ETSI TS 102 754 V1.1.1 (2008-06)

Technical Specification

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD); Technical characteristics of Detect-And-Avoid (DAA) mitigation techniques for SRD equipment using Ultra Wideband (UWB) technology

Reference
DTS/ERM-TG31A-0114

Keywords
radar, radio, SRD, UWB

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://webapp.etsi.org/IPR/home.asp).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

1 Scope

The present document provides the technical specifications of Detect And Avoid (DAA) mitigation techniques. These techniques are focused on the protection of active radio services.

The following DAA mechanisms have been identified to protect the:

- radio location services in the band 3,1 GHz to 3,4 GHz;
- broadband wireless access services in the band 3,4 GHz to 4,2 GHz;
- radio location services in the band 8,5 GHz to 9,0 GHz.

NOTE: The DAA mitigation techniques are to some extent generic and may also be used with modifications for the protection of other radio services in the future if the technical requirements are identified.

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.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
  - if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;
  - for informative references.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

For online referenced documents, information sufficient to identify and locate the source shall be provided. Preferably, the primary source of the referenced document should be cited, in order to ensure traceability. Furthermore, the reference should, as far as possible, remain valid for the expected life of the document. The reference shall include the method of access to the referenced document and the full network address, with the same punctuation and use of upper case and lower case letters.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

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] ECC DEC(06)04: "ECC Decision of 24 March 2006 amended 6 July 2007 at Constanta on the harmonized conditions for devices using Ultra-Wideband (UWB) technology in bands below 10.6 GHz" (2007/131/EC).

[i.2] ECC DEC(06)12: "ECC Decision of 1 December 2006 on the harmonized conditions for devices using Ultra-Wideband (UWB) technology with Low Duty Cycle (LDC) in the frequency band 3.4-4.8 GHz".

[i.3] Draft ECC Report 120 (March 2008): "ECC Report on Technical requirements for UWB DAA (Detect and avoid) devices to ensure the protection of radiolocation in the bands 3.1-3.4 GHz and 8.5-9 GHz and BWA terminals in the band 3.4 - 4.2 GHz.

[i.4] ECC TG3#18-18R0: "Flexible DAA mechanism based on "isolation criteria" between victim service and UWB devices", ECC TG3 Meeting 18, Mainz, March 2007.

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

avoid implementation time: maximum time taken to adjust to a new TX parameter set following signal level measurement and identification, Parameter: $T_{avoid\ impl}$

avoidance level: maximum amplitude to which the UWB transmit power is set for the relevant protection zone

channel availability check interval: maximum time between two consecutive detect operations, Parameter: T_{avail}

detect and avoid time: time duration between a change of the external RF environmental conditions and adaptation of the corresponding UWB operational parameters

detection probability: probability that the DAA enabled UWB device reacts appropriately to a signal detection threshold crossing within the detect and avoid time

in operation channel availability check time: minimum time the UWB device spends searching for victim signals during normal operation, Parameter: $T_{in\ op\ avail}$

maximum avoidance power level: UWB transmit power assuring the equivalent protection of the victim service

minimum avoidance bandwidth: portion of the victim service bandwidth requiring protection

minimum initial channel availability check time: minimum time the UWB device spends searching for victim signals after power on, Parameter: $T_{avail,\ Time}$

Non-Interference mode operation (NIM): operational mode that allows the use of the radio spectrum on a non-interference basis without active mitigation techniques

signal detection threshold: amplitude of the victim signal which defines the transition between adjacent protection zones, Parameter: D_{thresh}

signal detection threshold set: set of amplitudes of the victim signal which defines the transition between adjacent protection zones

victim signal: signal(s) of the service to be detected and protected by the DAA mitigation technique

3.2 Symbols

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

T	time
f	frequency
D	detection threshold
I	Isolation in dB
P	Power in dBm

3.3 Abbreviations

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

BWA	Broadband Wireless Access
DAA	Detect And Avoid
CEPT	European Conference of Postal and Telecommunications Administrations
CPC	Cognitive Pilot Channels
dBm	deciBel relative to 1 mW
ECC	Electronic Communications Committee
e.i.r.p.	equivalent isotropically radiated power
ERM	Electromagnetic compatibility and Radio spectrum Matters
LDC	Low Duty Cycle
NIM	Non Interference Mode
RF	Radio Frequency
SRD	Short Range Device
TPC	Transmit Power Control
UWB	Ultra WideBand

4 Detect and avoid

4.1 Introduction

The present clause defines a Detect And Avoid (DAA) based interference mitigation architecture for UWB devices to protect active victim services. In the following clauses the basis for and the individual DAA parameters for protection of specific services will be given.

4.2 Zone model

The flexible DAA concept is based on the definition of different zones for which an appropriate UWB emission power level is authorized. Each zone corresponds to a minimum isolation between the potential victim system and the potential UWB interferer. Based on the minimum isolation an equivalent degree (see note below) of victim service protection is derived. This concept is embodied in the zone model.

As existing systems are subject to technological change and other systems may be deployed or developed in the future e.g. IMT-Advanced, it should be noted that different zone parameters and transmission levels may be required.

The zone model is based on the isolation between the victim device and the UWB device. By deriving the distances based on the isolation it is possible to segment the region of space around the victim receiver into discrete zones. In the first zone, zone 1, the UWB device shall operate in the non-interference mode (NIM) as defined in the non DAA regulatory framework [i.1] and [i.2] using the parameters give in table 1. In the last zone, zone *N,* the UWB device can operate without restrictions up to the maximum permitted power level of -41,3 dBm/MHz or as defined in a future DAA regulation for the corresponding operational frequency range. Between the zone 1 and zone *N* an arbitrary number of transition zones 2 to *N* -1 may be defined, provided equivalent protection can be assured. Based on the result of the detection process (clause 5) the UWB device has to determine the corresponding zone it occupies.

Table 1: Non-interference mode parameters in the band 3,1 GHz to 9,0 GHz

Operational Frequency	NIM Power levels	NIM Power levels with LDC implemented
3,1 GHz to 3,4 GHz	- 70 dBm/MHz average. -36 dBm peak	Not applicable
3,4 GHz to 3,8 GHz	- 80 dBm/MHz average. - 40 dBm peak	- 41,3 dBm/MHz average. 0 dBm peak Standard LDC parameters as in [i.2]
3,8 GHz to 4,2 GHz	- 70 dBm/MHz average. -30 dBm peak	- 41,3 dBm/MHz average. 0 dBm peak Standard LDC parameters as in [i.2]
4,2 GHz to 4,8 GHz	- 41,3 dBm/MHz average. 0 dBm peak (see note 2)	- 41,3 dBm/MHz average. 0 dBm peak Standard LDC parameters as in [i.3]; relevant under phased approach concept
6,0 GHz to 8,5 GHz	- 41,3 dBm/MHz average. 0 dBm peak (see note 2)	Not defined
8,5 GHz to 9,0 GHz	- 65 dBm/MHz average. - 25 dBm peak	Not applicable
NOTE 1: As defined in the scope of the present document, the DAA mitigation only affects the frequency bands 3,1 GHz to 3,4 GHz, 3,4 GHz to 4,2 GHz and 8,5 GHz to 9 GHz. NIM power levels for the other frequency bands are included in this table for informative purposes. NOTE 2: Devices installed in road or rail vehicle need also TPC as defined in [i.1]		

The zone model is illustrated in figure 1 for $N = 4$. This example has been taken from the CEPT ECC TG3 regulatory discussion [i.4]. The transition zones in this example are defined based on a 10 dB pathloss step size.

