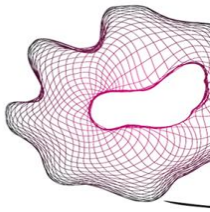
URSI GA:
Risk Based EMC for Complex Systems

EM Coexistence, Compliance and Compatibility;
Risk-Based vs. Rule-Based and
RED vs. EMCD



Frank Leferink, THALES & University of Twente

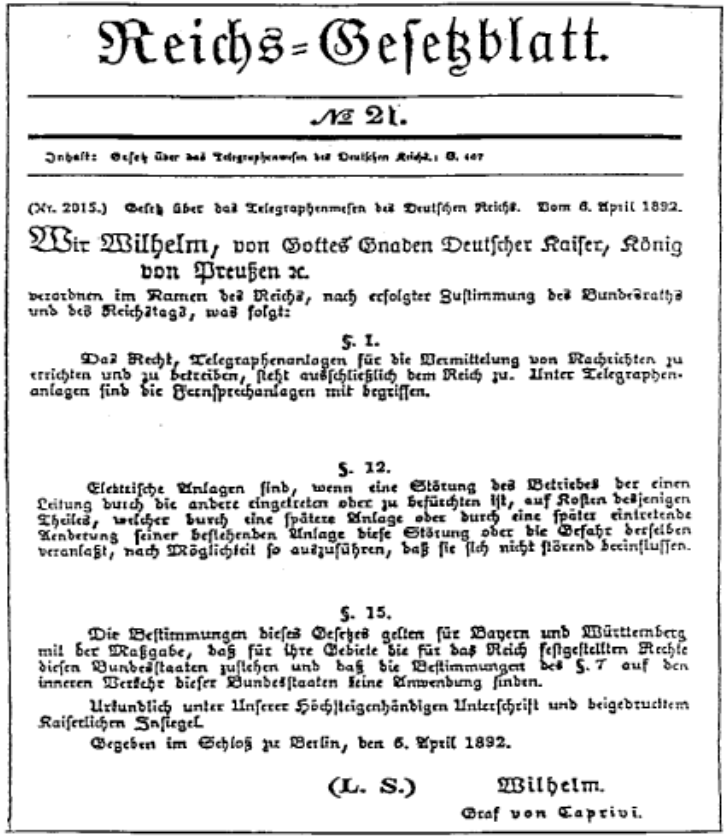
WATCH HOW CREDIT COUNTER STOPS

WHEN BUTTON IS PRESSED ON REMOTE CONTROL

MONEY KEEPS DROPPING WITHOUT BEING COUNTED.

MACHINE CAN HOLD AS MANY AS 2,000 COINS.

New technology: telephone … EMI



Reichs-Gesetzblatt.

№ 21.

Inhalt: Gesetz über das Telegraphenwesen des Deutschen Reichs. S. 467

(Nr. 2015.) Gesetz über das Telegraphenwesen des Deutschen Reichs. Vom 6. April 1892.

Wir Wilhelm, von Gottes Gnaden Deutscher Kaiser, König von Preußen ꝛc.

verordnen im Namen des Reichs, nach erfolgter Zustimmung des Bundesraths und des Reichstags, was folgt:

§. 1.

Das Recht, Telegraphenanlagen für die Vermittelung von Nachrichten zu errichten und zu betreiben, steht ausschließlich dem Reich zu. Unter Telegraphenanlagen sind die Fernsprechanlagen mit begriffen.

§. 12.

Elektrische Anlagen sind, wenn eine Störung des Betriebes der einen Leitung durch die andere eingetreten oder zu befürchten ist, auf Kosten desjenigen Theiles, welcher durch eine spätere Anlage oder durch eine später eintretende Aenderung seiner bestehenden Anlage diese Störung oder die Gefahr derselben veranlaßt, nach Möglichkeit so auszuführen, daß sie sich nicht störend beeinflussen.

§. 15.

Die Bestimmungen dieses Gesetzes gelten für Bayern und Württemberg mit der Maßgabe, daß für ihre Gebiete die für das Reich festgestellten Rechte diesen Bundesstaaten zustehen und daß die Bestimmungen des §. 7 auf den inneren Verkehr dieser Bundesstaaten keine Anwendung finden.

Urkundlich unter Unserer Höchsteigenhändigen Unterschrift und beigedrucktem Kaiserlichem Insiegel.

Gegeben im Schloß zu Berlin, den 6. April 1892.

(L. S.) Wilhelm.

