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INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

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Joint Rapporteur Group 8A-9B

LIAISON STATEMENT TO WP 8B

DISCUSSIONS ON RLAN DYNAMIC FREQUENCY SELECTION

JRG 8A-9B would like to thank WP 8B and its members for contributions received in the DFS Correspondence Group. JRG 8A-9B believes that valuable progress has been made on this subject and is seeking approval from WP 8A to consider a direct contribution to SG 8 to allow this document to go to DNR status. JRG 8A-9B would like to provide a current copy of this document for use in WP 8B's deliberations on the information requested below and would seek their continued participation in the DFS Correspondence Group.

In-service monitoring

In discussions of appropriate in-service monitoring for DFS to ensure protection of radiodetermination systems in the 5 GHz band associated with WRC-03 agenda item 1.5, JRG 8A-9B found a requirement to define the probability of a device using DFS detecting the radar system (see Annex 3 of the Attachment). JRG 8A-9B requests that WP 8B review this requirement and provide input on the required levels to JRG 8A-9B and that this information be made available to the DFS Correspondence Group. Given the need to complete the technical work on the DFS characteristics prior to the next SG 8 meeting it is requested that this information be developed prior to completion of the September 2002 WP 8B meeting.

Attachment: Document 8A-9B/TEMP/96: PDNR ITU-R M.[8A-9B/RLAN-DFS]

Attachment

Source: Document 8A-9B/TEMP/96

PRELIMINARY DRAFT NEW RECOMMENDATION ITU-R M. [8A-9B/RLAN-DFS]

Dynamic frequency selection (DFS)[1] in wireless access systems including RLANs for the purpose of protecting the radiodetermination service in the 5 GHz band

(Questions ITU-R 212/8 and 142/9)

The ITU Radiocommunication Assembly,

considering

a) that WRC-03 will consider an allocation to the mobile service in the bands 5 150-5 350 MHz and 5 470-5 725 MHz for the implementation of wireless access systems including RLANs under Resolution 736 (WRC-2000);

b) that there is a need to provide globally harmonized frequencies in the bands 5 150-5 350 MHz and 5 470-5 725 MHz for the mobile service for wireless access systems including radio local area networks (RLANs);

c) that the band 5 250-5 350 MHz is allocated to the radiolocation service on a primary basis; that the band 5 250-5 350 MHz is also allocated to the Earth exploration-satellite service (EESS) (active) on a primary basis;

d) that WRC-03 will consider additional primary allocations for the Earth exploration-satellite service (active) and space research service (active) in the frequency range 5 460-5 570 MHz;

e) that the band 5 470-5 650 MHz is allocated to the maritime radionavigation on a primary basis;

f) that the band 5 350-5 650 MHz is allocated to the radiolocation service on a secondary basis;

g) that WRC-03 will consider a review, with a view to upgrading, of the status of frequency allocations to the radiolocation service in the frequency range 5 350-5 650 MHz;

h) that ground-based radars used for meteorological purposes are authorized to operate in the band 5 600-5 650 MHz on a basis of equality with stations in the maritime radionavigation service (see RR No. 5.452);

j) that the band 5 650-5 725 MHz is allocated to the radiolocation service on a primary basis;

k) that procedures and methodologies to analyse compatibility between radars and systems in other services are provided in Recommendation ITU-R M.1461;

l) that representative technical and operational characteristics of radiolocation, radionavigation and meteorological radars are provided in DNR ITU-R M.[Doc. 8/74];

m) that Recommendation ITU-R M.1313 provides typical technical characteristics of maritime radionavigation radars in, *inter alia*, the band 5 470-5 650 MHz;

n) that wireless access systems including RLANs are capable of operating both indoor and outdoor;

o) that there is a need to protect the radars in the radiodetermination service operating in the bands 5 250-5 350 and 5 470-5 725 MHz,

recognizing

a) that the high RF power level and the receiver sensitivity of radars in the radiodetermination service in conjunction with the expected high density of wireless access systems including RLANs would, in general, not enable wireless access systems including RLANs and radars to operate satisfactorily on a co-channel basis in the absence of mitigation techniques;

b) that these wireless access systems including RLANs could be deployed in these bands as licence-exempt devices, consequently making control of their deployment density more difficult;

c) that there are various standards for RLAN specifications;

d) that administrations may consider procedures to confirm the ability of interference avoidance mechanisms to function correctly in the presence of the radar systems deployed in this band,

recommends

1 that, in order to facilitate sharing with radars, mitigation techniques as described in Annexes 1 and 2 be implemented by wireless access systems including RLANs in the bands used by radars at 5 GHz;

2 that the mitigation techniques comply with the detection and response requirement as given in Appendix 2 of Annex 2.