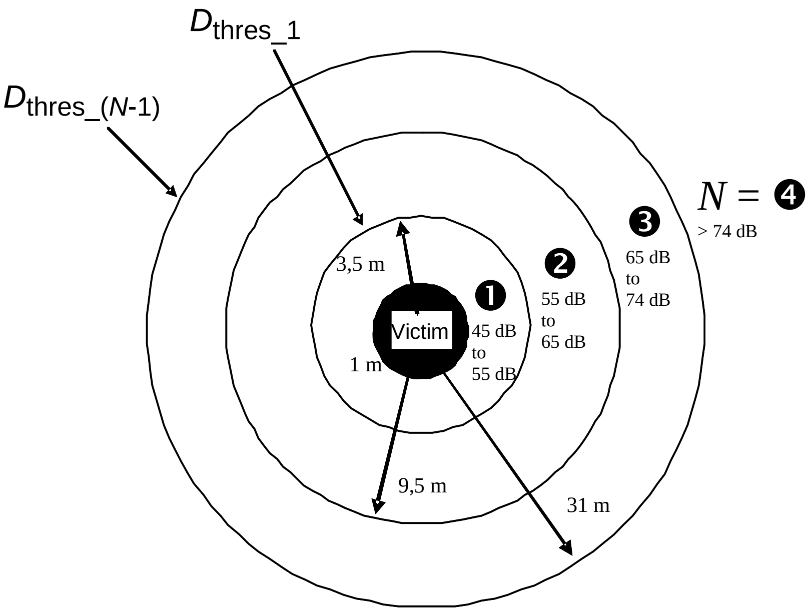

Figure 1: Zone model segmentation and corresponding path loss with LoS distance in meters for *N* = 4

4.3 Detect and Avoid operational flow

The defined zone model is incorporated into the overall detect and avoid operational flow. This flow is depicted in figure 2.

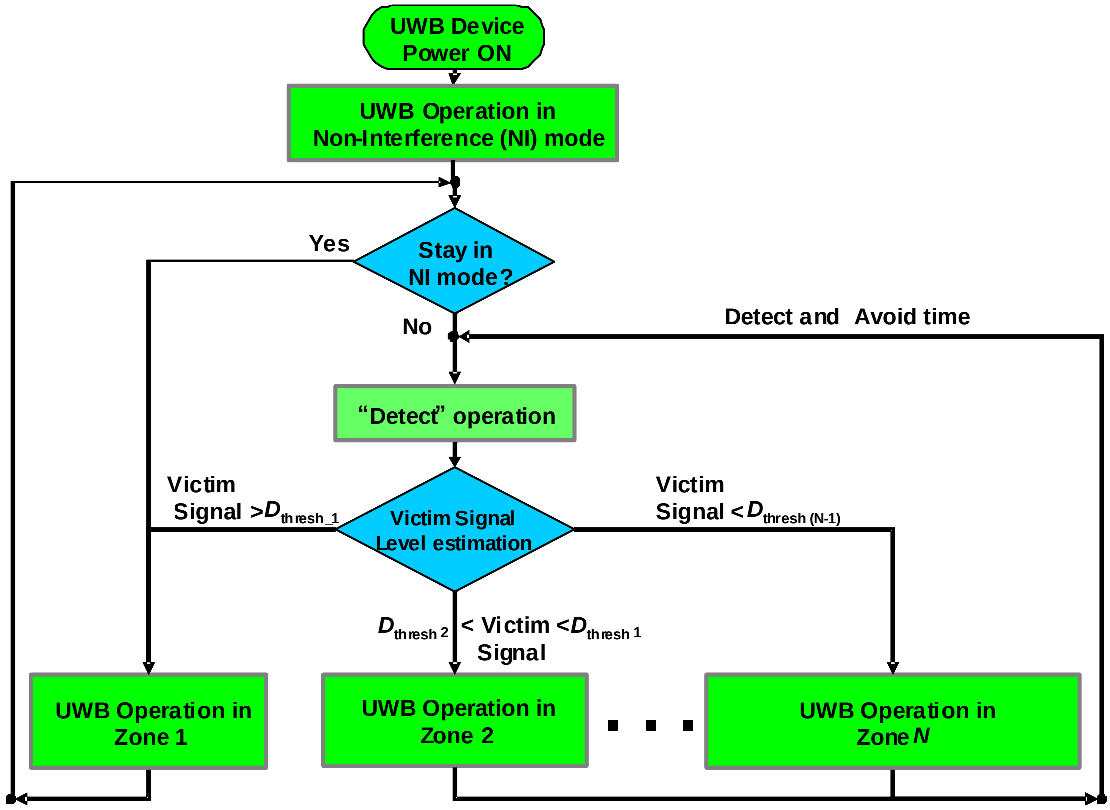

Figure 2: Detect and Avoid overview, including *N* zones

All UWB devices enter a non-interference mode at start-up. This non-interference mode can only be changed after a signal detect, estimation and decision process has been performed. Estimations are done against threshold levels D_{thres_n}, n = 1…*N*-1.

The non-interference mode operational zone can be subdivided into zones of equivalent protection where appropriate avoidance techniques are implemented. This gives rise to additional operational zones between the non-interference and free mode operational zones based on technical considerations. This multi zone concept is illustrated in figure 3 taking into account the reduction of the UWB transmit power after the application of the appropriate avoidance technique.

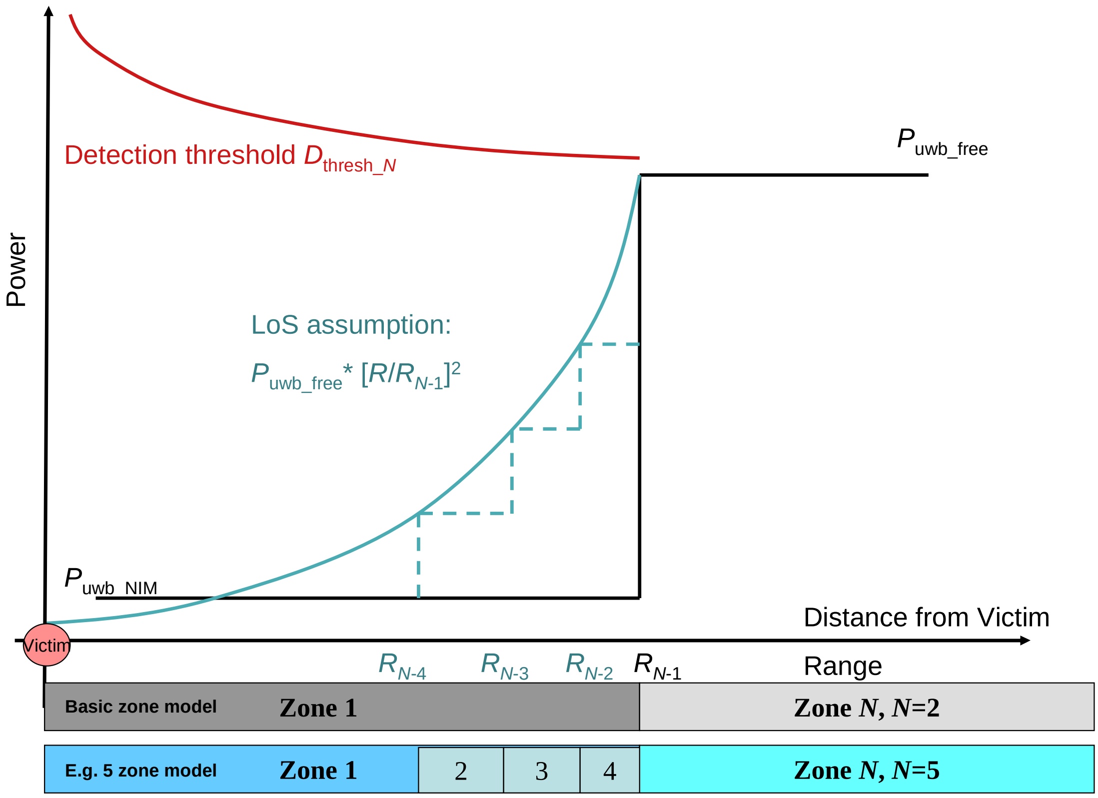

Figure 3: Illustration of multi zone concept based on equivalent protection levels

The basic zone model consists of two zones, the non-interference mode operational zone, zone 1, and the free mode operational zone, zone N, $N = 2$. The basic threshold level $D_{thresh\_(N-1)}$, separating free mode operational zone and the non-interference mode operational zone, is defined by two key parameters:

- Minimum needed isolation I, including margins for an interference free operation of the victim receiver, when in the presence of a UWB device operating in zone N.
- The transmit power of the victim device P_{TX_vic}.

