International Telecommunication Union

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Recommendation ITU-R F.1571

(05/2002)

Mitigation techniques for use in reducing the potential for interference between airborne stations in the radionavigation service and stations in the fixed service in the band 31.8-33.4 GHz

F Series

Fixed service

International Telecommunication Union

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R F.1571*

Mitigation techniques for use in reducing the potential for interference between airborne stations in the radionavigation service and stations in the fixed service in the band 31.8-33.4 GHz

(2002)

Scope

This Recommendation provides guidance on mitigating the potential for interference between airborne stations in the radionavigation service and stations in the fixed service in the band 31.8-33.4 GHz. Specific mitigation measures for the FS and aeronautical radionavigation service (ARS) are mentioned and the sharing studies deriving the potential for interference between these services is included in the Annexes.

The ITU Radiocommunication Assembly,

considering

a) that the band 31.8-33.4 GHz is allocated to the fixed service (FS) on a primary basis in all three ITU Regions;

b) that the 31.8-33.4 GHz band is available for applications in the high-density fixed service (HDFS);

c) that the band 31.8-33.4 GHz is also allocated to the radionavigation service (RNS) on a primary basis in all three ITU Regions;

d) that Recommendation ITU-R F.1097 contains details of mitigation techniques for unwanted emissions from the radiodetermination service, which could be used to minimize the potential for interference between airborne stations in the RNS and stations in the FS;

e) that radio-frequency arrangements including frequency block arrangements have been developed (see Recommendation ITU-R F.1520) in order to make the most effective use of the spectrum available;

f) that the RNS is used for weather avoidance and, in some cases, e.g. where the local air traffic control (ATC) services are not available, for takeoff and landing. The existing systems are also used for aerial delivery of cargo and personnel in support of international humanitarian operations;

g) that the band 31.8-33.4 GHz provides 1 600 MHz of contiguous spectrum, which is suitable for use in supporting FS applications such as access to the end user and the provision of infrastructure for mobile networks, e.g. IMT-2000,

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* Radiocommunication Study Group 5 made editorial amendments to this Recommendation in December 2009 in accordance with Resolution ITU-R 1.

noting

a) that one administration has implemented a limited number of airborne stations in the RNS in the entire 31.8-33.4 GHz band, operated worldwide;

b) that the band 31.8-33.4 GHz is not shared with the fixed-satellite service/mobile-satellite service,

recommends

1 that appropriate mitigation techniques should be used, where possible or practical, in order to significantly reduce the potential for interference between stations in the FS and airborne stations in the radionavigation service (see Notes 1 and 2).

These may include measures such as:

1.1 for stations operating in the FS: automatic transmitter power control (ATPC), forward error correction (FEC) coding, bit interleaving technique (BIT), robust access/modulation techniques, receiver blocking filter, robust synchronization and high performance antennas (see Note 3);

1.2 for stations operating in the RNS: frequency agile systems, RF filter installation in the radar transmitter and pulse coding in future systems;

2 that in addition to the appropriate mitigation techniques, some operational restrictions on both services may be necessary where practical or possible. These may include amongst others the following considerations:

2.1 airborne stations in the RNS are encouraged to avoid low operational altitudes and low down tilt antenna angles in the vicinity of urban areas (zero tilt angle corresponds to directions towards the horizon). These operational conditions do not apply to takeoff and landing;

2.2 systems in the FS are encouraged to avoid the use of high elevation angles;

2.3 stations in the RNS are encouraged, in the vicinity of urban areas, to use the centre gap of the FS RF arrangements in Recommendation ITU-R F.1520;

3 that the following Notes are considered as part of this Recommendation.

NOTE 1 – Annex 1 provides a summary of the conducted sharing studies. Annex 2 provides characteristics of existing airborne systems operating in the RNS in the frequency band 31.8-33.4 GHz. Characteristics of systems in the FS operating in the frequency band 31.8-33.4 GHz are contained in Recommendation ITU-R F.758.

NOTE 2 – Annex 3 outlines potential mitigation techniques and operational measures applicable to systems in the FS as well as airborne systems in the RNS.

NOTE 3 – ATPC is efficient in reducing the interference from systems in the FS to systems in the RNS, but may make FS receivers more susceptible to interference from systems in the RNS. ATPC may also be required to the RNS for its protection.

