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Technical Report

Broadband Radio Access Networks (BRAN);
5 GHz high performance RLAN;
Guide to the implementation of
Dynamic Frequency Selection (DFS)

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Broadband Radio Access Networks (BRAN).

The basis for this work was a document submitted by the Wi-Fi Alliance Regulatory Task Group as an Associate Member of ETSI. The initial goal of this coordination was to advance global 5 GHz spectrum access through harmonization of RLAN regulations.

1 Scope

Due to the scarcity of radio frequency spectrum, many radio systems have to share spectrum with other radio systems - in one form or another; 5 GHz Wireless Access Systems including Radio Local Area Networks (WAS/RLANs), also known as Wireless LANs, radio LANs, or RLANs, are no exception. Wireless LANs are allowed to operate in the 5 GHz bands which are also used by many radar systems.

The present document is intended to help the designers of Wireless LANs that operate in the 5 GHz frequencies understand the requirements for radar detection and avoidance. The performance requirements of such a mechanism, also known as DFS or Dynamic Frequency Selection, is further described in EN 301 893.

NOTE: It is advised to download the latest version of EN 301 893.

The present document deals only with the regulatory requirements and the philosophy under which they were issued. It does not provide design rules or example implementations. By avoiding such "blueprint" material, innovation among Wireless LAN designers is maintained and encouraged.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[i.2] ETSI EN 301 893 (V1.2.3): "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.3] ETSI EN 301 893 (V1.3.1): "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.4] ETSI EN 301 893 (V1.4.1): "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.5] ETSI EN 301 893 (V1.5.1): "Broadband Radio Access Networks (BRAN); 5 GHz high performance RLAN; Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

[i.6] ETSI TR 102 439 (V1.1.1): "Broadband Radio Access Networks (BRAN); Test Report Template for testing to EN 301 893 (V1.3.1) (R&TTE)".

[i.7] ETSI TS 101 475 (V1.3.1): "Broadband Radio Access Networks (BRAN); HIPERLAN Type 2; Physical (PHY) layer".

[i.8] ITU-R Recommendation M.1652: "Dynamic frequency selection (DFS) in wireless access systems including radio local area networks for the purpose of protecting the radiodetermination service in the 5 GHz band".

[i.9] ITU-R Recommendation M.1638: "Characteristics of and protection criteria for sharing studies for radiolocation, aeronautical radionavigation and meteorological radars operating in the frequency bands between 5 250 and 5 850 MHz".

[i.10] ERC Decision (99)23 of 29 November 1999 on the harmonised frequency bands to be designated for the introduction of High Performance Radio Local Area Networks (HIPERLANs).

[i.11] ECC Decision(04)08 of 9 July 2004 on the harmonised use of the 5 GHz frequency bands for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs).

[i.12] ITU-R Resolution 229: "Use of the bands 5 150-5 250 MHz, 5 250-5 350 MHz and 5 470-5 725 MHz by the mobile service for the implementation of wireless access systems including radio local area networks".

[i.13] Memorandum Opinion and Order FCC 06-96: "Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band".

[i.14] Report and Order FCC 03-287: "In the matter of Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band".

[i.15] Commission Decision 2005/513/EC of 11 July 2005 on the harmonised use of radio spectrum in the 5 GHz frequency band for the implementation of wireless access systems including radio local area networks (WAS/RLANs).

[i.16] Commission Decision 2007/90/EC of 12 February 2007 amending Decision 2005/513/EC on the harmonised use of radio spectrum in the 5 GHz frequency band for the implementation of Wireless Access Systems including Radio Local Area Networks (WAS/RLANs).

[i.17] ITU-R Report M.2115: "Testing procedures for implementation of dynamic frequency selection".

[i.18] NPRM FCC 03-110: "In the Matter of Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U NII) devices in the 5 GHz band".

[i.19] FCC Part 15.407: "Chapter I - Federal Communications Commission; Part 15 - Radio Frequency Devices - General technical requirements".

[i.20] IEEE 802.11: "IEEE Standard for Information Technology - Telecommunications and information exchange between systems - Local and Metropolitan networks - Specific requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications".