Then $D_{thresh\_(N-1)}$ is given as:

$$D_{thresh\_(N-1)} = P_{TX\_vic} - I$$

During the detection and estimation process performed by the UWB device, a received victim signal level will be compared to the threshold level $D_{thresh\_(N-1)}$. If the received victim signal level exceeds the threshold level $D_{thresh\_(N-1)}$ the UWB device shall operate in the non-interference mode. This signal level estimation is periodically updated in order to accommodate the potential changing RF environmental conditions. When changes in the RF conditions are detected the operational mode of the UWB device shall be adapted accordingly.

5 Detect framework

5.1 Introduction

The clause introduces the detection options and victim service related detection parameters for the definition of the DAA test specification requirements. The limits for the test are given in the victim service related annexes A to C and are determined in the relevant ECC deliverable [i.3].

5.2 Detect options

5.2.1 Measurement of received victim signal strength

The approach of the measurement of the received victim signal strength is depicted in figure 4. The reliability of the decision process in comparing the zone thresholds with the measured victim signals shall depend on the type of signal measured and the signal to noise level of the measurement. The signal to noise ratios achievable by the UWB devices will be dependent upon the manufacturers' implementation.

The frequency band selection shall take into account the operational frequency band of the UWB device and all potential victim services. For convenience this frequency band may be segmented to enhance both characterization and measurement procedure of amplitudes. Where any amplitudes are detected which are higher than the background noise of the receiver/measurement subsystem these shall be characterized.

If no signals are detected above the background noise no additional steps have to be taken. This implies that the minimum usable sensitivity (including a specified blocking capability) of the detector shall allow measurement of DAA threshold values. Regarding figure 4, i.e. the noise figure of the equipment shall not impair the detection capability of the DAA mechanism.

The process of characterization shall include not only the identification of the parameters of the received signals but also the comparison against a known and specified set of parameter (e.g. a pattern) of the potential victim services in the relevant frequency band. The details on how the characterization is performed will be left to the individual UWB implementation design. The more comprehensive the characterization information is, the better the possible match with the avoidance techniques and hence the higher the spectrum efficiency will be.

If none of the detected signals correspond to a potential victim service no further action is needed.

If at least one signal corresponds to a potential victim service, the relevant threshold sets of the zone model shall be selected. In the following step the members of the relevant threshold sets shall be compared to the corresponding characterized signal levels. Based on this comparison the UWB operational parameters shall be adapted.

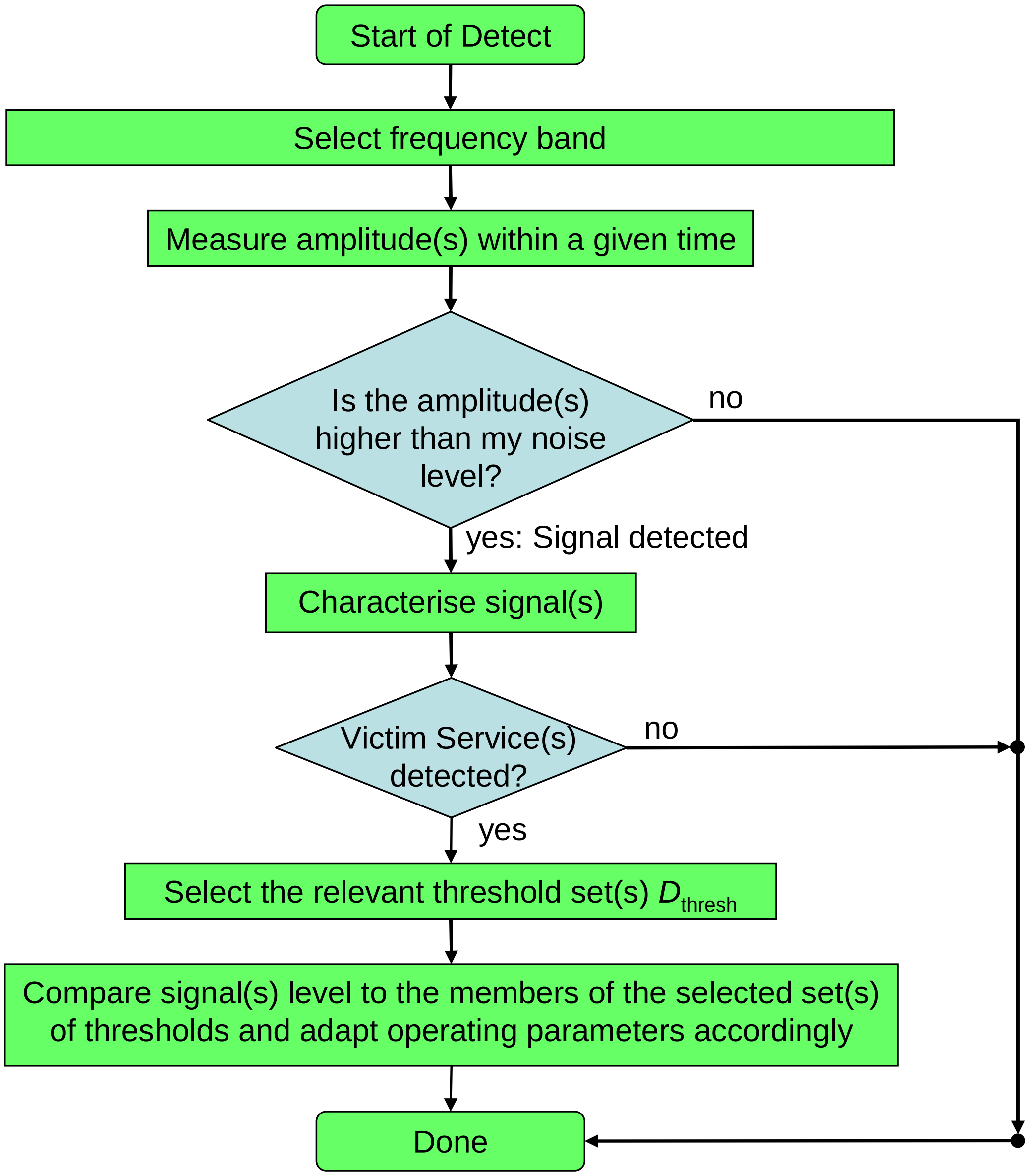

Figure 4: Detect flow diagram for victim signal strength measurement

5.2.2 Processing of available external victim service information

An alternative to the measurement approach (depicted in clause 5.2.1) is the use of current DAA information obtained from other devices or systems within the receive range of the UWB device (e.g. a centralized DAA detector). This information can be used by the UWB device to set its own DAA parameters for its local environment, e.g. membership of the peer group.

Received information comprises but is not restricted to:

- victim service information available from peer UWB devices;
- victim service information available on pilot channels, such as Cognitive Pilot Channels (CPC);
- control information from potential victim systems.

The scope of the information available to any UWB device is dependent on its specific implementation. The use of such information carries some risk, e.g. in a mobile environment the zone information may be rapidly outdated, under certain conditions potential victim service may be hidden from peer groups. The maximum distance among UWB devices processing external victim service information depends on the definition of the applicable zone model and the maximum distance shall be specified in case of the information originating from peer UWB devices.

The benefits to be accrued in using such information include increased reliability, detection speeds and lower processing overheads, e.g. information from collocated devices where common control information is shared.

The use of such information is both context specific and time critical.

The approach is depicted in figure 5.

