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EMC FOR FIXED INSTALLATIONS
DRONES FOR ELECTROMAGNETICS MEASUREMENTS

Online, Friday 18 June 2021

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PROGRAMME

- 12.30: Welcome [Morten Sørensen, Associate Professor, SDU - Centre for Industrial Electronics (CIE)]
- 12.35: Keynote speech: EMC Directive 2014/30/EU: compliance for Fixed Installations [Keith Armstrong, Director and Principal EMC Consultant, worldwide services, Cherry Clough Consultants Ltd.]
- 13.05: EMC Management of fixed installation [Per Thåstrup Jensen, Senior Technology Specialist, Force Technology]
- 13:30: Measurement campaign and wind turbines [Claus Grøn Lyngby, Specialist, EMC. Product Function Lead, Vestas Wind Systems A/S]
- 13:45: Interference examples from Noise Service, Danish Centre for Telecommunications (Støjtjenesten) [Torben Kamstrup, Engineer, Støjtjenesten, Energistyrelsen]
- 14:00: Drones for electromagnetics measurements [Rasmus Gupta, CEO, Viking Drone ApS]
- 14:15: Discussion, closing remarks and farewell [Morten Sørensen, Associate Professor, SDU - Centre for Industrial Electronics (CIE)]

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KEYNOTE SPEECH: EMC DIRECTIVE 2014/30/EU: COMPLIANCE OF 'FIXED INSTALLATIONS'

- Keith Armstrong, Director and Principal EMC Consultant, worldwide services, Cherry Clough Consultants Ltd.

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EMC Directive compliance for *Fixed Installations*, and items intended to be incorporated within them

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Introduction

- There has always been confusion about how the original EMC Directive (89/336/EEC) applied to custom-made (bespoke) equipment, and to systems and installations…
  - dispelling this confusion was a main aim of the EC's 1997 Guidelines on the EMC Directive
- Properly dealing with this confusion was a major change in 2004/108/EC (2nd Edition EMCD)…
  - and that new text is almost completely unchanged in 2014/30/EU (3rd Edition EMCD)

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The 3rd Edition of the EMC Directive: 2014/30/EU

replaced 2004/108/EC on 20 April 2016

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The 3rd Edition of the EMCD: 2014/30/EU

Every *individual item of manufacture* made available on the EU Market on/after 20 April 2016 must declare compliance to this, regardless of how long the products have been supplied in the EU!

29.3.2014 EN Official Journal of the European Union L 96/79

DIRECTIVE 2014/30/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 26 February 2014

on the harmonisation of the laws of the Member States relating to electromagnetic compatibility (recast)

(Text with EEA relevance)

apply across sectoral legislation in order to provide a coherent basis for revision or recasts of that legislation. Directive 2004/108/EC should be adapted to that Decision.

(4) Member States should be responsible for ensuring that radiocommunications, including radio broadcast reception and the amateur radio service operating in accordance with International Telecommunication Union (ITU) radio regulations, electrical supply networks and telecommunications networks, as well as equipment connected thereto, are protected against electromagnetic disturbance.

(5) Provisions of national law ensuring protection against electromagnetic disturbance need to be harmonised in order to guarantee the free movement of electrical and electronic apparatus without lowering justified levels of protection in the Member States.

(6) This Directive covers products which are new to the Union market when they are placed on the market, that is to say they are either new products made by a manufacturer established in the Union or products, whether new or second-hand, imported from a third country.

(7) This Directive should apply to all forms of supply, including distance selling.

(8) The equipment covered by this Directive should include both apparatus and fixed installations. However, separate provision should be made for each. This is so because, whereas apparatus as such may move freely within the Union, fixed installations on the other hand are installed for permanent use at a predefined location, as assemblies of various types of apparatus and, where appropriate,

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The UK's Law implementing 2014/30/EU

Statutory Instrument 2016 No. 1091

Came into force in December 2016

STATUTORY INSTRUMENTS

2016 No. 1091

ELECTROMAGNETIC COMPATIBILITY

The Electromagnetic Compatibility Regulations 2016

Made - - - -	*15th November 2016*
Laid before Parliament	*16th November 2016*
Coming into force - -	*8th December 2016*

The Secretary of State is a Minister designated(a) for the purposes of section 2(2) of the European Communities Act 1972(b) in relation to measures relating to apparatus which is liable to cause electromagnetic disturbance and to apparatus the performance of which could be affected by such disturbance.

These Regulations make provision for a purpose mentioned in section 2(2) of the European Communities Act 1972 and it appears to the Secretary of State that it is expedient for certain references to provisions of EU instruments to be construed as references to those provisions as amended from time to time.

The Secretary of State makes these Regulations in exercise of the powers conferred by section 2(2) of, and paragraph 1A(c) of Schedule 2 to, the European Communities Act 1972.

PART 1

Citation and commencement

1. These Regulations may be cited as the Electromagnetic Compatibility Regulations 2016 and come into force on 8th December 2016.

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Changes in 2014/30/EU (1)

- A lot of new definitions added
- Text now includes:
  "placed on the market"
  "made available on the market"
  "first taken into service"
- New Chapter: "Obligations of Economic Operators" covers all the requirements of 768/2008
- New Chapter: "Notification of Conformity Assessment Bodies" covers all the requirements of 765/2008
- New Article: "Procedure for dealing with apparatus presenting a risk at national level", *plus* the Technical Documentation must now include a Risk Assessment…
  - these are for non-safety-related EMI risks, only

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Changes in 2014/30/EU (2)

- In Annex I, the old "Protection Requirements" are now called "General Requirements"…
- Added to the list of exemptions…
  "(e) custom built evaluation kits destined for professionals to be used solely at research and development facilities for such purposes"
- There is some rewording of the text, presumably to improve its legal status…
  – but without any actual change in meaning
  (as far as I can determine or have heard about)

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Some products which used to declare conformity to EMCD and LVD *will have to* declare to the RED (Radio Equipment Directive) *instead*

- Under the old R&TTE directive (1999/5/EC), if a manufacturer incorporated a radio module compliant with 1999/5/EC and installed it according to its instructions, the overall product could be declared in conformity with the EMCD and LVD…
  - **BUT THIS IS NOT THE CASE NOW!** Such products must now declare compliance to the RED (2014/53/EU) only – *not EMCD and LVD* – and will need extra EMC testing
- BUT this only affects products (apparatus) – not *fixed installations* as defined in the EMCD, which will continue to be covered by the EMCD and LVD no matter how many radio functions their equipment uses

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Changes in 2014/30/EU (3)

- *Note* that 2014/30/EU adds certain marking and labelling requirements…
  - concerning indelibly marking the manufacturers name, postal address, and the serial number(s) of the equipment on items of equipment
  - and it adds requirements for Agents, Distributors and Importers, who now share the risks of non-compliance with the product manufacturers
- But these are unlikely to affect most '*fixed installations*'…
  - and I will provide the details on request

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The EMCD and Safety (1)

- **Neither 2014/30/EU, nor the previous editions of the EMCD (2004/108/EC, 89/336/EEC) covers safety**
- **Where errors or malfunctions in E/E/PE (electrical, electronic or programmable electronic) devices could have an impact on safety…**
  - **the work required to control electromagnetic interference (EMI) to achieve adequate levels of what is now known as Functional Safety could be very much greater than is required for compliance with the EMCD**

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The EMCD and Safety (2)

- **The basic standard on EMC for Functional Safety is IEC 61000-1-2:2016…**
  - **however, IEC TS 61000-1-2:2008 is a normative reference in IEC 61508 Ed2:2010 and so must be applied for 61508 compliance…**
    - **and there is an IET Code of Practice on how to do this…**
    - ***see the references at the end***
- **But we can *generally* say that applying good EMC practices for compliance with the EMCD to '*fixed installations*' *should help* reduce the possibility that interference (EMI) will increase safety risks**

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The EMCD and Safety (3)

- **The EMC Directive does not cover health hazards caused by human exposure to electromagnetic fields (EMFs)…**
  - **in the EU this is controlled, for the general public, by EC *Regulation* 1999/519/EC…**
    - **which gets its legal force via the Low Voltage Directive (2006/95/EC, replaces 73/23/EEC + 93/68/EEC)…**
    - **or via the Radio Equipment Directive (2014/53/EU)**
  - **and for workers it is controlled by 2013/35/EU**
    - ***see the references at the end for more information***

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The EMCD applies to *equipment* that is: a) *made available on the market*; or b) *put into service*

- **And its definition of *equipment* includes both *apparatus* and *fixed installations***
  - **with special legal meanings for the common words: *apparatus* and *fixed installation…***
  - **it treats *fixed installations* differently from *apparatus…***
  - **the terms *made available on the market* and *put into service* are not defined in the EMCD, so the EC's 'Blue Guide' definitions apply** ***see the references at the end***

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Fixed installations in the EU must *all* have complied with the EMCD from 20 July 2007

- There used to be guidance from the EC and UK on whether legacy installations must completely comply with the EMCD from 20th July 2007…
  - or only comply if they are modified…
  - or whether compliance only applied to areas whose EMC characteristics were affected by the modifications…
  - but this is missing from the EMCD and its EC Guide, and also missing from the UK's 2016 SI and its official guide…
  - so we have to assume that all legacy installations must now completely comply with the EMCD

which is ridiculous!

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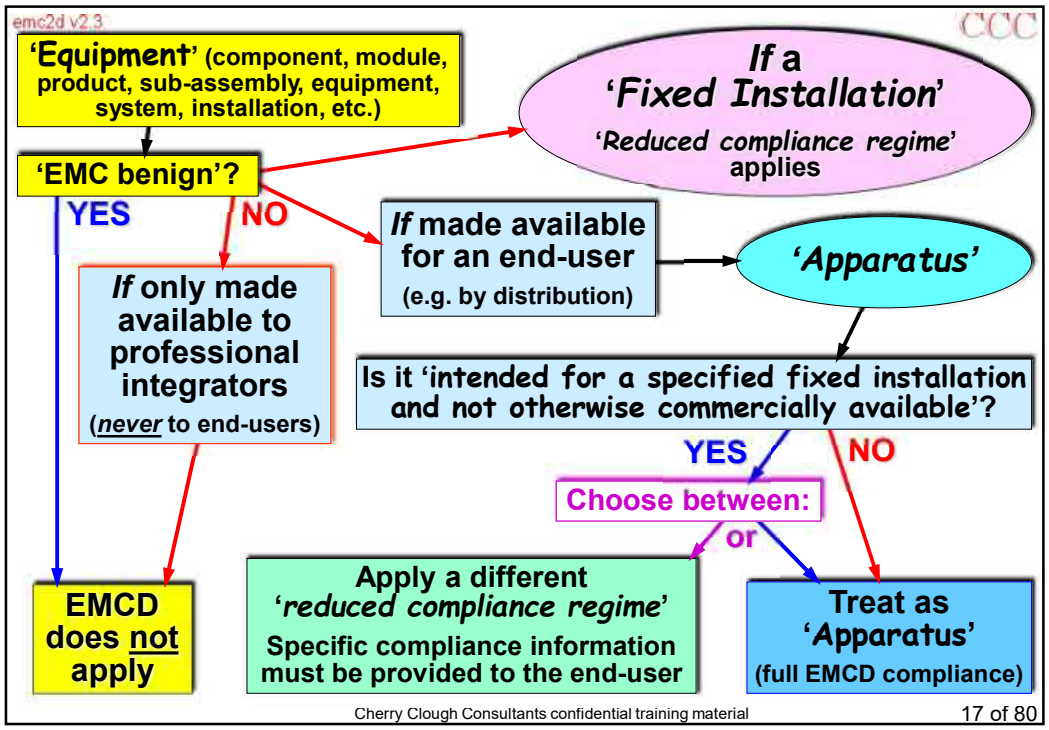
'Inherently benign equipment' is excluded from the scope of the EMCD (whether an *apparatus* or *fixed installation*)

- The EC Guide contains a list of what is currently considered to be ***inherently benign***…
  - but ***inherently benign equipment*** can never contain any semiconductors (rectifiers, transistors, ICs, etc.) or thermionic valves…
    - so beware of all equipment declared compliant with IEC/EN 60947-4-1, which erroneously states that bridge rectifiers are not 'electronic' and therefore no EMC testing is required for products that use only them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'Equipment' (component, module, product, sub-assembly, equipment, system, installation, etc.)
'EMC benign'?
YES
NO
If a 'Fixed Installation'
'Reduced compliance regime' applies
If made available for an end-user
(e.g. by distribution)
'Apparatus'
If only made available to professional integrators
(never to end-users)
Is it 'intended for a specified fixed installation and not otherwise commercially available'?
YES
NO
Choose between:
or
EMCD does not apply
Apply a different 'reduced compliance regime'
Specific compliance information must be provided to the end-user
Treat as 'Apparatus'
(full EMCD compliance)
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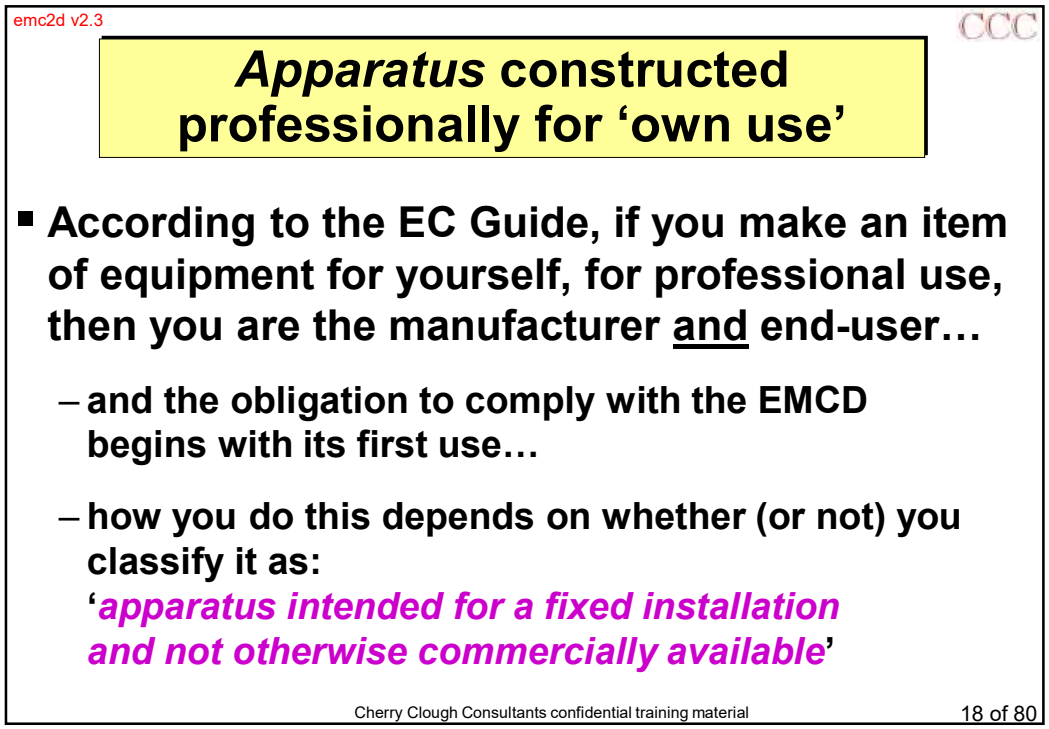
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Apparatus constructed professionally for 'own use'
According to the EC Guide, if you make an item of equipment for yourself, for professional use, then you are the manufacturer and end-user…
– and the obligation to comply with the EMCD begins with its first use…
– how you do this depends on whether (or not) you classify it as:
'apparatus intended for a fixed installation and not otherwise commercially available'
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Fixed installations are defined as…

- "*A particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location.*"
  - this definition covers all installations from the smallest residential electrical installations…
  - through commercial and industrial installations, e.g. computer networks, HVAC systems, production lines, etc…
  - to complete premises, sites, campuses, etc…
  - even national electrical, railway, telephone networks

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The EC Guide's examples of *fixed installations* include…

- Industrial, and power generating plants
- Electrical power distribution networks
- Telecommunication, and cable TV networks
- Computer networks
- Airport luggage handling, and runway lighting installations
- Automatic warehouses
- Skating hall ice rink machinery installations
- Storm surge barrier installations (with the control room etc)
- Wind turbine stations
- Car assembly plants
- Water pumping stations, and water treatment plants,
- Railway infrastructures
- Air conditioning installations

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Fixed installations *continued…*

- **A *fixed installation* is intended for <u>permanent</u> use at a <u>predefined</u> location…**
  - **which means it was constructed with the intention of being permanently situated at a particular location**
- **But if its constituent parts are expected to be moved during their expected lifetime and *taken into service* at another location…**
  - **then it is <u>not</u> after all a *fixed installation*, and should be treated as an *apparatus* instead**

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End-users create all sorts of *fixed installations…*

- **e.g. for a domestic multi-media system/installation**
- **But if they are not doing it professionally…**
  - **and if they only use *apparatus* that is CE-marked as being compliant with the EMC Directive…**
  - **and follow the manufacturers EMC instructions…**
  - **then no further EMC Conformity Assessment is required**

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Fixed installations cannot be 'supplied' to an end-user

- **Anything that is 'supplied' to an end-user is either *apparatus*…**
  - **or: "*apparatus intended for a specified fixed installation and not otherwise commercially available*" (e.g. custom-designed equipment)**

see later

for the EMC compliance of apparatus, see our relevant training course module

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Large machines

- **If a *large machine* meets the definition given for a *fixed installation*, then it is treated as such**
- **In all other cases, *large machines* are treated either as…**
  - ***apparatus…***
  - **or as '*apparatus intended for a specified fixed installation and not otherwise commercially available*'**

see later

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Mobile installations are defined as:

- "…a combination of apparatus and, where applicable, other devices, intended to be moved and operated in a range of locations."
  - the EC Guide gives the example of a portable broadcast studio
- ***Mobile installations*** **are treated as** ***apparatus*****…**
  - because, just like products that are placed on the market for anyone to purchase, they could be used anywhere in the EU

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"Moveable" installations ?

- Something that is constructed anew on each site, not necessarily in exactly the same way…
  - e.g. a fairground, touring music concert, etc. is not necessarily the same thing as a *mobile installation…*
  - and it is treated either as an *apparatus* or as a *fixed installation* according to each particular case

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"Systems"

- **The word 'system' does not appear *at all* in the EMCD…**
  - **except in connection with administrative systems…**
  - **although the EC's Guide discusses some types of 'systems', it is not comprehensive**
- **The word 'system' can describe a wide range of possible constructions…**
  - **and some companies are called 'system integrators'…**
  - **so we need to understand how the EMCD applies to 'systems', as we understand that word**

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Systems continued…

- **Where a system is created and supplied to an end-user by a manufacturer….**
  - **if it fits the EMCD's definition of *apparatus* it is treated in the same way – as an *apparatus*…**
  - **but a custom-engineered (bespoke) system is: '*apparatus intended for a specified fixed installation and not otherwise commercially available*'** ***see later***
- **But where end-users create their own systems…**
  - **they are either treated as *fixed installations* in their own right, or as parts of *fixed installations***

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Unlike *apparatus*, *fixed installations* are not required to have…

- an *electromagnetic compatibility assessment*
- a *Conformity Assessment*
- an EC *Declaration of Conformity (DoC)*
- the *CE marking* affixed

- But the EMCD does apply a "reduced compliance regime" to *fixed installations*…
  - *described in the next slides*

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All *fixed installations* must comply with the EMCD's *Essential Requirements*

Which have two parts….

1) The *General Requirements*

2) The *Specific Requirements for Fixed Installations*

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The *General Requirements* (1)

"Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:

(a) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunication equipment or other equipment cannot operate as intended;

(b) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use."

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The *General Requirements* (2)

- **Note the requirement:**
  "...having regard to the state of the art..."
  - **this does not mean that design & construction must always apply the state of the art in EMC...**
  - **it means that, at the time of the design and manufacture, the state of the art in EMC was understood and *was taken into account*...**
    - **which could mean not applying the state of the art, as long as this was decided by a competent person for good reasons...**
    - **and not merely because of ignorance of the state of the art**

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There are three parts to the *specific requirements for fixed installations*…

A) The application of *good engineering practices*

B) Assembly/installation "respecting the information on the intended use of its components, with a view to meeting the essential requirements"

C) Documenting the *good engineering practices* that have been employed…

- **this documentation kept ready for official inspection, by a named *Responsible Person*, for as long as the installation is in operation**

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What are *good engineering practices*?

The EC Guide says…

"Good engineering practice comprises of suitable technical behaviour taking into account recognised standards and codes of practice applicable to the particular fixed installation.

The "good engineering practices" referred to in Annex I, 2 mean practices which are good for EMC purposes, at the specific site in question.

General information on good engineering practice within the context of installations is available in several EMC handbooks, courses and technical reports."

Note: The EMC specifications in BS7671 (the IEE Wiring Regulations) are inadequate (at the moment, i.e. in the 18th Edition)

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What are *good engineering practices*? continued…

"For example some technical reports published by standardisation bodies deal with installation and mitigation guidelines for EMC. **(e.g. the IEC 61000-5 series)**

Good engineering practice, particularly in the field of EMC, are in constant evolution. Whilst there is a need to have regard for the 'state of the art' practices it does not necessarily follow that they are relevant for all installations.

Standards for installations cannot cover all specific local conditions: therefore it is necessary to be aware of some guiding principles when aiming to demonstrate installation according to good engineering practices:"

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What are *good engineering practices*? continued…

"- Emissions: take appropriate actions to mitigate the source of disturbances by EMC design, e.g. by the addition of filters or of absorption devices etc.

- Coupling and radiation: take appropriate actions in respect of distances, equipotential earthing, selection of cables, screening etc.

- Immunity: take appropriate actions to ensure that sensitive equipment is protected against the various types of disturbances that might be expected.

When applying the essential requirements to a defined fixed installation, it is essential to define the borderlines/geographical limits of this fixed installation in order to distinguish it clearly from the external environment."

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What are *good engineering practices*? continued…

"In an analogy with apparatus, it is fundamental to identify:

- The ports/interfaces where conducted (high or low frequency) disturbances may cross the borderline from or towards the fixed installation (power supply port, control and telecommunication ports etc.);
- The coupling mechanism with the external environment;
- The radiation towards or from the external environment.

It should be noted that it is not the purpose of the EMCD to ensure electromagnetic compatibility between specific equipment inside the borders of the defined fixed installation."

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Employing good EMC engineering practices…

- …is a problem for end-users, operators, system integrators, panel builders, custom engineers, installers, M&E contractors, etc…
- even today, many of them still know nothing about the *state of the art* in EMC engineering, e.g. they generally think that all that is required is:
  - assuming CE-marked equipment will not need any EMC engineering…
  - using single-point / star earthing/grounding…
  - terminating cable screens with a pigtail, at only one end…
  - grounding filters using *any length* of green/yellow wire…
- which are all generally <u>bad</u> for EMC these days

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A *Responsible Person* must by law be identified for each *fixed installation*

- This *Responsible Person* is responsible for ensuring that the *fixed installation* complies with the *Essential Requirements…*
  - which comprises the *General Requirements,* and the *Special requirements for fixed installations…*
  - and they must keep the *fixed installation's* EMC compliance documentation at the disposal of the national EMC authorities…
  - for as long as that *fixed installation* is in operation

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Each EU member state decides on the rules they will apply for identifying *Responsible Persons*

- For the UK: SI 2016 No.1091 defines a *Responsible Person* (for a *fixed installation*) as…
  - "…the person who installed the fixed installation…"
    - which is rather vague, made clearer by UK Government guidelines on EMC compliance
- Essentially, to be able to discharge their legal responsibilities…
  - *Responsible Persons* need <u>total control</u> of the EMC design and construction of their *fixed installations*

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Documenting EMC compliance

- **Where a simple *fixed installation* consists *solely* of *apparatus* (made available on the EU market for an end-user; declared EMCD-compliant, with CE marking affixed)…**
  - **the *Responsible Person* might be able to satisfy the documentation requirements simply by retaining the EMC instructions for installation, use and maintenance, provided by the suppliers…**
    - ***note:* manufacturers are required by the EMCD to provide EMC installation instructions to users…**
  - **and keeping records (e.g. of inspections) that show that the supplier's EMC instructions were followed**

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However, when documenting the EMC of a *fixed installation*, it is important to understand that: CE + CE ≠ CE !

- **Although the (so-called!) 'CE + CE = CE' approach is widely used by system integrators / installers…**
  - **it has no legal or technical justification, and never has had!**
  - ***it simply cannot be relied upon!***
  - **for more details on this, and what to do instead, see our training course:** https://www.emcstandards.co.uk/emc-for-systems-installations2

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But the compliance of a *fixed installation* can easily become complex, e.g… (1)

- **Suppliers' instructions can be contradictory…**
  - **often requiring significant EMC expertise to resolve the conflict using good EMC engineering practices**
- **Large numbers of fully-compliant *apparatus* can cause serious interference to other equipment in an installation, and even outside it…**
  - **especially variable-speed motor drives; variable-power industrial heaters; LED lighting; wireless communication systems; etc.**

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But the compliance of a *fixed installation* can easily become complex, e.g… (2)
– example of an HVAC system for an exhibition hall

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But the compliance of a *fixed installation* can easily become complex, e.g… (3)

- Imagine you have an industrial process plant that you want to duplicate to increase output…
  - measuring the EM environment, you find that the RF noise emissions from the existing plant are almost at the level where they would degrade digital TV reception over parts of the nearby town…
  - doubling the levels of emitted RF noise (by duplicating the process plant) would most likely cause many complaints of EMI…
  - so, the new duplicate plant must have at least 20dB lower emissions at digital TV frequencies

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Harmonised EMC standards make certain assumptions that are often not true, e.g….

