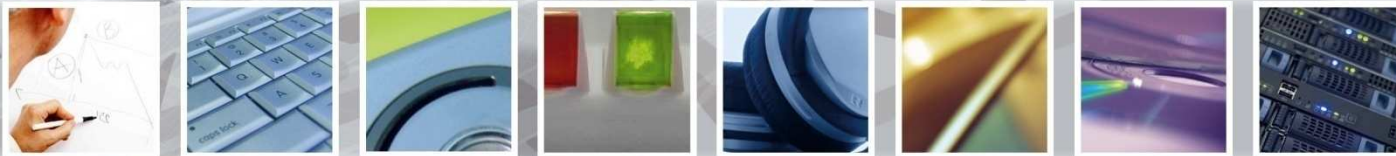


# The European Detect and Avoid approach for UWB

by  
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# Tutorial objectives

## ✓ Questions:

- What is “flexible Detect and Avoid (DAA)” for UWB?
- What are the possible detection methods?
- What are the possible avoidance strategies and techniques?



# DON'T PANIC

The European flexible DAA approach  
is “mostly harmless”!  
But, if some detail are not clear please  
ask and initiate a discussion.

This is not a scientific presentation but it  
should be an interactive tutorial!



# Tutorial Focus

## ✓ Questions:

- What is “flexible Detect and Avoid (DAA)” for UWB?
  - **Basics**
  - **Zone Model**
  - **LDC**
  - **DAA procedure**
- What are the possible detection methods?
- What are the possible avoidance strategies and techniques?
- How do can the DAA procedures be tested and certified?



# Legal basis for flexible DAA

EC decision 2009/343/EC, Annex section 1.2:

## 1.2 Appropriate mitigation techniques

Equipment using ultra-wideband technology shall also be allowed to use the radio spectrum with higher e.i.r.p. limits than mentioned in the table in section 1.1 when applying additional mitigation techniques as described in the relevant harmonised standards adopted under Directive 1999/5/EC or other mitigation techniques on condition that it achieves at least an equivalent level of protection as provided by the limits in the table in section 1.1. The following mitigation techniques are presumed to provide such protection:

1.2.1: LDC

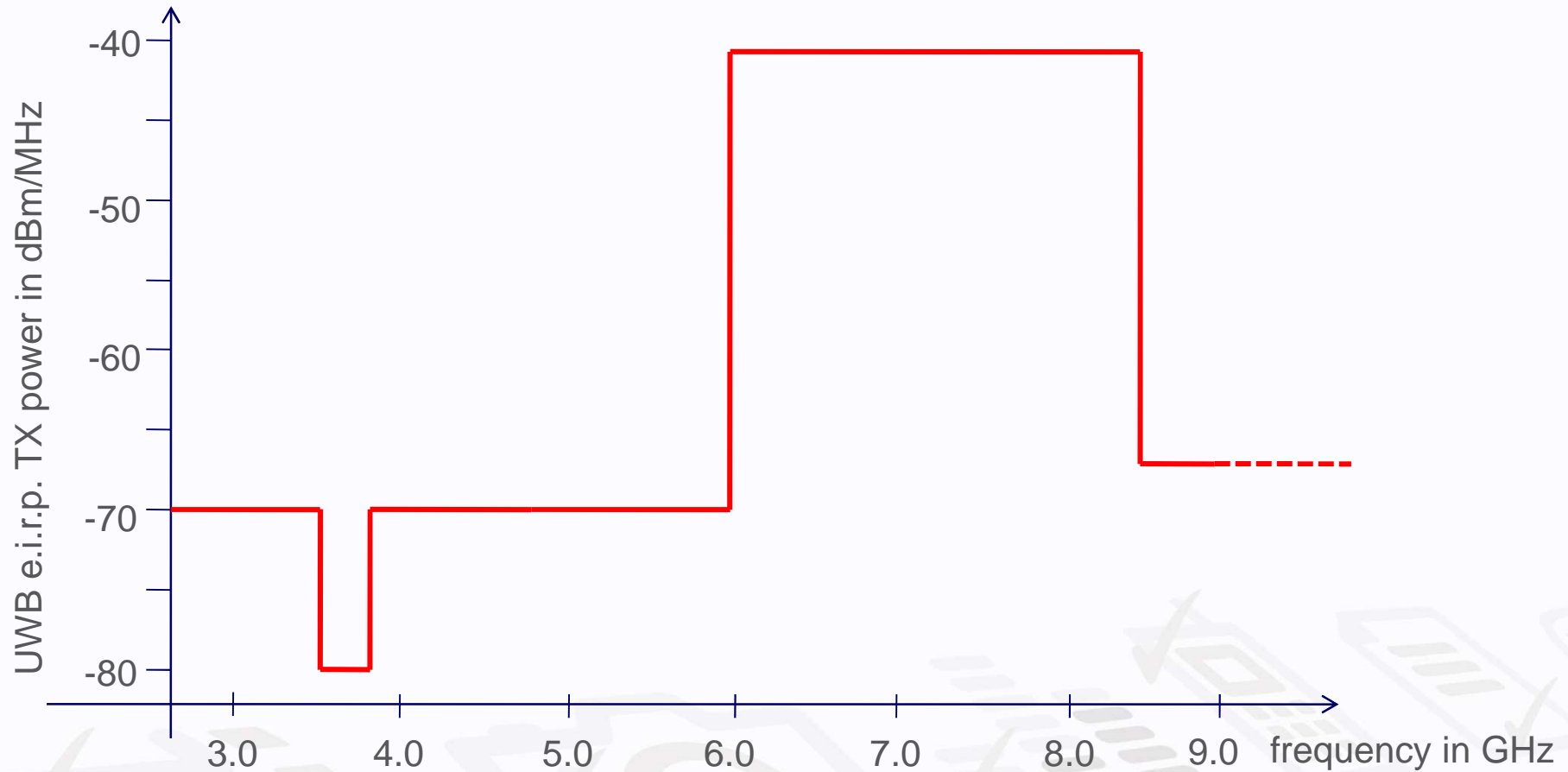
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1.2.2: DAA

.....