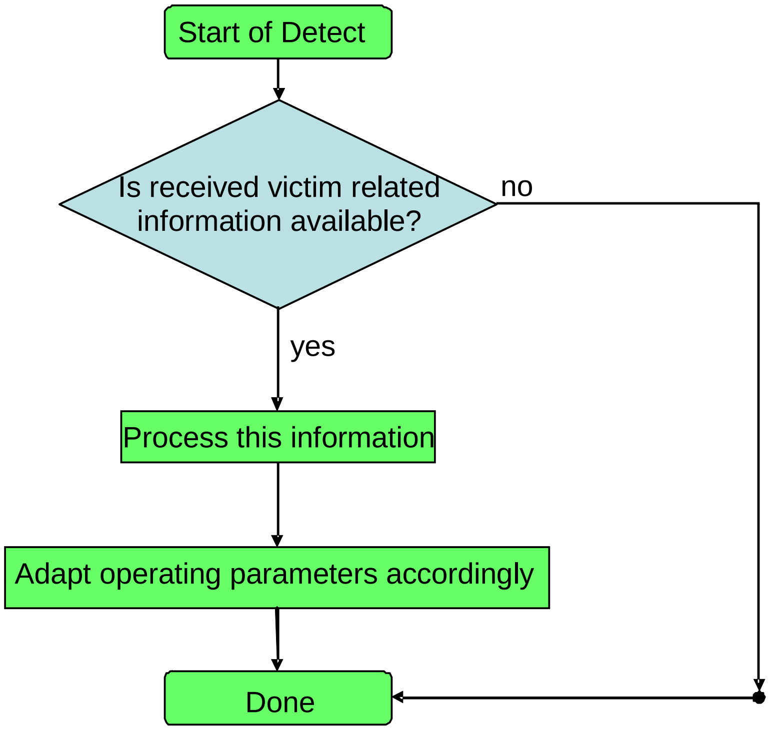

Figure 5: Detect flow diagram for processing of external information

5.2.3 Combination of both

It is expected that systems will use a combination of the local measurements and the available external information. The operational flow using the combined approach is given in figure 6.

This combined approach will optimize the UWB resource usage, improve detection performance, improve spectrum efficiency and minimize processing overhead.

This improvement is mainly reached by including the additional external information in the characterization step and the adaptation step of figure 4. This information flow is depicted in figure 6 by the dotted lines.

The particular implementation of these disparate sets of information will ultimately determine the extent of the possible improvements.

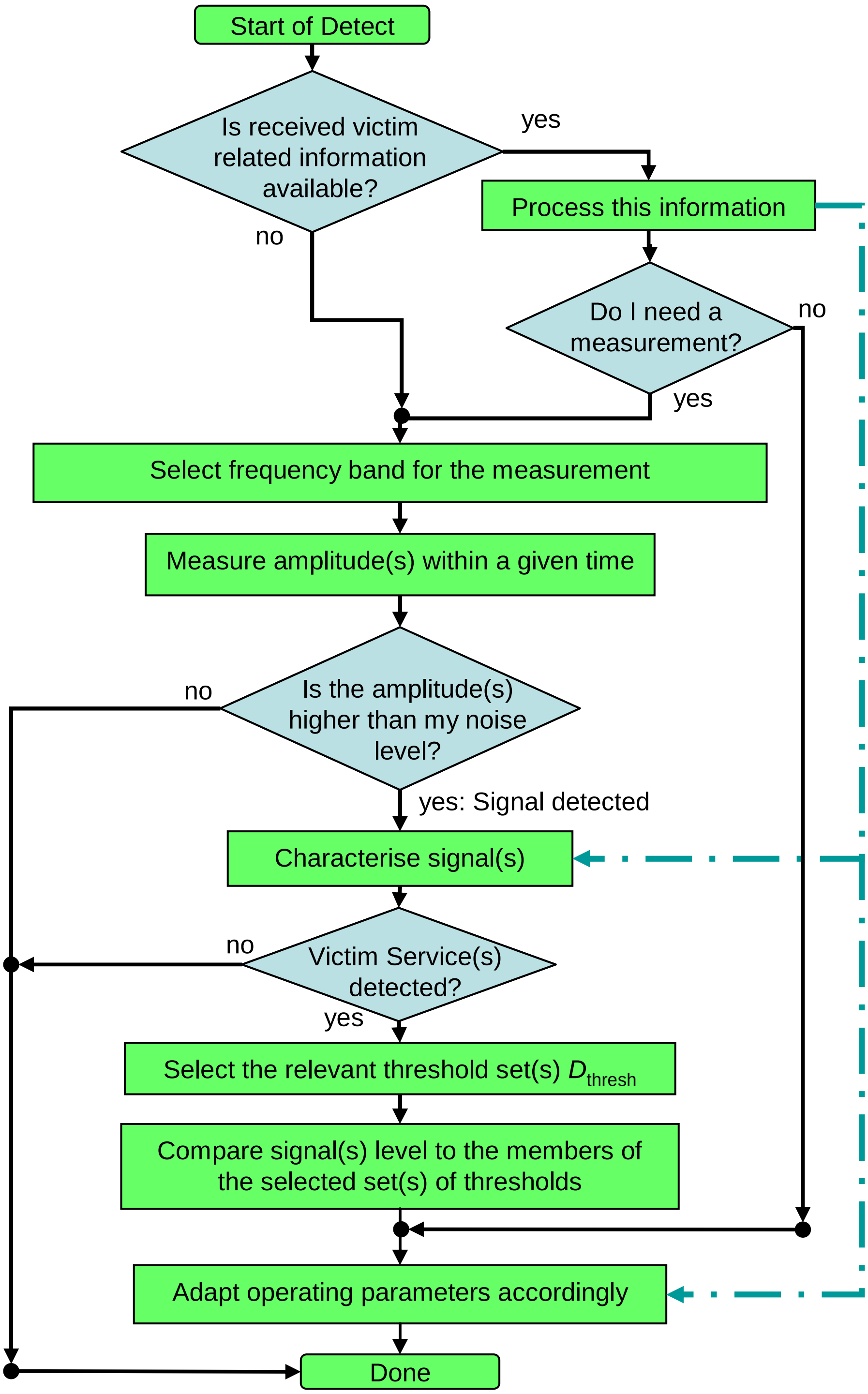

Figure 6: Detect flow diagram for the combination of internal measurements and external information

5.3 Detection parameters

5.3.1 Initial Channel availability check time

The UWB device shall perform victim system monitoring and shall be required to detect any actively operating victim system signals within a minimum time given by *Minimum Initial Channel Availability Check Time*, $T_{avail,\ Time}$. During the *Minimum Initial Channel Availability Check Time*, the device may operate in the non interference mode (NIM).

5.3.2 Detect and Avoid time

Time duration between a change of the external RF environmental conditions and update or adaptation of the corresponding UWB operational parameters.

The combined detect and avoid time shall include a number of parameters which are not accessible from the physical layer. These include:

- Channel Availability Check Periodicity: $T_{\text{avail, Period}}$.
- In Operation Channel Availability Check Time: $T_{\text{in op avail, Time}}$.
- Avoid Implementation Time: $T_{\text{avoid impl}}$.

The Detect and Avoid time is depicted in figure 2. The detect and avoid time shall be tested and a functional test will be specified for this.

5.3.3 Signal detection threshold

The UWB device shall employ a signal detection function that enables it to detect signals from active victim services. The currently identified services are BWA and radio location.

This function shall be able to detect victim service signals and measure if the power level is above or below the *Signal Detection Threshold*, D_{thresh} in any of the relevant frequency bands. This detection threshold is specified at the antenna input/connector assuming a 0 dBi antenna gain for each detection operation and may be based on multiple levels.

The signal detection performance will depend upon the type of signal from the victim service as well as the signal-to-noise ratio when measured at the UWB device. The signal detection shall ultimately determine the detection probability achievable. An example calculation is shown in annex E.

The signal detection threshold shall be verified and a functional test specified for this parameter.

5.3.4 Detection probability

The detection probability is the probability that the DAA enabled UWB device reacts appropriately to a signal detection threshold crossing within the detect and avoid time (see also clause 7.4). A minimum number of tests shall be specified to express the required detection probability with a specified confidence level.