Annex 1

of DNR ITU-R M.[8A-9B/RLAN-DFS]

Dynamic frequency selection (DFS) in wireless access systems including RLANS[2]

Resolution 736 calls, *inter alia*, for studies on the feasibility of sharing between the mobile service for "wireless access systems including RLANs"[3] and the radiodetermination service in the frequency bands 5 250-5 350 and 5 470-5 725 MHz. Link budget calculations have shown that interference mitigation techniques are required to enable sharing of WAS with other services such as radar systems. This DNR describes the interference mitigation technique(s) Dynamic Frequency Selection[4] as specified in the 5 GHz RLAN standards, with performance calculations based on typical implementations.

WAS and radars operating in the 5 GHz band will interfere when operating at the same frequencies and within range of each other.

Dynamic Frequency Selection (DFS) has then been envisaged to:

- **ensure a spread of the loading across the available spectrum of the WAS under the field of view of a satellite to reduce the aggregate emission levels at the satellites of the FSS (feeder links) and EESS (active) from WAS; and**
- **avoid co-channel operation with other systems, notably radar systems.**

Extension of the use of DFS as described herein allows WAS to avoid interfering with the radiodetermination service. The general principle applied is that WAS should detect interference and identify radar interferers and shall not use those frequencies used by the radar. Annex 4 provides a methodology for conducting sharing studies and a definition of a baseline scenario.

Annex 2

of DNR ITU-R M.[8A-9B/RLAN-DFS]

The use of dynamic frequency selection (DFS) in wireless access systems including RLANs for the purpose of protecting the radiodetermination service in the 5 GHz band

Scope of this Annex

WAS and radars operating in the 5 GHz band will mutually interfere when operating at the same frequencies and within range of each other. This Annex describes objectives and means to mitigate such interference.

An example of how a DFS mechanism could be described is given in Appendix 1 of this Annex.

The implementation of radar detection mechanisms and procedures used by WAS are outside the scope of this Annex 2. The main reasons for this are that:

a) WAS design affects implementation;

b) practical experience may lead to innovative and more efficient means than can be formulated today;

c) different manufacturers may make different implementation choices to achieve the lowest cost for a given level of performance; therefore only performance criteria rather than specifications for a particular mechanism should be given in regulatory documents.

Objective of the use of DFS with respect to radars

The objective of using DFS in WAS is to protect radars in the 5 GHz band. This is achieved by avoiding the use of or vacating a channel identified as being occupied by radar equipment based on detection of radar signals.

For the purpose of the Annex, a discussion of Radiodetermination systems in the 5 GHz range utilized in determining DFS characteristics can be found in Appendix 3.

DFS Performance Requirements

The DFS performance requirement is stated in terms of response to detection of an interference signal.

5 GHz WAS should meet the following detection and response requirements.

Procedures for compliance verification should be incorporated in relevant industry standards for RLANs.

Detection Requirement

The DFS mechanism should be able to detect interference signals above a minimum threshold. Detection times are given in Appendix 2 of this Annex.

NOTE − Actual detection time will depend on the strength and duration of the detected signal as well as on the type of radar system and its mode of operation. A lower value of the detected signal strength may cause a longer detection time but it also indicates a lower probability of interference between the systems.

Response Requirement

1) **If the WAS has not previously been in operation, it should not start transmission in any channel where the detection mechanism has determined that there is a radar signal present.**

2) **WAS should use detection time periods given in Appendix 2.**

NOTE − For WAS to resume operation on another channel in a coordinated fashion, some communication is required between the devices making up the WAS. Thus, operational traffic can be stopped very quickly upon detection of the radar signal but some intermittent control traffic will be needed after that.