- cellphones, walkie-talkies and ISM equipment are not used nearby (*but they are, in real life*)
- surges up to 2kV (*but 6kV or more will occur in real life unless IEC 62305-4 (lightning protection) has been fully and correctly applied to the site,*)
- electrostatic discharge up to 8kV (*but >15kV can easily occur during low humidity*)
- that only one type of EM Disturbance occurs at a time (*but this is not true in real life*)

- And they ignore some EM phenomena (*e.g. continuous EM disturbances between 2.5kHz and 150kHz)*

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Equipment that passes EMC tests can still cause/suffer EMI, *especially…*

- **electric trams and trains, even *if* they fully comply with EN 50121…**
- **diathermic heaters / plastic sealers, glue dryers, microwave heaters/cookers/dryers, induction heaters and hotplates, electromagnetic stirrers, electric welders, etc., even *if* they fully comply with EN 55011 (CISPR 11)…**
- **WPT (wireless power transfer) equipment, e.g. air-gap battery chargers for electric vehicles, even *if* they fully comply with EN 55011 (CISPR 11)…**
- **radio/wireless transmitters, inc. cellphones, walkie-talkies, Wi-Fi, etc. even *if* they fully comply with relevant ETSI or other wireless standards…**
- **PLC (power line communications: domestic data modems that use the mains wiring to carry data) even *if* they fully comply with EN 50561-1…**
- **power converters, especially grid-connected types for Solar PV cells, including those that use spare energy to heat domestic water…**
- **LED lighting / floodlighting even *if* fully compliant with EN 55015 (CISPR 15)**

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Interference within a *fixed installation*

- **Most people assume they can cause whatever interference they like within the boundaries of their site, plant, building, etc…**
  - ***but* if a fixed installation interferes with licensed radiocoms / telecoms within its site, it could have serious implications…**
  - **and because paramedics, ambulances, fire, other 'First Responders' rely on radiocomms, interference on site might contravene Health & Safety…**
  - **and what the possibility of interfering with drones, helicopters (e.g. police, ambulance, etc.) that might fly *low overhead*?**

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There are no mandatory requirements for the *types* of documentation that the *Responsible Person* must keep

– **but (except for the simplest systems) it should show how sufficient confidence in complying with the *Essential Requirements*, was achieved, e.g. by…**

- **knowledge of the EM environment (assessments, calculations, site measurements, etc.)**
- **knowledge of the EM characteristics of the equipment incorporated into the installation, and their suppliers' EMC recommendations for assembly/installation**
- **use of EM mitigation measures (segregation, shielding, filtering, galvanic isolation, suppression, etc.)**
- **calculations, simulations, experiments, trials, measurements, etc.**

emc2d v2.3

CCC

No mandatory requirements for the types of documentation continued…

– **<u>and</u> the use of good EMC engineering practices must be documented, e.g. by…**

- **reference to specifications describing the appropriate good EMC engineering practices…**
- **records of inspections, photographs, etc., showing that the specified practices were followed**

emc2d v2.3

CCC

There are no EMC test standards for *fixed installations*, for emissions or immunity…

- although CISPR 11 (EN 55011) includes an emissions test method for 'in-situ' measurement of large items of equipment after installation…
  - now being 'spun out' as CISPR 37, currently in draft…
  - often used to check an entire site is in compliance around its horizontal boundaries, *but this is outside its scope…*
- see https://www.emcstandards.co.uk/test: recommended on-site/in-situ test methods for emissions and immunity

- It is *possible* (but unlikely) that some suitable EMC test standards might be created in the future

emc2d v2.3

CCC

Responsible Persons (1)

- Because the EMC responsibilities of *Responsible Persons* continue throughout the operational life of their *fixed installations*…
  - *Responsible Persons* should be employed by the owner/user/operator of their *fixed installations*
  - e.g., contractors are increasingly being employed by site owners/operators to undertake Facilities Management (FM)…
  - so it seems reasonable that they might be officially appointed to be the *Responsible Persons* for the *fixed installations* they manage…
    - which could well be the systems they were paid to install

emc2d v2.3

CCC

Responsible Persons (2)

- **A *Responsible Person* does not have to know anything about EMC, or EMCD compliance…**
  - **they can delegate other people or companies to do it all for them…**
  - **but cannot delegate their legal responsibilities!**
- **If a delegated person or company gets it wrong, the law still blames the *Responsible Person*…**
  - **who may of course choose to use civil law to personally sue the delegated person or company for damages**

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CCC

Responsible Persons (3)

- **Some *Responsible Persons* will no doubt (incorrectly) try to treat EMC compliance in the same way as technical issues such as National Electrical Wiring Regulations…**
  - **by not bothering to learn anything about it…**
  - **simply expecting their suppliers and the electricians, installers, M&E Contractors, etc., they employ *to do it all for them*…**
  - ***and*, at the end of their work, expect them to provide all of the EMC compliance documentation that *Responsible Persons* are required by law to keep ready for inspection**

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CCC

Responsible Persons (4)

- **But few suppliers or M&E contractors have adequate EMC competencies (yet)…**
  - **and ensuring EMCD compliance for a *fixed installation* can be a complex issue…**
    - **requiring a level of overall knowledge and control of the installation's EMC that most of them don't have...**
  - **or are <u>not permitted to have</u>…**
    - **especially when a contractor is employed just to work on a small modification…**
    - **e.g. merely determining the EM environment using on-site EMC tests – needed to even *begin* any EMC compliance work – can cost over €2k per day**

emc2d v2.3

CCC

Responsible Persons (5)

- **There can be several *fixed installations* on a given site (e.g. computer network, HVAC system, etc.)…**
  - **each with their own *Responsible Person***
- **In such situations it seems reasonable (to me) that they should coordinate their activities so that…**
  - **the entire site does not cause unacceptable interference to other equipment or sites…**
  - **and the different *fixed installations* on the site do not interfere with each other**

emc2d v2.3

CCC

When a site, plant or building is sold to a different owner…

- then the new owner's appointed *Responsible Persons* become responsible for all of the good EMC engineering practices of their *fixed installations*….
- and all of their EMC compliance documentation…
  - since 20th July 2007

- I strongly recommend checking the EMC compliance documentation *prior to purchase*…
  - to help avoid taking on unknown financial risks

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CCC

If complaints of interference have been received concerning a *fixed installation*…

…the National EMC Authority will probably request evidence of compliance…
and/or conduct an EMC site survey

- Where non-compliance is established…
  - the authorities may impose measures to bring it into compliance with the *Essential Requirements*…
  - and until they are convinced, they may insist that the fixed installation remains shut down

emc2d v2.3

CCC

Future compliance

- **Some sites are located remotely, which helps them avoid suffering/causing interference…**
  - **but what if – in the future – radio, telecoms or other equipment is used nearby?**
    e.g. if a public road, housing/commercial/industrial estate, hospital, airport, etc., is built nearby?
- **Should the existing site be made to comply with such future requirements now…**
  - **so as not to have to be modified later on in case of such developments?**
    - **no UK Government guidance, when asked this on 29th Nov. 2007**

emc2d v2.3

CCC

Future compliance continued…

- **The EM environment is always changing**
  (e.g. 5G cellphones, the IoT and IIoT, LED lighting / floodlighting, the increasingly widespread use of noisy switching power conversion to save energy and the planet, etc.)…
  - **and as equipment wears and ages its EM performance (e.g. shielding, filtering, surge suppression) degrades…**
  - **but *fixed installations* must continue to comply with the EMCD throughout their operational life!**

our continuously updated course on 'Good EMC engineering for Cabinets, Systems and Installations' covers all such issues

emc2d v2.3

CCC

Including EMC in contracts

- I ***very strongly recommend*** **M&E contractors, system integrators, installers, etc., identify all the *Responsible Persons* and contractually agree with them…**
  - **what EMC activities they are required to perform…**
  - **what EMC checks or tests they must perform…**
  - **what EMC documents they must provide at the end…**
  - **and how much they will be paid for doing the EMC work required by the *Responsible Person*…**
  - ***before quoting for a contract!***
  - **I have been involved with some very unpleasant and costly situations caused by both sides having different assumptions about the EMC compliance of fixed installations**

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CCC

'Items' intended for incorporation into a fixed installation

- **the word 'item' is used here to mean any electrical equipment, e.g. systems (of any size), products, sub-systems, devices, etc.**

- **It could be *apparatus* as defined in the EMCD…**
  - **placed on the EU market with a DoC and CE marking**
- **Or it could be *apparatus* specially made for that installation (typically: custom-engineered, bespoke, etc.)…**
  - **and not otherwise commercially available to an end-user as a single functional unit**

emc2d v2.3

'Apparatus' must fully comply with the EMCD, including the provision of comprehensive EMC instructions for installation, use and maintenance

- I recommend obtaining all EMC instructions *before making a purchasing decision*, then checking…

  a) is it reasonable? (e.g. it doesn't specify costly or hard-to-get cables, filters or shielding)…

  b) does it follow good *modern* EMC engineering practices *e.g. as described in our training courses*

For example: I would always suspect anything that requires 'single-point earthing/grounding' or connecting cable shields at one end only, of probably having a bad EMC design!

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Apparatus incorporated into a fixed installation continued…

- A common problem is that the *apparatus* may not have been intended for use in the EM environment obtaining in the *fixed installation* in question…
  - e.g. a desktop or laptop PC used to control a heavy-industrial process (even if placed in a steel box for protection)…
- *Responsible Persons* need to ensure EMC compliance of their *fixed installations* is not compromised…
  - so should *never* assume that just because an *apparatus* is CE marked it does not need additional EMC mitigation (filtering, shielding, suppression, etc.)…
    - even if the *apparatus* is known to be fully compliant with all its relevant EMC test standards!

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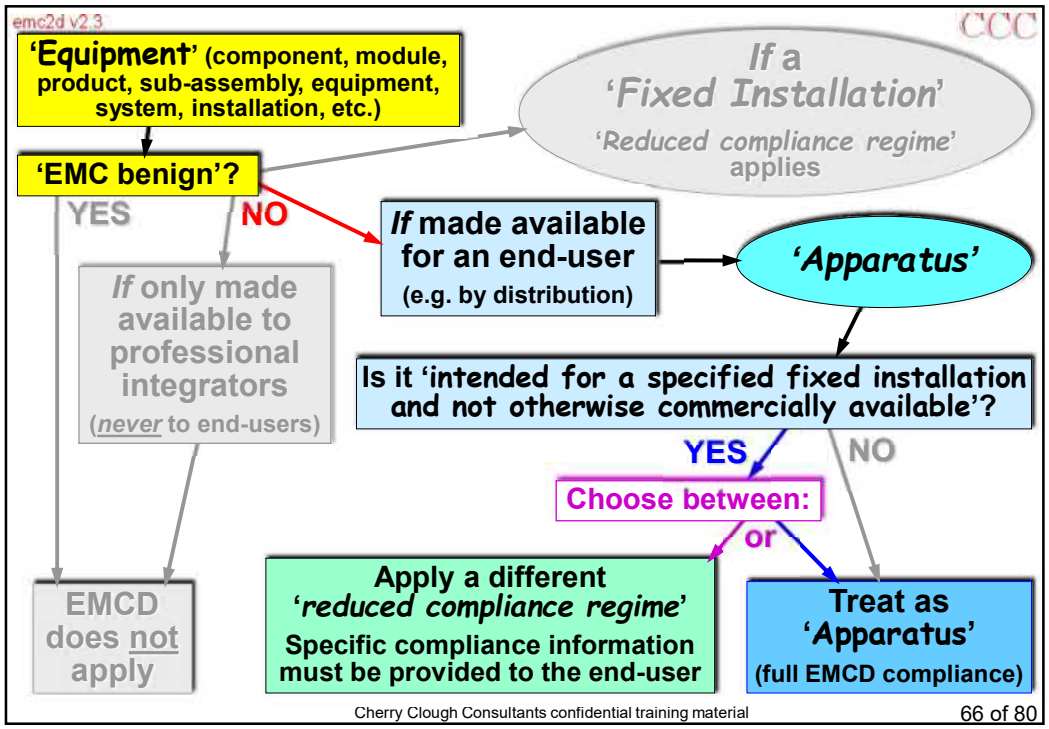
CCC

Where an item is *apparatus* intended for incorporation into a specified *fixed installation*…

- and is ***not*** otherwise commercially available to an end-user as a single functional unit,
  i.e. it is custom-designed, bespoke, etc…
- the manufacturer can choose to apply a '*reduced compliance regime*' that is different from the one applied to *fixed installations*, and does not require…
  - a) Compliance with the *Essential Requirements*
  - b) An *EMC conformity assessment procedure*
  - c) The *CE marking* to be affixed



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CCC

According to the EC Guide, an *apparatus* only qualifies for the *reduced compliance regime*…

- *if there is a direct link between the manufacturer of that specific apparatus…*
- *and the owners, installers, designers, operators or responsible persons of the fixed installation for which that specific apparatus is intended*

- **Note: CE marking must not be affixed to any apparatus using the *reduced compliance regime*…**
  - **but of course CE marking will generally be required by other Directives, e.g. the LVD, Machinery Directive, RED, etc.** *!!!*

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CCC

Where an item is apparatus intended for incorporation into a specified *fixed installation*… continued…

- **Where a design is to be incorporated into more than one identical *fixed installation*…**
  - **establishing that the electromagnetic environments of those fixed installations are very similar indeed…**
  - **can allow the *reduced compliance regime* to be used for the manufacture and storage of multiple items of a given design of apparatus**

emc2d v2.3

CCC

All such equipment ***must*** be provided to their end user with documents that…

- identify the *fixed installation* it is intended for…
- describe the *fixed installation's EMC characteristics*…
- indicate the precautions to be taken when incorporating the equipment into the *fixed installation* so that it does not compromise that *fixed installation's* EMCD compliance…
- uniquely identify the item by its type, batch and serial numbers (or any other identifying information)…
- give its manufacturer's name and address (or that of its EU importer)

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CCC

How does the RED apply to *apparatus intended for a specified fixed installation and not otherwise commercially available*?

- RED Article 3.2 (Radio Spectrum) still applies
- RED Article 3.1a (Safety, corresponding to the LVD) still applies
- RED Article 3.1b (EMC, corresponding to the EMCD) does not apply…
  - except that some EMC testing might be required to prove that the apparatus does not interfere with its own radio functions

I recommend asking a RED Notified Body such as www.acbcert.com

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How does the RED apply… continued…

- **Most such *apparatus* will probably be what the RED calls '*Combined Equipment*"…**
  - **the easiest compliance with ETSI EG 203 367 (or the REDCA guidance) and ETSI EN 301 489-1, is when a single Radio Part (e.g. a WiFi module) is installed *fully in accordance with its manufacturer's instructions***
    - **compliance rapidly gets more complex and costly if the *Combined Equipment* has two or more Radio Parts, especially when they can operate at the same time…**
    - **or if any Radio Part's installation instructions were not *fully applied* (e.g. if using a different mounting or antenna)…**
    - **or if any Radio Part has been modified in any way**

I can provide advice on EMC compliance under the RED, and the EMC of 'Combined Equipment'

emc2d v2.3

Some useful references on EMC law

- **The EMC Directive, 2014/30/EU:**
  http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014L0030
- **The EC's official webpage for 2014/30/EU:**
  http://ec.europa.eu/growth/sectors/electrical-engineering/emc-directive
  (the EC's Guide to 2014/30/EU is available from this site, under 'Guidance')
- **The UK's 2016 EMC Regulations:**
  www.legislation.gov.uk/uksi/2016/1091/pdfs/uksi_20161091_en.pdf
- **The UK's official guide to the 2016 EMC Regulations:**
  https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/640794/nlf-emc-regulations-2016-guidance.pdf

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CCC

Some useful references on EMC law continued…

- **The EC's "Blue Guide on the implementation of EU product rules, 2016", from:**
  https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016XC0726(02)&from=BG
- **A great deal of valuable EMC information is available for free from www.emcstandards.co.uk, e.g….**
  - **'How to Assess an EM Environment'**
  - **'The RSS method' for adding up emissions from different items of equipment, using a spreadsheet**
  - **'On-Site EMC Testing Procedures' for emissions and immunity**
  - **'Good EMC Engineering Practices' articles and references**
    - **and training courses are available for purchase on-line, at prices that individuals can afford**

Cherry Clough Consultants confidential training material 73 of 80

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CCC

Some useful references on EMC engineering

- **Free 'REO' guides from:**
  www.emcstandards.co.uk/emc-for-systems-installations1

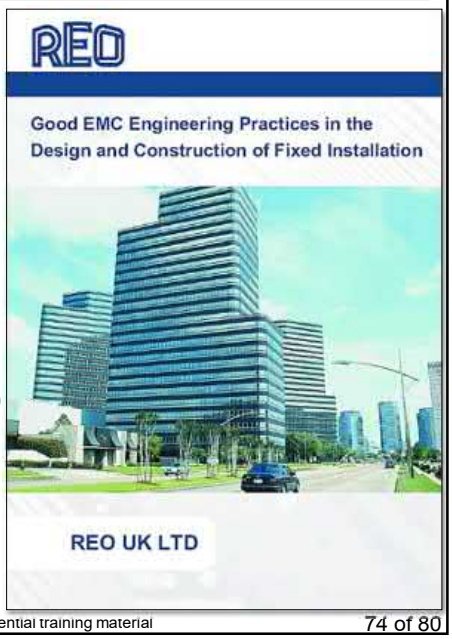
  Good EMC Engineering Practices in the Design and Construction of Fixed Installation

  Complying with IEC 61800-3 – Good EMC Engineering Practices in the Installation of Power Drive Systems

  Mains Harmonics **(problems & solutions)**

  Power Quality **(problems & solutions)**

  Good EMC Engineering Practices in the Design and Construction of Industrial Cabinets **(relevant for all types of electrical/electronic equipment)**



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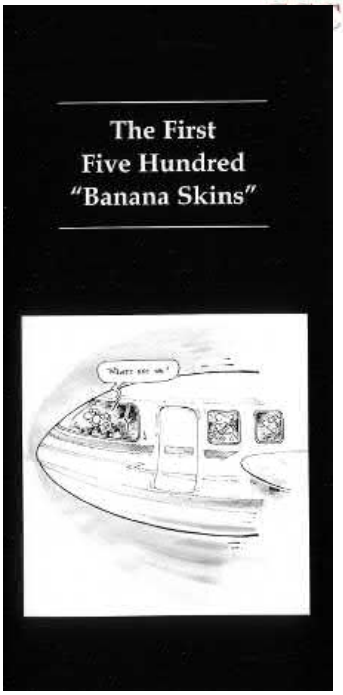
Some useful references
continued…

- ***The First 500 Banana Skins***
  - **500 reports and anecdotes of real-life interference incidents, ranging from amusing, through costly, to deadly**
    - **very useful for convincing managers that EMC is a real issue that often costs companies large amounts of money, and can even cause bankruptcy**
  - **order from:** www.emcstandards.co.uk/books4
- **Also – over 870 reports and anecdotes concerning EMI, free from:** www.emcstandards.co.uk/emi-stories



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CCC

Some useful references continued…

- ***EMC for Systems and Installations,* Tim Williams and Keith Armstrong, Newnes, 2000, www.bh.com/newnes, ISBN 0-7506- 4167-3 (RS Components Part No. 377-6463) available from:** www.emcstandards.co.uk/books4
- **7 EMC Guides on doing EMC emissions and immunity testing, including EM phenomena and legal compliance, REO (UK) Ltd., available from:** www.emcstandards.co.uk/emc-testing
  - **Note: these were written some time ago, so please always use the latest version of the relevant test standards and don't simply follow these guides slavishly.**
    You will probably find that their basic test philosophies/methods are unchanged, but always check carefully anyway!

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CCC

EMC-related functional safety issues are *not* covered by the EMCD, but see…

- **IEC 61000-1-2:2016, "*Electromagnetic Compatibility (EMC) – Part 1-2: General – Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena*."**
- ***"Code of Practice on Electromagnetic Resilience"*, The IET (London, UK) 2017, purchase from:** www.theiet.org/resources/standards/emr-cop.cfm or https://electrical-shop.theiet.org/books/standards/emr-cop.cfm
- **And numerous articles and conference papers on this topic are posted at:** www.emcstandards.co.uk/emiemc-risk-management

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CCC

The exposure of the *general public* to EM fields is not covered by the EMC Directive, but see…

- **EC Regulation 1999/159/EC:** https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:199:0059:0070:EN:PDF
- **An EC document on Public Health and EMFs, at:** https://ec.europa.eu/health/archive/ph_determinants/environment/emf/brochure_en.pdf
  - **and one from the World Health Organisation:** https://www.who.int/peh-emf/publications/facts/fs304/en/
- **Elektromagnetische velden in arbeidssituaties, juni 2006:** https://www.arboportaal.nl/documenten/brochure/2016/07/01/elektro--magnetische-velden-in-arbeidssituaties

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The exposure of *workers* to EM Fields is not covered by the EMC Directive, see…

- **Directive 2013/35/EU, from:** https://osha.europa.eu/en/legislation/directives/directive-2013-35-euelectromagnetic-fields, **or from…**
  http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013L0035
- **UK Statutory Instrument 2016 No.588, HEALTH AND SAFETY**
  The Control of Electromagnetic Fields at Work Regulations, 2016,
  http://www.legislation.gov.uk/uksi/2016/588/pdfs/uksi_20160588_en.pdf
- **"*Non-binding guide to good practice for implementing Directive 2013/35/EU Electromagnetic Fields, Guide for SMEs*"…**
  http://ec.europa.eu/social/BlobServlet?docId=14749&langId=en
  For the 'Comprehensive' version of this guide:
  https://osha.europa.eu/en/legislation/guidelines/non-binding-guide-goodpractice-implementing-directive-201335eu
  Practical Guide Vol 1: https://publications.europa.eu/en/publication-detail/-/publication/c6440d35-8775-11e5-b8b7-01aa75ed71a1
  Practical Guide Vol 2, Case Studies:
  https://publications.europa.eu/en/publication-detail/-/publication/e71e8b3f-8775-11e5-b8b7-01aa75ed71a1

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EMC Directive compliance for *Fixed Installations*, and items intended to be incorporated within them

the end

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EMC Management of Fixed Installation

18 June 2021 IEEE EMC DK Chapter

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About FORCE Technology

We:

- are one of the leading technological service companies on the international market
- are independent and self-governing
- have a strong Scandinavian base

Our:

- work is based on the most recent technological knowledge
- development budget is more than 26 mill. EUR

We transform highly specialised engineering knowledge into practical and productive solutions for a number of industries.

A GTS* COMPANY

As a GTS company, we are dedicated to develop and use technologies and new knowledge for the benefit of Danish companies and the Danish society as a whole.

GTS ADVANCED TECHNOLOGY GROUP

*) GTS - Danish government-approved Research and Technology Organisation

FORCE TECHNOLOGY

FORCE Technology at a glance

50 %+

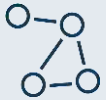
INTERNATIONAL TURNOVER

More than 50% of our turnover derive from our international customers through export or foreign activities.

9,000+

CLIENTS

Every year, we provide service to thousands of Danish and international clients, private as well as public.



50

DISCIPLINES

FORCE Technology consists of business areas with profound professional competences ready to serve the clients from their first idea through development and testing to certification and inspection.

450+

UNIQUE FACILITIES

FORCE Technology possesses one of Scandinavia's largest collections of unique facilities and laboratories that ensures e.g. testing, demonstration, and documentation of new technologies and products.

1,400

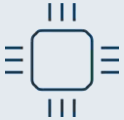
EMPLOYEES

- PhD — 4%
- Postgraduate degree — 24%
- Other technical staff — 51%
- Other non-technical staff — 21%

5,000+

COURSE PARTICIPANTS IN 2018

We spread our knowledge by running more than 400 courses and events annually. Also, more than 350 companies in our network and professional societies benefit from our knowledge.



35+

NEW R&D PROJECTS IN 2018

In 2018, we launched more than 35 new research and development projects for example within the fields of: IoT, materials technology, bioenergy, microelectronics and sensor technologies.

150+

COLLABORATION PROJECTS

FORCE Technology's co-operation with all the Danish and several international universities ensures our clients' access to future technology and knowledge. It keeps us at the forefront of the technological development.

Content of presentation

1. EMC and requirements
2. Large or fixed installations
3. EMC zones
4. Mitigations

What does EMC mean?