# EC DEC 2009/343 Table 1.1 levels







# Non-Interference Mode (NIM)

- ✓ Operation mode of the UWB device which guarantees the protection of victim services without additional mitigation techniques
- ✓ Two basic NIM operations for UWB devices:
  - TX power reduction to the regulatory limits for non DAA devices as defined in table 1.1 of EC DEC/2009/343
  - Low duty cycle operation (LDC) with  $-41.3\text{dBm/MHz}$  as defined in 1.2.1 in EC DEC/2009/343
- ✓ Reference protection for the flexible DAA approach based on the assumption of an equivalent protection of the potential victim services



# Example NI mode LDC

## ✓ LDC Parameter in actual EC regulation:

- $T_{on\_max} = 5 \text{ ms}$
- $\Sigma T_{off} > 950 \text{ ms per second}$
- $\Sigma T_{on} < 5\% \text{ per second and } 0.5\% \text{ per hour}$

## ✓ Max Mean e.i.r.p. power: -41.3dBm/MHz





# Example NI mode power levels

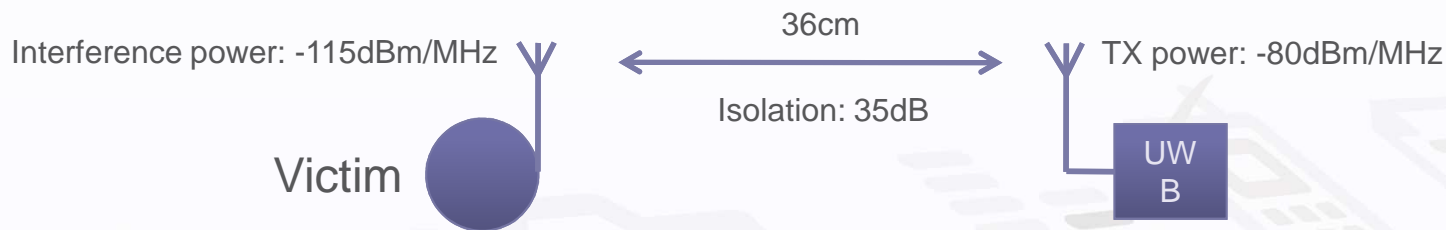
- ✓ 3.1GHz to 3.4GHz: -70dBm/MHz
- ✓ 3.4GHz to 3.8GHz: -80dBm/MHz
- ✓ 3.8GHz to 4.8GHz: -70dBm/MHz
- ✓ 8.5GHz to 9.0GHz: -65dBm/MHz



# NI mode in BWA bands

## ✓ 3.4GHz to 3.8GHz:

- Defined 36cm mitigation distance → 35dB isolation between victim (BWA system) and UWB device
- Interference power received at victim:  
-115dBm/MHz < thermal noise at room temperature



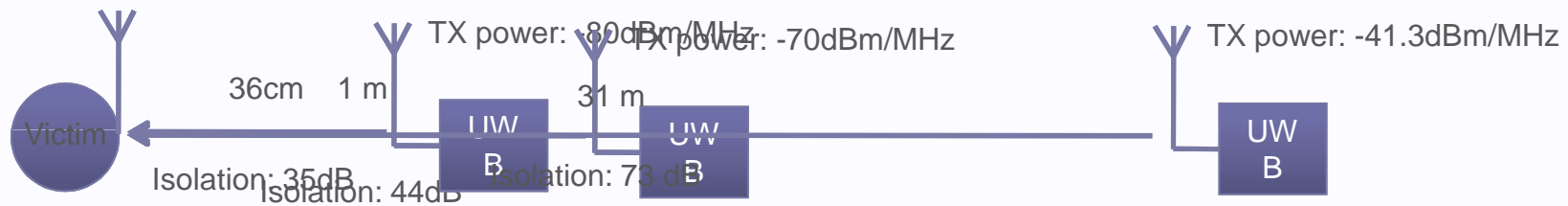


## Idea

- ✓ If the UWB device would know the value of the isolation to a victim it could adjust its TX power accordingly
  - Victim device protection (“UL-detection”)
- ✓ In contrast to “DL-detection”:
  - Service area protection
  - Independent of relative victim and UWB device location and thus the isolation



# Allowed TX UWB power versus distance/isolation



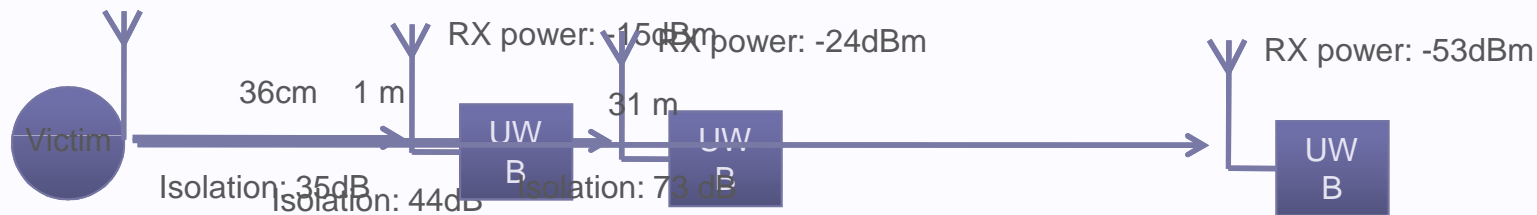
## Conditions:

- Line-of-Sight (LoS)
- No fading
- No additional attenuation



# RX power from victim at UWB device versus distance/isolation

Victim TX power: 20dBm

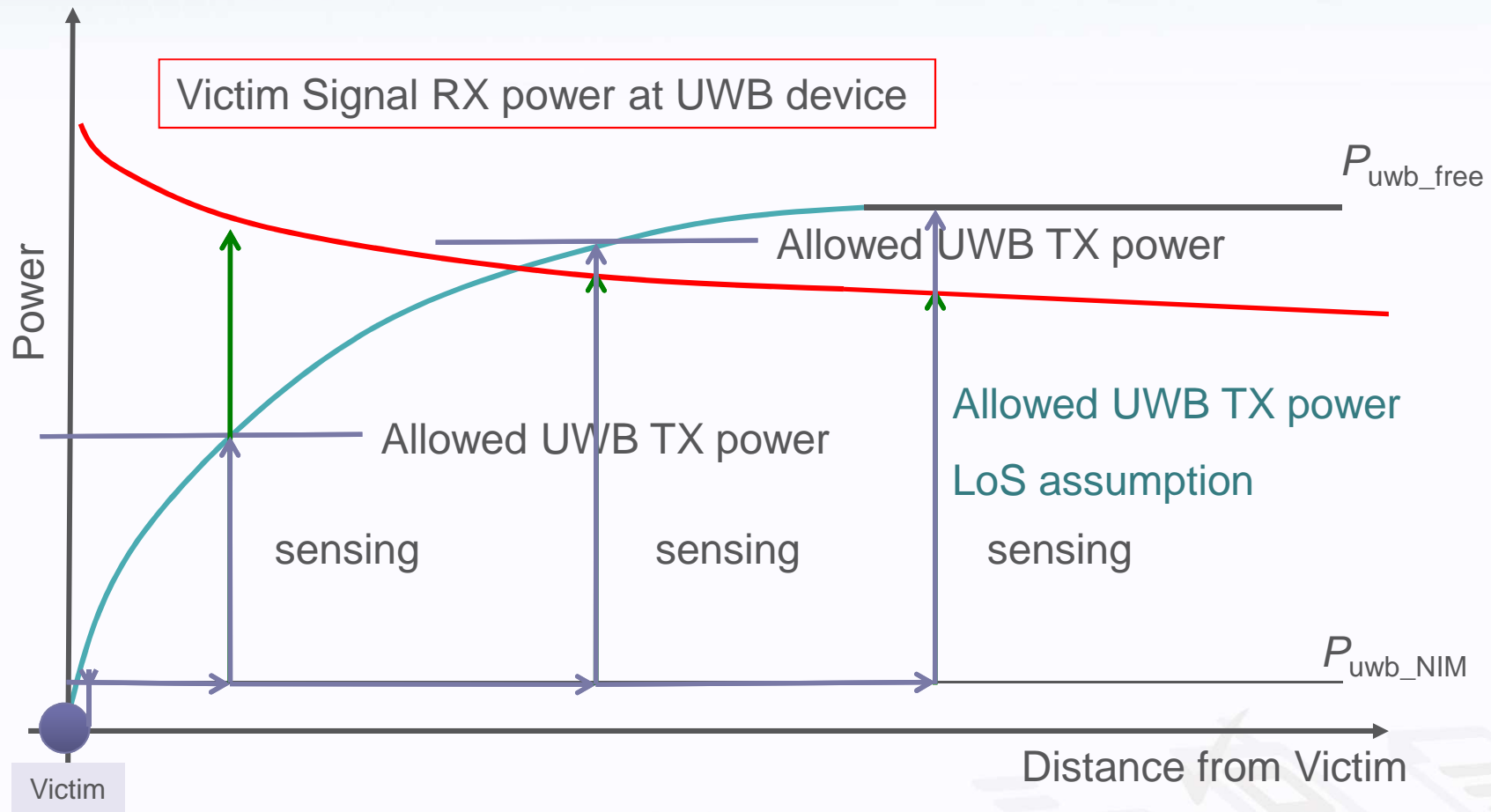


## Conditions:

- Line-of-Sight (LoS)
- No fading
- No additional attenuation



# Full flexible DAA





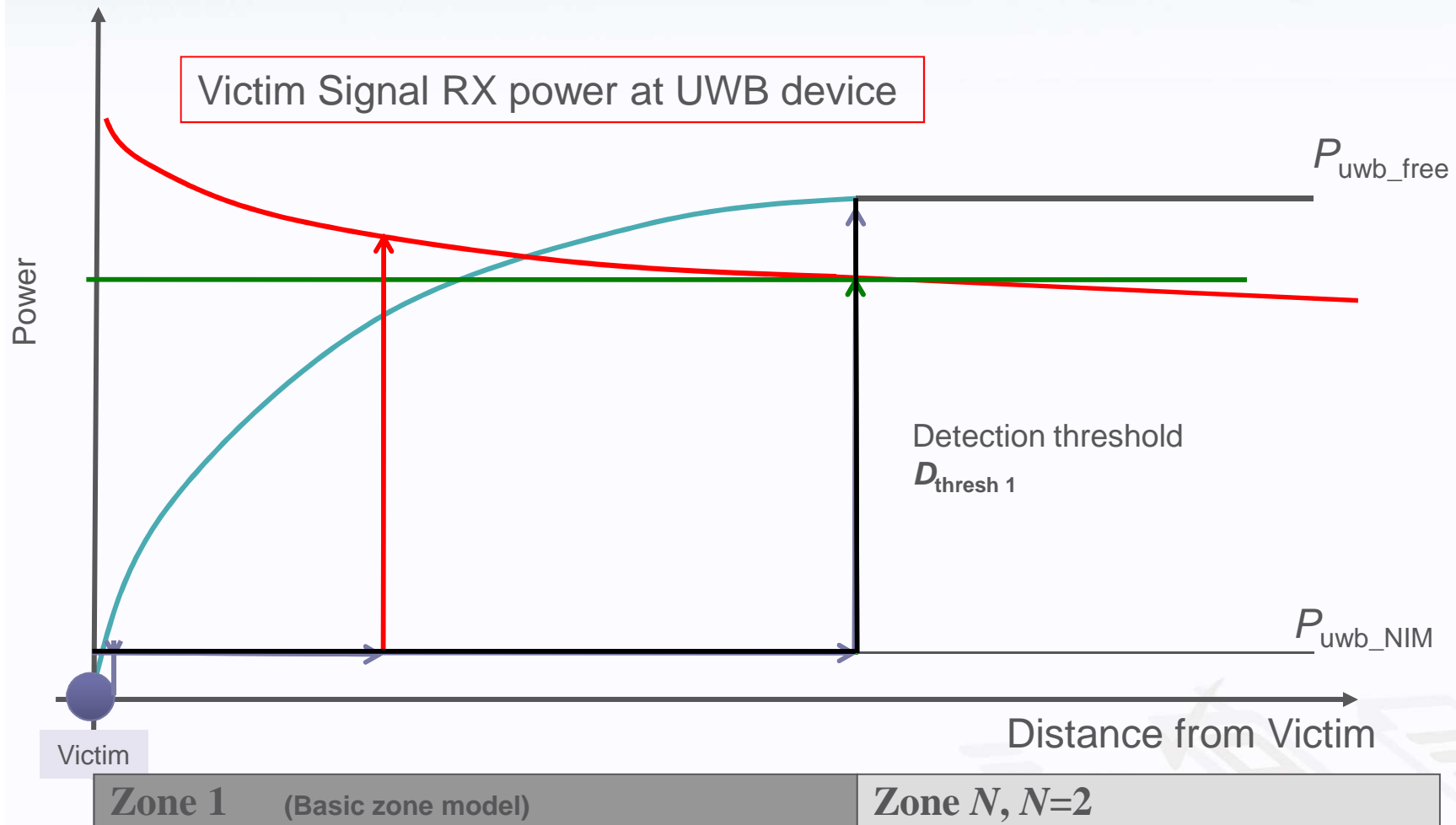


# Full flexible DAA model

- ✓ The UWB device evaluates the isolation to the potential victim and adapts its TX power correspondingly in a continuous way
- ✓ This approach is very complex
- ✓ Testing almost impossible
- ✓ But, it would be inline with the EC rules!
- ✓ CEPT has proposed an simpler version of the flexible DAA using discrete values

