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CHAPTER 3 – RADIO COMMUNICATION

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AIRCRAFT COMMUNICATION SYSTEMS

Aircraft communication systems are used to communicate between in-flight aircraft and air traffic controllers, between aircraft on taxiways and airport ground controllers and between aircraft and airline personnel.
Recent developments have made possible automatic data transfer by VHF or Satellite Communication (SATCOM). SATCOM also offers an alternative to HF for voice communications and the possibilities of telephone and internet for passengers.
It has long been a requirement that aircraft remain in communication with ATC wherever they may be and this has been made possible by using HF and VHF propagation paths. VHF communication systems are limited in range to line-of-sight whereas HF systems can use the refractive properties of the ionosphere to achieve longer ranges.

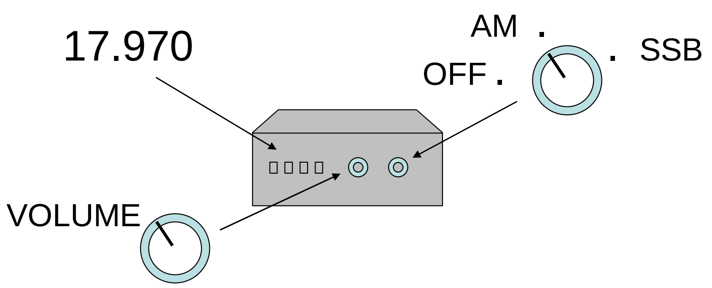
HF COMMUNICATIONS

The allocated frequencies used by commercial aviation to transmit and receive information are between 2MHz and 22MHz. This information can be in the form of a transmitted voice or a coded digital signal and the HF communication system can operate in several modes, briefly described as follows:

CONTINUOUS WAVE (CW) With CW, the transmitter is keyed on and off by a Morse key. This is not normally used in civil aviation.

AMPLITUDE MODULATION (AM) An amplitude modulated wave consists of a carrier frequency and a pair of sideband frequencies for each audio modulating frequency.

SINGLE-SIDEBAND (SSB) The sidebands of a carrier wave are the bands of frequencies produced by adding or subtracting the modulation frequency from the carrier. SSB which is more accurately termed Single Sideband Suppressed Carrier, performs the same communication functions as AM but with greater efficiency. A single sideband is transmitted and the carrier is suppressed to the point of nonexistence. The entire transmitted signal is useful and so a greater range can be achieved for the same transmitter power.



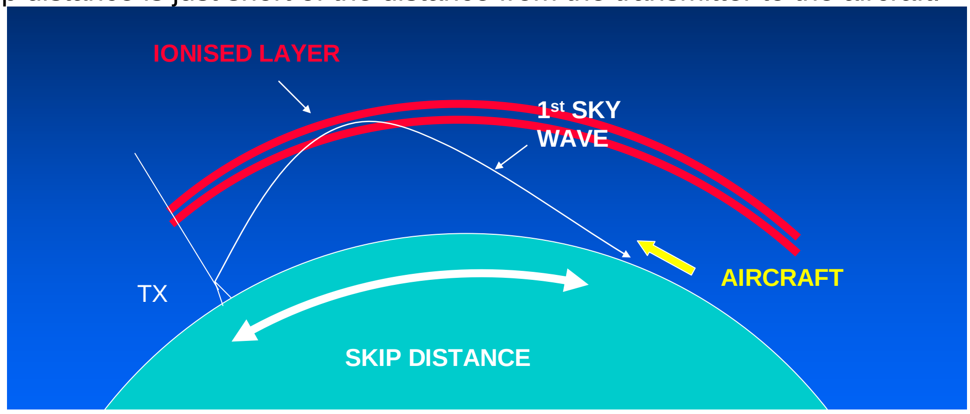
WHY USE HF?

When compared with the alternatives of MF and LF, HF has the following advantages:

a. Sky waves are available day and night.
b. Less ionospheric attenuation and less static than at lower frequencies
c. 1000 nm range is available with efficient power use.
d. Smaller aerials can be used.

CHOICE OF HF FREQUENCY

If the frequency is too low, excessive ionospheric attenuation will weaken the signal. If the frequency is too high, the skip distance will exceed the distance between the aircraft and the transmitter and the signal will not be heard. The MAXIMUM USABLE FREQUENCY (MUF) is the highest frequency available for a given distance and state of the ionosphere. At the MUF, skip distance is just short of the distance from the transmitter to the aircraft.