EMC: Electromagnetic Compatibility
(Danish: Elektromagnetisk sameksistens)

- “The ability of an apparatus or a system to function according to its specifications in its environment without disturbing other equipment.”

- EMC is the ideal situation, where electrical disturbance does not occur.

Why bother with EMC?

Conclusion:

You MUST comply with EMC requirements! Both EU- and international requirements.

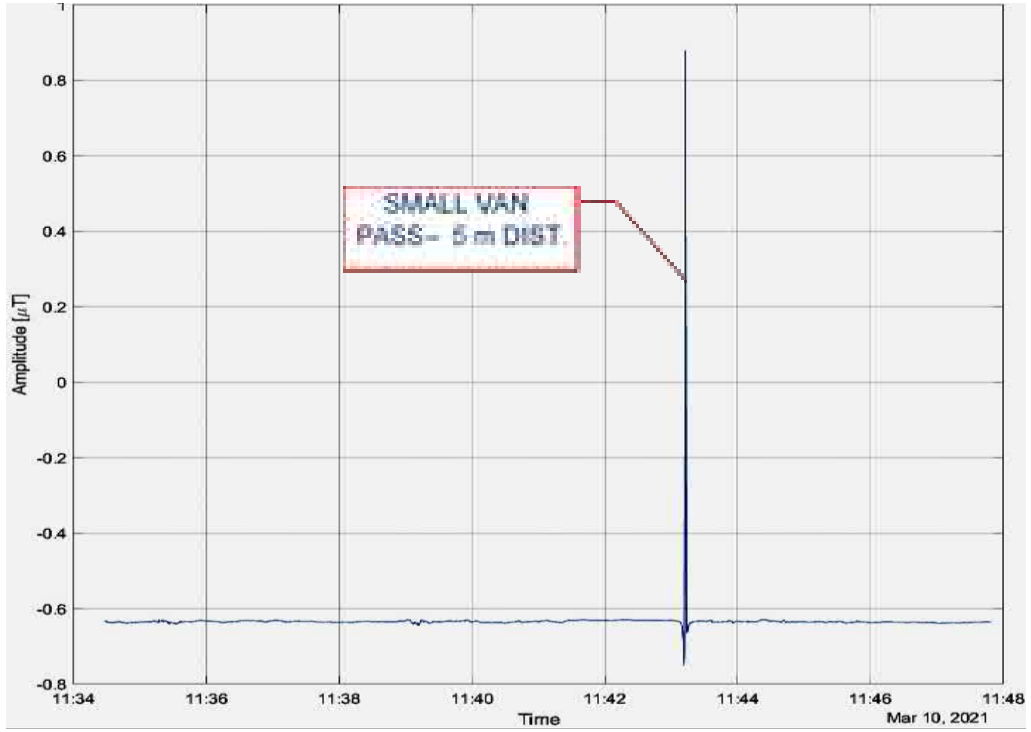
The benefit:

It makes sense to establish good EMC performance

– and properly applied, the EMC requirements can even improve your position on the market and reduce your costs on field errors or break-downs.

Where do the requirements come from?

- Design spec's and functional spec's (essential requirements ?)
- Special considerations
- Contractual requirements
- Requirements for a Site Survey?
- EMC directive 2014/30/EU



On the basis of these inputs a

EMC specifikation

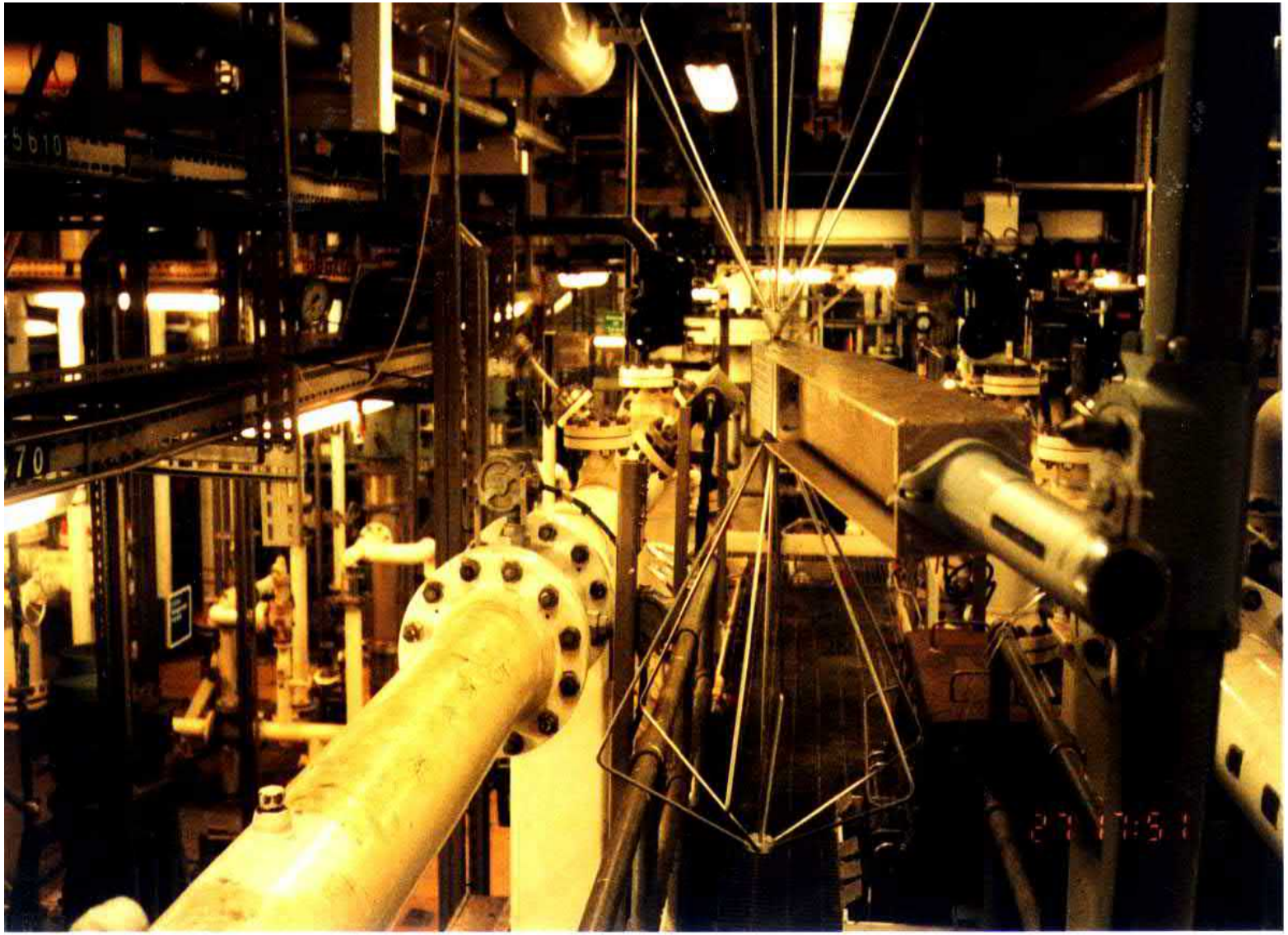
or a

Conformity Requirement Specification

is written

EMC in large installations

EMC in large installations



Directives – New approach

- New Approach directives are based on the following principles.
  - Harmonisation is limited to essential requirements.
  - Only products fulfilling the essential requirements may be placed on the market and put into service.
  - Harmonised standards, the reference numbers of which have been published in the Official Journal and which have been transposed into national standards, are presumed to conform to the corresponding essential requirements.
  - Application of harmonised standards or other technical specifications remains voluntary, and manufacturers are free to choose any technical solution that provides compliance with the essential requirements.
  - Manufacturers may choose between different conformity assessment procedures provided for in the applicable directive.

Essential requirements – New approach

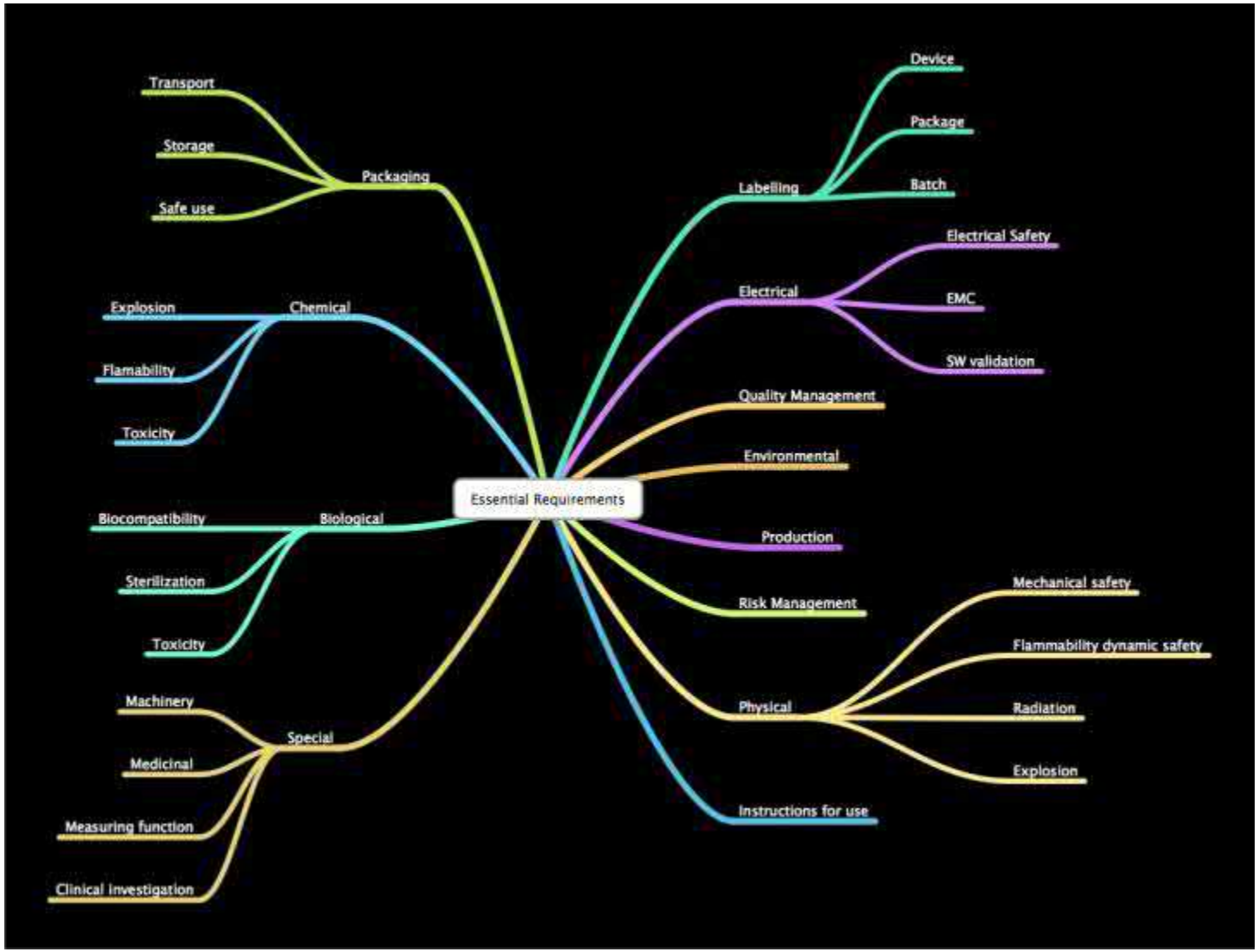
The essential requirements are usually given in annex 1

- EMC directive (EMCD): ½ page
- Radio Equipment Directive (RED): 1 page
- Low Voltage Directive (LVD): 1 page
- Machinery directive (MD): Risk analysis + 30 pages
- Medical Device directive (MDD): 82 essential requirements
- Medical Device REGULATION (MDR): Even more complex than MDD (from May 26 2021)

LINK to many DIRECTIVES:

https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards_en

82 Essential Requirements MDD



Essential requirements for fixed installations

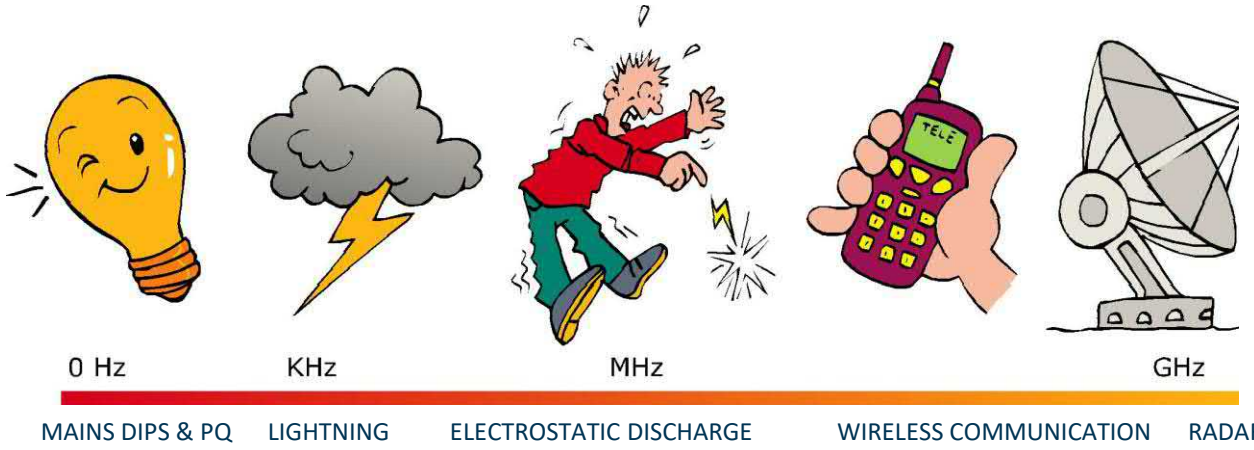
Article 19 and Annex 1

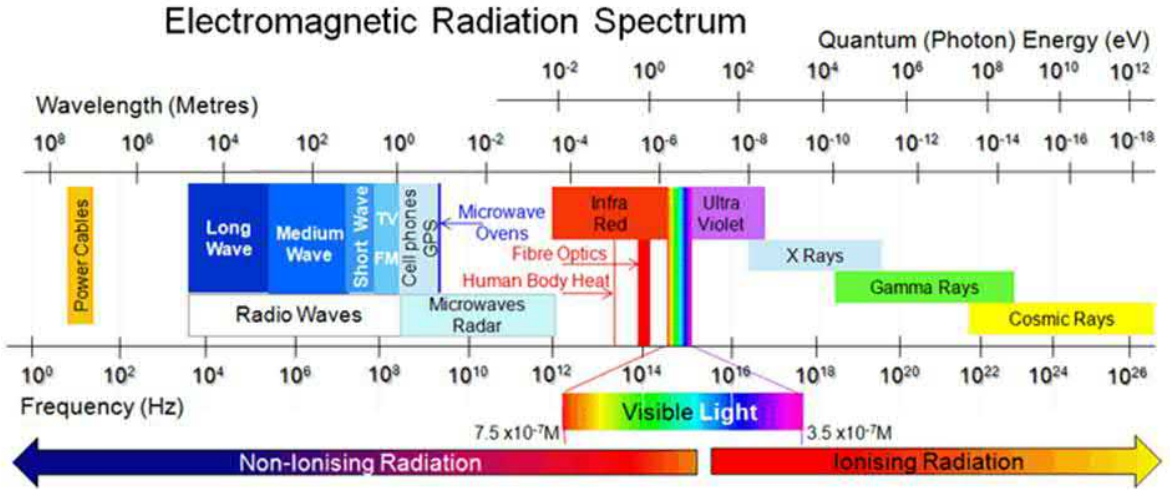
- Specific requirements for fixed installations and intended use of components. A fixed installation shall be installed applying good engineering practices and respecting the information on the intended use of its components, with a view to meeting the essential requirements set out in point 1.
- The good engineering practices referred to in point 2 of Annex I shall be documented and the documentation shall be held by the person or persons responsible at the disposal of the relevant national authorities for inspection for as long as the fixed installation is in operation.

Basic standards

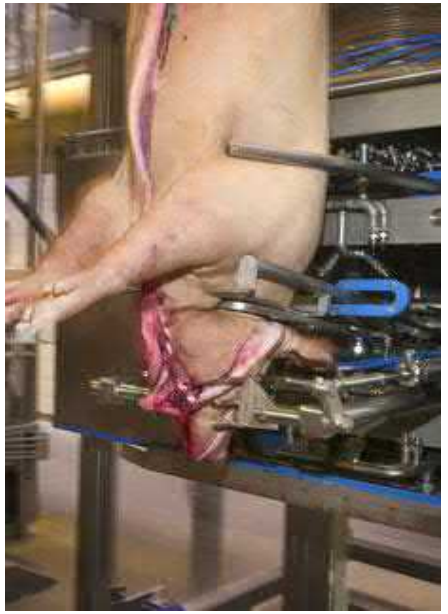
Description of the phenomena:

- ESD
- Mobile telephones
- Transmitters
- Transients
- Mains interruptions
- Magnetic fields
- Interference from commutator motor
- Interference from IGBTs, thyristors and triacs
- Interference from computers
- Click interference





Generic standards



Description of the environment:

- Residential
- Commercial
- Light industry
- Industry
- Hospital
- Agriculture

- **Residential**
- **Commercial and light industry**
- **Industry**

Product standards

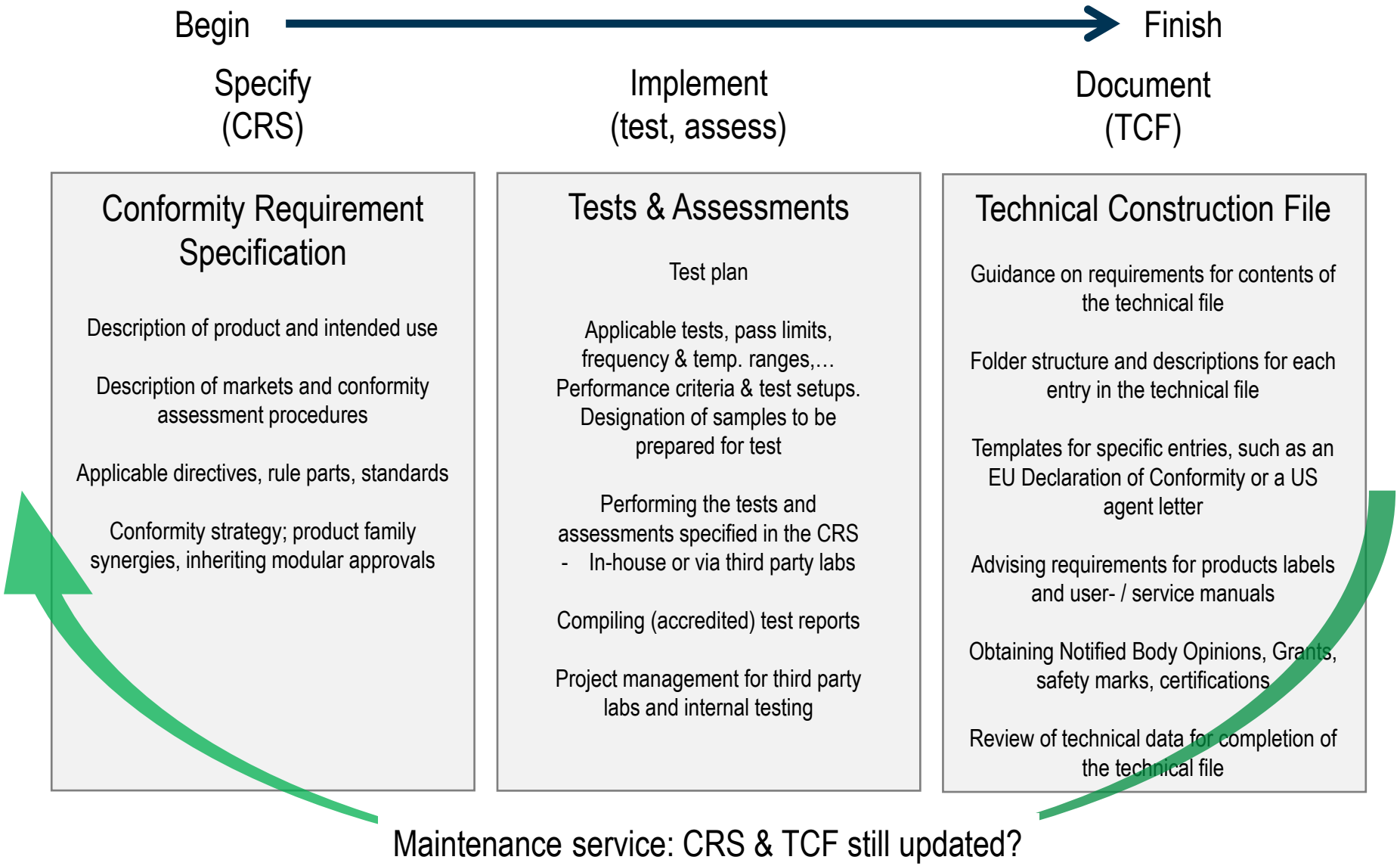
Description of operational mode and performance criteria:

- How shall the EUT be operating during test?
- How shall a failure be defined?
- How shall a failure be detected (criteria?)
- Increase or relaxation of test levels

Concept of EMC Management

- Electrical environment is important for the EMC requirements
- Numerous client cases and projects have shown that complex large installation or buildings always cause problems
- It is costly to solve the problems at a late stage
- Therefore, EMC needs to be handled from the beginning so mitigations can be planned
- The planning and handling can be done systematically and efficient, and mitigation can be included in the project plan.
- We call that **EMC Management**

Contents of a product approval project



Examples of fixed installations

- Industrial plants
- A hospital or a research center
- Power plants
- Power supply network
- Telecommunication networks
- Cable TV networks
- Computer networks
- Airport luggage handling installations
- Airport runway lighting installations
- Railway infrastructures

Fixed - ?

Guidelines for EMC in Installations

- Describe the intended use
- List the active apparatus and systems in the installation
- List interference sources in the environment
- List potential victims of interference in the environment
- Make a risk assessment
- Collect EMC information of the apparatus in the installation
- Ask for EMC test reports
- Perform a gap analysis
- Perform additional tests if necessary
- Mitigations

Emission classes (sources)

Definition of emission classes		
Class	Class name	Examples
1	Very low noise level	Simple clocks, weighing equipment, mechanical (non-electrical equipment) or electrical equipment with a documented performance, which is better than the emission limits of the generic standards (residential, commercial and light-industrial environments)
2	Low noise level	Most laboratory equipment, computers, printers, etc. Equipment meeting the emission limits of the generic standards (residential, commercial and light-industrial environments).
3	High noise level	Machinery, HVAC systems, mains power transformers, motor drives, etc. Normal industrial equipment meeting the emission limits of the generic standards (industrial environment).
4	Very high noise level	Very powerful sources of EM noise, such as trains, tram-lines, MR scanners, ISM equipment, radio transmitters, welding equipment, etc. Note: Safety related to human exposure to electromagnetic fields is not considered in this guideline.