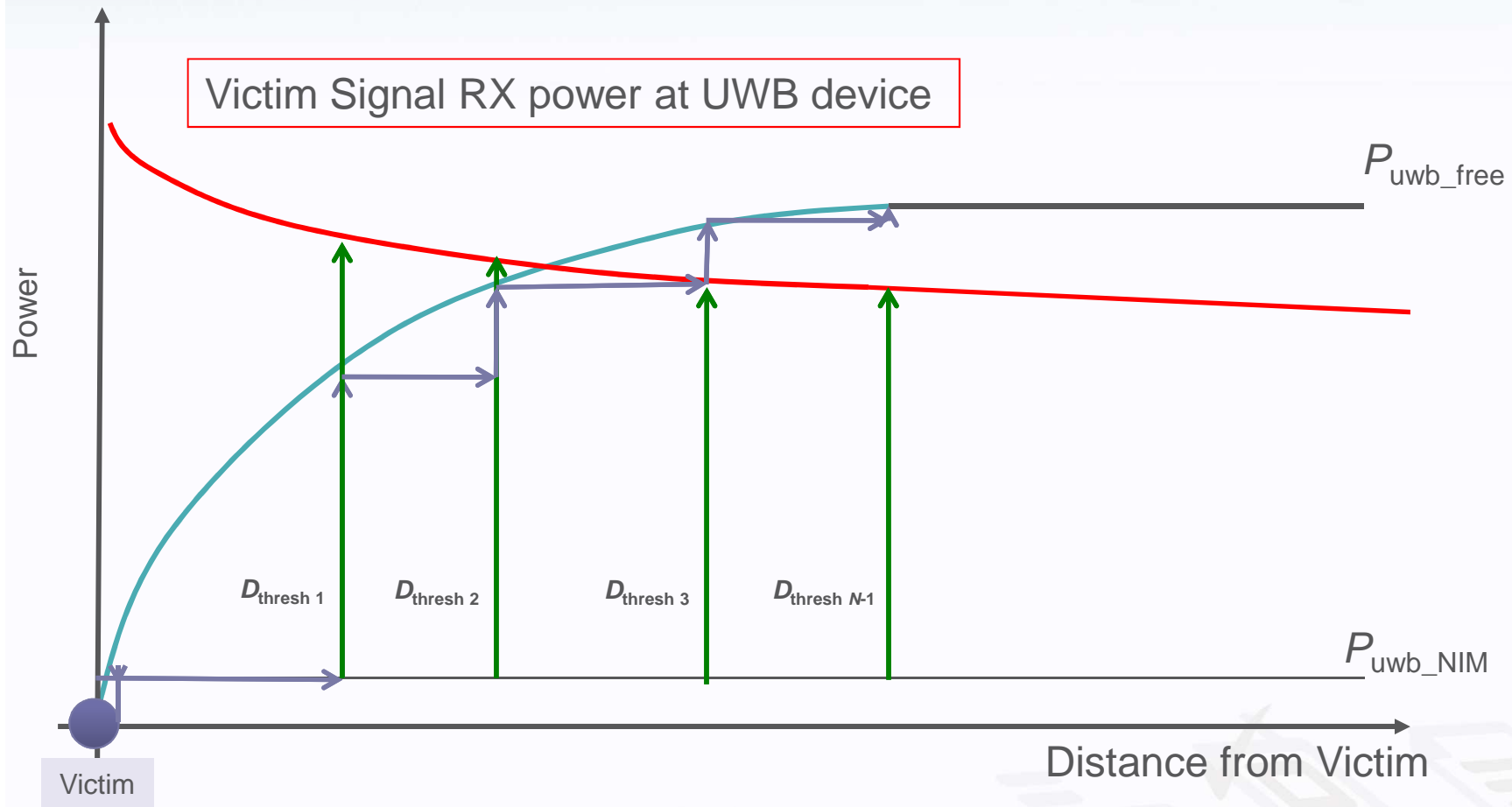


# Zone Model in flexible DAA I





# Zone Model in flexible DAA II



Zone 1

2

3

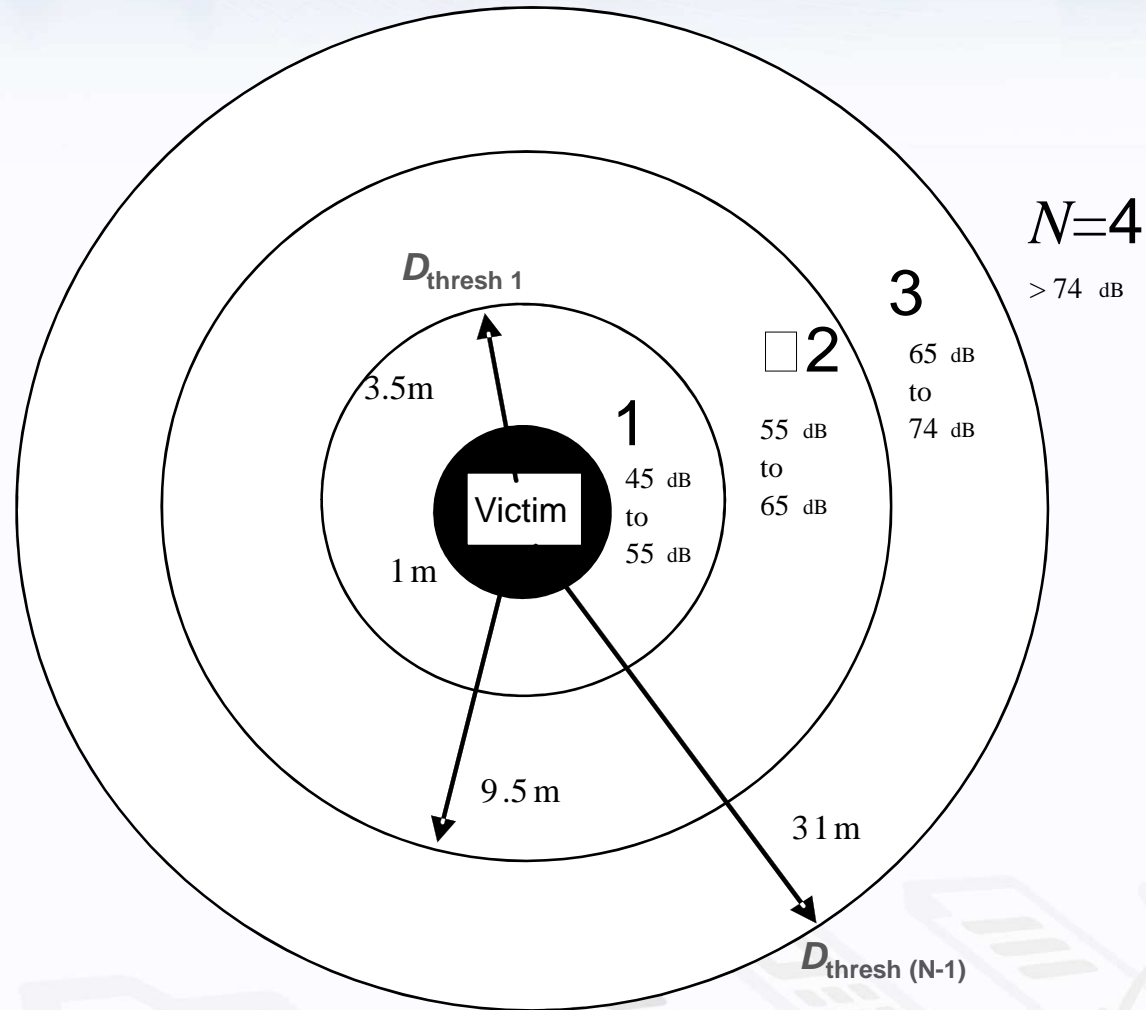
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Zone N, N=5