[i.21] IEEE 802.11a-1999 [ISO/IEC 8802-11:1999/Amd 1:2000(E)] (Supplement to IEEE Std 802.11, 1999 Edition): "Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHz Band".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purpose of the present document, the terms and definitions given in EN 301 893 and the following apply:

HIPERLAN 2: High Performance Radio Local Area Network type 2 as described in e.g. TS 101 475 [i.7]

3.2 Symbols

For the purposes of the present document, the following symbols apply:

dBi	antenna gain in decibels relative to an isotropic antenna
dBm	dB relative to 1 milliwatt
GHz	GigaHertz
Hz	Hertz
kHz	kiloHertz
MHz	MegaHertz

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 301 893 and the following apply:

DFS	Dynamic Frequency Selection
EIRP	Equivalent Isotropically Radiated Power
FCC	Federal Communications Commission
FH	Frequency Hopping
HIPERLAN	High Performance Radio Local Area Network
ITU	International Telecommunications Union
LAN	Local Area Network
MIMO	Multiple-Input and Multiple-Output
NTIA	National Telecommunications and Information Administration
pps	pulses per second
PRF	Pulse Repetition Frequency
R&TTE	Radio and Telecommunications Terminal Equipment
RADAR	RAdio Detection And Ranging
RF	Radio Frequency
RLAN	Radio Local Area Network
TCAM	Telecommunication Conformity Assessment and Market surveillance committee
TPC	Transmitter Power Control
WAS	Wireless Access System

4 Purpose of the present document

DFS is a sharing mechanism that will allow wireless LANs to share the 5 GHz frequency spectrum with various radar systems. DFS assures that the wireless LANs do not cause interference to the radar systems. EN 301 893, which is based on ITU-R Recommendation M.1652 [i.8] on DFS characteristics and parameters, provides detection threshold criteria and test patterns for DFS implementation. A DFS design that is able to meet all the test criteria may not necessarily detect all of the various radars in the real world.

The interaction between radar systems and wireless LANs is complex and the variation in radar characteristics is considerable. In order for DFS to be effective, it should be designed with a good understanding of these complexities and variations. The present document aims to facilitate that understanding and to help, indirectly assure that DFS designs meet their main purpose: effective detection and avoidance of co-channel operation with radar systems.

5 The importance of Spectrum Sharing

Spectrum sharing is rapidly becoming the solution to the increasing demands for bandwidth of many different applications. In the case of wireless LANs, the initial air interfaces used licence exempt spectrum (often called unlicensed spectrum) in the 915 MHz (US only) and 2,4 GHz bands, in which various kinds of low power radio and non-radio devices are allowed to operate, including industrial, scientific and medical systems.

As wireless LANs developed into a major communications technology, the market demand for more spectrum became apparent. Regulators world-wide stepped up to that challenge and after a long period of preparation, agreed to allow wireless LANs to operate in the 5 GHz band.

This is only one example of how demand for spectrum was met by allowing two different systems, RLANs and radar systems, to share a given frequency range.

Essential to the success of sharing spectrum now and in the future is that the deployed systems meet the necessary technical requirements for sharing. These requirements include the detection of other primary spectrum users and avoiding interference to them. Establishing the sharing criteria may be a technically complex and involved process, but it is of the utmost importance that technical experts developing such techniques are aware of the wider issues of sharing and communicate well with spectrum managers and incumbents.

Failure of the sharing regime in a given band has potentially severe ramifications. Depending on the regulatory regime, national administrations may take appropriate measures to withdraw non-compliant equipment from the market or from service, prohibit its placing on the market or putting into service or restrict its free movement.

With the above in mind, it will be clear that, to secure access to shared spectrum for future technologies and applications, the DFS based sharing regime developed for the 5 GHz band has to succeed. Its success depends primarily on the effectiveness of the DFS implementations in products that are brought to market. The present document is intended to help designers of DFS based equipment, to achieve that objective.

6 A short history of "DFS"

6.1 Europe Spawns the Idea

In 1999, the CEPT published ERC Decision (99)23 [i.10] on the harmonized frequency bands to be designated for the introduction of High Performance Radio Local Area Networks (HIPERLANs). In total 455 MHz of spectrum was allocated in Europe to these Hiperlans under more or less similar conditions (power levels, DFS, TPC), and this was later adopted as the basis for a global allocation at WRC-03. Devices operating in the band 5 150 MHz to 5 350 MHz were restricted to indoor use only and were limited to 200 mW EIRP. Outdoor operation was limited to 5 470 MHz to 5 725 MHz but they could use power levels up to 1 W EIRP. DFS and TPC were required when operating in 5 250 MHz to 5 350 MHz or 5 470 MHz to 5 725 MHz.