At night, if the same frequency is used as in the day, skip distance will increase due to the weakening of the ionosphere. The aircraft may then be in the dead space and so communication would not be possible. To avoid this problem, night frequencies are about half the day frequencies.

The aircraft in the picture is flying towards the east at sunset. The HF frequency for communication with a station ahead of the aircraft would be about half the frequency for any station behind

.

The factors affecting HF range are as follows:

a. Transmitter power
b. Time of Day
c. Season (Summer/Winter) – (Note maximum ionospheric attenuation occurs at mid-day but the ionosphere is most unstable at sunrise and sunset.)
d. Sudden Ionospheric Disturbances (SIDs)
e. Geographical location
f. Frequency in use
g. Receiver sensitivity

These factors also affect the range of unwanted transmissions that cause interference. Interference varies diurnally, seasonally and geographically.

HF communications are normally by transmissions that are **J3E** (Single side band suppressed carrier)

VHF COMMUNICATIONS

The frequencies used by aviation lie between 118.000 and 136.975 MHz with adjacent channels at 25 kHz or 8.33 kHz spacing. The transmissions are classified as A3E and are amplitude modulated and vertically polarised. Propagation is by direct wave and range is therefore limited to 'line of sight'.

The main factors affecting VHF range are as follows:

a. Transmitter power
b. Height of the transmitter and receiver
c. Obstacles (such as mountains) between the transmitter and the receiver
d. Receiver sensitivity

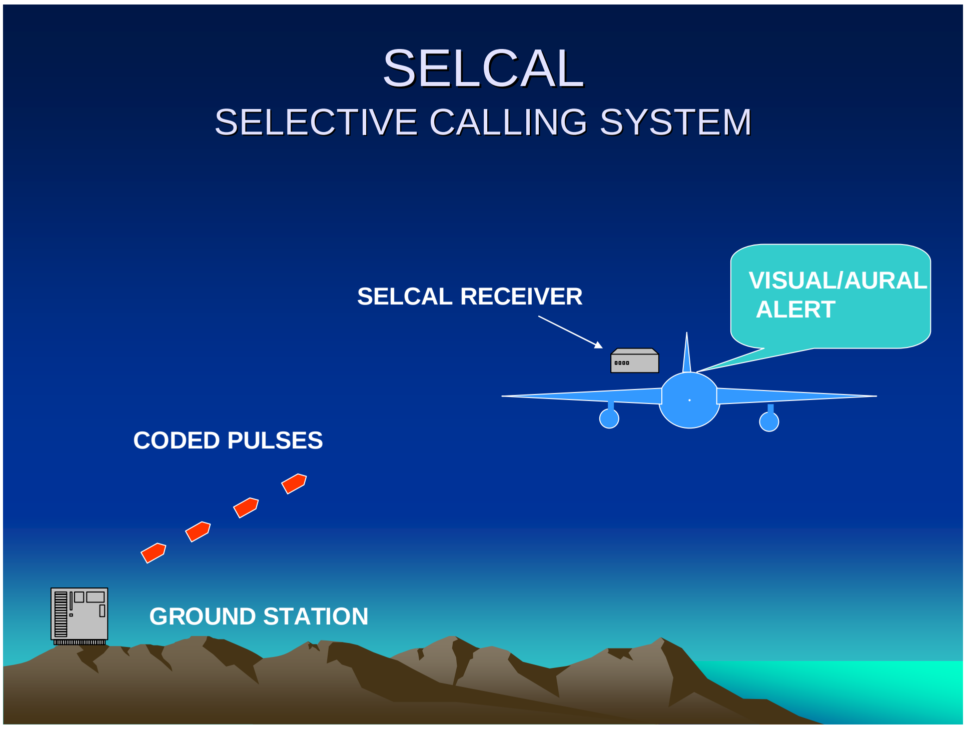
WHY USE VHF?

The 'line of sight' limitation effectively prevents interference from other stations that are working on the same frequency and naturally occurring radio waves, emitted by thunderstorms for example, cause little interference to VHF communications. The short wavelengths of VHF allow small, aerodynamic aerials to be used.