# Zone Model in flexible DAA III

- Example BWA system
- 4 Zones in flexible DAA
- Victim Noise Sensitivity:  
- 115dBm/MHz
- LoS channel conditions  
between victim and  
UWB devices
- [distance] = m  
[isolation] = dB





# Startup considerations

- ✓ Startup of UWB device:
  - In secure mode, thus using NIM
  - If needed sense environment or gets external infos
  - Move out of NIM only when not in vicinity of potential victim
  - Based on identified zone start non NIM operation
  - Minimum scan time is defined in regulation: “Minimum initial channel availability check time”



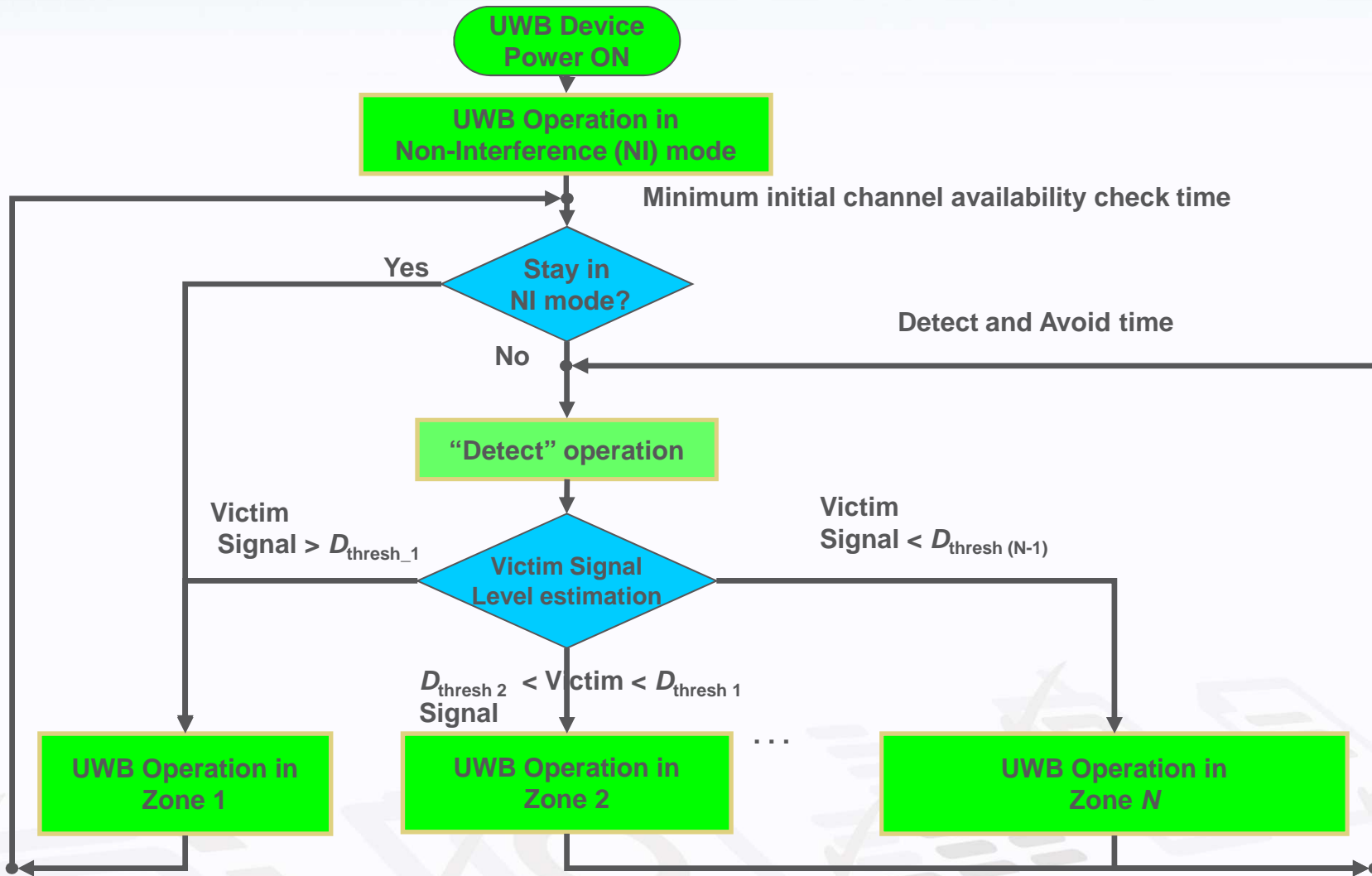
# In-operation considerations

- ✓ In operation mode → no NIM
  - Continuous update of zone information
  - Defined maximum reaction time in case of a zone change
  - Only zone decreases are regulatory relevant
  - Zone increases are important for the UWB performance
  - Regulatory parameter “Detect and Avoid Time” defines the maximum reaction time allowed.