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Immunity classes (victims)

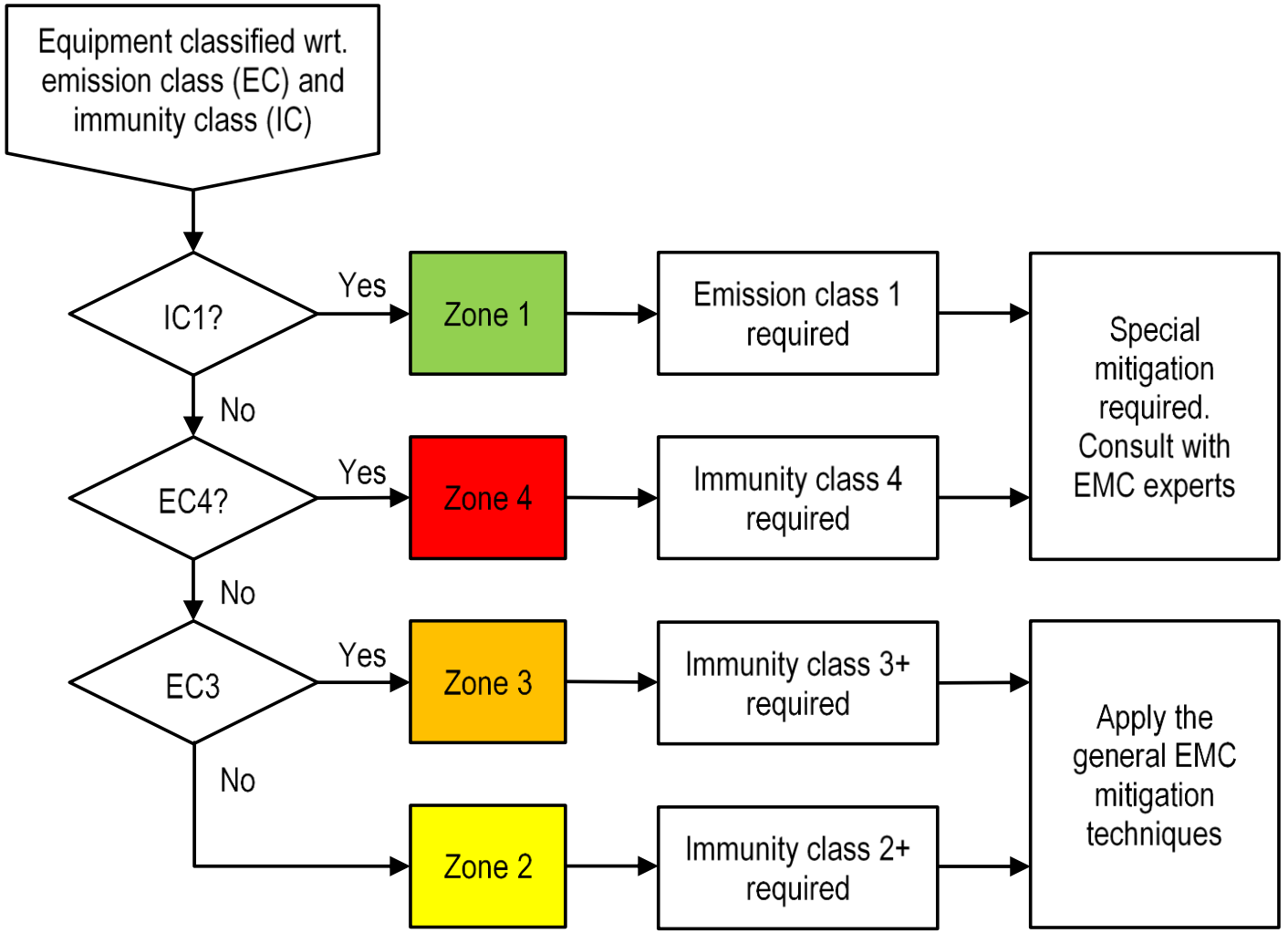
1	Class name	Examples
	Very low immunity level	E.g. electron microscopes, e-beam and NMR/MRI scanners. Very sensitive equipment, which can not be used in a normal environment without additional mitigations.
2	Low immunity level	Most laboratory equipment, computers, printers, etc. Equipment meeting the immunity levels defined for residential, commercial and light-industrial environments by the generic standards.
3	High Immunity level	Machinery, HVAC systems, mains power transformers, motor drives, etc. Normal industrial equipment meeting the immunity levels defined for industrial environment by the generic standards.
4	Very high immunity level	Equipment with a documented very high immunity level, exceeding generic standards. NB: Ensure, that immunity to all relevant phenomena has been verified at above-normal immunity levels.

Example – EMC Zones:

Definition of EMC zones		
Zone	Class name	Examples
1	Very low noise level	Laboratories with sensitive equipment, such as electron microscopes, oscilloscopes, measuring instruments, etc. Or normal sensitive equipment used in sensitive test setups.
2	Low noise level	Normal residential, commercial and light-industrial environment as defined by the generic standards. Offices, server installations, etc.
3	High noise level	Normal industrial environment as defined by the generic standards. Machinery, HVAC systems, mains power transformers, motor drives, etc.
4	Very high noise level	Zones with potentially powerful sources of EM noise, such as the area around LR3.

FORCE TECHNOLOGY

Example – EMC zones



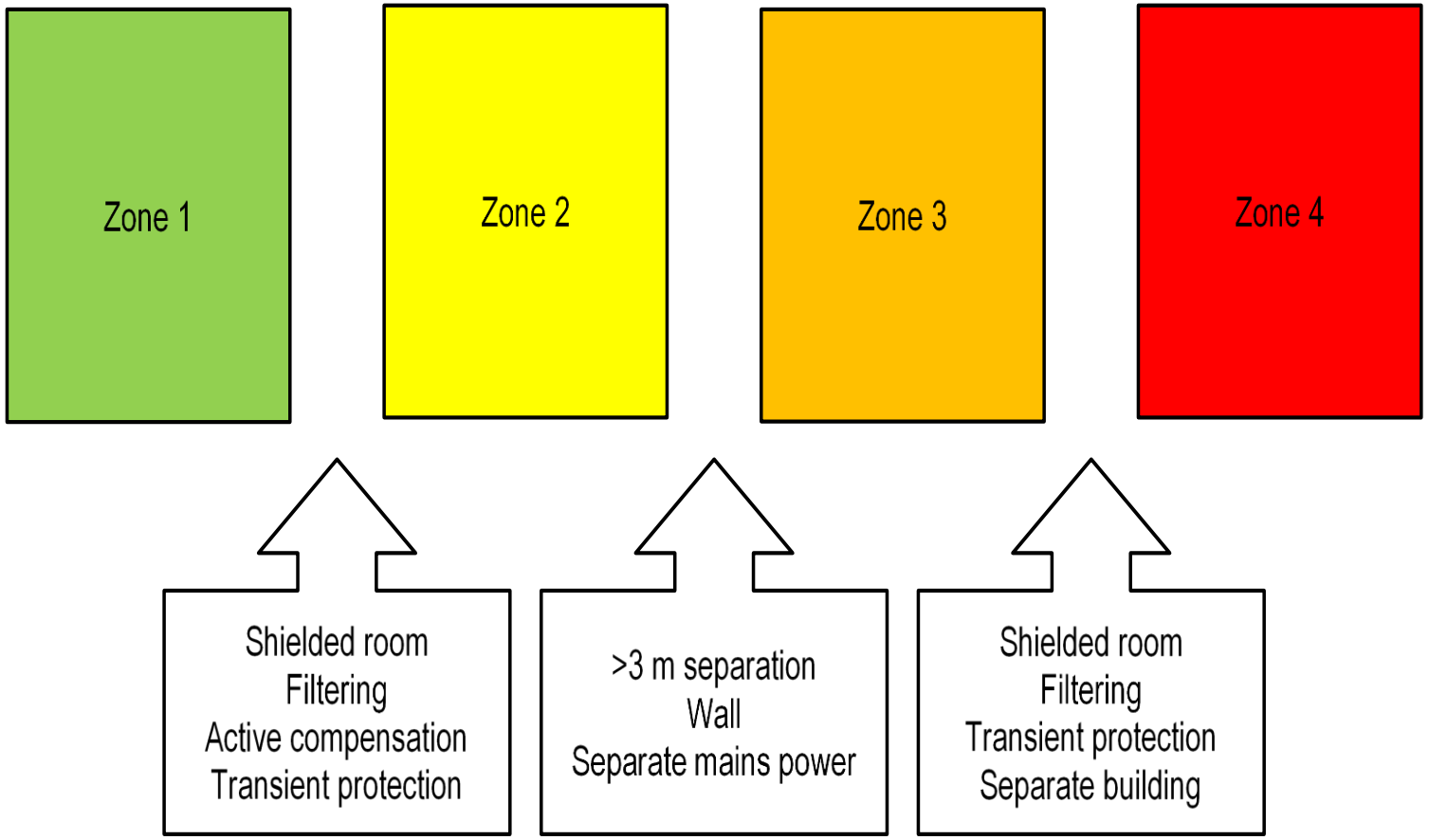
EMC parameters:

(most parameters are covered by equipment EMC approval)

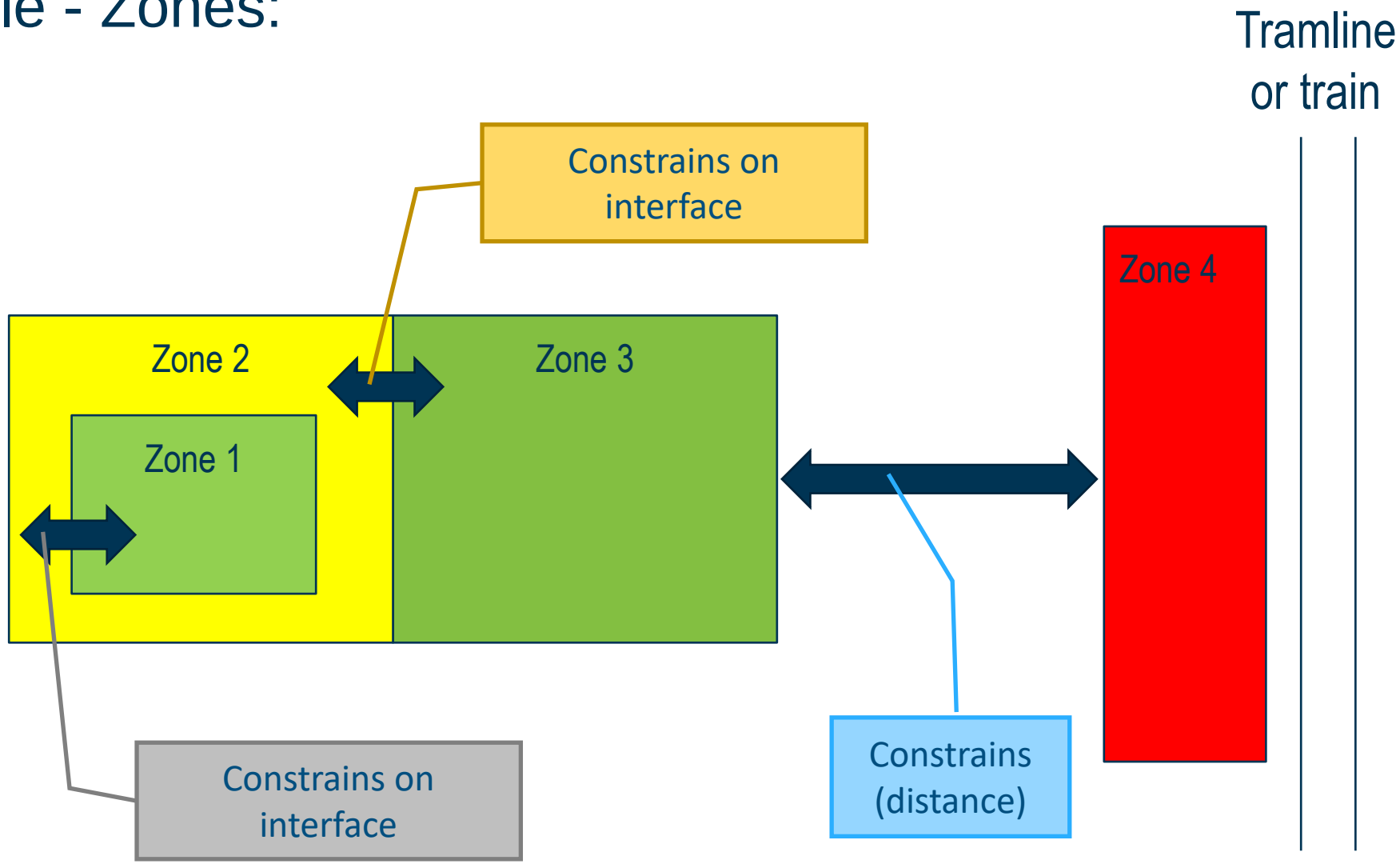
Test type
DC Magnetic field
DC Magnetic field rate of change
DC electric field
Low frequency magnetic field
Low frequency electric field
Radiated immunity
Transient fields
Power frequency magnetic field [A/m]
Pulsed magnetic field
Conducted emission
Intended Radio transmission power
Conducted immunity I/O port 0.15-80 MHz
Conducted immunity DC port 0.15-80 MHz
Conducted immunity AC port 0.15-80 MHz
ESD contact discharge
ESD air discharge
Fast transients I/O port
Surges I/O port
Fast transients DC port
Surges DC port
Fast transients AC port
Surges AC port
RED = known issues Yellow = further investigation recommended

FORCE TECHNOLOGY

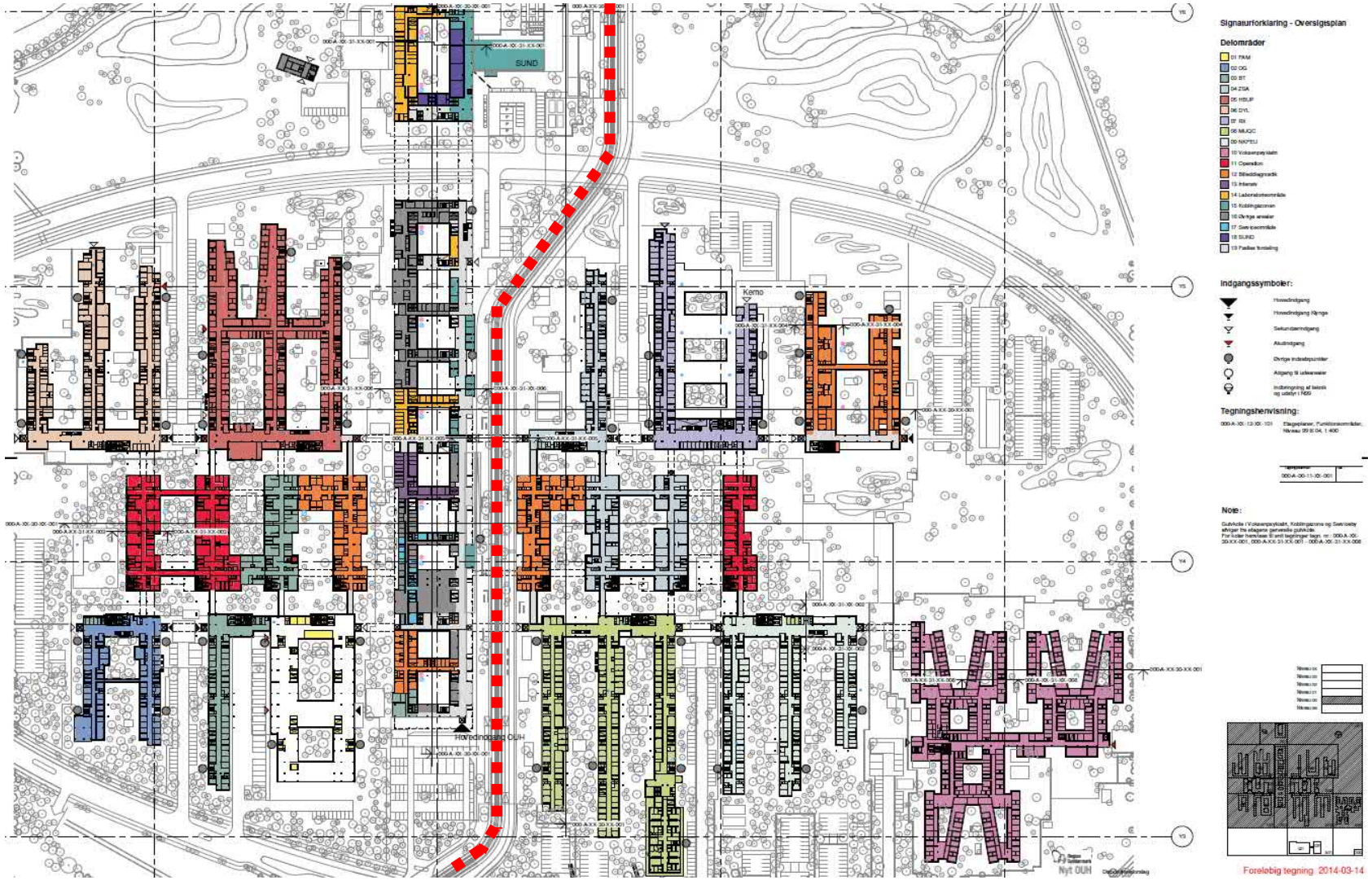
Example - Zones:



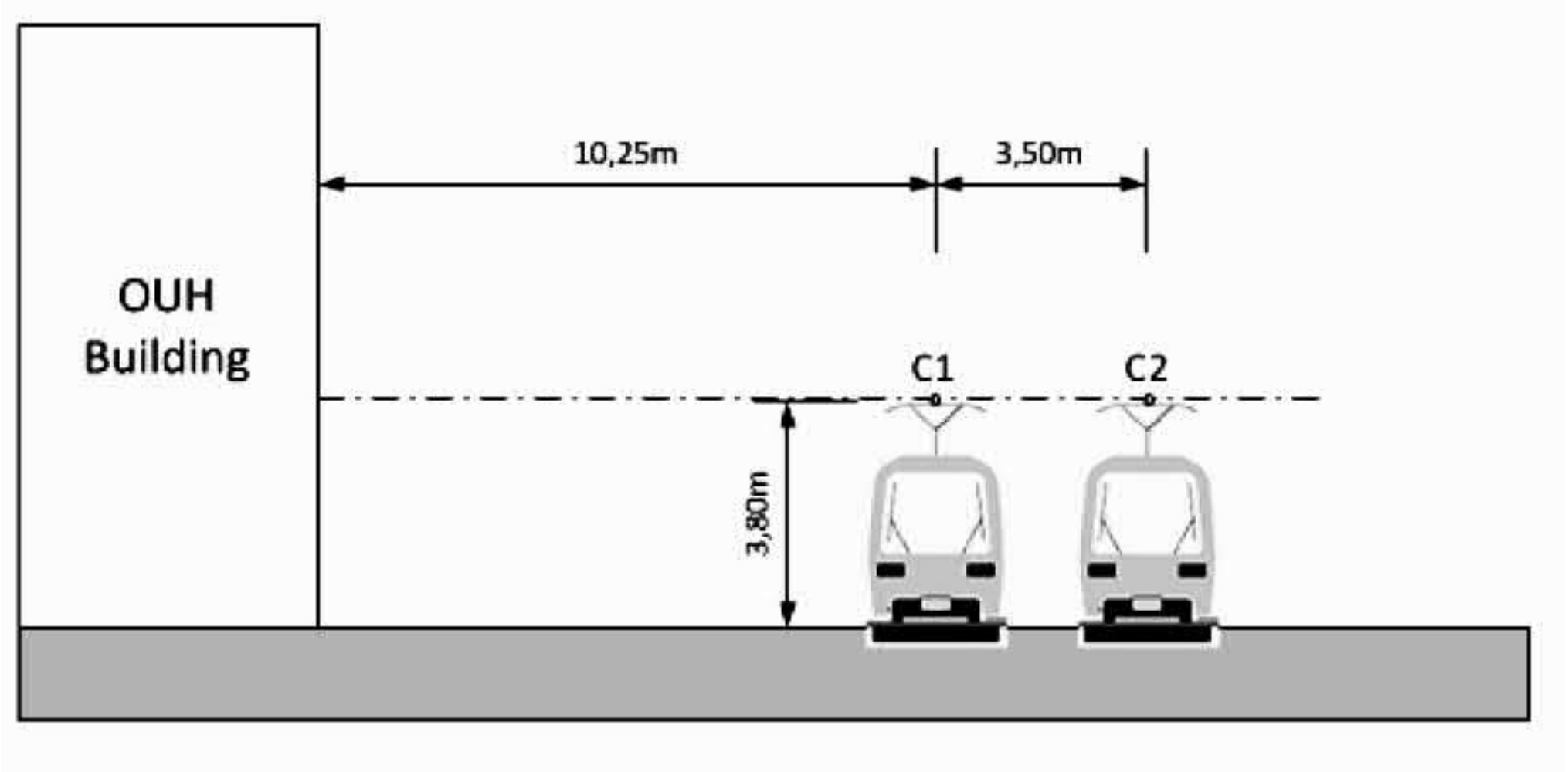
Example - Zones:



Example – a tramline in the New OUH hospital

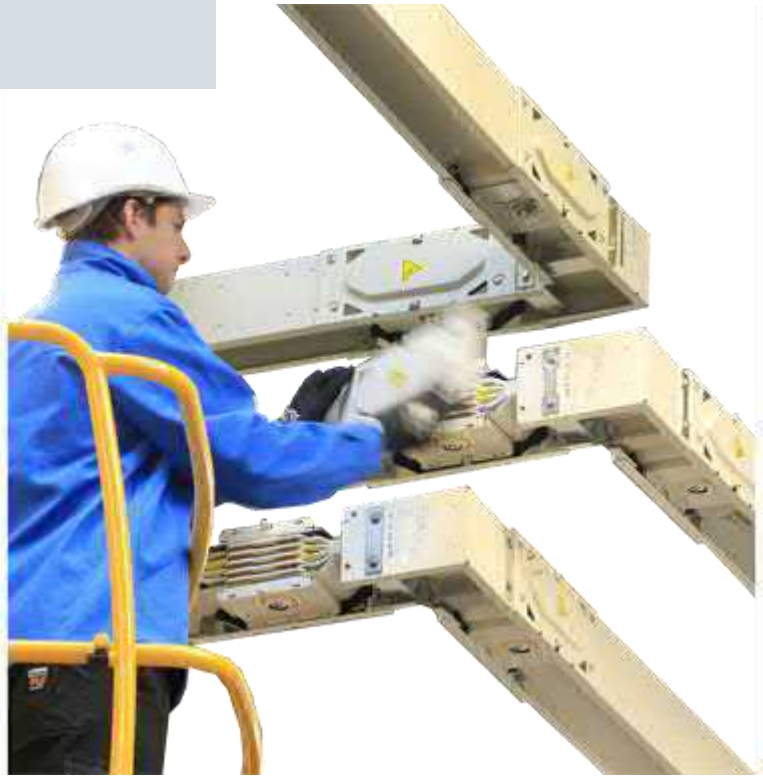


Example – traction current and medical equipment



Possible mitigations:

- Zoning !
- Distance
- Equalization of potentials
- Cable types and routing
- Balancing of 3-phase loads
- Active compensation systems
- Busbar trunking systems for power
- Shielded rooms (not useable for DC fields)



EMC - avoid surprises at the end of the tunnel

Thank you for listening

Vestas

Wind. It means the world to us.™

EMC for fixed installations and large size/high power equipment Wind turbines

Claus Grøn Lyngby

EMC Specialist

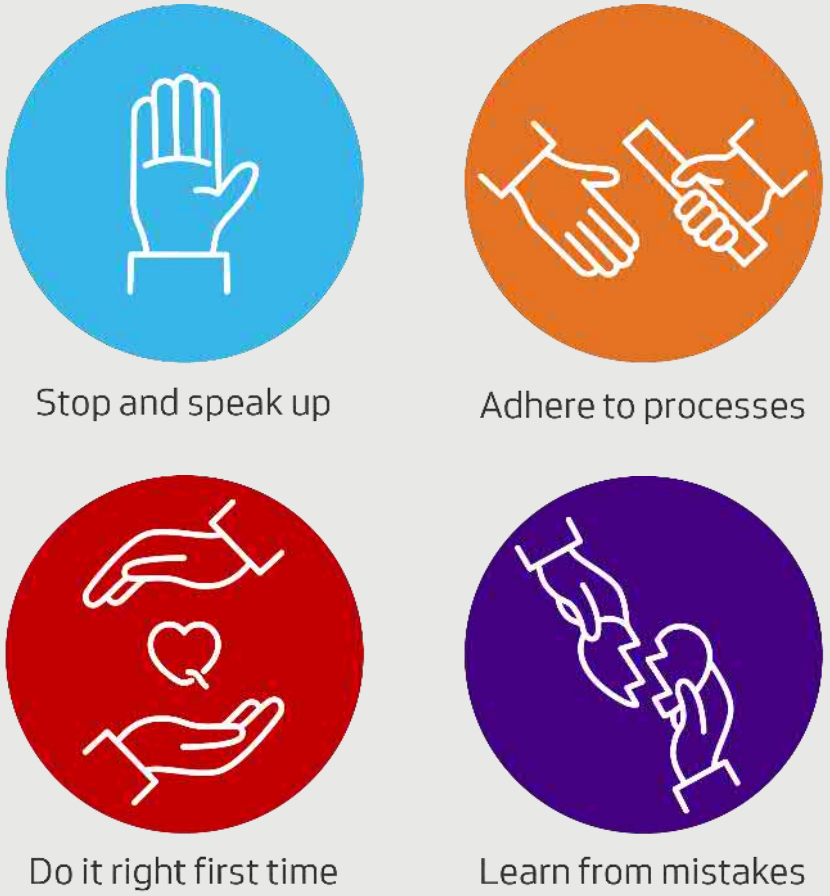
Product Functional Lead

Vestas

18-06-2021

Today’s quality message

Quality at the heart of everything we do



Share an example of a time where you applied or saw one of our four quality behaviours in action?

Share your call to action:

- What should we do more of?
- Or stop doing?

