

ELEVENTH AIR NAVIGATION CONFERENCE

Montreal, 22 September to 3 October 2003

Agenda Item 7 Aeronautical air-ground and air-to-air : communications

VHF DATA LINK MODE 4 CONSIDERATIONS

(Presented by the International Coordinating Council
of Aerospace Industries Associations)

SUMMARY

The paper presents an overview of the aircraft aspects of multiple VHF transmitter-receiver installations, with particular reference to Air Transport Class large aircraft, VDL Mode 4, and spectrum usage. This paper summarises the issues surrounding VDL Mode 4 in the context of VHF communications, and makes recommendations.

The conference is invited to agree that ICAO should follow these recommendations.

Action by the conference is in paragraph 5.

1. VHF COMMUNICATIONS INSTALLATIONS ON AIRCRAFT

1.1 Aircraft carry typically two or three VHF transmitter-receiver installations, for safety-of-flight and operational efficiency purposes. Typically, there is one antenna per transmitter-receiver installation, and the installations are used independently, where one or more installations may be simultaneously transmitting, while the other installations may be simultaneously transmitting or receiving. Typically, to ensure proper antenna decoupling, some antennas are installed on the upper fuselage, and some on the lower fuselage. This allows satisfactory communications with radio stations that are located a comparatively short distance below or above the aircraft, and a comparatively large distance horizontally, in any direction, up to the line-of-sight horizon at the en-route altitude.

1.2 Aircraft are comparatively small radio sites, and aircraft radios, although of high quality, are not absolutely perfect. Filters in the receivers reject signals at frequencies other than the desired receive frequency, and filters in the transmitters remove spurious frequencies other than the desired transmit frequency, each to a considerable, but not absolute extent. Although the antennas are separated from each other by as large a distance as is feasible, given the dimensions of the airframe, when a radio on the aircraft is transmitting, other radios on the aircraft will receive a signal from this very close (co-site) transmitter, that is very much larger than the desired signal from the distant station that is being received.

1.3 Depending on the design of the radios, specially their filters and the non-linearities of the transmitter and the receiver, which produce undesired intermodulation product signals at frequencies which are a complex mixture of the signals on the aircraft, when a radio transmits, the other receivers receive undesired signals on a few frequencies that may interfere with a desired distant (and hence weak) signal, and prevent its reception, or make it difficult to understand. This phenomenon is called co-site interference. Co-site interference is also used to describe interference from aircraft that are operating closely together, such as on the aprons, taxiways and runways of an airport.

2. INSTALLATIONS ON AIR TRANSPORT AIRCRAFT

2.1 Air Transport aircraft are passenger and freight aircraft such as those presently manufactured by Airbus, Boeing and others, as distinct from smaller regional, business and general aviation aircraft.

2.2 VHF communications installations on Air Transport aircraft use radios that have the highest performance of all civil aircraft radios, notably with transmitter powers and receiver sensitivities that substantially exceed the regulatory minima, enhancing safety, when communicating with distant or weak stations. The higher power and sensitivity affect co-site interference.

2.3 The larger airframe sizes, and the resulting larger feasible antenna-to-antenna distances on Air Transport aircraft reduce, but do not completely eliminate, co-site interference from another radio transmitting on the same aircraft. On Air Transport aircraft, antennas on the same (upper or lower) side of the fuselage are isolated by 35 dB or more, and antennas on opposite sides of the fuselage by 50 dB or more, because the round metallic fuselage offers a degree of protection. To give an idea of the dimensions involved, 35 dB of space isolation is obtained when antennas have 12 Metres (about 40 Ft.) linear space separation. There are no arrangements for deliberately degrading receiver performance, so as to mask co-site interference from another radio transmitting on the same aircraft, as necessitated and implemented on smaller aircraft. The squelch circuitry on Air Transport aircraft does indirectly mask co-site interference, reducing the receive range of a given radio when another radio is transmitting on the same aircraft.

2.4 Air Transport VHF communication installations are built so that there is no co-site interference, provided that the transmit and receive frequencies are separated by at least 6 MHz for radios with both antennas the same side of the fuselage, or 2 MHz with both antennas the other side of the fuselage, because of the protection afforded by the fuselage. To reduce these frequency separations meaningfully would require lower transmitter powers or lower receiver sensitivities, thus degrading safety, antenna separations beyond feasibility on most aircraft, or filtering that is beyond currently envisaged technology for these radios. Interference in the form of squelch breaks occurs on a few frequencies within these separations, depending on the detail design of the radios used, but almost all frequency pairs are free of squelch breaks,

leading to the perception of generally satisfactory operation. While the squelch circuitry generally prevents annoying squelch breaks, this solution for reducing co-site interference has the effect of reducing the receive range of the radio, whenever another radio is transmitting on the same aircraft.