Graf von Caprivi.

Power and communication systems are both using earth (ground) as return current path:

Interference

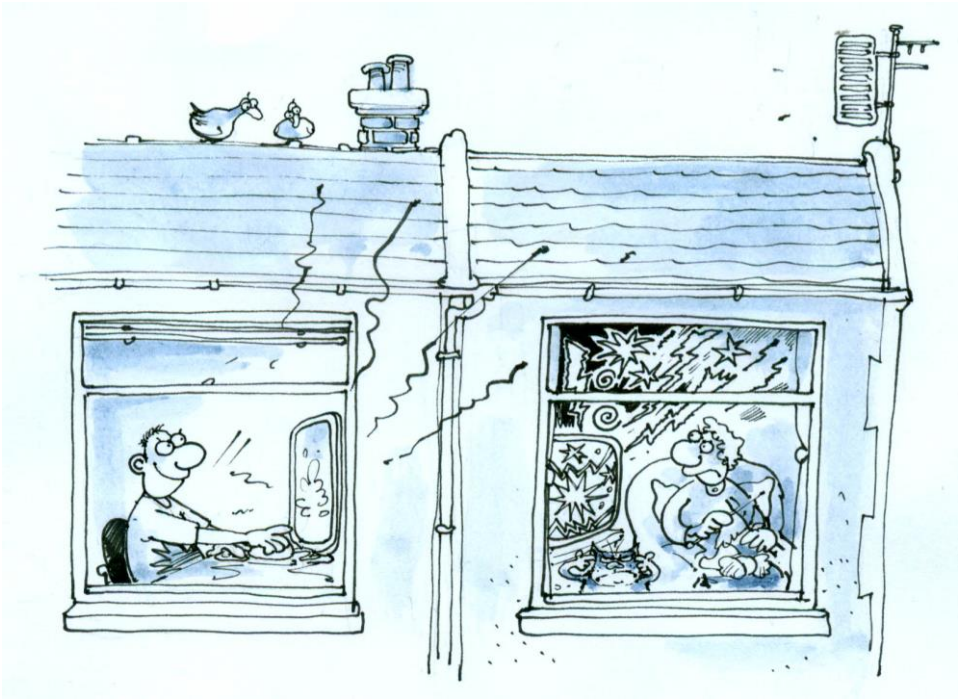
‘§ 12

As far as possible, electric equipments must be designed in a way that interferences do not occur.’

Already in 1892

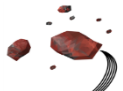
Frank Sabath/ Heyno Garbe

New technology: radio, TV … EMI



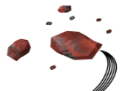
Cartoons made by Rupert Beasley

Basic solution?