In the mean time ETSI had started the development of a Harmonized Standard that included the first DFS conformance specification ever developed. Initially, a standard was drafted specifically for HIPERLAN 2. That approach was changed in light of the success of the IEEE 802.11 [i.20] technologies and finally, in June 2003, ETSI sent the first version of the technology neutral harmonized standard, EN 301 893 [i.2], into national voting just prior to the start of the WRC-03.

6.2 ITU-R Recommendation M.1652

ITU-R Recommendation M.1652 [i.8] states that DFS is recommended in the 5 250 MHz to 5 350 MHz and 5 470 MHz to 5 725 MHz bands in order to eliminate potential RLAN interference to the radar systems. This mechanism is assumed to detect radar and to ensure that wireless LANs do not operate on those channels on which radars are operating.

This recommendation specifies the DFS detection and performance requirements but does not specify how DFS is to be implemented. However, it does define test procedures for validating DFS detection and performance.

6.3 WRC-03 - ITU-R Resolution 229

In 2003, after a preparation of many years, the International Telecommunications Union (ITU), at its World Radio Conference 2003 (WRC-03), agreed on a new frequency allocation on a co-primary basis to the mobile service for the implementation of wireless access systems including radio local area networks (WAS/RLANs) systems noting however that in the bands 5 250 MHz to 5 350 MHz and 5 470 MHz to 5 725 MHz, stations in the mobile service shall not claim protection from radiodetermination services. This was subject to technical and regulatory provisions included in the radio regulations, given in Resolution 229 [i.12] (WRC-03) that makes the Annex 1 of ITU-R Recommendation M.1652 [i.8] mandatory. This includes specific provisions to protect the incumbent systems; including military and weather radars.

6.4 DFS developments outside Europe: the example of the US

In 2000, as the RLAN industry in the US was preparing to enter the 5 GHz spectrum market with products designed to the IEEE 802.11a [i.21] standard, manufacturers with worldwide distribution were concerned that Europe would restrict this band to HIPERLAN (High Performance Radio LAN) products as specified in ERC Decision (99)23 [i.10]. HIPERLAN was a specific RLAN technology developed by ETSI. The ERC Decision (99)23 [i.10] mandated two mechanisms to protect radars and other primary users of this band: DFS (Dynamic Frequency Selection) and TPC (Transmit Power Control). As a result, a project, P802.11 TGh, was started to add these mechanisms in the IEEE 802.11 [i.20] standard, with the assumption that if these additional regulatory requirements were met, global adoption of IEEE 802.11a-1999 [i.21] would be possible.

At that time the 5 GHz band for RLANs in the US was restricted to the 5 150 MHz to 5 250 MHz, 5 250 MHz to 5 350 MHz and 5 725 MHz to 5 825 MHz bands, but planning was already in the works for the 2003 meeting of the World Radiocommunication Conference, to add the 5 470 MHz to 5 725 MHz band. This made DFS even more important for the US market. Over the course of the next three years, the FCC, with the help of the wireless LAN industry and the NTIA, developed the DFS rules for the US.

The spectrum used within US Federal agencies is administered by an Executive Branch organization known as the NTIA (National Telecommunications and Information Administration). Spectrum allocated for use by US commercial and private citizens is administered by the FCC (Federal Communications Commission).

When considering opening the 5 GHz band for use by wireless LANs, the NTIA expressed a strong desire that products entering the new band would adequately protect US military radars. This requirement was the basis of the US position at the WRC-03 which developed the first DFS requirements document - ITU-R Recommendation M.1652 [i.8].

During the period 2003 to 2006, the FCC with the help of the wireless LAN industry and the NTIA, developed the DFS rules for the US.

Since ETSI BRAN developed the first 5 GHz Harmonized Standard (EN 301 893 (V1.2.3) [i.2]) in 2003, the DFS test specification included in this standard became the basis for the development of the FCC DFS test specification and other test specifications in other countries.