6 Avoidance options

6.1 Introduction

The aim of the avoidance process is to protect the victim service receiver while maintaining an operational link with peer UWB devices.

Following the detection and identification of a victim system the selected avoidance option shall ensure the required protection level at the victim receiver.

The avoidance options fall into four major categories:

- power reduction;
- spatial avoidance;
- frequency avoidance;
- time sharing.

Any of these techniques may be used individually or in combination to protect the victim services provided that the avoidance levels given in the victim service related annexes are met.

The currently qualified techniques for use with UWB devices are given in clauses 6.2 to 6.7, however, other techniques may be used where equivalent protection can be demonstrated.

6.2 Transmit power management

Transmit power management is the reduction of the UWB transmission power over the complete UWB operational band to the required level.

6.3 Band relocation

Band relocation is an avoidance technique where the transmit band of the UWB device is relocated in the frequency domain to eliminate interference with the victim service. This protection may either be done by band shifting or band switching.

Band shifting is a partial relocation of the active transmission band of the UWB device within the original operational frequency band whereas band switching means that a new operational frequency band is selected by the UWB device.

6.4 Frequency band notching

Frequency band notching is a frequency dependent transmit power management technique which protects the victim services frequency band. This technique has the advantage that out-of-victim-band UWB transmissions may be made at the maximum permitted power for the operational band in use (see also clause 6.8.1).

6.5 LDC

Low duty cycle techniques decrease the total transmitted energy integrated over a period of time. This is achieved by transmitting at the maximum power for the given frequency band but restricting the transmission in duration.

This technique is an unsynchronized time sharing avoidance method. As a consequence the LDC technique does not eliminate interference to the victim services but it may reduce the effect of the interference.

NOTE: LDC is not considered a suitable technique for the radio location service.

6.6 Antenna techniques

Antenna techniques in general rely on the spatial distribution of the transmitted UWB signal. The spatial distribution of the signal may be controlled by the directivity of the antenna used. Possible examples include: switching, re-orientation, phased arrays.

6.7 Combinations

In order to achieve the protection criteria and maintain an operational link with peer devices it may be necessary to combine a number of the avoidance techniques mentioned above.

6.8 Avoidance parameters

6.8.1 Minimum avoidance bandwidth

This is the minimum bandwidth over which the UWB devices shall reduce their transmission power below the maximum avoidance level. The values for the minimum avoidance bandwidth are given in annex A to C.

6.8.2 Maximum avoidance power level

The maximum avoidance power level is the UWB transmit power assuring the equivalent protection of the victim service. In the basic two zone model the maximum avoidance power level is equivalent to the NIM power level given in table 1. In the multizone model there is be a hierarchy of avoidance power levels associated with each zone where the lowest maximum avoidance power level in the hierarchy equals the NIM power level.

6.9 Switching to LDC

UWB devices having LDC and DAA implemented and operating in all or part of the frequency band from 3,4 GHz to 4,2 GHz may also switch on the LDC parameter set to avoid interference to BWA services as shown in table 2.

Table 2: LDC limits

LDC parameter	Value
Maximum Tx on	≤ 5 ms
Minimum Mean Tx off	≥ 38 ms (mean value averaged over one (1) second)
Accumulated minimum Tx off (Σ Tx off)	≥ 950 ms in one (1) second
Maximum accumulated transmission time (Σ Tx on)	18 s in one (1) hour

7 Test considerations

7.1 General considerations

Any test must verify that the UWB device can detect a victim service and react within a specified time. Therefore the tests must be able to measure the detect and avoid times and the chosen avoid options.

As far as possible tests shall be representative of the normal deployment of UWB devices which may be static, walking or vehicle-based. In the case of moving devices, the interfering signals from the UWB devices and the received signals from victim services will vary in amplitude with time and distance from the victim. This was illustrated in figure 3. The UWB device will react only if a victim signal crosses a given threshold and the amplitude of the specified test signal shall, as far as possible, reflect the changing conditions of the signal.

Under certain conditions it may be that multiple victim services will be in use in the same UWB operational band. In this case it will be important that the test establishes that the UWB device reacts to the simultaneous presence of these signals in such a way that all services are adequately protected. In any operational band the test set-up used shall simulate all the victim services present.

7.2 Considerations for radio location services

A set of representative test patterns, simulating the full set of operational modes of radio location services will be specified. These patterns will use a combination of radar signal parameters such as pulse repetition interval, pulse width, modulation, bandwidth or burst repetition frequency.

NOTE: This is comparable to the DFS mechanism used by 5 GHz WLAN for the protection of radio location services.

7.3 Considerations for BWA services

The peak and average power of a BWA system based on OFDM is governed by the number of subcarriers and not the individual carrier modulation. In this case the use of a specific modulation scheme emulating the victim signal for test is assumed not to be critical.

During test the emulated victim signal must have the same peak to average ratio given by the BWA OFDM modulation scheme. The bandwidth of the signal shall be the maximum and the minimum of the victim service. The carrier frequency shall be within the victim service operational band.

In the particular case of frequency duplexing systems the test must differentiate between up- and down-link frequency bands in order to allow the optimum selection of the avoidance technique. Where FDD systems are deployed the duplex spacing for the particular region shall be used to assess the detection capabilities of the UWB device under test.

In the event that this differentiation can not be made by the UWB device the complete victim service band must be protected.

In the case of the BWA services a set of four critical applications have been identified [i.3] and shall be tested. The corresponding timing patterns are illustrated in figure 7. These timing parameters are used to define the BWA detect and avoid timing in annex B.

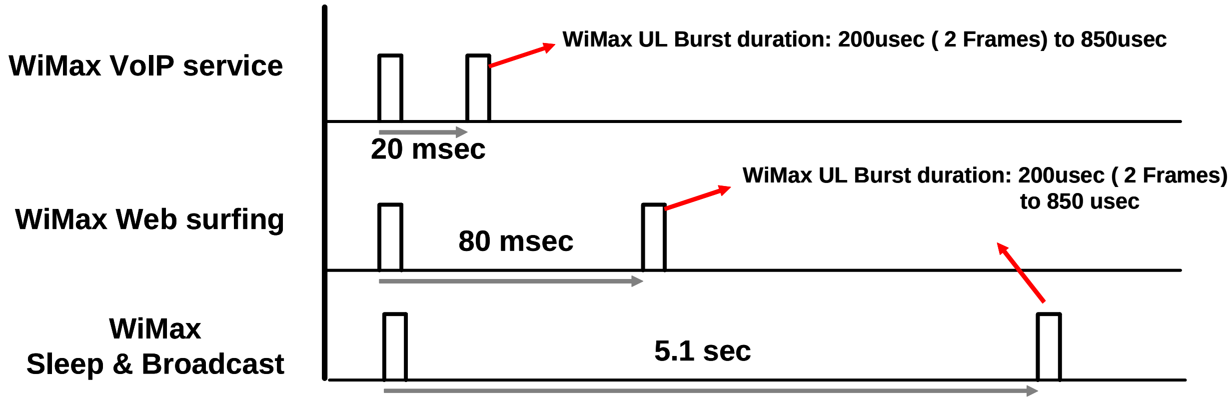

Figure 7: Typical BWA timing patterns for victim signal emulation

7.4 Maximum uncertainty

The measurement uncertainty for the measurement of each DAA parameter shall be defined.

Measurements shall be repeated in order to determine an adequate detection probability with acceptable uncertainty for the selected victim signals.

The reliability of the decision process in comparing the zone thresholds with the measured victim signals will depend on the type of signal measured and the signal to noise level of the measurement. The signal to noise ratios achievable by the UWB devices will be dependent upon the manufacturers' implementation.

A minimum number of tests shall be specified to express the required detection probability with a specified confidence level.