# Flexible DAA flow Diagram





# DAA parameter I

- ✓ DAA threshold levels
- ✓ Initial Channel Availability Check Time
- ✓ NIM power level
- ✓ Detect and avoid time
- ✓ Default avoidance bandwidth
- ✓ Initial detection probability
- ✓ In-operation detection probability



# DAA parameter S-Band Radar

- ✓ Band: 3.1GHz to 3.4 GHz
- ✓ NIM power: -70dBm/MHz
- ✓ LDC allowed
- ✓ Threshold level: -38dBm (2 Zone model)
- ✓ Default avoidance bandwidth: 300MHz
- ✓ Initial Channel availability check time: 14s
- ✓ Detect and Avoid time: 150s



# DAA parameter BWA systems

- ✓ Band: 3.4 GHz to 3.8 GHz
- ✓ NIM power: -80dBm/MHz
- ✓ LDC allowed
- ✓ Threshold level: -38dBm or -61dBm (3 Zones)
- ✓ Default avoidance bandwidth: 200MHz
- ✓ Initial Channel availability check time: 5.1s
- ✓ Detect and Avoid time: 2s, 15s, 60s



# DAA parameter X-Band radar

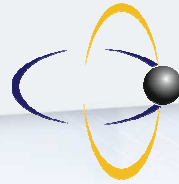
- ✓ Band: 8.5GHz to 9.0GHz
- ✓ NIM power: -65dBm/MHz
- ✓ No LDC allowed
- ✓ Threshold level: -61dBm
- ✓ Default avoidance bandwidth: 500MHz
- ✓ Initial Channel availability check time: 14s
- ✓ Detect and Avoid time: 150s



# Conclusions

- ✓ The original EU UWB regulation gave only limited access to the lower band (3.1GHz to 4.8GHz), the new regulation will open the band by introducing additional mitigation techniques
  - Flexible DAA
- ✓ The European “Flexible Detect and Avoid” approach can pave the way towards a worldwide regulation using DAA
- ✓ Flexible DAA delivers equivalent protection to the potential victim systems combined with a manageable complexity increase at the UWB device site
- ✓ During the regulation process a close collaboration between the incumbent systems and the new entrance was the key to a successful solution





# FBCONSULTING

THINK WIRELESS FOR TOMORROW

## ✓ Thank you!

### ✓ FBCConsulting S. à r.l.:

- European Regulation and Standardization
- EU Research Project Consulting
- Research in the domain of wireless system and short range device
- ETSI Member

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# Additional Slides

- ✓ Backup Slides with additional information



# Tutorial objectives

## ✓ Questions:

- How does the UWB regulation and standard looks like?
- What is “flexible Detect and Avoid (DAA)” for UWB?
- **What are the possible detection methods?**
- What are the possible avoidance strategies and techniques?
- How do can the DAA procedures be tested and certified?



# Detection process

- ✓ UWB needs to detect a signal
- ✓ All detected signals need to be identified
- ✓ Only relevant signals need to be taken into account
- ✓ Problem: Signal identification
  - Discrimination of Spurious emissions
  - Non victim systems emissions
  - Etc.

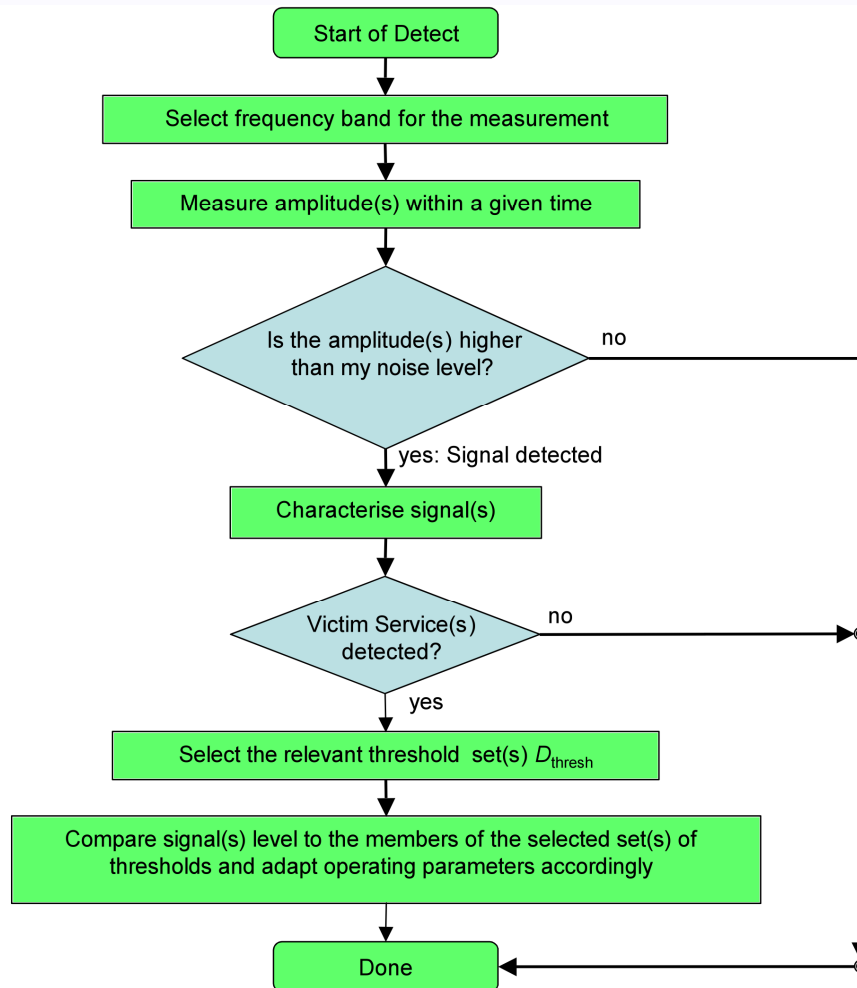


# Possible Detection Strategies

- ✓ Victim signal detection (Non data aided):
  - Energy detection
  - Coherent detection
  - Patter identification
- ✓ Use of external information (intersystem and intra system information, Data aided detection)
  - Information available in existing Piconets
  - Cognitive Pilot Channel (CPC)
  - Geolocation (GPS, etc.)
- ✓ Combined/Hybrid systems