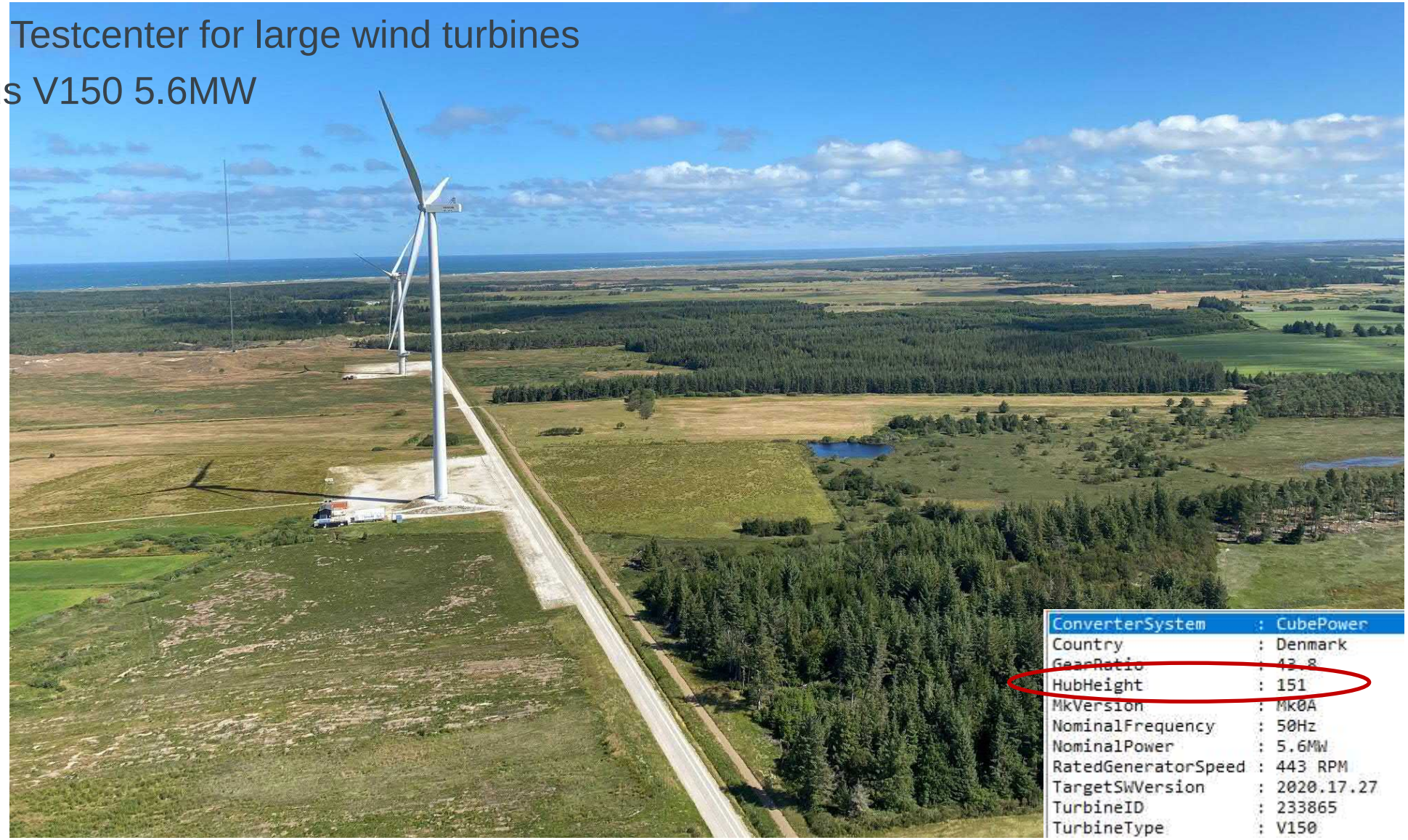
EMC for fixed installations and large size/high power equipment
Wind turbines

Vestas®

RF Field emission measurements on wind turbines

Østerild, Testcenter for large wind turbines

EnVentus V150 5.6MW



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EMC Standards

For RF emission standards for wind turbines

Standards	Title	Method	Status
CISPR 11	Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement	In situ	Released
IEC 61000-6-4	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	Test site	Released
IEC 61400-40	Wind energy generation systems - Part 40: Electromagnetic compatibility (EMC) - Requirements and test method	In situ	On hold (CD)
CISPR 37	Industrial, scientific and medical equipment - Limits and methods of *in situ* measurements and measurements of large size/high power equipment	In situ / Defined site	DC released Approaching CD

All mentioned standards refers to the IEC/CISPR 16 series for further generic details

RF frequency ranges for wind wurbines

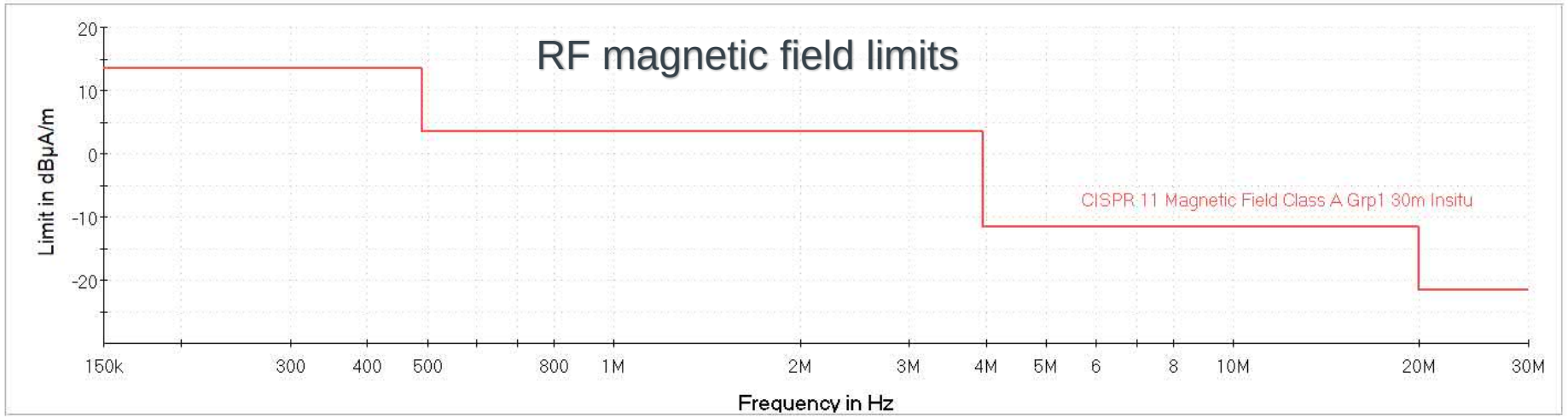
RF field emission measurements on wind turbines

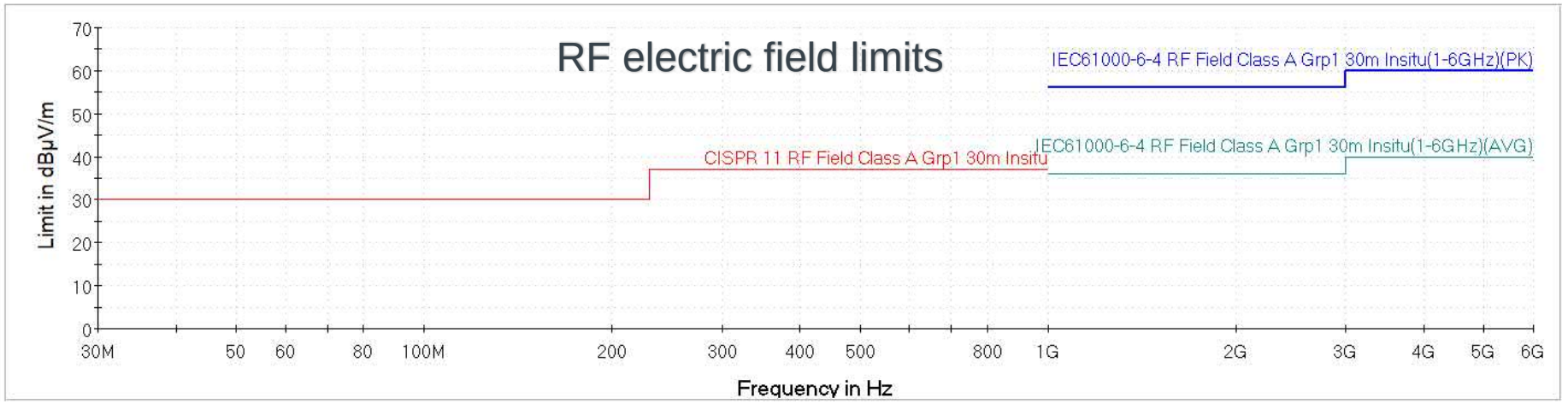
Standards	Frequency range (where limits applies)	Detector	BW	Antenna
CISPR 11	150kHz – 30MHz	Quasi peak	9kHz	Magnetic, Loop
	30MHz – 1GHz	Quasi peak	120kHz	Electric, Biconical / Logperiodic / Bilog
IEC 61000-6-4	30MHz – 1GHz	Quasi peak	120kHz	Electric, Biconical / Logperiodic / Bilog
	1GHz – 6GHz	Peak/Avg	1MHz	Electric, Biconical / Logperiodic / Bilog
IEC 61400-40 CD	150kHz – 30MHz	Quasi peak	9kHz	Magnetic, Loop
	30MHz – 1GHz*	Quasi peak	120kHz	Electric, Biconical / Logperiodic / Bilog
CISPR 37 DC	150kHz – 30MHz	Quasi peak	9kHz	Magnetic, Loop
	30MHz – 1GHz*	Quasi peak	120kHz	Electric, Biconical / Logperiodic / Bilog

Limits depends on the measurement distance but are similar across standards
* In the frequency range above 1 GHz limits are not specified.

RF field emission limits for wind turbines

Limits derived from CISPR 11 and IEC 61000-6-4

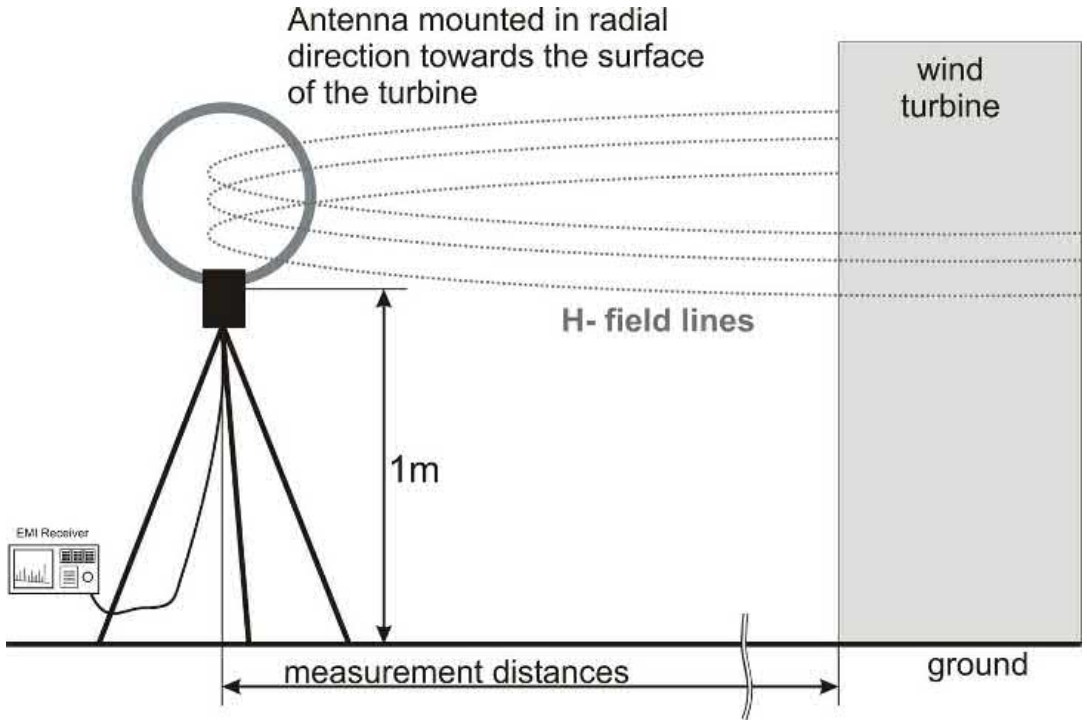


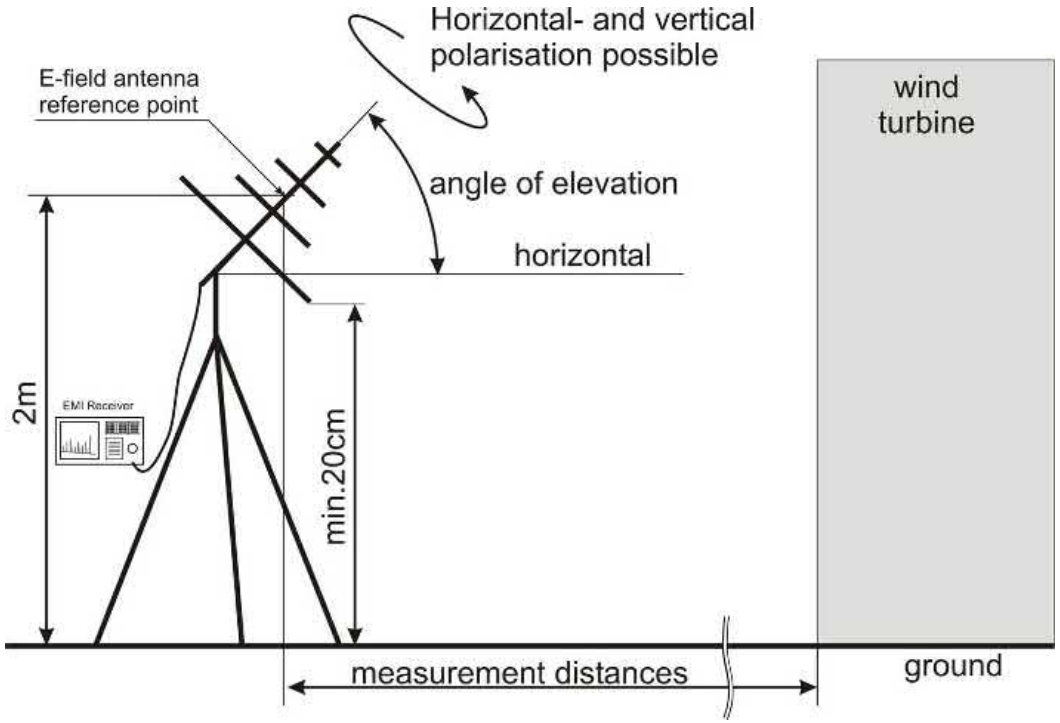


Limits depends on the measurement distance – here extrapolated to 30m

RF Field Emission measurement site

Antenna setup

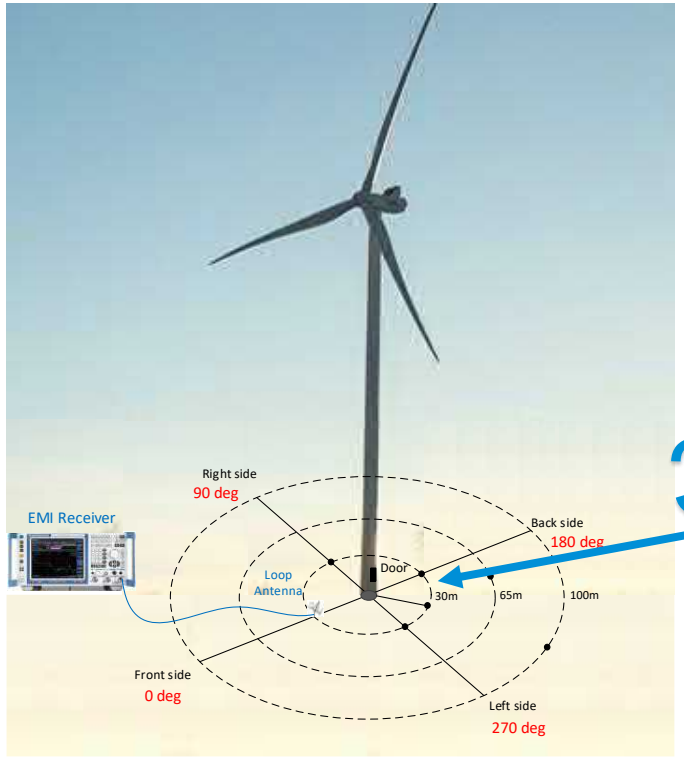




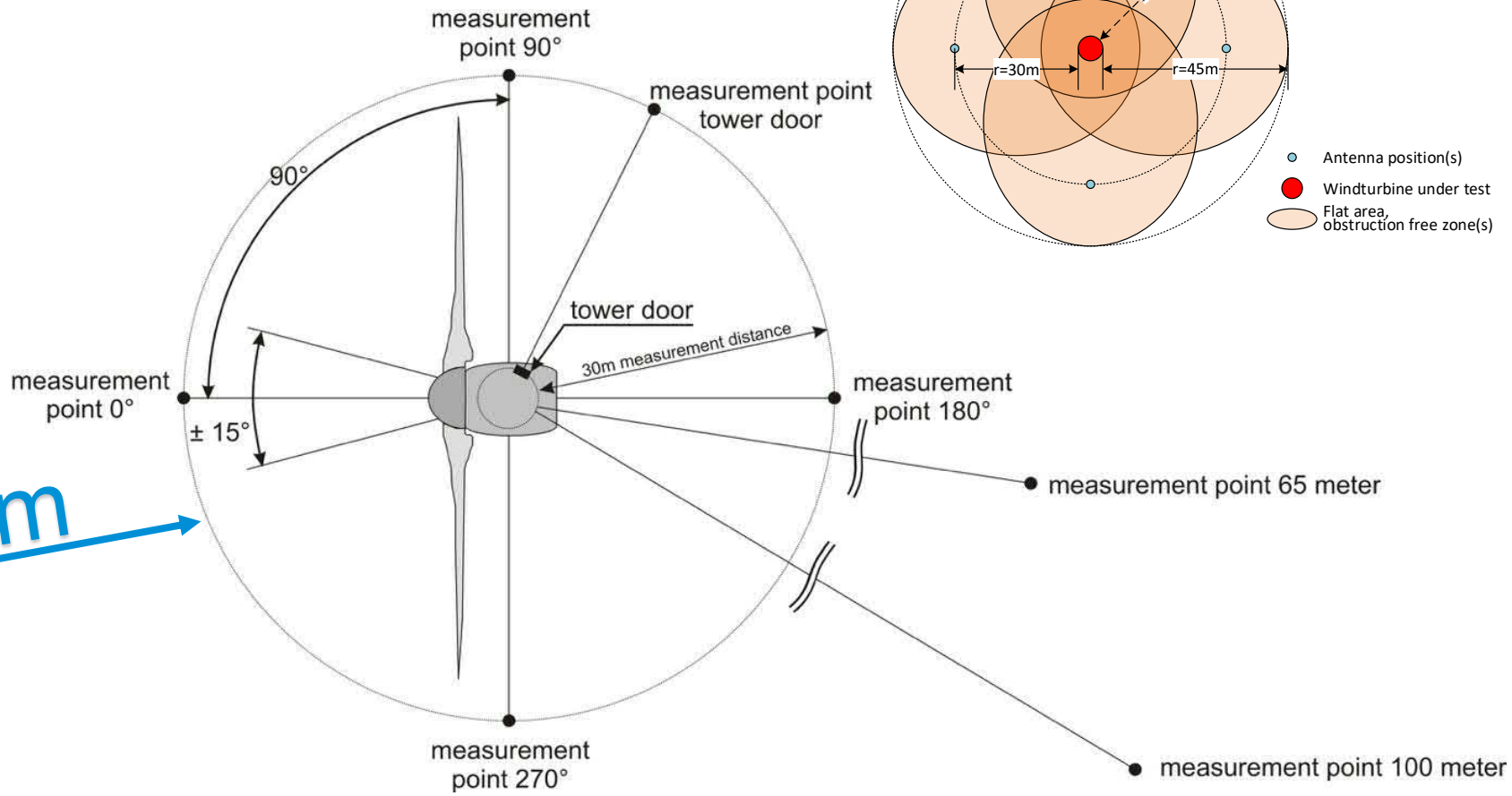
As described in CISPR 11 and IEC 61400-40 CD (Wind turbine approach)
CISPR 16-2-3 describes height scan – not applicable for wind turbines

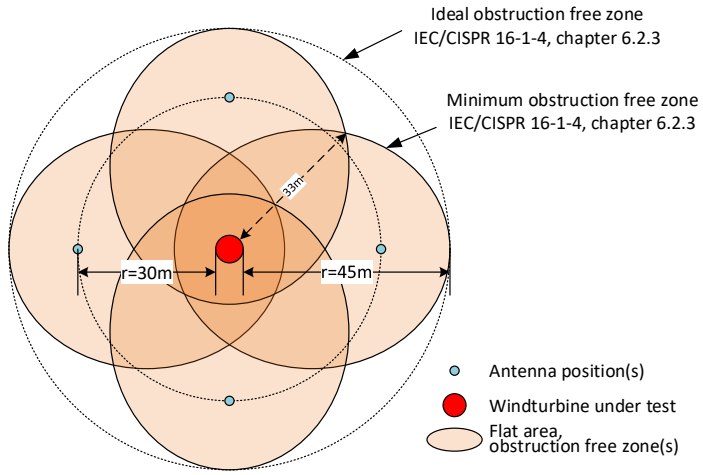
RF Field Emission measurement site

Antenna position setup



30m





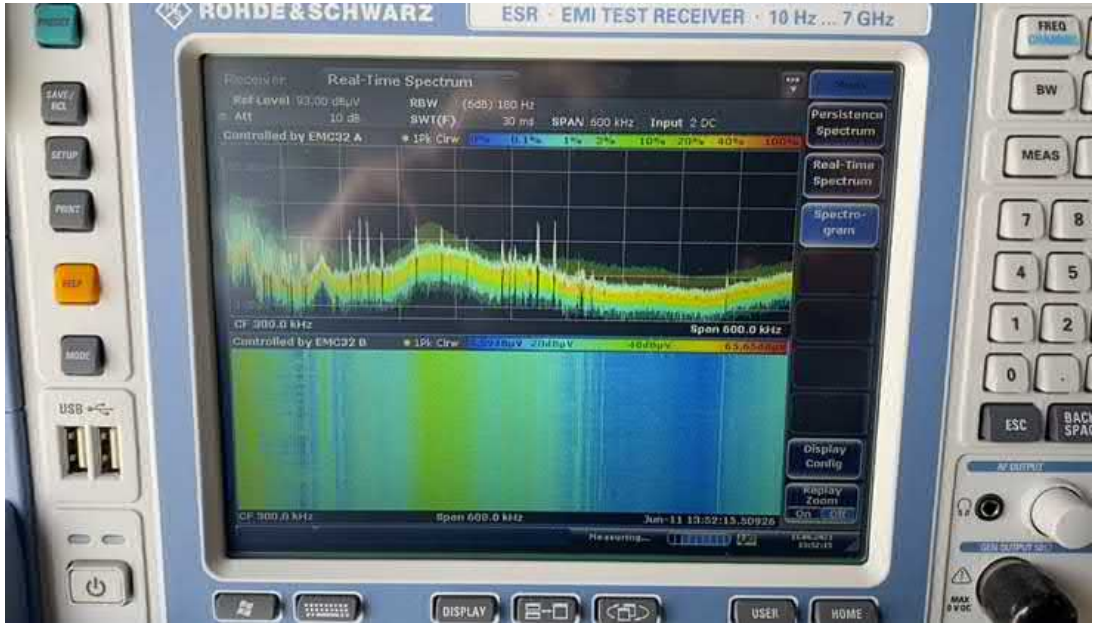
As described in CISPR 11 and IEC 61400-40 CD (Wind turbine approach)

Vestas

Measurement operating modes

The EMI Receiver shall operate with the following setup:

- Quasipeak mode below 1GHz. Peak/average above 1GHz
- Observation time for each frequency step is 1 full rotor revolution. (Deviation from 1. sec according to CISPR)
- It is of huge advantage to use EMI receiver in FFT mode (Time domain)
- For investigations other detectors and settings can be used