Appendix 1

(to Annex 2)

Example Radar detection and associated DFS procedures

The purpose of this appendix is to describe how a WAS *could* implement radar detection and the associated procedures for clearing a channel so as to avoid interfering with a radar system. The actual operation may vary with the type of WAS and with the actual design of a specific RLAN implementation, however, the general definitions and rules described in this Appendix should be followed. Annex 4 provides methodology for conducting sharing studies and a definition of a baseline scenario.

The description is given in terms of a set of *definitions* and *rules.*

1 Definitions

The following definitions are given for use within this document:

Available Channel:	**A radio channel on which a *Channel Availability Check* has not identified the presence of a radar.**
Channel Availability Check	**A check during which the WAS listens on a particular radio channel to identify whether there is a radar operating on that radio channel.**
In-Service Monitoring	**Monitoring of the *Operating Channel* to check that a co-channel radar has not moved or started operation within range of the WAS.**
Received Radar Signal	**A signal as defined in Section 1 of Appendix 2. This definition contains parameters for the received signal strength (field strength) threshold, pulse duration and pulse repetition rate.**
Operating Channel	**Once a WAS starts to operate on an *Available Channel* then that channel becomes the *Operating Channel*.**
Channel Move Time	**The time needed by a WAS to cease all transmissions on the Operating Channel upon detection of an interfering signal above the DFS detection threshold. Transmissions during this period will consist of intermittent management and control signals required to facilitate vacating the Operating Channel.**
DFS Detection threshold	**The required detection level defined by detecting a received signal strength (RSS) that is greater than a threshold of [tbd] dBm within the WAS channel bandwidth.**

2 Procedures

2.1 Finding an initial Available Channel

Before a WAS transmits, and if no *Available Channel* has yet been identified, it shall undertake a *Channel Availability Check* on a radio channel before it is used for transmission. Consequently, when a network is installed and first powered on, *Channel Availability Check*(*s*) should be undertaken, so as to identify at least one *Available Channel*. Having identified an *Available*

***Channel*, the WAS can start operation on that channel; the checking of other radio channels to identify other *Available Channels* is optional.**

2.2 Starting Operation

Once a WAS starts to operate on an *Available Channel* then that channel becomes the *Operating Channel*.

2.3 Monitoring the Operating Channel

***In-Service Monitoring* is performed by the WAS to re-check the *Operating Channel* for co-channel radar signals that may have come within range of the WAS or started operation on the *Operating Channel*.**

3 Implementation Aspects

The following text is provided for informative purposes.

WAS should incorporate the following mechanisms in order to fulfill radar interference mitigation:

- **Means to perform the detection of signals that meet the specifications given in Section 1 of Appendix 2.**
- **Means to inform the associated stations of the WAS of the presence of a radar and/or change of status of the *Operating Channel* and of the status of other Channels.**

3.1 Radar Signal Detection

Radar signals may occur at any time and they may occur in the presence of co-channel WAS signals.

While finding an initial *Available Channel*, the WAS will not be operational and this will assure rapid and reliable detection of any radar signal with the possible exception of very slowly rotating radars. However, these will be detected by the *In-Service Monitoring*.

During *In-Service Monitoring* the radar detection function continuously searches for radar signal patterns - during or in between normal WAS transmissions. For weakly received radar signals, this may increase the time needed for radar signal detection. This is reflected in the criteria proposed in the Appendix 2 of this Annex.

3.2 Channels Move Time

Every WAS has at least one device - e.g. an Access Point - that plays a coordinating role. This device also has the responsibility to coordinate, after a radar presence has been detected, the cessation of use of the *Operating Channel* and the move to an *Available Channel*.

Such coordination requires the broadcasting of commands to cease all operational transmission and to affect a move to (one of) the *Available Channels* identified by the *Channel Availability Check*. This broadcast will be repeated a number of times to assure reception by all member devices. Part of the RLAN population may be in so-called Sleep Mode in which the devices re-awaken at intervals of typically hundreds of milliseconds but extremes of up to 60 seconds are possible. Disregarding the latter, the broadcast has to be repeated a number of times during the *Channel Move Time* to assure that for all practical purposes, all of the RLAN devices will have left the channel.