Annex 1

Summary of sharing studies between stations in the FS and airborne stations in the RNS

1 Background

Resolution 126 (WRC-97) resolved to conduct, as a matter of urgency, the appropriate studies in time for WRC-2000 to determine what criteria would be necessary for sharing between stations in the fixed service and stations in the other services to which the frequency band 31.8-33.4 GHz is allocated. In response to this Resolution, ITU-R adopted Question ITU-R 224/9 (1997) addressing sharing criteria between stations in the FS and RNS in this band. The conducted sharing studies are summarized below.

2 Interference to the FS from the RNS

Calculation of separation distance is based on a probabilistic approach as well as on a deterministic approach (worst-case based on minimum coupling loss (MCL)). In principle, the studies show that if the required minimum separation distance between systems in the two services to preclude interference cannot be assured, then appropriate measures, including mitigation techniques and/or some restrictions on operational conditions, will be needed to facilitate sharing.

Further, the studies indicate that the concept of geographical coordination may be difficult to apply for the mobile radar systems.

The pulsed nature of the interfering radar signal allows for shorter separation distances compared to a non-pulsed interfering source. This has been taken into account in the relevant sharing studies as well as the impact of short duration pulsed, extremely high-power interference of the airborne radar system into the FS receiver.

The studies indicate that, without some operational restrictions and appropriate mitigation techniques, severe interference events may occur during exceptional main beam coupling between the antennas of the radar system and the fixed system.

Various combinations of aircraft altitudes, radar tilt angle and fixed system antenna elevation angle can generate such events. However, the probability of such events is expected to be low. Further, the events will be short in duration due to the narrow radar antenna beam and the antenna rotation.

The studies outlined necessary criteria, in terms of required mitigation techniques (see Annex 3) for the FS and primarily some limitations on radar operational altitude and/or tilt angle in particular in the vicinity of urban areas. In particular, the studies indicate that the fixed system antenna elevation angle and the radar tilt angle are crucial.

In cases where suitable mitigation techniques and/or restrictions on operational conditions are not applicable, appropriate and agreed operational procedures should be applied.

3 Interference to the RNS from the FS

Considering traditional point-to-point (P-P) systems with a low density of terminals, assuming worst-case scenarios and operational altitudes of the RNS above approximately 4 000 m and some limitations on the tilt angle, the sharing studies show that required unavailability criterion of the airborne radar system will be met.

Considering high-density point-to-multipoint (P-MP) applications, assuming densities of 1 000 [1] terminal stations/km^2 and 0.3 central stations/km^2, respectively, the sharing studies, using practical assumptions, show that the performance of the airborne radionavigation radar will be acceptable over urban areas. This conclusion is reached assuming that the aircraft operate at altitudes above roughly 6 000 m and with antenna down tilt angles of more than 20°. In addition, the antenna elevation angles of HDFS stations, oriented toward the aircraft, are encouraged not to exceed approximately 5°.

HDFS systems may require higher elevation angles than 5° in dense urban areas. For these cases appropriate mitigation techniques should be taken into account in order to reduce the possible interference to the airborne radar system.

Required criteria, in terms of required mitigation techniques and operational restrictions, are established in the conducted sharing studies. Used propagation models cover the most recent versions of Recommendations ITU-R P.452 and ITU-R P.676. The antenna radiation patterns are modelled by the most recent versions of Recommendations ITU-R F.699, ITU-R F.1245 and ITU-R F.1336. Technical characteristics for the considered P-P and P-MP systems in the FS are based on inputs from Recommendation ITU-R F.758.

Since the airborne radar operates throughout all phases of aircraft flight, it is not apparent that interference, without countermeasures, can be avoided in all cases.

Mitigation techniques such as high-performance antennas, ATPC, etc. implemented in future P-MP applications, will ensure that the availability criteria of the airborne radar system may be met. Concerning mitigation techniques for the radar system, frequency agile systems and pulse-coded systems have high potential with respect to the increase in the resistance to interference (see Annex 3 for more details).

4 Summary

The sharing studies show that high-density systems in the fixed service can coexist with the currently limited deployment of airborne systems in the RNS in the band 31.8-33.4 GHz. This conclusion is reached with the assumption of some limitations on both services.