Annex A (normative): Radio location services in the band 3,1 GHz to 3,4 GHz

Table A.1: Band 3,1 GHz to 3,4 GHz: Radio Location systems Detect and avoid parameter set

Parameter		Zone 1	Zone 2
Minimum Initial channel availability Check time	$T_{avail, Time}$	14 s	
Detection Probability (for initial detect operation)		99 %	
Signal detection threshold	D_{thresh}	D_{thresh_1} = -38 dBm	
Avoidance Level (UWB Tx Power)		-70 dBm/MHz	-41,3 dBm/MHz
Minimum Avoidance Bandwidth		300 MHz	
Detect and Avoid time		5 min	
Detection probability		99 %	
Possible Avoidance Options		All except LDC	

Annex B (normative): Broadband wireless access services in the band 3,4 GHz to 4,2 GHz

Table B.1: BWA Detect and avoid parameter set

Parameter		Zone 1	Zone 2	Zone 3
Minimum Initial channel availability Check time	$T_{avail, Time}$	5,1 s		
Detection Probability (for initial detect operation)		99 %		
Signal detection threshold	D_{thresh}	D_{thresh_1} = -38 dBm	D_{thresh_2} = -61 dBm	
Avoidance Level (UWB Tx Power)		-80 dBm/MHz	-65 dBm/MHz	-41,3 dBm/MHz
Minimum Avoidance Bandwidth		10 MHz		
Possible Avoidance Options		All		

Table B.2: BWA Detect and avoid timings

BWA system / mode	*Detect and Avoid Time*	*Detection Probability* (for continuous detect operation)
VoIP	2 s	95 %
Web surfing	15 s	95 %
Sleep mode	60 s	95 %
Multimedia broadcasting	15 s	95 %

Annex C (normative): Radio location services in the band 8,5 GHz to 9,0 GHz

Table C.1: Band 8,5 GHz to 9,0 GHz: Radio Location systems Detect and avoid parameter set

Parameter		Zone 1	Zone 2
Minimum Initial channel availability Check time	$T_{avail, Time}$	14 s	
Detection Probability (for initial detect operation)		99 %	
Signal detection threshold	D_{thresh}	D_{thresh_1} = -38 dBm	
Avoidance Level (UWB Tx Power)		-65 dBm/MHz	-41,3 dBm/MHz
Minimum Avoidance Bandwidth		500 MHz	
Detect and Avoid time		1 to 5 minutes	
Detection probability		99 %	
Possible Avoidance Options		All except LDC	

Annex D (normative): Test Procedure for the radio location DAA test

D.1 Introduction

In the present clause the test procedure for the radio location DAA test is depicted. The UWB DAA device under test shall be verified under normal operational conditions.

The DAA test is split into two main operational tests:

- start-up test and;
- in-operation test.

The start-up test verifies the operation of the UWB DAA device during the initial start-up when the DAA UWB device intends to operate directly in a non NIM. Thus the UWB DAA device need to be set in an operational condition in which this is guaranteed.

The in-operation test is intended to verify the dynamic behaviour of the UWB DAA device under test. During this test the UWB DAA device under test shall operate in a normal dynamic operational mode. The manufacturer has to declare this normal operational mode taking into account the zone model.

All tests should be performed in radiated mode. Where applicable, two UWB DAA devices which can establish a data link connection shall be used in order to guarantee a normal operational mode of the system.

D.1.1 Start-up test

The clauses below define the procedure to verify the *Minimum Initial Channel Availability Check* by ensuring that the UWB DAA device is capable of detecting radar pulses at the beginning and at the end of the *Minimum Channel Availability Check Time.* This is illustrated in figure D.1. This test is only relevant when the UWB DAA device intends to start operation in a non NIM mode. Thus the UWB DAA devices need to be set in a typical operational mode where a non NIM operation is required.

D.1.1.1 Tests with a radar burst at the beginning of the Minimum Initial Channel Availability Check Time

The steps below define the procedure to verify the radar detection capability on the selected channel when a radar burst occurs at the beginning of the *Minimum Initial Channel Availability Check Time*.

a) The UWB DAA device will be switched off. The signal generator used to generate the test patterns in table D.1 will be connected to an antenna of suitable characteristics to permit the UWB DAA device to be illuminated with a field equal to the threshold detection limit.

b) The UWB DAA device is powered on at T_0. T_1 denotes the instant when the UWB DAA device has completed its power-up sequence (T_{power_up}) and is ready to start the radar detection. The *Minimum initial Channel Availability Check* is expected to commence at T_1 and is expected to end no sooner than $T_1 + T_{avail\_time}$ unless a radio location signal is detected sooner.

NOTE: Additional verification may be needed to define T_1 in case it is not exactly known or indicated by the UWB DAA device.

c) A radar burst is generated in the relevant radio location frequency band using radar test signal #1 defined in table D.1 at a level of 10 dB above the level defined in annexes A and C This single-burst radar test signal shall commence within 2 sec after time T_1.

d) It shall be recorded if the radar test signal was detected.

e) The steps b) to d) shall be repeated for each of the radar test signals defined in table D.1 and at levels defined in annexes A and C.

f) A timing trace or description of the observed timing and behaviour of the UWB DAA device shall be recorded.

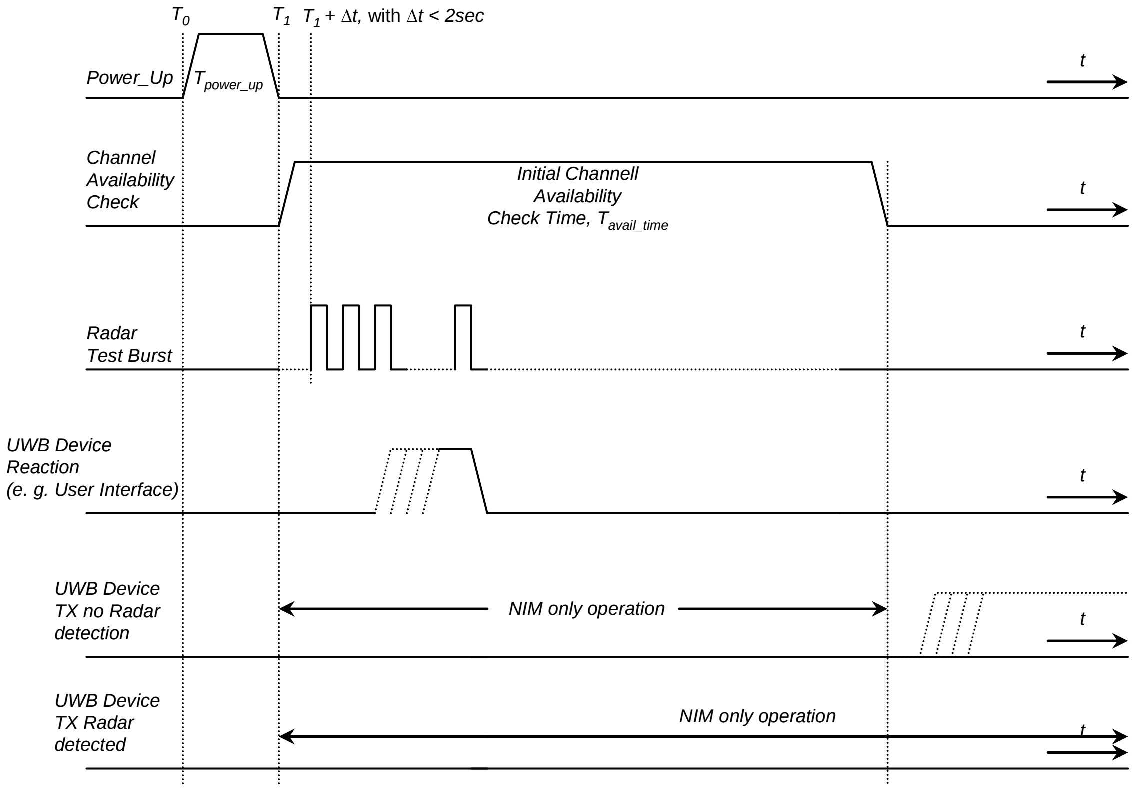

Figure D.1: Example of timing for radio location testing at the beginning of the Minimum Initial Channel Availability Check Time, UWB DAA device intent to operate in a non NIM mode

D.1.1.2 Tests with radar burst at the end of the Minimum Initial Channel Availability Check Time

The steps below define the procedure to verify the radar detection capability on the selected channel when a radar burst occurs at the end of the *Minimum Initial Channel Availability Check Time*. This is illustrated in figure D.2:

a) The UWB DAA device will be switched off. The signal generator used to generate the test patterns in table D.1 will be connected to an antenna of suitable characteristics to permit the UUT to be illuminated with a field equal to the threshold detection limit.

b) The UWB DAA device is powered up at T_0. T_1 denotes the instant when the UWB DAA device has completed its power-up sequence (T_{power_up}) and is ready to start the radar detection. The *Minimum Initial Channel Availability Check* is expected to commence at instant T_1 and is expected to end no sooner than $T_1 + T_{avail\_time}$ unless a radar is detected sooner.