Appendix 2

(to Annex 2)

Radar signal detection criteria

1 Detection Criteria

The radar signal to be detected by a WAS is defined as follows:

- **the received signal strength (RSS) shall be greater than a DFS detection threshold level of [tbd] dBm within the WAS channel bandwidth;**
- **pulse repetition rates in the range 200-4000 pulses per second;**
- **nominal pulse widths in the range 0.1-100 μs.**

2 Behavioural Criteria

The following table provides values for the specified parameters associated with the behaviour of WAS. The operating procedures and the definition of these parameters are given in the Appendix 1 of this Annex. Annex 3 describes a methodology to calculate probability of detection for WAS devices using DFS during In-Service Monitoring.

Parameter	Value
Channel Availability Check time	[60 sec prior to use a channel]
In-Service Monitoring detection probability	tbd
Channel Move Time	[10] s

Appendix 3

(to Annex 2 to Attachment 10)

Use of Characteristics of radiolocation, maritime radionavigation and meteorological radars

The technical characteristics of some meteorological, radiolocation and maritime radionavigation radars operating in the bands between 5 250-5 350 MHz and 5 470-5725 MHz can be found in ITU Recommendation M.[SG8/74]. This information is used for the determination of the technical requirements of the Dynamic Frequency Selection (DFS) mechanism to be implemented in the Radio LAN, which is identified as necessary to enable the introduction of WAS in the mobile service (to be considered under Resolution 736, WRC-2000) in these frequency bands used by radars. Specifically radars A-S are considered in development of DFS characteristics.

Table 1 below gives the allocations of sub-bands of the 5 GHz range to the Radiodetermination service:

TABLE 1

Band (MHz)	Allocation
5 250-5 255	Radiolocation
5 255-5 350	Radiolocation
5 350-5 460	Aeronautical Radionavigation
5 460-5 470	Radionavigation
5 470-5 650	Maritime Radionavigation (Note 1)
5 650-5 725	Radiolocation
5 725-5 850	Radiolocation

NOTE 1 – In accordance with 5.452 of Radio Regulations, between 5 600 and 5 650 MHz, ground-based radars for meteorological purposes are authorized to operate on a basis of equality with stations in the maritime radionavigation service.

NOTE 2 – This document does not consider the aeronautical radionavigation radar since the 5 GHz band allocated to the ARNS is the frequency band 5 350-5 460 MHz which is not envisaged for the introduction of WAS in the mobile service.

Annex 3

Methodology to Calculate the probability of detection of radars by WAS devices using DFS in the 5 GHz band during In-Service Monitoring

The following methodology considers the probability that a WAS device operating in the 5 GHz band using DFS will successfully detect during In-Service Monitoring a 5 GHz radar operating in the radiodetermination service.

1) Determine the amount of time that an individual device will be in the mainbeam of the radar antenna (i.e. 3 dB beamwidth/antenna scan rate). Table 1 identifies the radar parameters to be used as a baseline in the study.

TABLE 1

Radar	A	C	E	F	G	H	I	J
3 dB Beamwidth (degrees)	0.65	0.95	0.55	1	1.65	0.5	0.5	1.5
Scan Rate (degrees/sec)	0.65	36	24	48	48	18	18	1.2
Analysis Time (msec)	1000	26	23	21	34	28	28	1250
Radar	P	Q	S					
3 dB Beamwidth (degrees)	2.6	1.6	2					
Scan Rate (degrees/sec)	72	90	20					
Analysis Time (msec)	36	18	100					

2) Radars K, L, M, N, O and R are not listed in the table because these radars do not utilize a 360 degree scan type of function. For these radars, it is recommended to use an analysis time of 100 msec.

3) Based on a distribution of WAS devices using data rates as shown in Table 2 below, create a waveform to represent 1500 byte packets, and listening periods in length (x)*9 + 50 microseconds, where x is a random integer between 2 and 32 (i.e. 31 discrete possible durations, uniformly distributed).

TABLE 2

Device Data Rate (Mbit/sec)	Device Weighting Factor
6	0.1
12	0.1
18	0.1
24	0.3
36	0.3
54	0.1

The waveform is created by first selecting the data rate of the device transmitting a packet, using the weighting factors shown above. A simulated 1500 byte packet is then created using the data rate selected. The packet is followed by a quiet period that is required by the WAS network to facilitate the multiple devices using the network sharing the access media (i.e. the WAS channel). This quiet period is available for in-service monitoring. The quiet period is chosen as defined above. Another 1500 byte packet is then created in the same manner as the first, with another quiet period following. This is repeated until the waveform is the same length (in time) as the duration of time a WAS device is in the mainbeam of the antenna, as calculated in 1.