Based on the above, WRC-2000 suppressed Resolution 126 (WRC-97) and in footnote RR No. 5.547A stated that administrations should take practical measures to minimize the potential interference between stations in the FS and airborne stations in the RNS in the 31.8-33.4 GHz band, taking into account the operational needs of the airborne radar systems.

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[1] The number of simultaneously active terminals is significantly lower than this figure.

Annex 2

Characteristics of radionavigation systems in the 31.8-33.4 GHz band

1 Operational conditions

Radionavigation systems identified to operate in the band 31.8-33.4 GHz are onboard aircraft. The system operates worldwide mostly continuously during flight. This encompasses an altitude range of from just off the ground to approximately 30 000 ft (or 9 000 m). Flight times can be up to six hours, and typically the majority of the time is spent en route, but some longer time at either the departure or destination points is expected. Information from one administration indicates that it operates a limited number of aircraft worldwide with radionavigation systems in this frequency band.

Up to 18 aircraft operating these radionavigation systems can be active in a small geographic area (i.e. separated by less than a kilometre from each other), though most often only 1 to 3 aircraft will be operating simultaneously together.

The term "radionavigation" throughout this Recommendation refers to an airborne radar system operating in the 31.8-33.4 GHz band. One administration has reported worldwide use of this band for the RNS in terms of a limited number of airborne radar systems. The actual radar system is used for ground mapping, weather avoidance and navigation, but not primarily for functions such as airport approaching and landing. Future replacement of some of the fixed frequency systems with the frequency agile system is envisaged.

2 Technical characteristics

Two radar systems are implemented: one system using fixed frequency (of 80% of aircraft stations) and one system (of 20% of aircraft stations) with the option to use frequency agility (nine channels in the band 32.2-33 GHz). The technical characteristics of systems operating in the RNS are given in Table 1.

From the Table, it can be concluded that the concept of pulse compression technique using coded pulses (with error detection capability) is not implemented in the considered radar systems.

Furthermore, the large bandwidth of 37 and 17 MHz respectively in comparison to the bandwidth $1.2/0.2 = 6$ MHz (0.2 μs pulse width), indicates that digital signal processing is not utilized. From the Table, the radar term 10^6/(pulse repetition frequency (prf) × pulse width (μs)) is determined to 2 500 (System 1) and 3 125 (System 2). This factor is essential in determining protection criteria for stations in the FS interfered with radar systems.

It should be noted that the antenna rotation is mechanically, i.e. the antenna beam is not electronically controlled.

TABLE 1

Technical characteristics of systems in the RNS operating in the band 31.8-33.4 GHz

Parameter	System 1	System 2
Tuning type	Fixed frequency; tunes continuously across 31.8-33.4 GHz	Fixed frequency or frequency hopping; operates in either mode on one of nine discrete channels spaced 100 MHz apart (32.2-33 GHz)
Emission type	Unmodulated pulses	Unmodulated pulses
RF emission bandwidth (MHz)	37	17 (instantaneous) 117 (hopping)
Pulse width (μs)	0.2	0.2
prf (pps)	2 000	1 600
Peak transmitter power (kW)	60	39
Receiver IF bandwidth (–20 dB) (MHz)	40	17
Receiver noise figure	11	11
Antenna type	Parabolic reflector	Parabolic reflector
Antenna main beam gain (dBi)	44	41.1
Antenna scan	Elevation: –30° to +10°, manual Azimuth: 360° at 7, 12, or 21 rpm	Elevation: –30° to +10°, manual Azimuth: 360° at 12 or 45 rpm

Annex 3

Mitigation techniques and operational measures

1 Technical and operational measures

RR footnote No. 5.547A states that administrations should take practical measures to reduce the potential interference between airborne stations in the RNS and stations in the FS in the band 31.8-33.4 GHz, taking into account the operational needs of the RNS.

This Annex provides guidance on technical and operational measures that may reduce the potential interference.

2 Measures – FS

Enhancements to future FS systems in terms of ATPC and robust error correcting coding should be easy and relatively inexpensive to implement. In particular, in combination with bit interleaving (see Recommendation ITU-R F.1097), FEC has shown to be efficient with respect to particularly short duration burst errors.