Wind turbine operating modes

For RF emission measurements on wind turbines

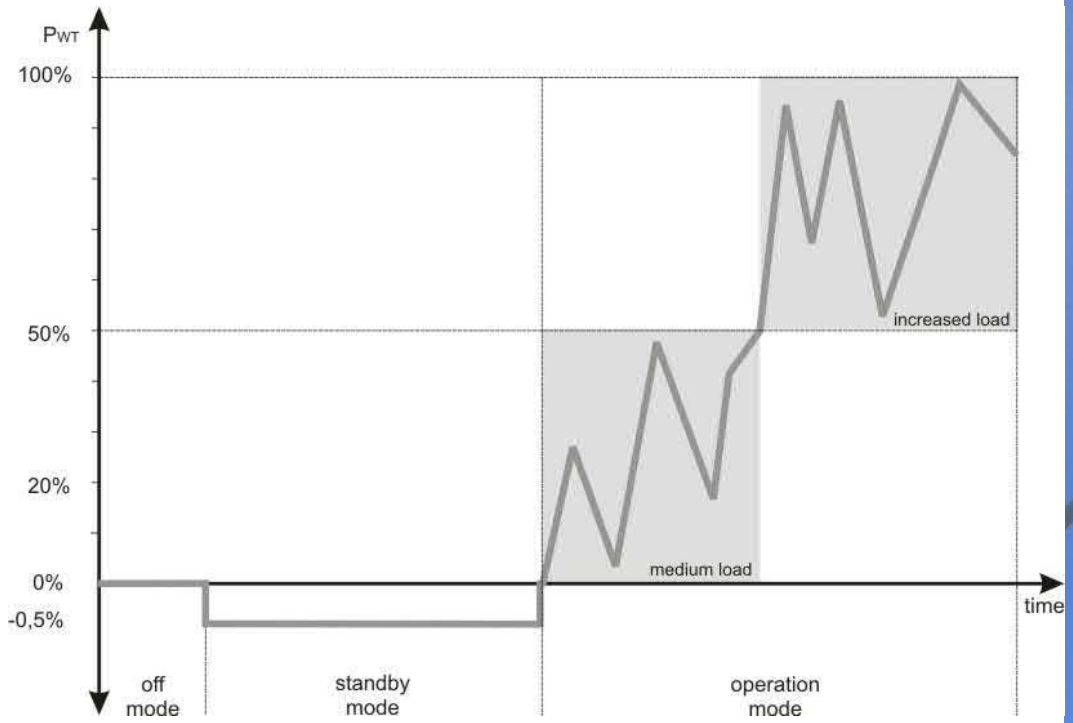
Minimum recording

- Produced power (wind dependent)
- Nacelle position
- Weather conditions

Additional recording

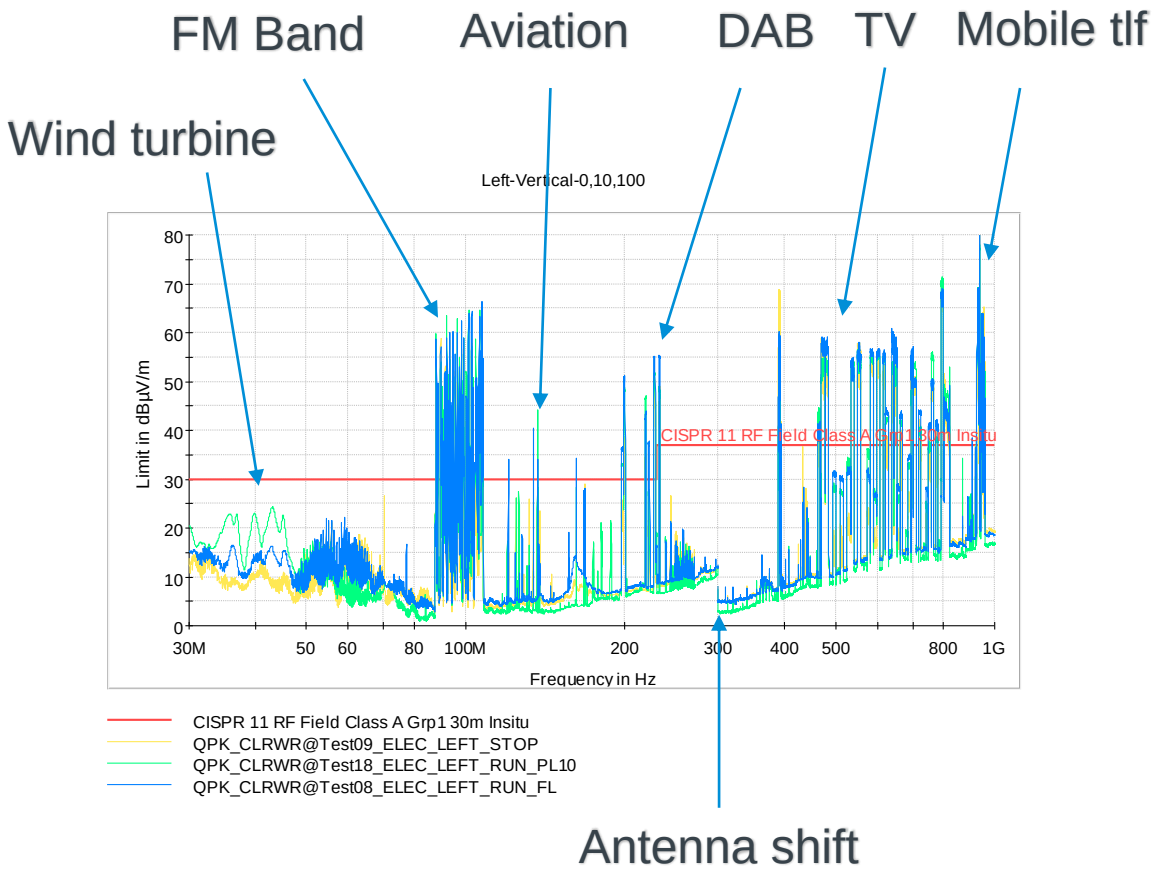
E.g. for investigations

- Generator rpm
- Rotor rpm
- Blade pitch position
- Yaw motor operation
- Etc.



Wind turbine measurements

RF emission results and ambient



Vestas®

Wind. It means the world to us.™

Thank you

PE-Region Platform

Friday den 18. juni 2021

Energistyrelsen

Who are we?

Danish Energy Agency, Centre for Telecommunication are a government agency under Danish Ministry af Climate, Energy and Utilities.

”Støjtjenesten” are a small unit under Centre for Telecommunication, with 19 man-years.

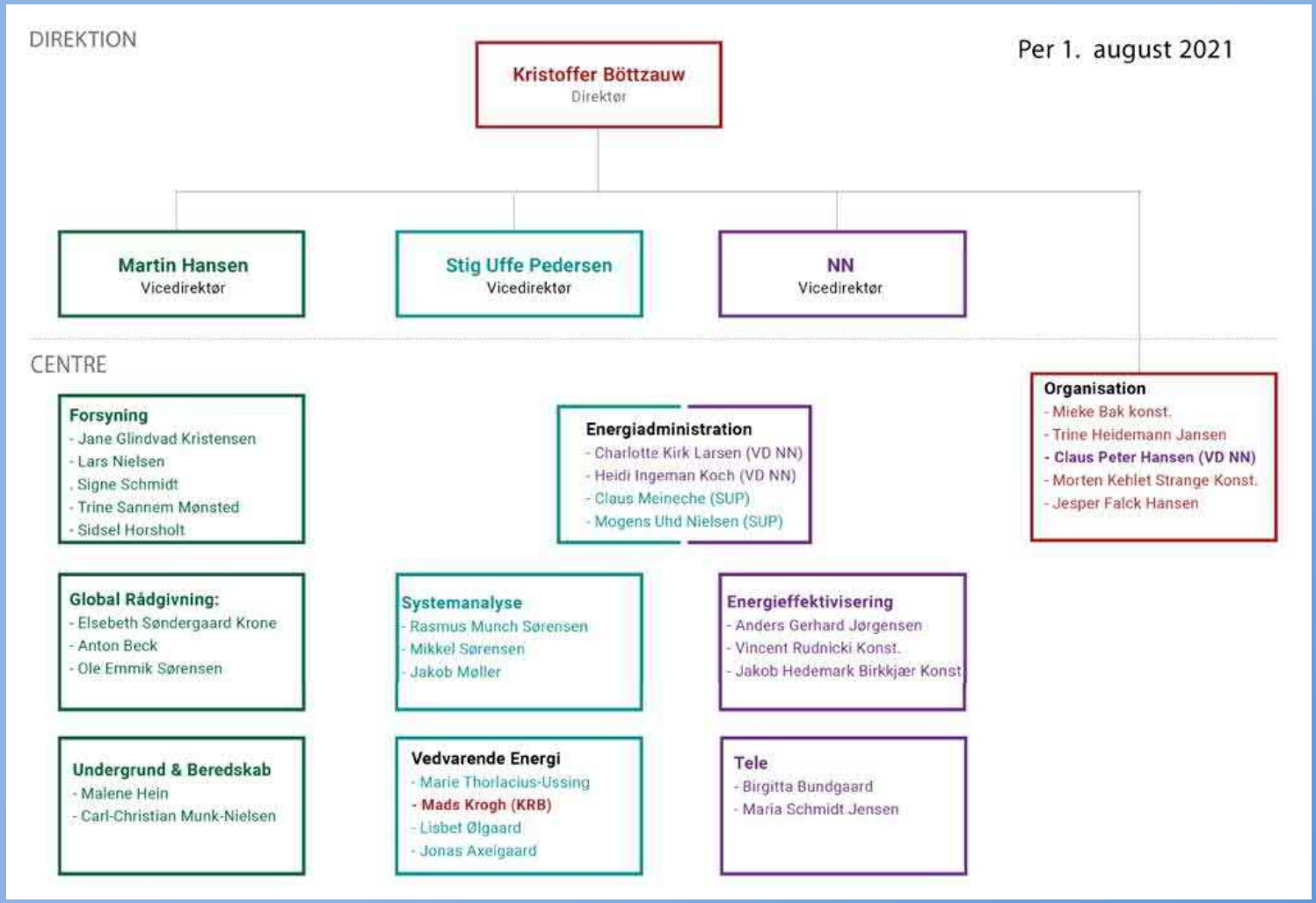
We are 3 outgoing employees, which covers all of Denmark.

Rene Ellekær Greve; Sjælland og Bornholm.
Stig Vestergaard; SønderJylland og Fyn.
Torben Grønkær Kamstrup; Midt- og NordJylland.

Energistyrelsen

We are looking on noise and disturbances, when we are getting inquiries from companies and citizens.

We are making measurement on FM radio lacations all over Denmark, to see if they are complies there permits.


DIREKTION
Per 1. august 2021
Kristoffer Böttzauw
Direktør
Martin Hansen
Vicedirektør
Stig Uffe Pedersen
Vicedirektør
NN
Vicedirektør
CENTRE
Forsyning
- Jane Glindvad Kristensen
- Lars Nielsen
- Signe Schmidt
- Trine Sannem Mønsted
- Sidsel Horsholt
Energiadministration
- Charlotte Kirk Larsen (VD NN)
- Heidi Ingeman Koch (VD NN)
- Claus Meineche (SUP)
- Mogens Uhd Nielsen (SUP)
Organisation
- Mieke Bak konst.
- Trine Heidemann Jansen
- Claus Peter Hansen (VD NN)
- Morten Kehlet Strange Konst.
- Jesper Falck Hansen
Global Rådgivning:
- Elsebeth Søndergaard Krone
- Anton Beck
- Ole Emmik Sørensen
Systemanalyse
- Rasmus Munch Sørensen
- Mikkel Sørensen
- Jakob Møller
Energieffektivisering
- Anders Gerhard Jørgensen
- Vincent Rudnicki Konst.
- Jakob Hedemark Birkkjær Konst
Undergrund & Beredskab
- Malene Hein
- Carl-Christian Munk-Nielsen
Vedvarende Energi
- Marie Thorlacius-Ussing
- Mads Krogh (KRB)
- Lisbet Ølgaard
- Jonas Axelgaard
Tele
- Birgitta Bundgaard
- Maria Schmidt Jensen

Energistyrelsen

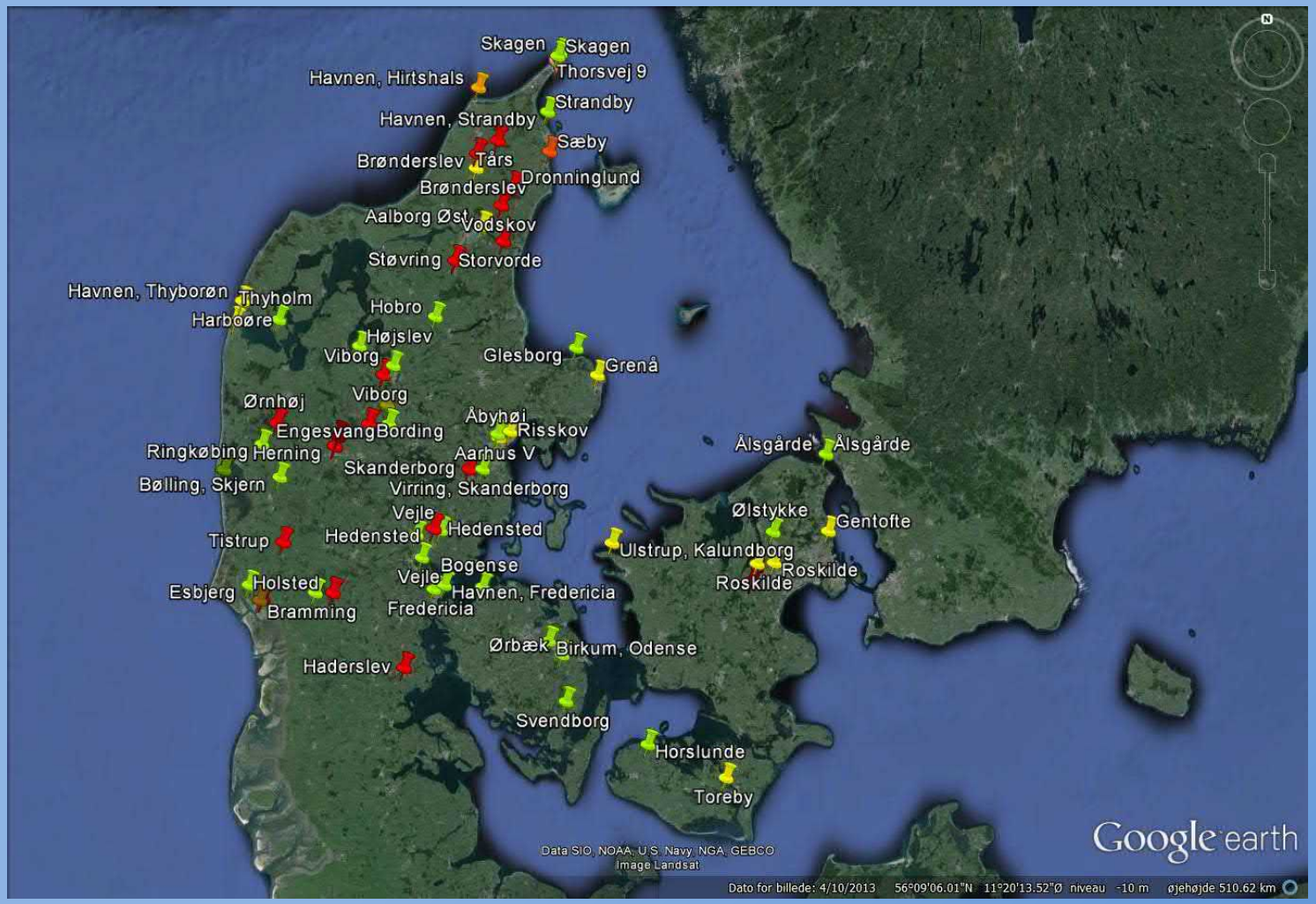
Why frequency management ?

- Radio frequencies: A limited natural resource
- Frequencies exceeds national borders
- Planning to promote users access to a wide, varied an cheap supply of telecommunications services
- Planning to promote real competition
- Planing to avoid disturbances
- Planning effective resource frequencexploitation

Energistyrelsen

- We have seen about 250 mobilrepeater cases from 2013 to 2020.
- There have been about 450 cases every year, for the last 3 years.
- The cases are from the whole frequenceband.
  - Mobile companies
  - Radio amateurs
  - Radio and Television
  - Land mobile services
  - Distress and security

Energistyrelsen



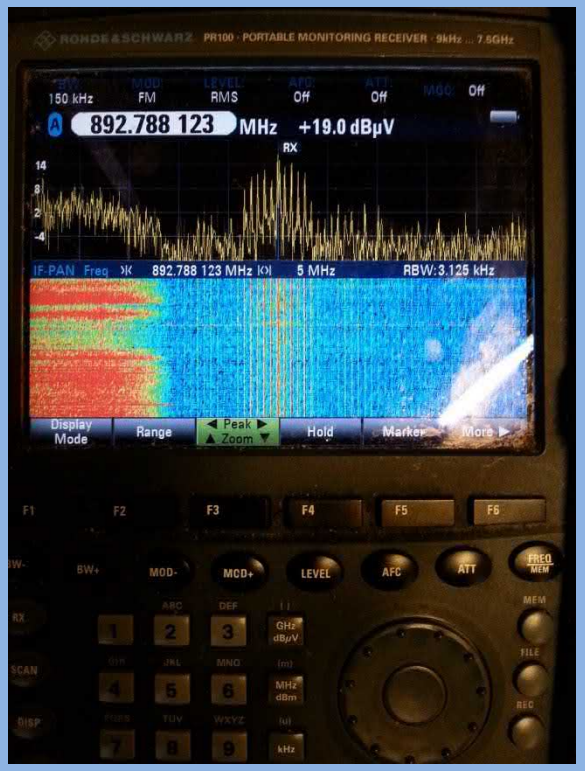
Distribution of mobile repeater cases. Slices of the cases.

Energistyrelsen

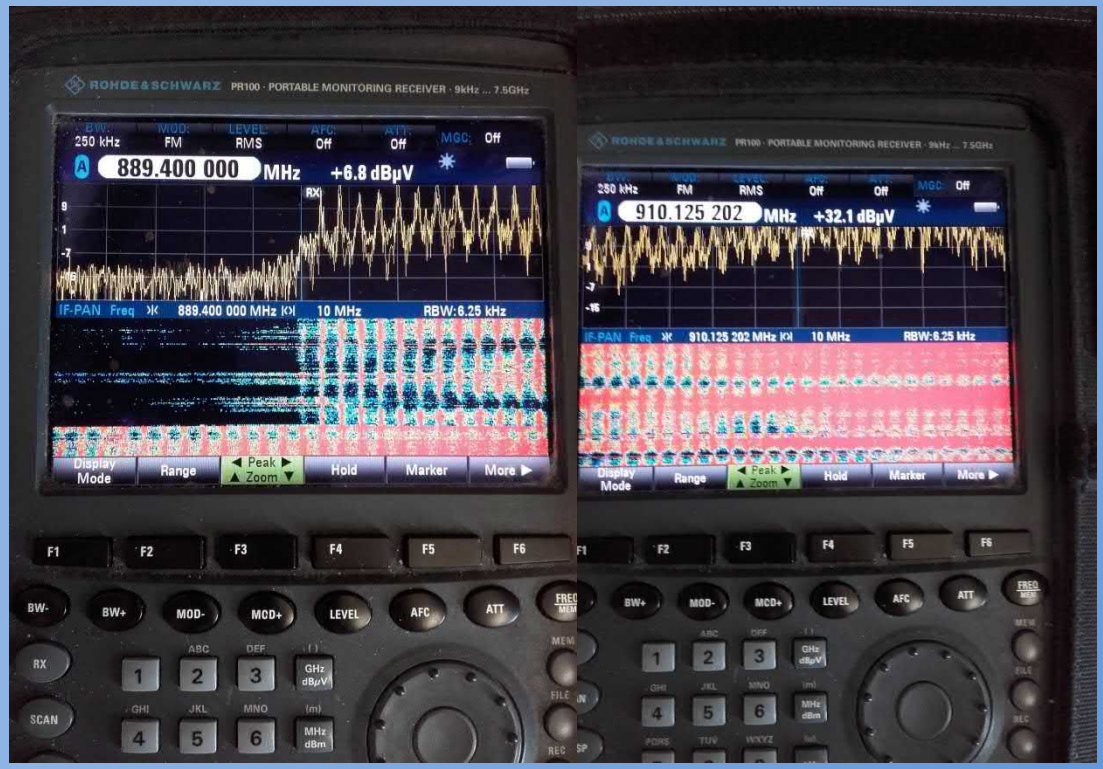
Noise sources are many.

- LED
- Halogen lamps
- Frequency converter
- Switch mode power supply
- Antenna amplifier
- Small range devices
- Mobile repeaters
- HDMI og DVI cables
- US Dect telefon og alarms

Energistyrelsen

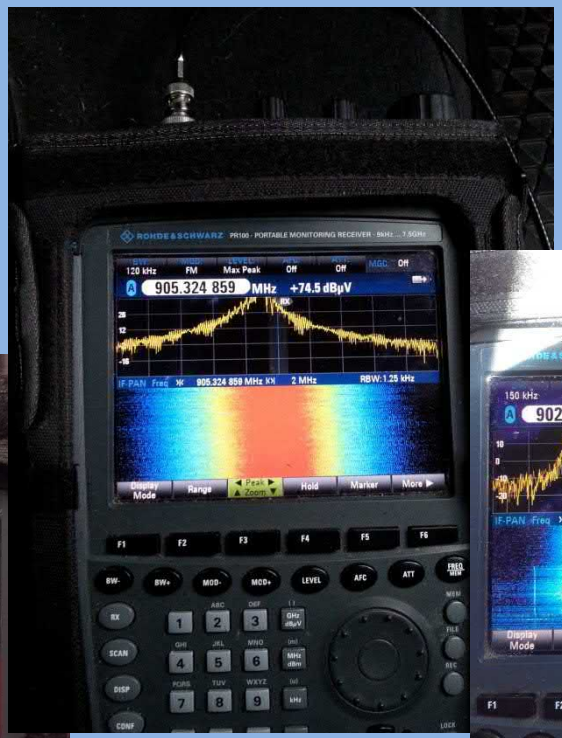


DVI cabel

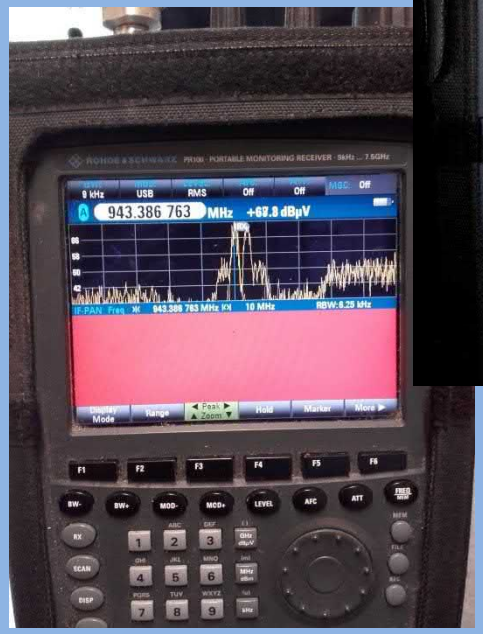


Jammer

Energistyrelsen

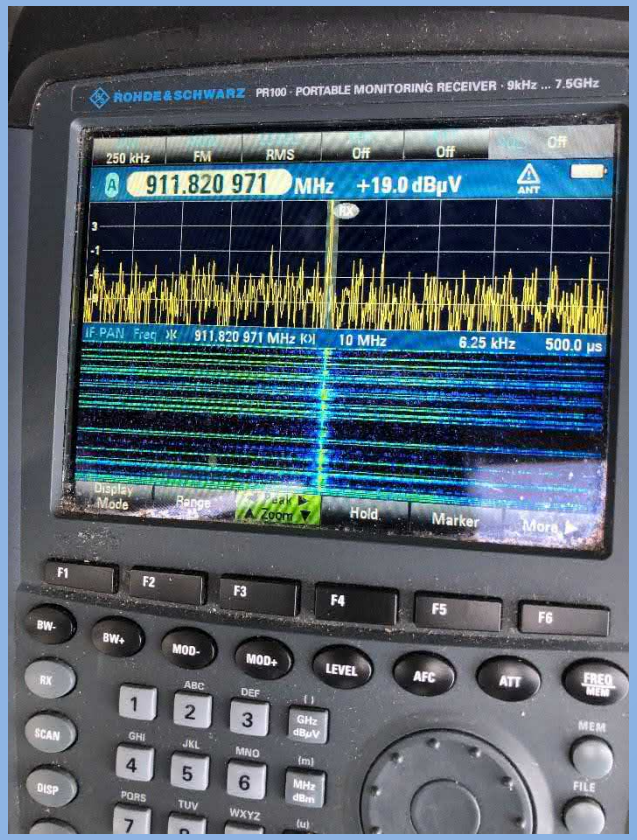


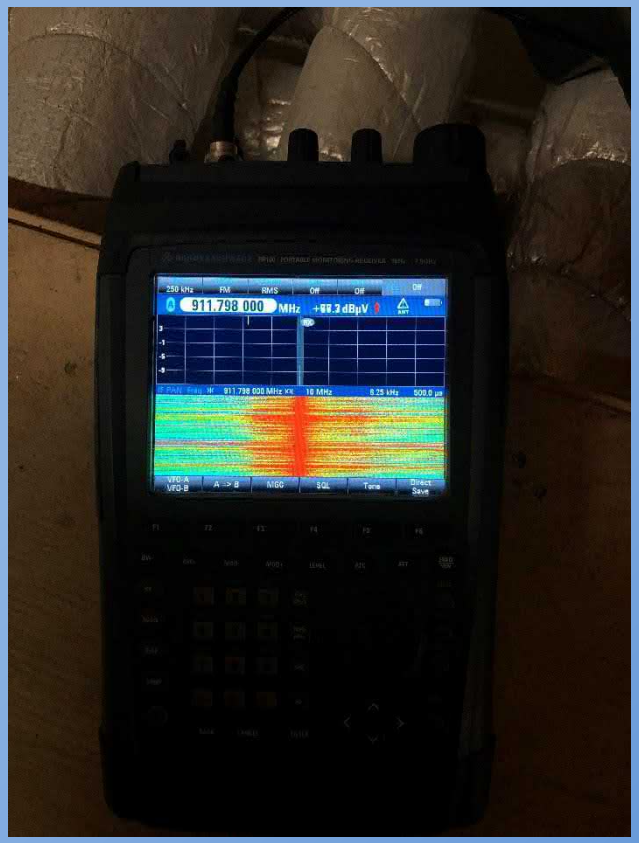
Disturbance on U900



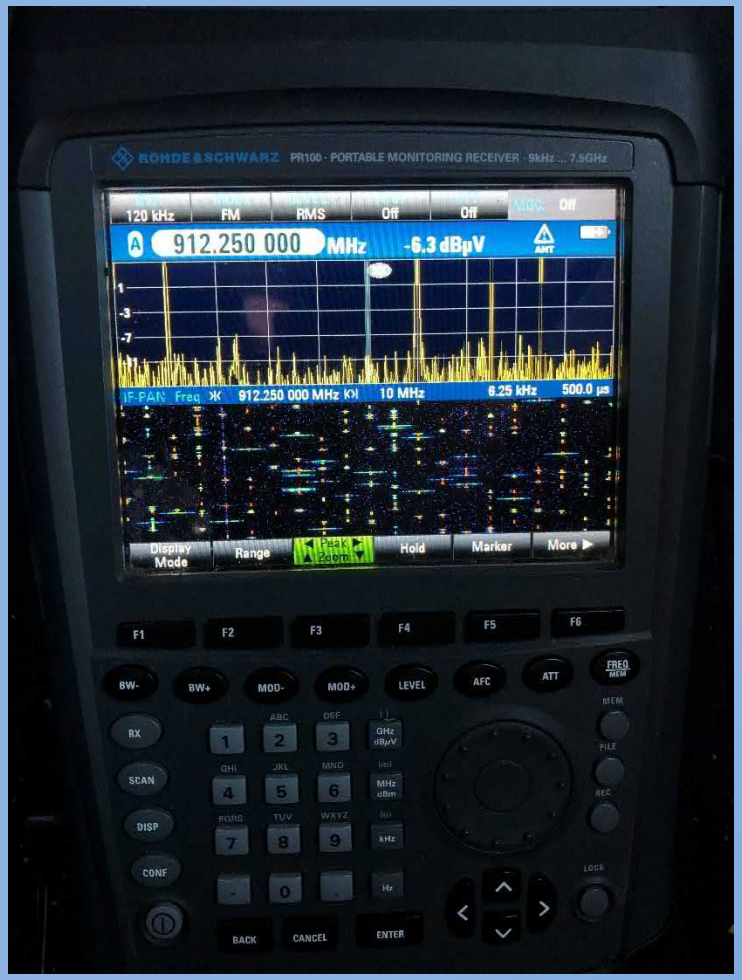
Disturbance in LTE

Disturbance on 80 meter.