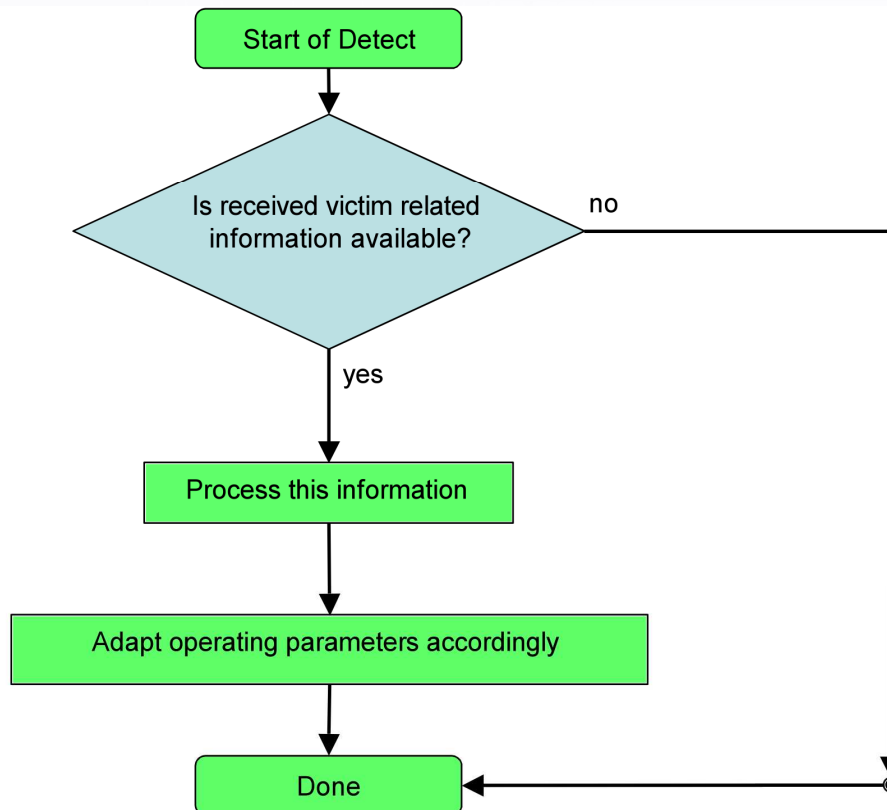
# Victim signal detection flow



- ✓ Spectrum sensing
- ✓ Signal identification using stored information
  - Pattern
  - Threshold sets
  - Victim Service bands



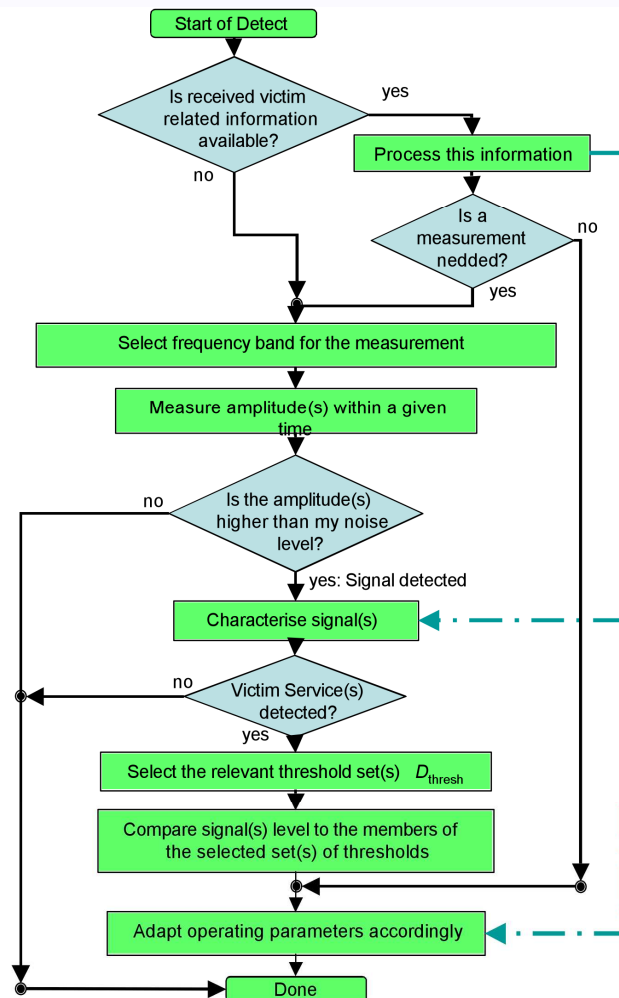
# Detection using external information



- ✓ Collocated devices
- ✓ Existing piconets
- ✓ Cognitive pilot channel
- ✓ Geo-location information like GPS



# Combined/hybrid detection flow



- ✓ Combine sensing and external information
- ✓ Most reliable solution
- ✓ Exchange of information using LDC mode





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# Avoidance Strategies

## ✓ In Time

- LDC, time sharing,

## ✓ In Space

- Antenna techniques,

## ✓ In power

- Power control, power reduction, switch off

## ✓ In frequency

- Notching, sub-band switching (two band hopping, FFI), BG switching

## ✓ Hybrid solutions



# Example for flexible Avoidance Methods in frequency domain