NOTE: Additional verification may be needed to define T_1 in case it is not exactly known or indicated by the UWB DAA device.

c) A radar burst is generated in the relevant radio location frequency band using radar test signal #1 defined in table D.1 at a level of 10 dB above the level defined in Annex A and C. This single-burst radar test signal shall commence towards the end of the minimum required *Minimum Initial Channel Availability Check* Time but not before time T_1 + 10 sec.

d) It shall be recorded if the radar test signal was detected.

e) The steps b) to d) shall be repeated for each of the radar test signals defined in table D.1 and at levels defined in Annex A and C

f) A timing trace or description of the observed timing and behaviour of the UWB DAA device shall be recorded.

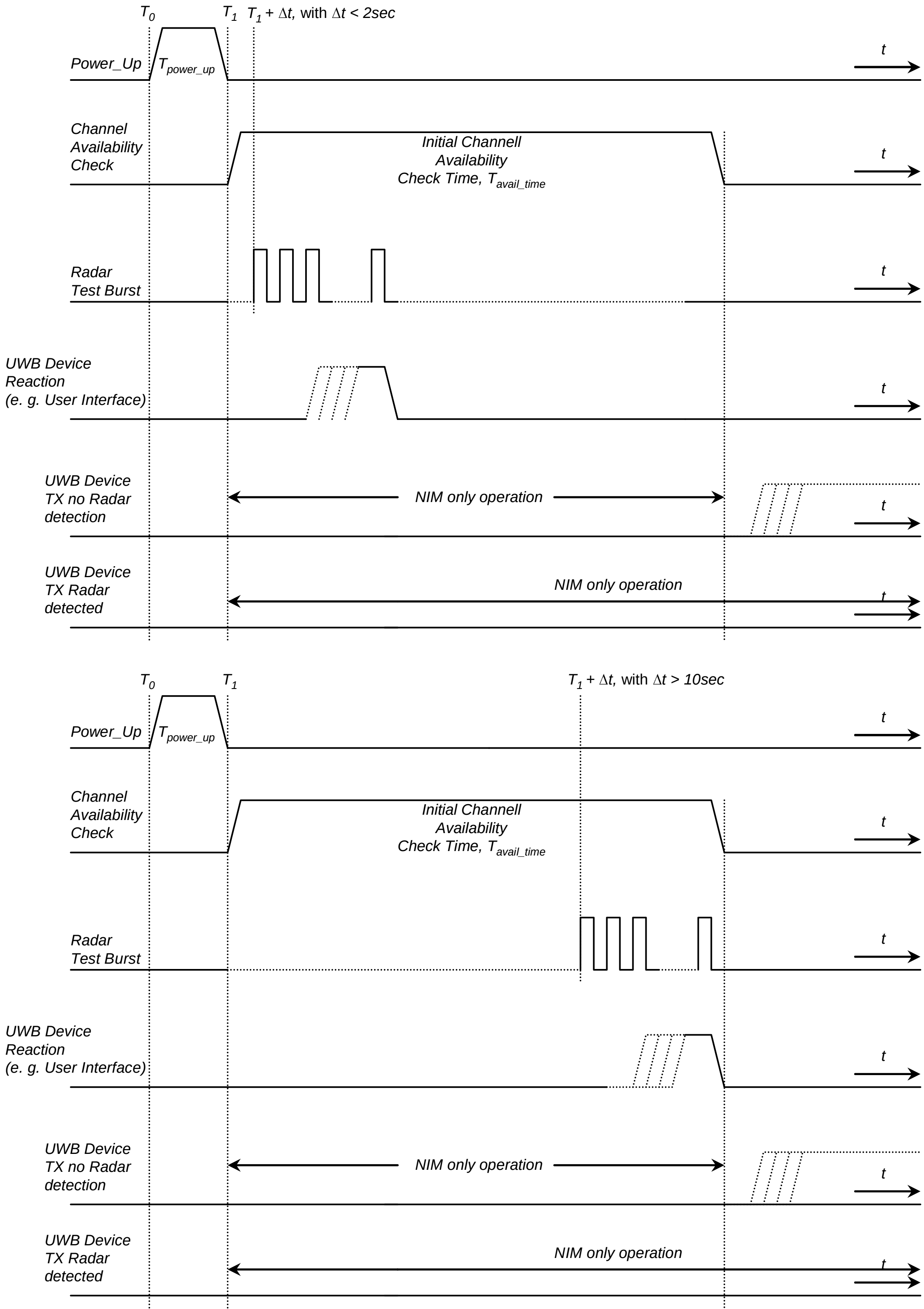

Figure D.2: Example of timing for radar testing towards the end of the Minimum Initial Channel Availability Check Time

D.1.2 In-Service Test

In this clause the performance of the UWB device in operation will be tested. Here the main parameters to be tested are the Detect and Avoid time and the corresponding detection probability.

The steps below define the procedure to verify the *In-Service Monitoring* and the *Interference Detection Threshold* during the *In-Service Monitoring*. The main parameter to check here is the "*Detect and Avoid Time*" and the corresponding detection probability.

a) The signal generator used to generate the test patterns in table D.1 will be connected to an antenna of suitable characteristics to permit the UWB DAA to be illuminated with a field equal to the threshold detection limit.

b) A UWB DAA device pair with radar interference detection function shall transmit a test transmission sequence between them in accordance with clause D.3 in the relevant radio location frequency band.

c) At a certain time T_0, a radar burst is generated in the relevant radio location frequency band using radar test signal #1 defined in table D.1 and at a level defined in annexes A and C. The radar burst shall be repeated with the Burst Repetition Frequency f_{BRF} until the end of the Detect and Avoid time or the detection of the radio location signal by the UWB DAA device.

d) It shall be recorded if the radar test signal was detected by monitoring the corresponding required avoidance action.

e) The steps b) to d) shall be repeated at least 20 times in order to determine the detection probability for the selected radar test signal. The detection probability shall be compared with the limit specified in table D.1.

f) The steps b) to e) shall be repeated for each of the radar test signals defined in table D.1 and at levels described in annexes A and C.