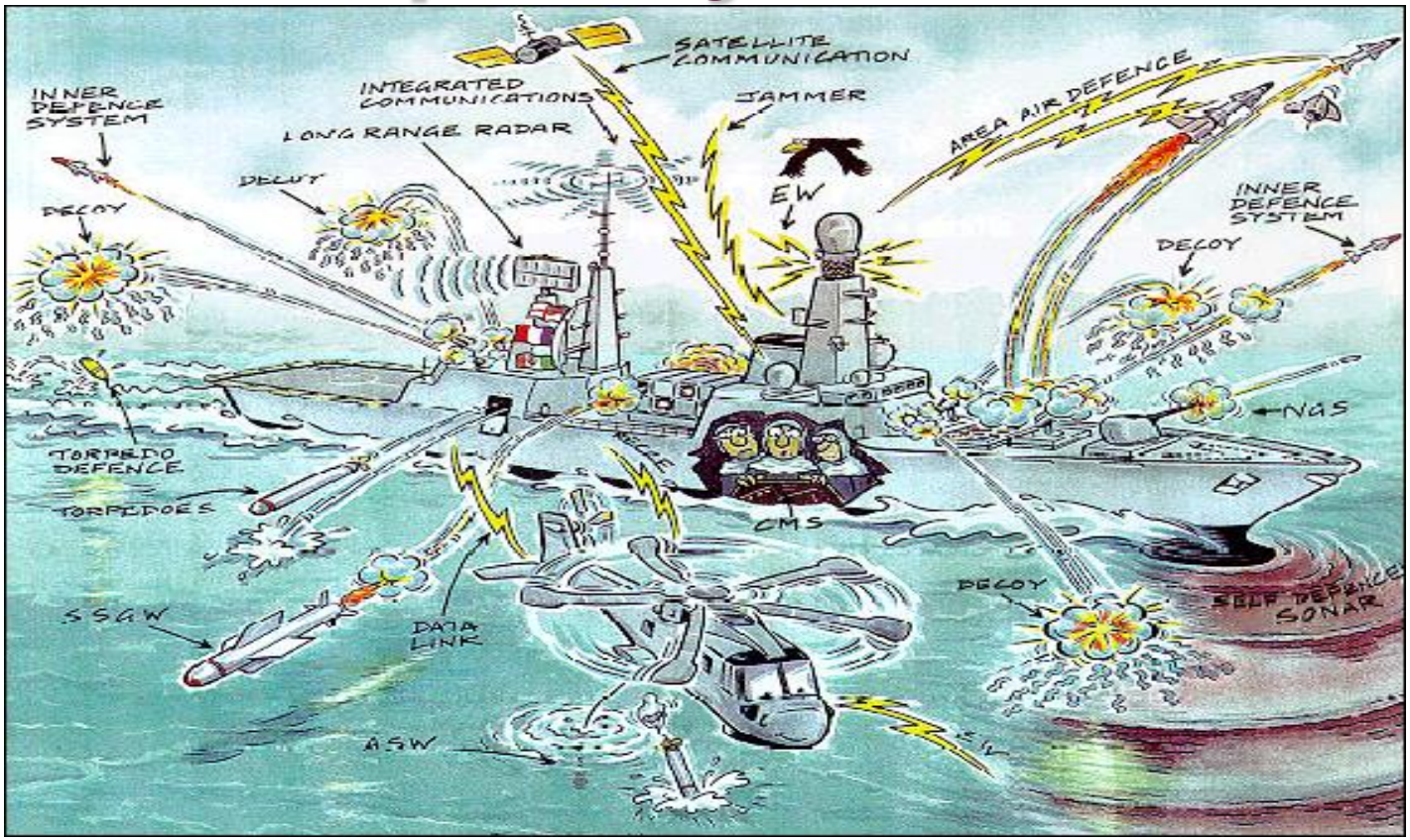


Basic solution!

Rules (standards)

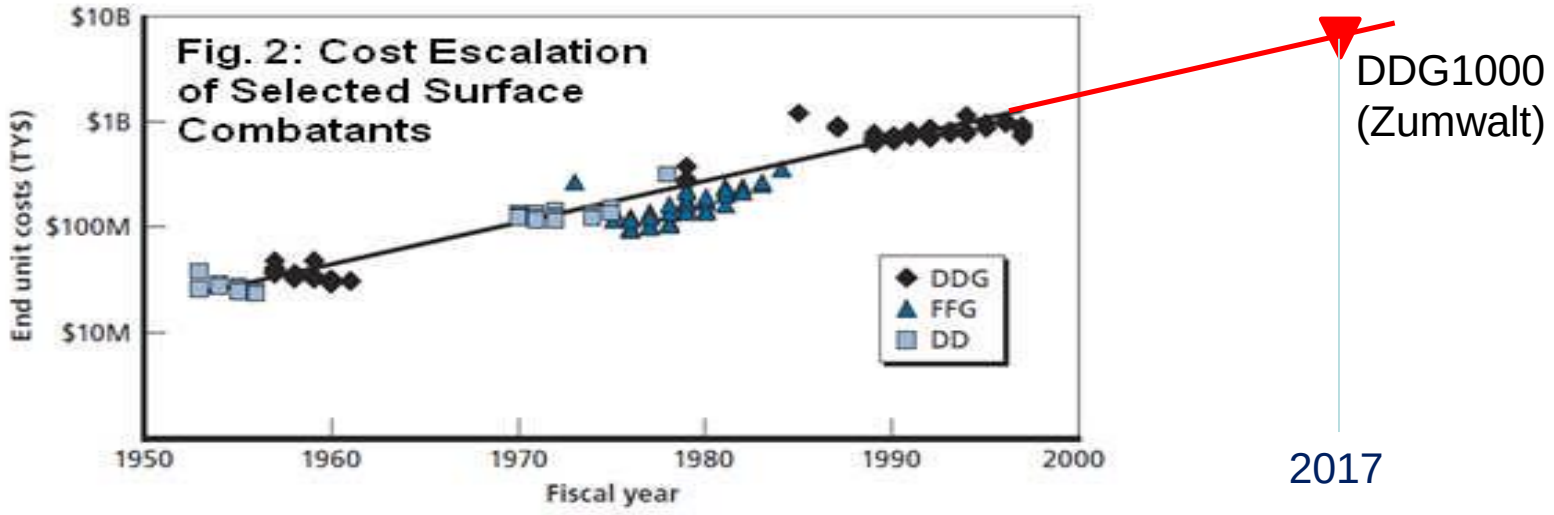


Complex systems…..