Repeater seen on the scope.



RFID grid on the scope.

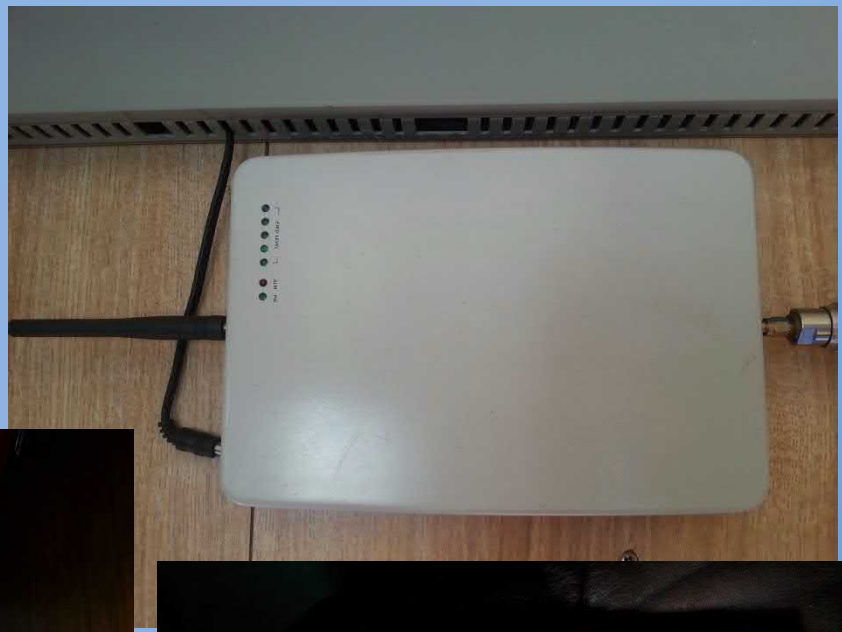
Energistyrelsen

Price sign, which we can see round in Denmark. From this we can see noise in the amateur band 3,7 MHz.

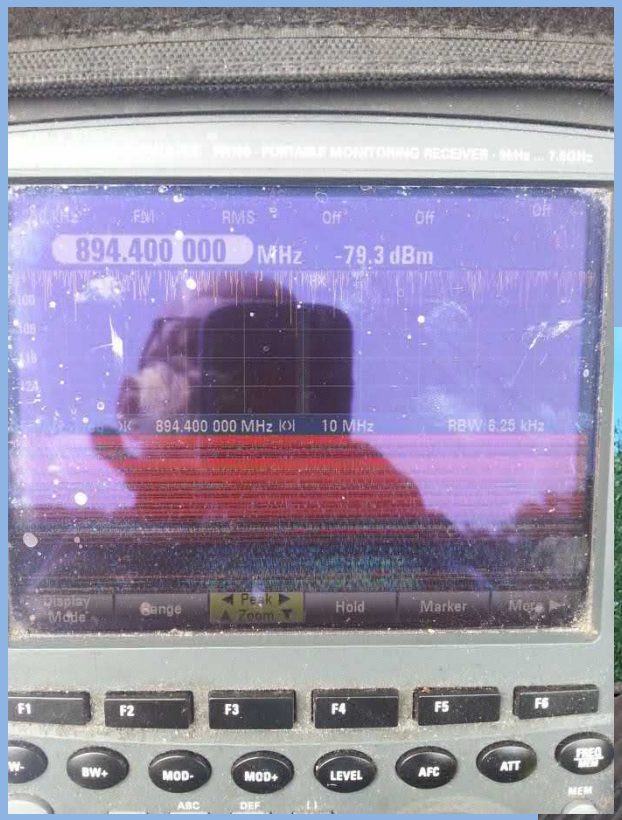
Energistyrelsen

Energistyrelsen

Diffent noise sources.

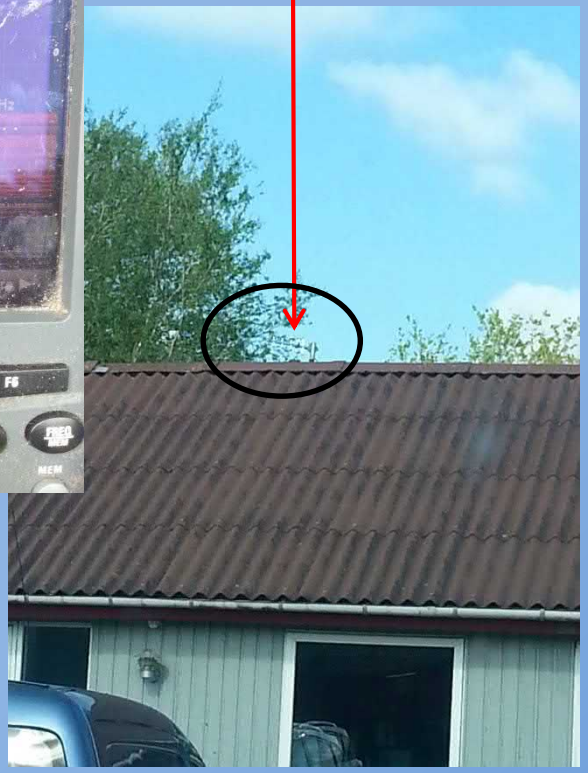


Energistyrelsen



Signal on the receiver

The antenna



Mobilrepeateren.

The interfering signal.

Source. Mobilrepeater.

VIKING DRONE

A flying start for drone-based ideas.

Discovering the Need

For a new drone platform

- Drones are inflexible and do not allow for on-board processing out-of-the-box.
- EU drones are very expensive and high risk for industry decision makers.
- Similar development headaches are shared across various companies with no universal solution.
- Data collection requires computation, storage, connectivity, drone control and coordination.

VALI THE DATA-SECURE INDUSTRIAL DRONE

LIKE A FLYING LAPTOP

COMPLETELY IN-LINE WITH COMPLIANCE

TRANSPARENCY IN DATA SECURITY

DESIGNED FOR EASY INTEGRATION

SAFE UNIVERSAL PLATFORM

Our Team

Rasmus Gupta
CEO
Founder

Frederik Sørensen
COO
Co-founder

Philip Salmony
Chief Electronics and Control Systems Engineer, Co-founder

Arne Devos
Embedded Software and Firmware Engineer

Natasha Goodwin
Head of Marketing

Focused Development

In order to control quality, data security, and computer integration - the complete system is built from the chip level and up.

Made in EU:
All materials, circuit boards, and assembly.

Accurate and precise sensors with <1cm position and<0.5° heading using Dual RTK GNSS.

Stable in high winds up to 15 m/s.

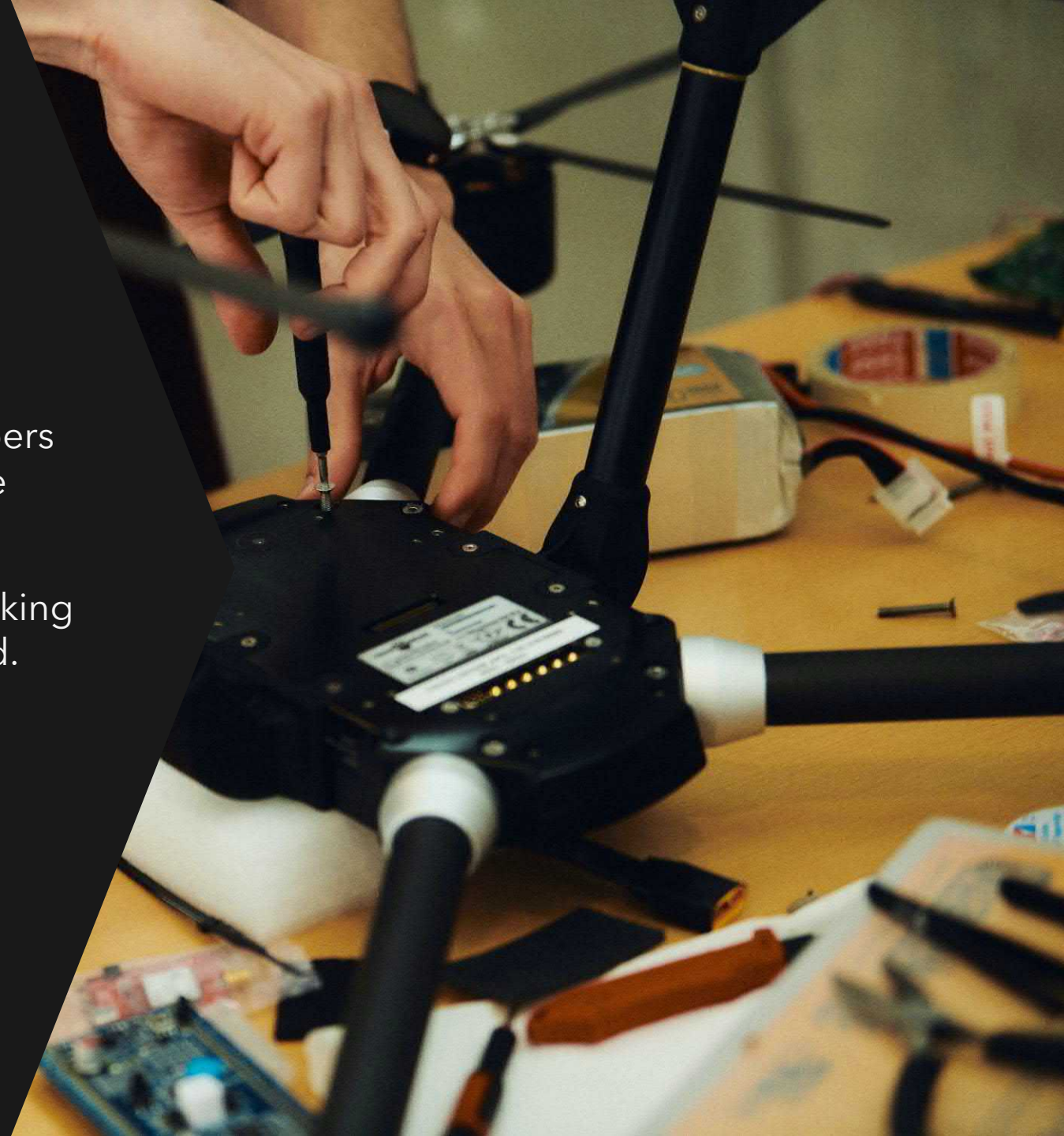
Focused Development

The perfect drone platform for developers and integrators to build upon and scale their business.

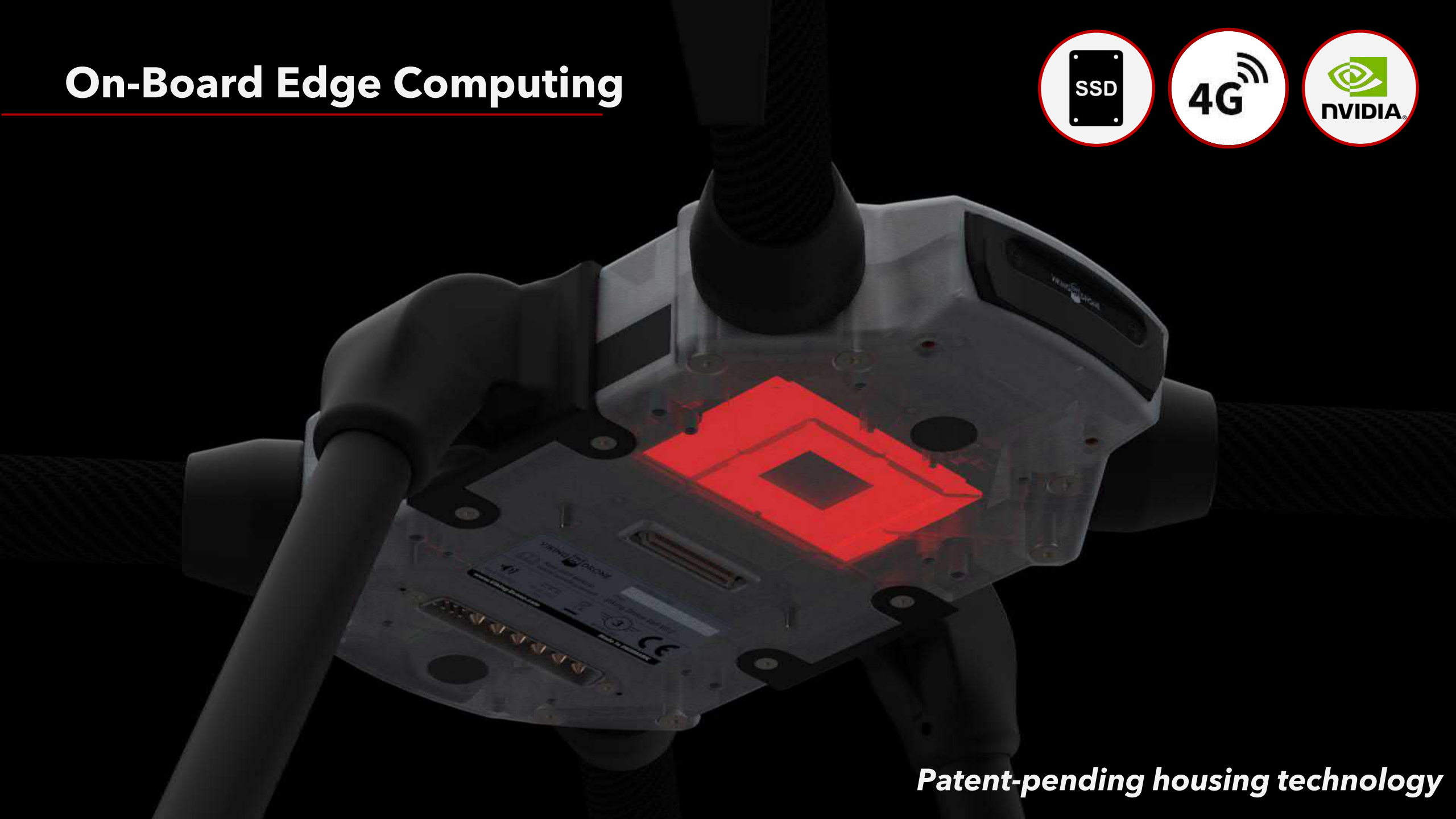
Funding received to ensure full CE-marking certification and tests will be performed.

A drone that provides the highest data security level possible.

IP56 Ingress protection
Operational in all-weather conditions



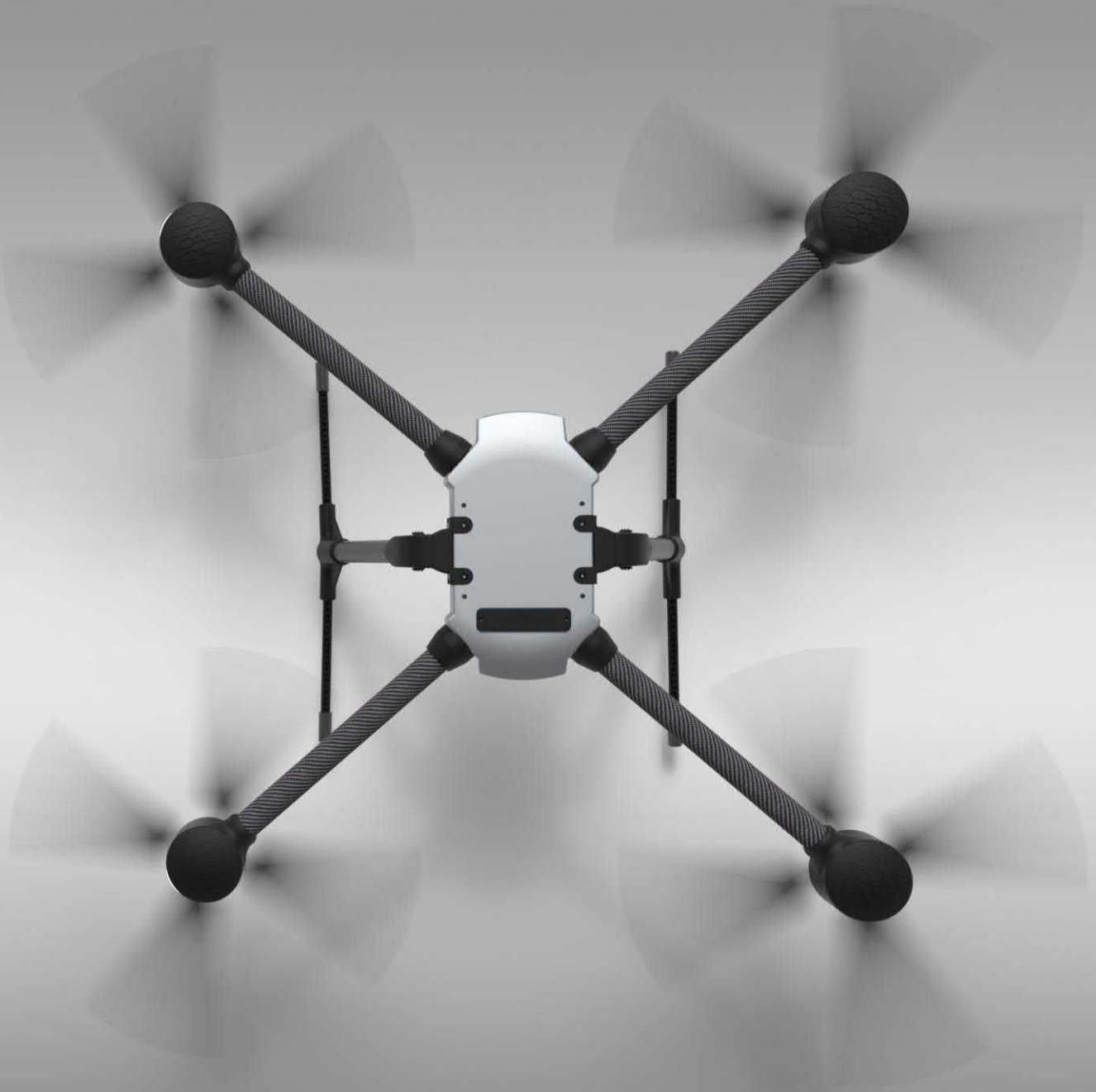
On-Board Edge Computing



Patent-pending housing technology

Using the drone for EMC Measurements

- Can be easily equipped with Software Defined Radio (SDR).
- Can be equipped with omnidirectional antenna or directional horn antenna.
- All drone electronics are currently undergoing EMC testing, strict EMC limit.
- All electronics are placed inside a shielded housing.
- Option to turn off I/O, radio modules etc.
- Drone is fully programmable to follow flight path in order to obtain EMC measurement.
- AI and Machine learning can be used on-board with SDR for EMC measurement optimization.



Fully Connected

Wi-Fi

4G

868MHz
Telemetry

2.4GHz
80 MBit
Wireless
Ethernet

HDMI™

SUPERSPEED+ USB CERTIFIED 10Gbps

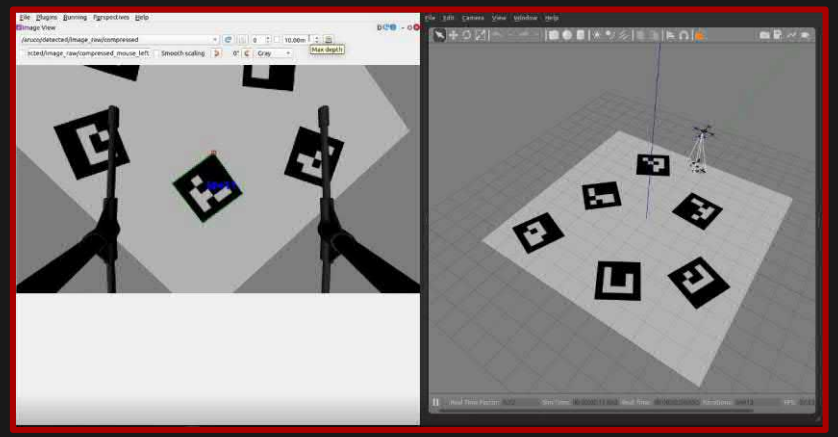
Gigabit
Ethernet

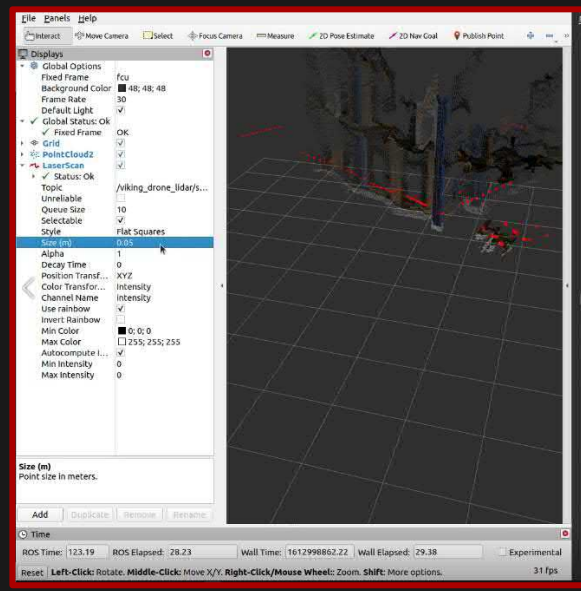
MIPI-CSI2
CAN BUS
FMU UART

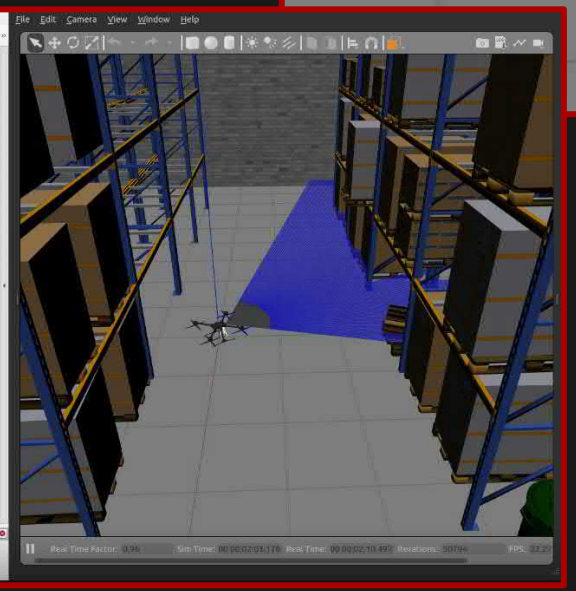
USB 2.0
FMU I2C
... More.