SELCAL

SELCAL (Selective Calling System) is designed to alert flight crew when an ATS unit is trying to establish contact. It allows the crew to operate without maintaining a continuous listening watch and so the distraction of hearing messages intended for other aircraft is avoided.

When SELCAL is in use, the ground unit selects the SELCAL 4-letter code of the desired aircraft and activates the ground transceiver. The code is received by the aircraft transceiver and sent to the SELCAL equipment that recognises the proper sequence and time duration of the code and then alerts the crew by means of visual or aural signals. The code, consisting of two consecutive tone pulses, is assigned to the aircraft from 2970 possible codes. The visual/aural alert to the crew consists of a bell, chime, lamp or any combination.



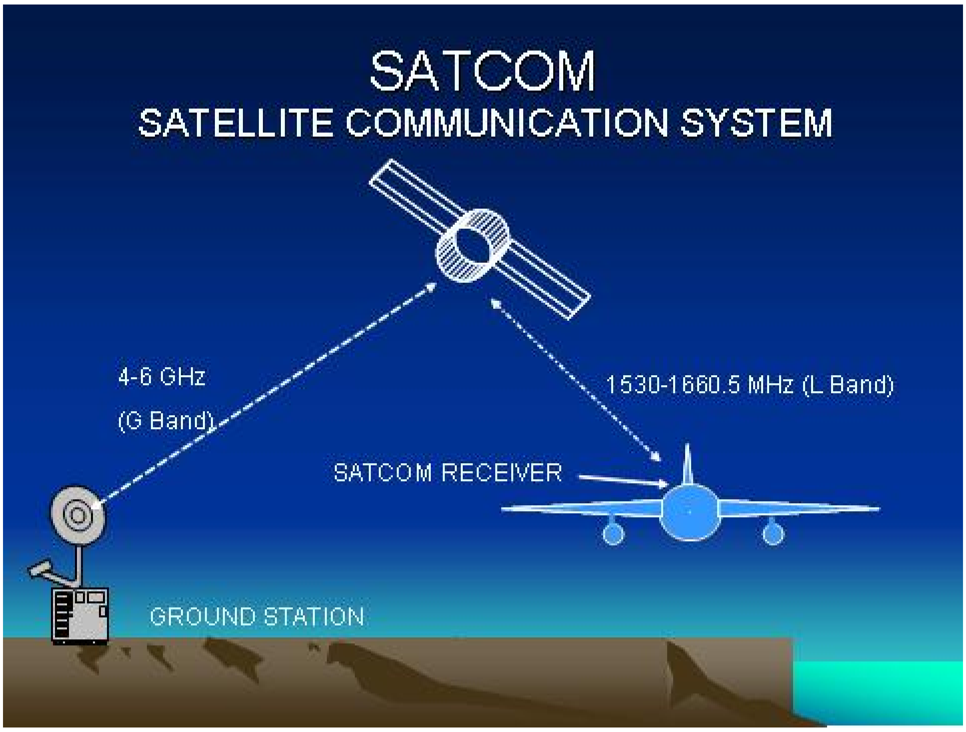
The use of SELCAL is prescribed by legislation:

- You must inform the ground station of your intention to use SELCAL
- The ground station must agree and must be capable of transmitting the aircraft's SELCAL code.

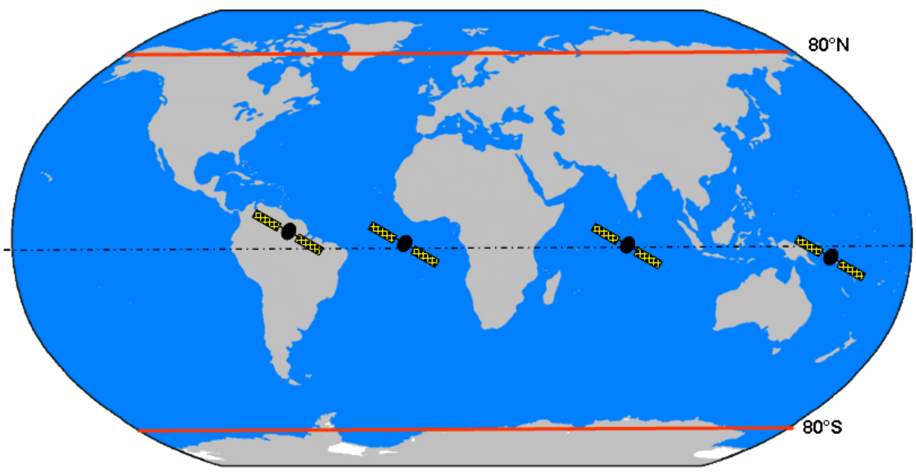
SELCAL should be checked before entry into any airspace in which it is to be used. It is also prudent to check it before flight. If unserviceable, a 'listening watch' must be maintained.

