potentially unsettled weather conditions.
- Water droplets, hail, and snow produce a radar reflection. Modern systems can tell a great deal about the conditions and structure of storms.
- The system indicates to the pilot the best course to minimise turbulence or damage to the aircraft .

Weather radar

Civil and Military radomes



Weather radar antenna

Weather radar display

Radio altimeter

- If a radar is pointed down, it can measure the height of an aircraft above the ground.
  - Note a 'radio altimeter' measures height not altitude (which is height relative to sea level)
- Radio altimeters are most useful at lower altitudes (<600m) and are commonly used as a landing aid and also as a sensor for GPWS (Ground Proximity Warning Systems).
- CFIT (Controlled Flight Into Terrain) can still occur even with the GPWS. Military planes that fly close to the ground to avoid enemy radar use a forward looking system.

Air Traffic Controller (ATC) Transponder

- The ATC transponder is required to be fitted to almost all aircraft (including hot air balloons in some areas).
- It is a radio device that can identify the aircraft – it originated as a device to identify friendly aircraft during conflict, and still has this role (IFF - Identify Friend Foe) amongst others.
- It is often described a 'radar' but in reality it is a RX/TX system that transmits specific data when requested to do so by a received interrogating signal.
- In its basic form it transmits an code to identify the aircraft when requested by air traffic control.

TCAS – Traffic Alert & Collision Avoidance System

- The TCAS system is an extension of the ATC transponder.
- All aircraft (properly equipped) send out interrogation pulses and listen for replies. Each aircraft thus builds up a picture of other aircraft in the vicinity.
- By doing this many times a second the TCAS system can work out if any of the aircraft nearby are likely to either collide or come to close to each other.

TCAS – Traffic Alert & Collision Avoidance System

- TA
  - TA displayed when the point of least separation is between 20 and 48 seconds
  - Audio warning of 'Traffic, Traffic' announced
  - TA will proceed RA by around 15 seconds, the crew should attempt to gain visual contact with the aircraft in conflict
- RA
  - RA displayed when the point of least separation is between 15 and 35 seconds
  - Typical audio warnings are
    - 'Climb, Climb'
    - 'Descend, Descend'
    - 'Reduce climb, Reduce climb'
  - Finally 'Clear of conflict'

Instruments

Older stand alone ATC instrument – typical of aircraft ~30 years ago (although many still fly)

Modern integrated radio control unit – with ATC, comms, ADF etc

Antennas on a civil airliner