4) Create a waveform based on the Pulse Repetition Rate and pulsewidth of the radar being analysed. The values to be used for the baseline are shown in Table 3 below. The waveform should be of the same duration as calculated in 1.

TABLE 3

Radar	A	C	E	F	G	H	I	J	
Pulse Width (:sec)	2	0.95	1.1	0.8	3	0.8	0.8	0.1	
PRR (pps)	250	200	2000	250	259	250	200	100,000	
Radar	K	L	M	N	O	P	Q	R	S
Pulse Width (:sec)	1	0.25	0.25	0.25	100	20	1	7	1
PRR (pps)	3000	200	200	200	320	500	750	1000	200

5) Determine if a detection event occurs by determining if radar pulses in the simulated radar waveform align with the listen periods in the simulated RLAN network waveform.

6) Repeat the simulation multiple times, recording the occurrence, or lack of occurrence of detection events, using this data to calculate the probability of detection (i.e. percentage of simulations during which the radar pulse is considered to be detected).

7) Probability of detection in n rotations:

p = probability of detection in one rotation;

pn = probability of detection in n rotations;

$$pn = 1-(1-p)^n$$

Annex 4

Methodology for conducting sharing studies involving WAS including RLANs and Radiodetermination Systems in the 5 GHz Band

The following considerations should be utilized to define the baseline scenario for studies to be conducted in determining DFS parameters:

1) **Recommendation ITU-R M.1461 should be utilized in interference calculations.**

2) **Three concentric rings should be utilized to define the RLAN deployment as shown in *Table 1*. Uniform distribution of devices in each zone should be utilized throughout each volumetric zone including height.**

TABLE 1

WAS user Distribution

	Urban Zone	Suburban Zone	Rural Zone
Radius from the centre	0-4 km	4-12 km	12-25 km
WAS user Percentage	60%	30%	10%
Building Height	30 m	6 m	6 m

3) **A total of 2753 WAS devices operating on a co-channel basis with a radiodetermination system at a given moment should be utilized.**

4) **WAS Power distribution in *Table 2* should be utilized.**

TABLE 2

WAS Power distribution

Power level	1 W	200 mW	100 mW	50 mW
% of WAS users	5%	25%	40%	30%

5) **Tracking radars should be modeled starting with random placement and a random start angle and then moved directly overhead to the opposite horizon.**

6) **Maritime radars should be modeled starting at the horizon to the rural area and tracked into the center of the Urban zone.**

7) **Airborne radars should be modeled starting at the horizon to the rural area and tracked over the center of the Urban zone.**

8) **If a sufficient Channel Availability Check time is utilized it is expected that fixed scanning radars will be protected at the threshold levels discussed. Therefore the studies should focus on the following radars:**

K, P, Q, R, S as defined in ITU-R DNR M.[SG 8/74].

9) **For ground-based radars a random propagation factor should be utilized in determining the propagation pathloss to each WAS device. A value from 20 to 35 Log D should be used. In addition a random building/terrain propagation attenuation should be used. A value from 0 to 20 dB should be used.**

9*bis*) For airborne radars, free space loss + 17 dB should be used.

9*ter*) For maritime radars, free space loss + 0 to 20 dB should be used.

10) A smooth earth line-of-sight calculation should be utilized. Any WAS devices beyond the line-of-sight should be discounted.

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[1] Dynamic Frequency Selection (DFS) is a general term used in this Recommendation to describe mitigation techniques that allow, amongst others, detection and avoidance of co-channel interference with respect to radar systems.

[2] RLANs are described in M.1450.

[3] Throughout this Recommendation the term WAS is used to replace “Wireless Access Systems including RLANs”.

[4] The DFS feature was specified in the 5 GHz RLAN standards initially in order to mitigate interference among uncoordinated RLAN clusters, and to provide optimised spectral efficiency for high capacity high bit rate data transmission.