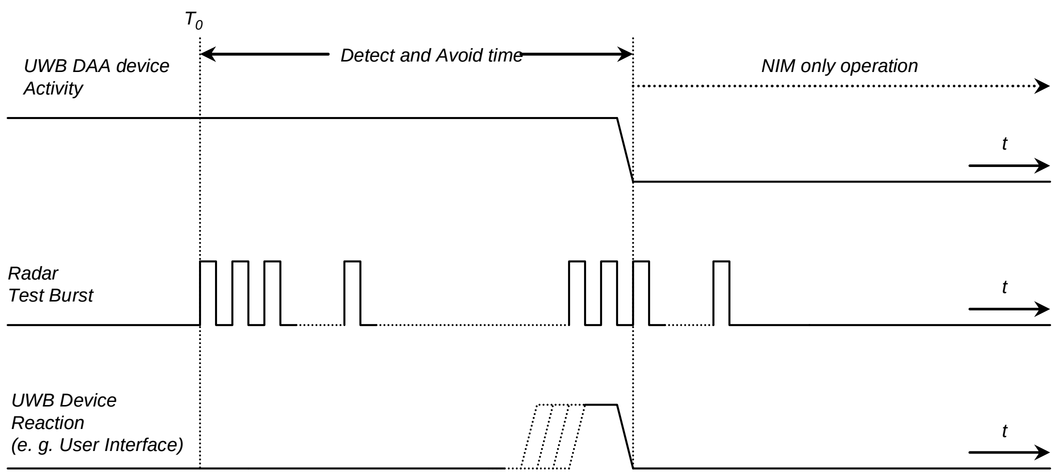

Figure D.3: Example of timing for radio location testing during In-Service Monitoring

D.1.3 Test patterns for the radio location DAA test

Table D.1: Preliminary parameters of radio location test signals

Radar test signal	Pulse width W [µs] (see note 5)	Pulse repetition frequency f_{PRF} [pps]	Pulses per burst [PPB] (see note 1)	Burst repetition frequency f_{BRF} [bps]	Detection probability with 50 % channel load
1 - Variable	0.4, 0.6, 0.8, 1.0	5 000 - 16 000 (see note 6)	25 - 75	0.2 - 0.08	P_d > 90 %
2 - Variable	1, 2, 5	200 - 1 000 (see note 6)	5 - 15	0.2 - 0.08	P_d > 90 %
3 - Variable	10, 15	200 - 1 000 (see note 6)	5 - 15	0.2 - 0.08	P_d > 90 %
4 - Variable	10, 20, 40, 60, 100	100 - 500 (see note 6)	2 - 5	0.2 - 0.08	P_d > 90 %
5 - Variable	1, 2, 5, 10, 15	1 000 - 5 000 (see note 6)	5 - 15	0.2 - 0.08	P_d > 90 %

NOTE 1: This represents the number of pulses seen at the UWB DAA device per radar scan:
N = [{antenna beamwidth (deg)} × {pulse repetition rate (pps)}] / [{scan rate (deg/s)}].
Chose randomly a number of pulses in the given limits.
L = PPB*1/f_{PRF}, Burst length in seconds.

NOTE 2: The test signals above only contain a single burst of pulses. See figure D.4.

NOTE 3: The number of pulses per burst given in this table simulate real radar systems and take into account the effects of pulse repetition rate and pulse width on the detection probability for a single burst.

NOTE 4: Pd gives the probability of detection per simulated radar burst and represents a minimum level of detection performance under defined conditions - in this case a 50 % traffic load.
Therefore Pd does not represent the overall detection probability for any particular radar under real life conditions. In general 2 sequential bursts are needed to achieve a real life detection rate of better that 99 % for any radar that falls within the scope of this table.

NOTE 5: The pulse width used in these tests is assumed to be representative of real radar systems with different pulse widths and different modulations. The pulse width is assumed to have an accuracy of ±5 %.

NOTE 6: Chose PRF randomly in the given range.

NOTE 7: The burst repetition frequency f_{BRF} is used in the In-Service Monitoring test setup.

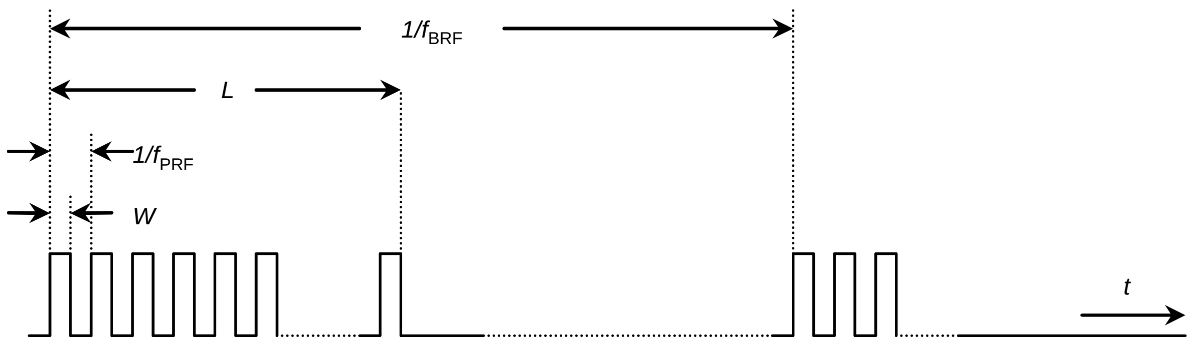

Figure D.4: General structure of the bursts for DAA radio location test transmissions

Annex E (informative): Detection threshold and range

In the present annex the detection thresholds defined in the present document, annexes A to C are further explained.

As an example the detection of a radio location victim service operating in the frequency range between 3,1 GHz and 3,4 GHz is used.

In table E.1 five cases for the detection of a S-band radio location victim system are depicted.

Table E.1: Calculation of radar detection threshold in the S-Band for different cases; source: ECC Report 120 [i.3]

	Case A	Case B	Case C	Case D	Case E
f/GHz	3,10	3,10	3,10	3,10	3,10
Victim power dBm e.i.r.p.	65,00	65,00	65,00	65,00	55,00
max antenna gain dBi	40,00	40,00	40,00	40,00	25,00
p_eirp_Victim dBm	105,00	105,00	105,00	105,00	80,00
p_eirp max W	3,16E+07	3,16E+07	3,16E+07	3,16E+07	1,00E+05
Victim thermal noise dBm/MHz	-114,00	-114,00	-114,00	-114,00	-114,00
I/N dB	-6,00	-6,00	-6,00	-6,00	-6,00
Imax/Victim dBm/MHz	-120,00	-120,00	-120,00	-120,00	-120,00
PSD_uwb dBm/MHz e.i.r.p.	-41,00	-50,00	-65,00	-70,00	-41,00
protection distance/m Free space loss	6817,71	2419,01	430,17	241,90	1212,38
protection distance/m NLOSs (Exp 3.5)	155,11	85,80	31,98	23,02	57,82
Power flux density at the UWB device at the protection distance W/m^2	5,41E-02	4,30E-01	1,36E+01	4,30E+01	5,41E-03
Power flux density at the UWB device at the protection distance dBm/m^2	17,34	26,34	41,34	46,34	7,34
Antenna Gain UWB dBi	0	0	0	0	0
Received power at the UWB Device at the protection distance dBm	-14,00	-5,00	10,00	15,00	-24,00
Detection Threshold at UWB device antenna in dBm	-38	-38	-38	-38	-38
Distance to Radar victime device at threshold level in m	108053,37	108053,37	108053,37	108053,37	6076,29
Difference to needed minimum protection distance	101235,66	105634,35	107623,20	107811,47	4863,91

The worst case is given in case E where the radio location system uses a very low peak TX power and a very low antenna gain. The received power at the UWB device from the radio location system can be calculated as follows:

Received power = Victim e.i.r.p. power (dBm) + Victim Antenna gain (dB) + UWB Antenna gain (dB) - Pathloss and

Pathloss = 32,5 dB + 20 log (f) (in GHz) + 20 log (protection distance relative to 1m for free space loss)

Taking into account the defined detection threshold D_{thres_1} of - 38 dBm gives a margin of 14 dB. This margin can be translated into a protection distance at the threshold level.

In case E the protection distance at the detection threshold is 6 076 m. Taking into account the minimum protection distance needed we can observe an additional distance of around 5 km. A car driving with a speed of 100 km/h in the direction of the main beam of the radio location system takes 3 minutes to cover the additional protection distance.

For cases A to D this additional distance is in the range of 100 km. It would take a car more than one hour to cross the additional protection distance.

The defined detection threshold is thus directly related to the *Detect and Avoid time* for the dynamic update of the protection status of the UWB DAA device. The lower the detection threshold for a given parameter set of the victim service the longer the potential *Detect and Avoid time* without increasing the risk of interference towards the potential victim service.

History

Document history		
V1.1.1	June 2008	Publication