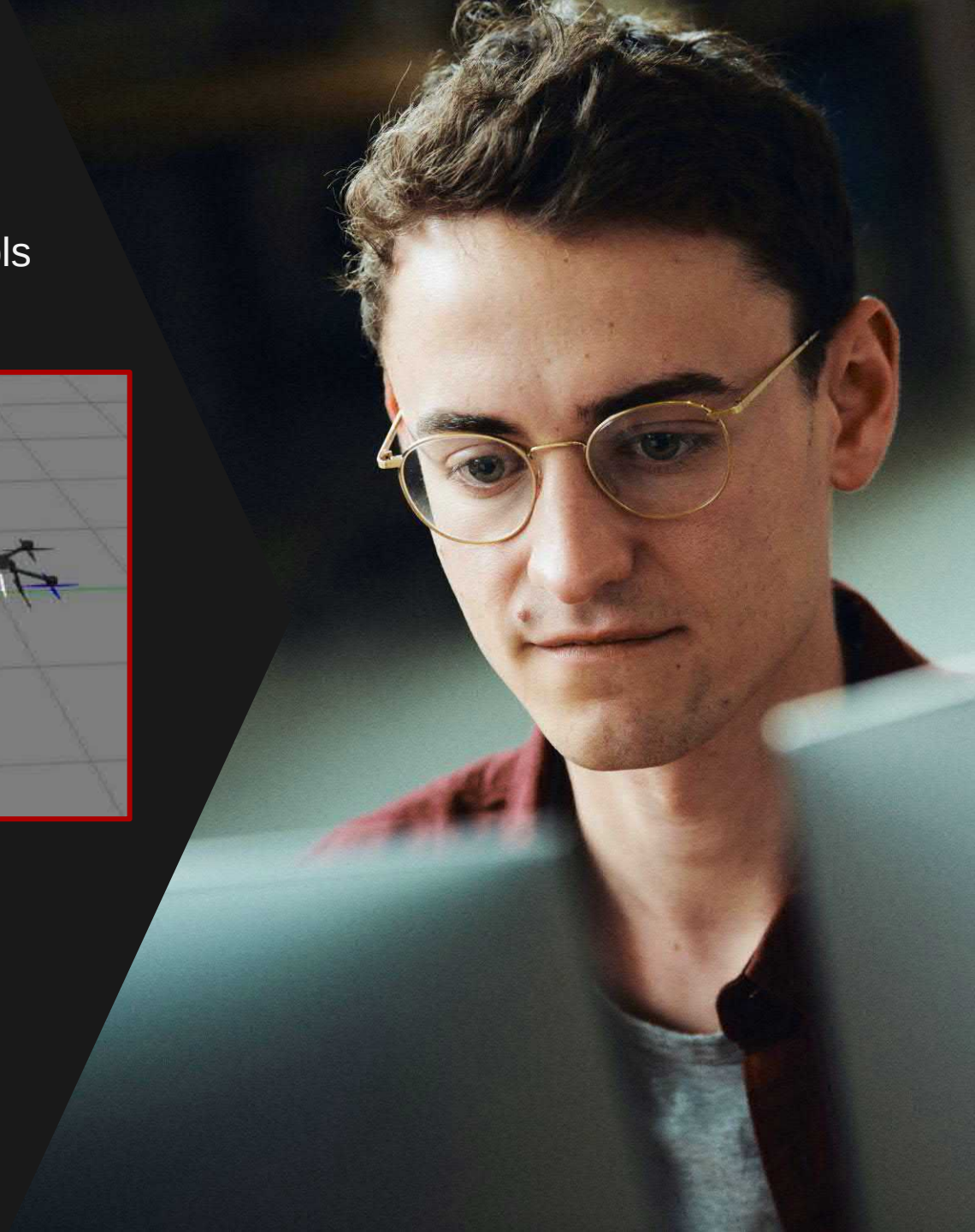
Program > Simulate > Fly!

Viking Drone supports developers through free-to-access tools such as Gazebo Simulation Environment for our customers.









Our Early Adoptor Program

EAP Contract
Includes 10h support

Get early-bird access
to the technology

2 of 10 drones left
(17th June 2021)

Future discount for
EAP participants

6.000 EUR
(1x Vali V0.3)

Vali V1.0 will be improved
with feedback from
EAP participants

Thank you!

Find us online:

www.Viking-Drone.com

LinkedIn.Viking-Drone.com

Contact@Viking-Drone.com

Or contact me directly

Rasmus Gupta
CEO / CTO, Founder
RG@Viking-Drone.com

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PROGRAMME

- 12.30: Welcome [Morten Sørensen, Associate Professor, SDU - Centre for Industrial Electronics (CIE)]
- 12.35: Keynote speech: EMC Directive 2014/30/EU: compliance for Fixed Installations [Keith Armstrong, Director and Principal EMC Consultant, worldwide services, Cherry Clough Consultants Ltd.]
- 13.05: EMC Management of fixed installation [Per Thåstrup Jensen, Senior Technology Specialist, Force Technology]
- 13:30: Measurement campaign and wind turbines [Claus Grøn Lyngby, Specialist, EMC. Product Function Lead, Vestas Wind Systems A/S]
- 13:45: Interference examples from Noise Service, Danish Centre for Telecommunications (Støjtjenesten) [Torben Kamstrup, Engineer, Støjtjenesten, Energistyrelsen]
- 14:00: Drones for electromagnetics measurements [Rasmus Gupta, CEO, Viking Drone ApS]
- **14:15: Discussion, closing remarks and farewell [Morten Sørensen, Associate Professor, SDU - Centre for Industrial Electronics (CIE)]**

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SDU
Center for Industrial Electronics
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CENTRE FOR INDUSTRIAL ELECTRONICS

- The Centre for Industrial Electronics (CIE) was founded in 2017 by an academia-industry-public partnership to

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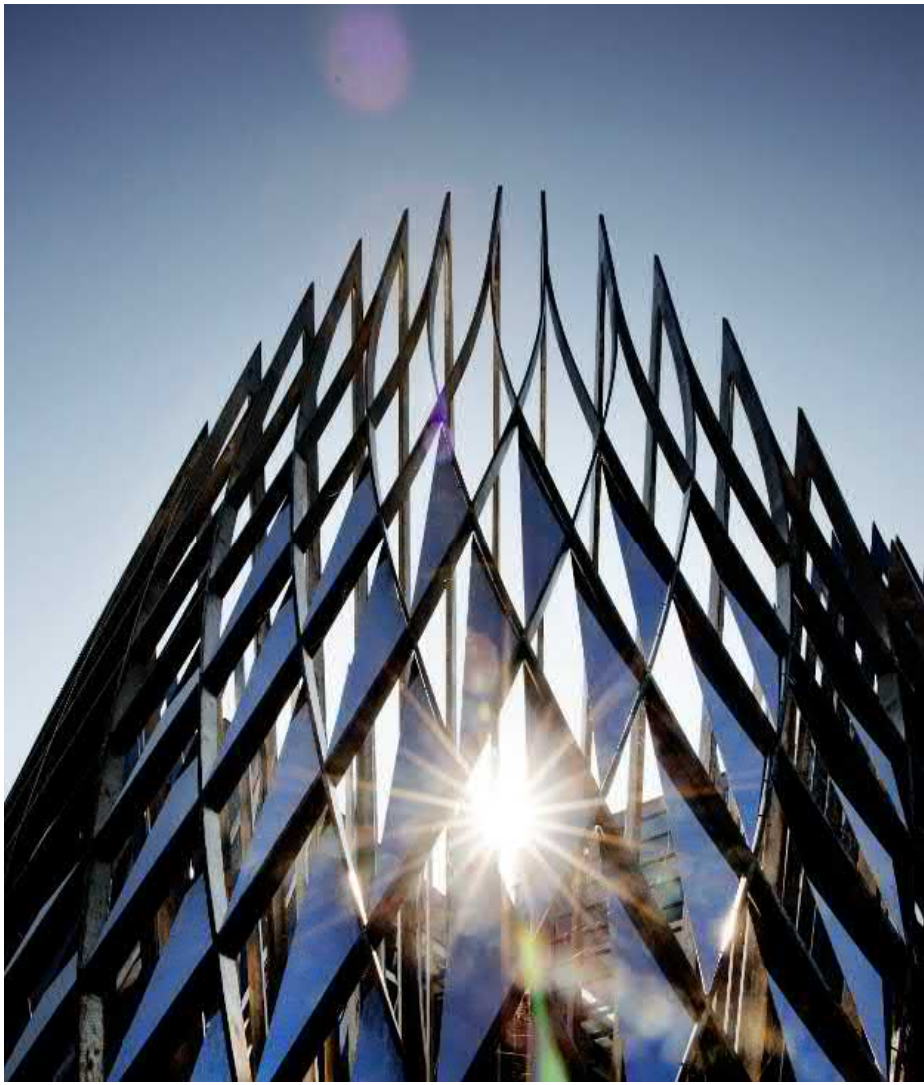
- Educate the next generation engineers,
- Conduct world-class research and translate technology into application – certain focus drives and passive components – European Center for Power Electronics (ECPE) competence center – EPCIA member
- Testing and Reliability - CIE collaborates with companies with service and consulting activities



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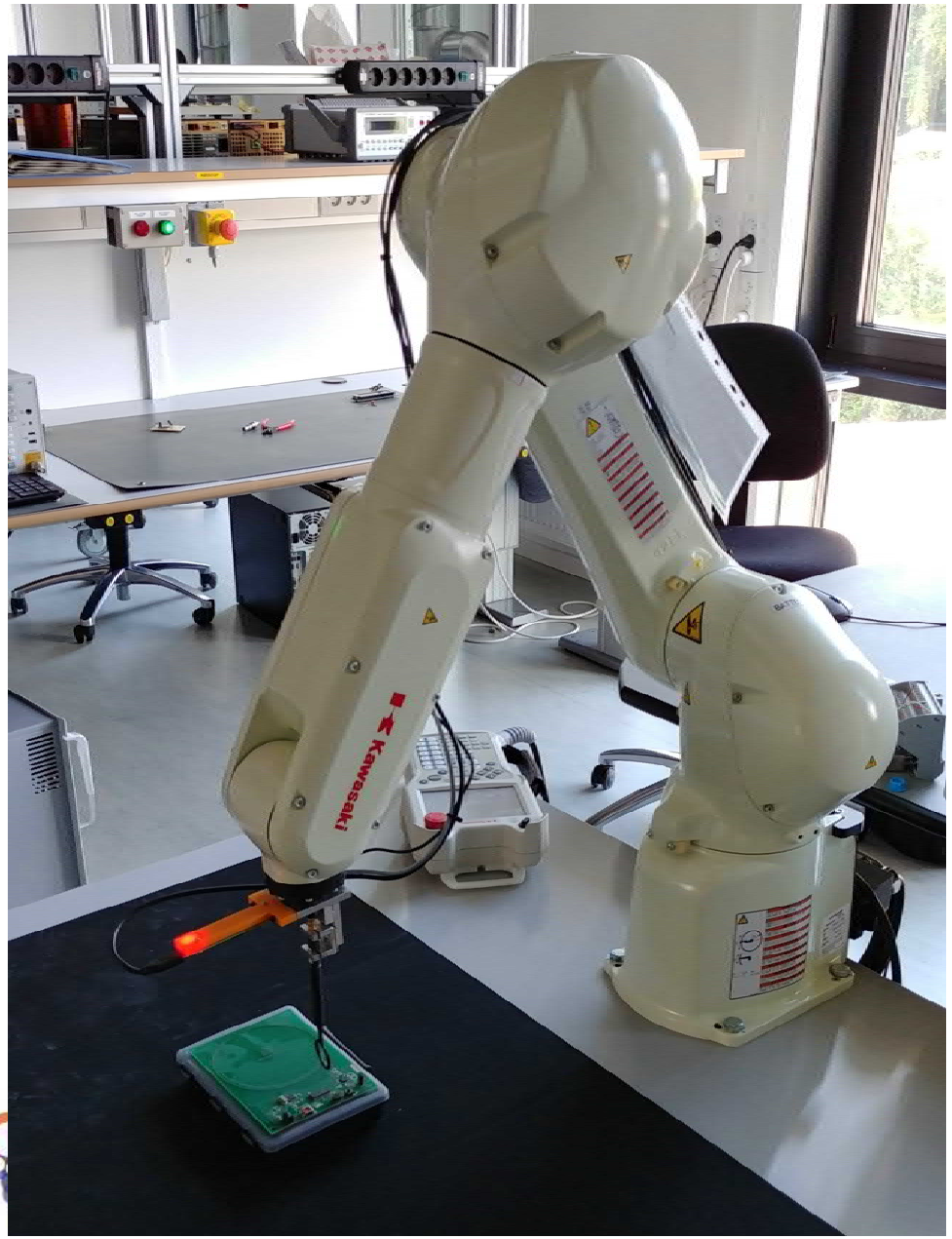
The EMC Research Group at a Glance

- Currently 2 associate professors, 1 engineer, and 2 PhD-student.
- Planning to enrol several PhD-students and postdocs the year to come.
- Broad research interest including radiated and conducted emission, radiated immunity, spurious emission, desense, ESD, burst, surge, and harmonic power.
- Special research interest:
  - Power electronic and EMC.
  - Hybrid magnetic structures for EMI filtering.
  - Connection between EMC at module level and system level.
  - Near-field scanning.
  - Desense.
  - Applications of circuit and 3D full wave electromagnetic simulations.
- Please contact Morten Sørensen, Soerensen@sdu.dk for more information.



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Drones for Electromagnetic Measurements - an Example

- H. Pienaar and H. C. Reader, "Multicopter metrology platform for propagation measurements," *2015 International Conference on Electromagnetics in Advanced Applications (ICEAA)*, 2015, pp. 370-374, doi: 10.1109/ICEAA.2015.7297138.
- H. Pienaar, A. J. Otto, P. S. van der Merwe, D. B. Davidson and H. C. Reader, "Building electromagnetic shielding characterisation using multicopter," *2016 Asia-Pacific International Symposium on Electromagnetic Compatibility (APEMC)*, 2016, pp. 309-312, doi: 10.1109/APEMC.2016.7522721.

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DRONE FOR MEASUREMENT OF SHIELDING EFFECTIVENESS

- A special designed drone was used to measure the shielding effectiveness of South Africa's Karoo Array Processing Building. (South African Radio Astronomy Observatories).

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GROUND LEVEL MEASUREMENTS VS. DRONES

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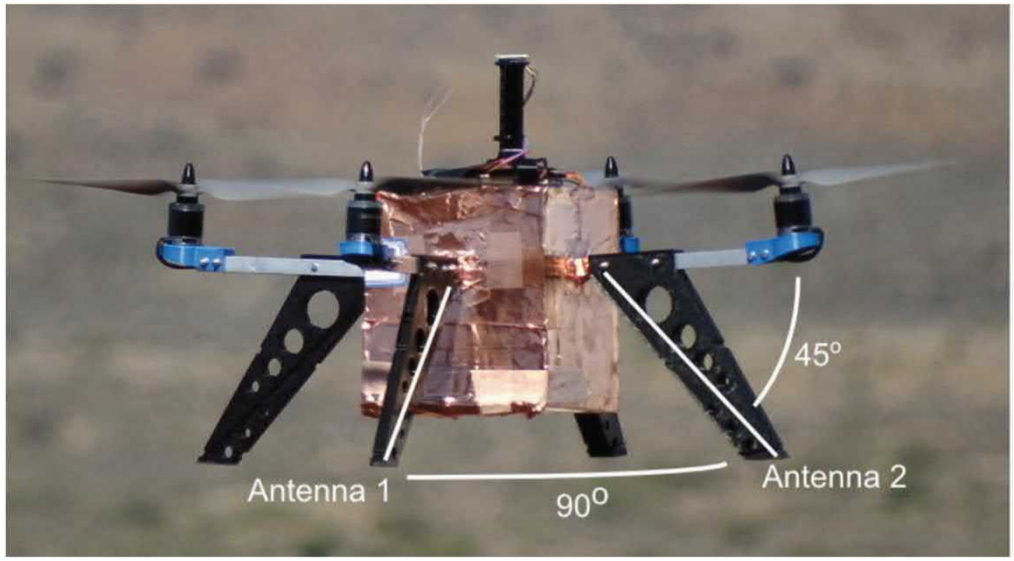
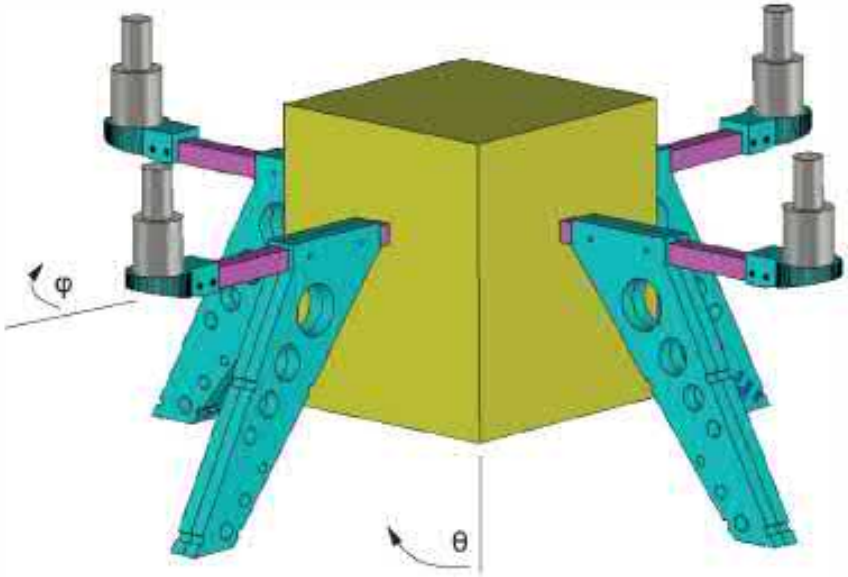
THE DESIGN OF THE DRONE





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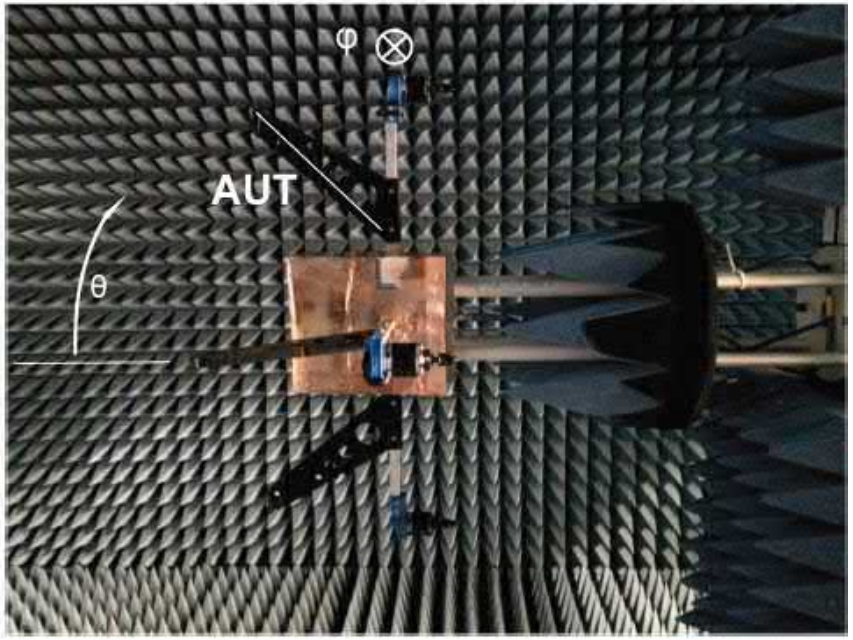
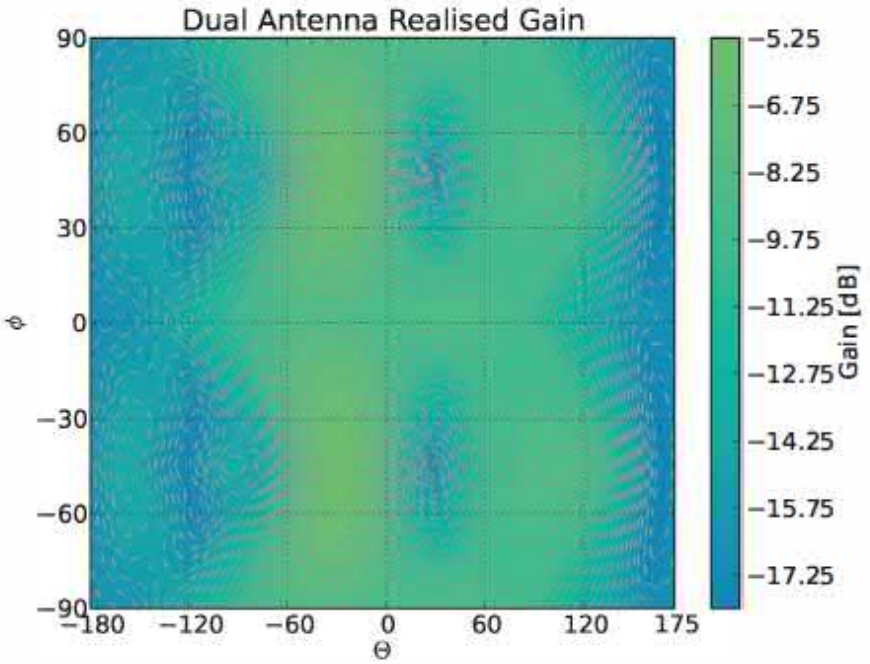
THE DRONE AS AN ANTENNA





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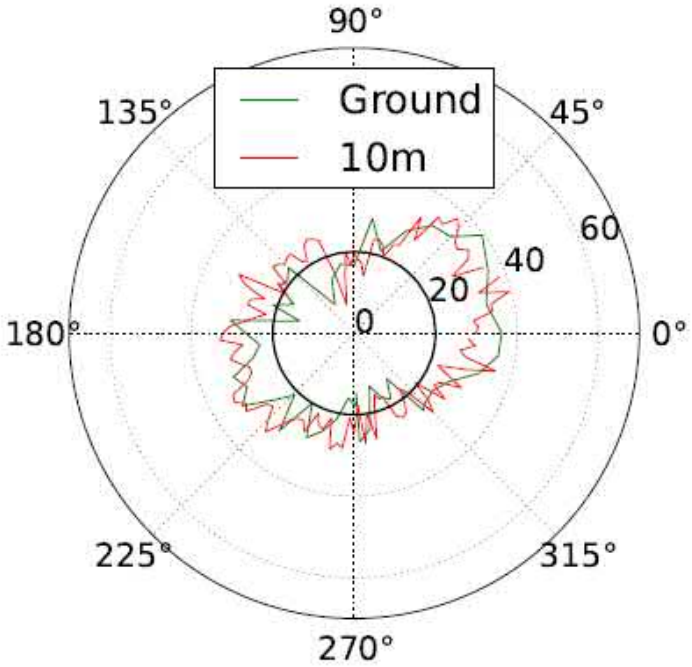
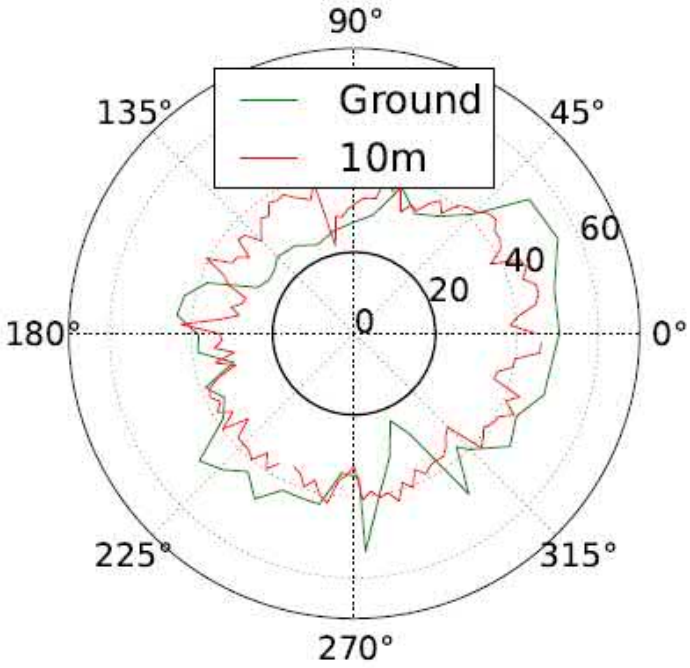
RESULTS



290 MHz



905 MHz

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THE NEED FOR LARGE SCALE MEASUREMENT SYSTEMS

- Electrification is a big part of the green revolution
  - Windmills, solar converters, electrical vehicles, production facilities, HVAC systems, wireless power transfer, data centers etc.
  - The electrification creates electromagnetic noise that is a threat for various kind of wireless communication.
  - Because of the increasing size, there is a need for flexible radiated emission measurement.
  - The combination of electrification and the emerge of more wireless communication including IOT will cause even more interference in the future and, hence, there is a need for effective large-scale interference finding.

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