SATCOM

SATCOM (Satellite Communication System) uses satellites as relay stations to transmit over long distances, instead of HF frequencies which are susceptible to atmospheric interference. SATCOM supports a wide range of services such as flight deck voice communications, passenger telephone/internet and ACARS (also described in this section).



The satellite and ground station relay a wide range of data to and from the aircraft and airlines, airports, air traffic control and telecommunications via the public network. The satellite service, which is available to marine and land users as well as aviation, provides coverage by means of geostationary satellites. These satellites have an oribital period of 1 sidereal day and are situated above the equator. The coverage they provide is between latitudes 80^{O}N and 80^{O}S. SATCOM has become increasingly important as ADS (automatic dependent surveillance) has become effective. ADS is a system that uses satellite communication data links to allow air traffic control to monitor the position of aircraft by interrogating the on-board navigation systems such as GNSS (global navigation satellite system).



SATCOM SATELLITE NETWORK

AIRCRAFT COMMUNICATION ADDRESSING AND REPORTING SYSTEM (ACARS)

ACARS provides a means to transmitting or receiving information directly between the aircraft and ground stations by data link. It reduces the requirement for voice communications by reporting automatically to the airline the arrival and departure times of aircraft and other operational flight data, such as fuel status and flight delay information.

Other advantages include:-

a. Ground monitoring of aircraft engines and other parameters.

b. Exchange of information concerning arrival and connecting flights for the benefit of passengers

c. Reduction of the number of frequency changes in the aircraft.

d. A more reliable selective calling system.

ACARS SYSTEM DESCRIPTION

The ACARS system consists of a ground station network and airborne subsystem. ACARS shares one of the aircraft's VHF communication radios and operates by means of pre-selected frequencies which include 131.55 MHz. The use of VHF limits ACARS to line-of-sight range, but satellite developments now permit the use of ACARS via SATCOM, so extending its use to oceanic flights. The airborne subsystem consists of the ACARS Management Unit and the flight deck printer. It also uses the FMS Control Display Units (CDUs) and one VHF receiver-transmitter through the radio tuning panel. ACARS ground facilities consist of VHF radio stations, a central computer processor, a switching system and airline computer systems. Note that the VHF frequencies used by ACARS may become congested and may suffer from interference in the same manner as VHF communication frequencies.

ACARS OPERATIONS

Flight crew can access the ACARS via any one of the aircraft's CDUs by selection from the basic CDU menu. Flight crew can then send requests, reports and plain language text. Messages can be received and either displayed on the CDU or printed on the flight deck printer. The hard copy printout of data may include weather reports, dispatch messages and amended fuel plans. The interface through the CDU also allows the crew to enter information into the data link system by means of the alphanumeric keyboard.

The information is then transmitted from the aircraft to the ACARS ground radio station from where it is relayed to the central computer processor. Once converted into an airline operations message, it is then sent to the correct airline by means of the automatic electronic switch system. In this way, ACARS is shared by many airline operators.

An ACARS message displayed on a CDU

SOME ACARS RELATED TERMINOLOGY

Data Link	A system that allows the exchange of digital data by means of a radio frequency link. ATCSS is a data link used by the air traffic control system. ACARS is a data link used by airline command, control and management systems.
Management Unit	The MU organises and formats the flight data that is sampled during the course of the flight and crew initiated messages. It also monitors all ground-to-air transmissions to determine whether the message matches the aircraft designation.
OOOI	OOOI is an abbreviation for OUT-OFF-ON-IN which are events recorded by ACARS. The OUT event is recorded when the aircraft is clear of the gate and ready to taxi. The OFF event occurs when the aircraft has lifted off the runway. The ON event occurs when the aircraft has landed. The IN event occurs when the aircraft has taxied to the ramp area.
Down Link	The radio transmission path downward from the aircraft to the Earth.
Uplink	The radio transmission path upward from the Earth to the aircraft.
Demand Mode	An ACARS mode of operation in which communications may be initiated by the ground processor or the airborne system.
Polled Mode	The alternative to Demand Mode. In Polled Mode the airborne system transmits only in response to received uplink messages (polls).