2.5 VHF frequencies in use in the most demanding airspaces do not always allow the separations described above. ATM procedures allow for safe operation on the occasions that an aircrew will occasionally fail to hear or act on a transmission, because of a radio fault, simultaneous transmission by another aircraft, call-sign or selection confusion, or interfering transmissions. Exceptionally, when poor communications persist, ATM procedures allow for continued safe operations, but with operational penalties. When co-site interference to a safety-of-life VHF signal occurs, as happens occasionally at present, the aircrew has the ability to easily temporarily halt the interfering non-safety-of-life VHF transmissions from their own aircraft, so that interference does not persist for the time needed, with little or no operational penalty. Co-site interference presently occurs from AM voice transmissions, and from data link transmissions, with less severity because they are usually shorter. The co-site interference from voice and data link transmissions is of the same nature, and is handled in the same way.

2.6 There are a number of longer-term solutions, such as changing one of the frequencies in use, or using a radio with readjusted filters that may, or may not, resolve the local problem. Frequently, the optimal solution is to rely on the aircrew to temporarily halt the interfering transmission.

2.7 VHF data link Mode 4 has been proposed for communications, navigation and surveillance purposes. When used for surveillance purposes, aircraft transmissions are permanent and periodic, and if turned off, destroy the ability to perform their surveillance function. Therefore the existing mitigations are no longer usable, and need to be replaced with more rigorous frequency separation, unless the existing VHF communication radios are also replaced by radios with high-performance filters that have not yet been envisaged.

3. SPECTRUM EFFICIENCY

3.1 The aviation VHF communications spectrum is a scarce and precious resource. Its use is mainly for safety-of-life voice services, other operational voice services, and data link services used initially and mainly for operational services, and increasingly for safety-of-life services, using VDL “Mode A” (ACARS) and VDL Mode 2, with future use of VDL Mode 3 planned in some of the most demanding airspace. The use of safety-of-life AM voice services is expanding, and the European CAAs and administrations expect that this expansion may lead to saturation of this spectrum, in the most demanding airspaces, by around 2013.

3.2 Adding frequency allocations for another future service such as VDL Mode 4 over a wide area would reduce the frequencies available for present and planned safety-of-life services in the most demanding airspaces.

3.3 VDL Mode 4 has advantages that are well-known, mainly arising from its protocols. Unfortunately, these advantages apply to data links, a small proportion of the spectrum used, and they do not apply to voice, the main spectrum user and safety-of-life service. It also has disadvantages, compared with existing services. Therefore, the spectrum efficiency gains that some stakeholders expect from the use of

VDL Mode 4 apply to a small part of the spectrum, and can have little overall effect, should the expectations be validated.

3.4 In the short time remaining until spectrum saturation occurs, it is questionable that any worthwhile overall advantage would be gained by a transition to this new service, even before taking account of the time and cost impacts for the aircraft installation, training, maintenance, spares and other issues.

4. CONCLUSION

- a) Frequency planning should take into account the better-than-regulatory performance of in-service airborne VHF communications installations, and not just regulatory performance.
- b) Because the presently used procedures and mitigations allow safe service, by the crew temporarily halting transmission of interfering VHF voice and data link transmissions, frequency planning should take into account VHF installations where aircrews may not temporarily stop transmissions (such as surveillance transmissions) that may interfere with reception of safety-of-life signals.
- c) Consequently, in order to take into account the performance of in-service radio installations on Air Transport category aircraft, frequency planning should take into account the need to separate, by at least 6 MHz, the VDL Mode 4 frequencies used for Surveillance from the VHF frequencies used for safety-of-life communications, in the same and adjacent areas.
- d) Before allocating VDL Mode 4 frequencies in a given area for communications, surveillance, or navigation purposes, account should be taken of the resulting reduced availability of spectrum for safety-of-life VHF communication services that presently use AM voice, and data link services that use VDL “Mode A” (ACARS), Mode 2, and plan to use VDL Mode 3, with particular attention to spectrum saturation in the most demanding airspaces, and the transition.

5. ACTION BY THE CONFERENCE

5.1 The conference is invited to agree on the following recommendation:

Recommendation 7/xx — VHF frequency planning and airborne radio performance

That ICAO:

- a) consider the performance of in-service radio installations when conducting frequency planning work;
- b) consider the performance of in-service radio installations and the potential inability of aircrews to temporarily turn off future interfering VHF co-site surveillance transmissions, when conducting frequency planning work for safety-of-life VHF communication services; and
- c) consider the potential degradation of spectrum availability for safety-of-life VHF communications services when applications for new services are being considered, especially in the most demanding airspaces and in the transition.

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