In order to further reduce the potential for interference, certain access/modulation techniques less susceptible to pulsed energy, robust synchronization schemes and RF-blocking filter are available to the FS. Furthermore, improved antennas combined with modest limitations on elevation angle will reduce the potential for interference between both systems.

However, too stringent limitations on antenna elevation angle may tend to limit the architecture of P-P and P-MP systems to be deployed in the 31.8-33.4 GHz band.

3 Measures – RNS

Possible measures include consideration of operational altitude, antenna down-tilt angle, priority channel schemes, RF-filtering and pulse coding for future systems.

Mitigation techniques in terms of pulse coding for the RNS means that the radar transmits a coded sequence in each burst (a "signature" for the radar station equivalent to the principal of spread spectrum systems). The processing gain achieved thereby has the effect of increasing the signal-to-noise ratio in the radar receiver, which improves the radar performance in an interference environment. Similar RNS applications in other bands have implemented pulse coding as an efficient mitigation technique.

Retrofitting existing radionavigation equipment with pulse coding circuitry would not be feasible, but the requirement for future equipment is possible. In particular, the frequency agile mode of the RNS system will improve the sharing possibilities. This should be viewed in the light that operational limitations on the RNS may in some cases be difficult to implement due to the high mobility of the service and the demands of the service to use the full capability of the system when sufficiently removed from the urban environment.

However, in order to provide some measures of protection for the FS, in particular in urban areas, the RNS may be able to take certain operational measures, such as channel selection to reduce interference and minor limitations on operational altitude and/or tilt angle. Below certain altitudes and down-tilt angles of its antenna, airborne radars operating in the RNS may cause interference to stations operating in the FS. It is possible that these particular modes of the radar represent a small per cent of time of its overall operation, or that operational agreements between the services can be reached on a local basis to minimize the amount of time that these modes are used. In either of these cases, the potential for interference can be greatly minimized. Further, it has been identified that the radionavigation systems are either tunable or use discrete channel frequencies. It is also possible that either through judicious selection in the FS frequency planning or operational selection of frequency of operation of the radionavigation systems the potential for interference can be minimized, e.g. that the stations in the RNS systems are encouraged, in the vicinity of urban areas, to use the centre gap of the FS radio-frequency arrangements contained in Recommendation ITU-R F.1520.

Both of the above possibilities will require further cooperation between the radio services in the future.

4 Band segmentation

Band segmentation would reduce the efficiency of spectrum use, providing less bandwidth needed for the frequency hopping systems in the RNS and possibly insufficient bandwidth for channel plans and separation requirements for forward and return links in the FS. Therefore, band segmentation should not be implemented.

5 Summary

In order to eliminate or reduce the potential for interference operational measures and efficient mitigation techniques are recommended.

The interference from radar to the FS is usually considered as the worst case. Stations in the FS may, with low probability, be exposed to severe interference from the airborne stations in the RNS, having a very short duration (a few milliseconds). Suitable mitigation technique for this type of short-duration interference is error-correcting coding which will reduce the effects of this type of short-term interference.

P-MP systems, using sectored or omnidirectional antennas may, in some cases, experience severe interference with slightly longer duration due to the wider antenna beamwidth. Mitigation techniques such as spread spectrum systems (code division multiple access (CDMA)), FEC coding, antenna selection, BIT or diversity are commercially available techniques which reduce the potential for interference.

Concerning the long-term interference due to spurious radar-emission, an RF blocking filter (at the fixed receiver site) may be used to protect the FS station from radar interference.

In addition, RF wave-guide filters at the radar transmitter will suppress radar spurious emissions by additionally 40 to 50 dB.

In concluding, the potential for interference between airborne stations in the RNS and stations in the FS can be reduced by implementing the following options, where possible or practical (see also Recommendation ITU-R F.1097):

FS

– ATPC (see Note 3).

– FEC coding.

– BIT.

– Spread spectrum systems (CDMA).

– Frequency hopping.

– Microwave RF filters (including RF blocking filter at the receiver).

– High performance antennas.

– Limited antenna elevation.

RNS

– Pulse compression (future systems).
– Frequency hopping.
– Microwave transmitting RF filters.
– Antenna selection (radiation pattern).
– Restrictions on operational altitude (in the vicinity of urban areas).
– Restrictions on down tilt angle (in the vicinity of urban areas).