WORKSHEET - RADIO COMMUNICATION

1. SATCOM is a communication system that uses satellites as relay stations. The orbit of the satellites is:

   (a) inclined to the plane of the equator so that they cover the entire globe in a day as the earth's surface transits beneath.
   (b) from pole to pole, with consecutive passes over the same place every 12 hours.
   (c) circular at an altitude that provides an orbital period of exactly 12 hours.
   (d) in the plane of the equator, having an orbital period of approximately 1 day.

2. What coverage of the earth do the satellites provide?

   (a) The satellites transit the earth to effectively provide global coverage.
   (b) From 85^0N to 60^0S, according to the plane of orbit of the satellites.
   (c) Each satellite covers about a third of the earth's surface between the latitudes of 75^0N and 75^0S.
   (d) Each satellite orbits at a different latitude between 80^0N and 80^0S to provide global coverage.

3. SATCOM satellites receive aircraft messages on ________ frequencies and transmit them to ground earth stations on __________ frequencies.

   (a) VHF UHF
   (b) VHF SHF
   (c) UHF EHF
   (d) UHF SHF

4. SATCOM supports a range of services which include:
   (i) ACARS data link
   (ii) Flight deck and passenger voice
   (III) FAX

   (a) All of the above
   (b) (i) and (ii) but not (iii)
   (c) (i) and (iii) but not (ii)
   (d) (ii) and (iii) but not (i)

5. A communication facility has the ICAO designation J3E. This refers to:

   (a) VHF amplitude modulated double side-band telephony.
   (b) HF amplitude modulated single side-band suppressed carrier telephony..
   (c) HF frequency modulated double side-band telephony.
   (d) VHF frequency modulated single side-band telephony.

6. Short range aviation communications are provided by VHF on frequencies between ________ at _________ spacing.

(a)	118 and 137 MHz	25 kHz
(b)	118 and 137 MHz	50 Hz
(c)	108 and 118 MHz	50 kHz
(d)	112 and 118 MHz	25 Hz

7. Long range aviation communications by HF are provided using frequencies between:-

   (a) 2 and 22 kHz
   (b) 2 and 22 MHz
   (c) 3 and 30 kHz
   (d) 3 and 30 MHz

8. Asuming the same ionospheric conditions, the use of a lower HF frequency will result in: (i) more static interference
   (ii) less ionospheric attenuation
   (iii) greater skip distance

   (a) All the statements are true
   (b) Only (i) and (ii) are true
   (c) Only (ii) and (iii) are true
   (d) Only (i) is true

9. You are onboard an aircraft travelling westward at dusk with HF stations ahead and behind the aircraft. The available frequencies at each station are 8 Mhz and 14 MHz. How would you select the frequencies?

	Ahead	Behind
(a)	8	8
(b)	14	14
(c)	8	14
(d)	14	8

10. Primarily ACARS is a communications data link system between ___________.

(a) aircraft and airline
(b) aircraft and ATC
(c) ATC and airline
(d) aircraft and aircraft

11. Which of the following statements are true with reference to SATCOM?

(i) Communications are virtually unaffected by meteorological conditions.
(ii) Ground earth stations link into the conventional public and private telephone networks.
(iii) The satellites provide worldwide, global coverage.

(a) All are true
(b) Only (i) and (iii) are true
(c) Only (ii) and (iii) are true
(d) Only (i) and (ii) are true

12. When using HF at night, you find that you are unable to establish communications with a particular station but you are able to hear another station which is at a greater distance in the same direction. This is likely to be occurring because:

(a) the station is beyond the skip distance of your transmission.
(b) of signal cancellation resulting from interference between the surface wave and skywave from the selected transmitter.
(c) the first skywave at night is transmitted beyond the critical angle.
(d) the frequency you are using is too high.

13. The primary cause of congestion in the MF and LF bands is:

(a) Inadequate geographical separation between stations operating on the same or similar frequencies.
(b) Skywave interference by day and night from distant transmitters.
(c) The wide bandwidth of FM transmissions.
(d) An inadequate passband at the receiver to accept the bandwidth of AM transmissions.