RECOMMENDATION ITU-R M.1372-1*

Efficient use of the radio spectrum by radar stations in the radiodetermination service

(Questions ITU-R 35/8 and ITU-R 216/8)

(1998-2003)

Summary

This Recommendation provides some of the methods that can be used to enhance compatibility between radar systems operating in radiodetermination bands. Several receiver post-detection interference suppression techniques currently used in radionavigation, radiolocation and meteorological radars are addressed along with system performance trade-offs (limitations), associated with the interference suppression techniques.

The ITU Radiocommunication Assembly,

considering

a) that the radio spectrum for use by the radiodetermination service is limited;

b) that the radiodetermination service provides essential functions;

c) that the propagation and target detection characteristics to achieve these functions are optimum in certain frequency bands;

d) that the necessary bandwidth of emissions from radar stations in the radiodetermination service are large compared with emissions from stations in many other services;

e) that efficient use of the radio spectrum by radar stations in the radiodetermination service can be achieved by reducing transmitter unwanted emissions and utilizing interference suppression techniques;

f) that methods to reduce spurious emissions of radar stations operating in the 3 GHz and 5 GHz bands are addressed in Recommendation ITU-R M.1314;

g) that the inherent low duty cycle of radar systems permits the use of interference suppression techniques to enable radar stations in close proximity to use the same frequency,

recommends

1 that interference suppression techniques such as, but not limited to, those contained in Annex 1, should be considered in radar stations to enhance efficient use of the spectrum by the radiodetermination service.

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* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Maritime Radio Committee (CIRM), and the World Meteorological Organization (WMO).

Annex 1

Interference suppression techniques

1 Introduction

As spectrum demands for radiodetermination bands increases, new radar systems will need to utilize the spectrum more effectively and efficiently. There will be heavily used areas throughout the world where radiodetermination systems will have to operate in high pulse density environments. Therefore, many radar systems may be subjected to pulsed interference in performing their missions. The incorporation of interference suppression circuitry or software in the design of new radar systems will ensure that system performance requirements can be satisfied in the type of pulsed interference environment anticipated.

Interference suppression techniques, are generally classified into three categories: transmitter, antenna, and receiver. Receiver interference suppression techniques are more widely used. Receiver interference suppression techniques are categorized into predetection, detection and post-detection.

The following is a brief discussion of several interference suppression techniques currently used in radionavigation, radiolocation and meteorological radars. System performance trade-offs (limitations), are also addressed for many of the interference suppression techniques.

2 Antenna beam scanning suppression

Interactions between two radars of different types almost always involve asynchronism between the scanning of the two antenna beams. Consequently, the situations that are normally of concern are limited to:

– radar side lobe/back lobe to radar side lobe/back lobe;

– radar main beam to radar side lobe/back lobe;

– radar side lobe/back lobe to radar main beam.

The antenna side-lobe and back-lobe levels are generally determined by the radar antenna type (e.g. reflector, slotted array, or distributed phased array). Reflector type antennas typically have average antenna back-lobe levels of –10 dBi. Consequently, back-lobe-to-back-lobe coupling is typically 70 to 80 dB weaker than main-beam-to-main-beam coupling. Slotted array antennas and distributed phased array antennas can achieve back-lobe levels of approximately –30 to –40 dBi resulting in back-lobe-to-back-lobe coupling typically 90 to 120 dB weaker than main-beam-to-main-beam coupling.

The power coupled between two radars (radar 1 and radar 2) is proportional to the sum of the gain of radar 1 antenna in the direction of radar 2 the gain of radar 2 antenna in the direction of radar 1. The sum of the two antenna gains (G1(dBi) + G2(dBi)) is commonly referred to as the mutual antenna gain. As the two antennas rotate, the mutual gain fluctuates rapidly by large amounts. Since the rotations of the two radar antennas are asynchronous, i.e. since their rotation rates are not rationally related, any one point on each radar's antenna's pattern lies in the direction of the other radar shifts progressively through every point on that other radar's pattern. Eventually, the main-beam peak of each antenna will point toward the other radar at the same time. However, that event will be exceedingly rare and fleeting. The vast majority of the time, illuminations of each radar by the other radar's main beam will occur when the other radar illuminates the weak side lobe of the other radar.

This is especially the case when 3-dimensional radars, which use pencil beams scanned in elevation as well as azimuth, interact with 2-dimensional radars, which almost invariably scan only in azimuth. Thus, the pencil beams of 3-dimensional radars normally spend much of the time searching regions above the horizon, where they cannot couple strongly to the surface-based radionavigation radars. Furthermore, some 3-dimensional radars often use electronic steering and scan in deliberately pseudo-random patterns or patterns that are quasi-random because they adapt to the target environment. In such cases, the main beam of the 3-dimensional radars revisit the direction of 2-dimensional radars only at irregular intervals instead of periodically. The fact that main beams of all radars are narrow causes the fraction of time during which main-beam-to-main-beam conjunctions prevail to be extremely small.

Figure 1 shows a temporal pattern of mutual gain between two planar-array radar antennas with both radar antenna beams scanning the horizon. Figure 2 shows the temporal pattern of mutual gain between two planar-array radars with one of the radars beam scanning 45° above the horizon. Figure 3 shows a mutual antenna gain distribution for two reflector type antenna radars with gains of 27 dBi on the horizon. The Figure shows that only three per cent of the time the mutual antenna gain exceeds 0 dBi, and fifty per cent of the time the mutual antenna gain is below –19 dBi. Figure 3 also shows mutual antenna gain curves for two planar array type antennas with both radar main beams on the horizon, and with one main beam elevated 45°.

FIGURE 1

Sample of mutual-gain pattern for planar-array RL and RN radar antennas with RL beam on horizon (spans 7 scans of the RL radar antenna)