USA: '*Documents for Ship Cost Reduction*'

'The cost of Navy ships is escalating at an unsustainable rate'



*'A surprisingly large part of this escalation is attributable to **Standards** and **Specifications**' **(~ rules)***

M. Arena et. al., Why has the cost of Navy ships risen?', RAND National Defense Research institute, prepared for the US Navy, 2010

USA: '*Documents for Ship Cost Reduction*'

- Top 10 of cost-driver standards,
  3 out of them are EMC:
  - *'MIL-STD-461E Electromagnetic Interference (EMI)'*
  - *'MIL-STD 464A Electromagnetic Environmental Effects (E3) Requirements for Systems'*
  - *'MIL-STD-469B Radar Engineering Interface Requirements, Electromagnetic Compatibility – Frequency Spectrum Guide for Radar'*

M. Arena et. al., Why has the cost of Navy ships risen?', RAND National Defense Research institute, prepared for the US Navy, 2010

Canada: *'Estimating the Cost of Naval Ships'*

Many reports published in 2015-2017:

- *'Cost growth trend in naval ship construction since the 1960s is twice the rate of inflation'*
- *'Additional increase above inflation was caused by 'requirements creep' '* **(including rules)**

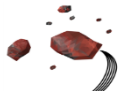
Solution (?)

Rules and Standards

Yes, it solved most interference problems

But increasing costs

Can we do it better for complex systems?



Risk based approach for naval ships

- Assessment of:
  - the expected actual EM environment,
  - immunity and emission characteristics of equipment

- Then: Implement necessary measures (incl. non-technical)

- No expensive hardening and testing of all individual equipment to very specific standards (i.e. rule based)

Risk based approach for naval ships

- Thus:
  - Instead of hardening all equipment,
    we specify and control the EM environment
  - That means we accept the EMC performance of most equipment as it is, but put effort in controlling the EM environment and hardening of only some equipment
  - And **keep in control** during the process

From ‘rule based’ to ‘risk based’

- How can we do this? M-C-I-V:
  - EMC **M**anagement (what, when, who)
  - EMC **C**ontrol (risk management)
  - EMC **I**mplementation (how)
  - EMC **V**erification (check)

From ‘rule based’ to ‘risk based’

- How can we do this? M-C-I-V:
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Lloyd's Register

Risk vs. Rule based

- In military and other professional (aerospace) domains this is called ‘’EMC Engineering’’
- But rule-based remains often the default, due to lack of competences

- Trend in civil domains
  - European Directive EMC 2014: see ‘’Blue Guide’’ 2016
  - Medical: IEC 60601-1-2: Medical electrical equipment - EMC Requirements and (EMI) tests, full implementation 2019

Risk vs. Rule based, EMC Dir.

- Equipment in EU shall fulfil the essential requirements of the EMC-D:
- *'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 telecommunications 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'*

Risk vs. Rule based, EMC Dir.

- Common approach of most suppliers:
  follow the harmonized EN/IEC standards (‘’rules’’):
  results in ‘presumption of conformity’.

- The European Commission ‘’Blue Guide’’ of 2016 gives a clear explanation on using Harmonised Standards (next page)

Risk vs. Rule based, EMC Dir.

- European Commission Blue Guide 2016:
  'Harmonised standards never replace legally binding essential requirements. A specification given in a harmonized standard is not an alternative to a relevant essential or other legal requirement but only a possible technical means to comply with it. In risk related harmonisation legislation this means in particular that a manufacturer always, even when using harmonised standards, remains fully responsible for assessing all the risks of his product in order to determine which essential (or other) requirements are applicable.'

Risk vs. Rule based, EMC Dir.

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- So risk-based should already be the default approach!!

Risk vs. Rule based, Medical

- IEC 60601-1-2: Medical electrical equipment - EMC Requirements and (EMI) tests

- 4th edition published in 2014, and fully in force in 2019

- More risk-based EMC in this new edition
  - Risk caused by EMI shall be taken into account
  - Results in risk management policy
  - Should be made for every (unique) EM environment

Risk analysis, medical

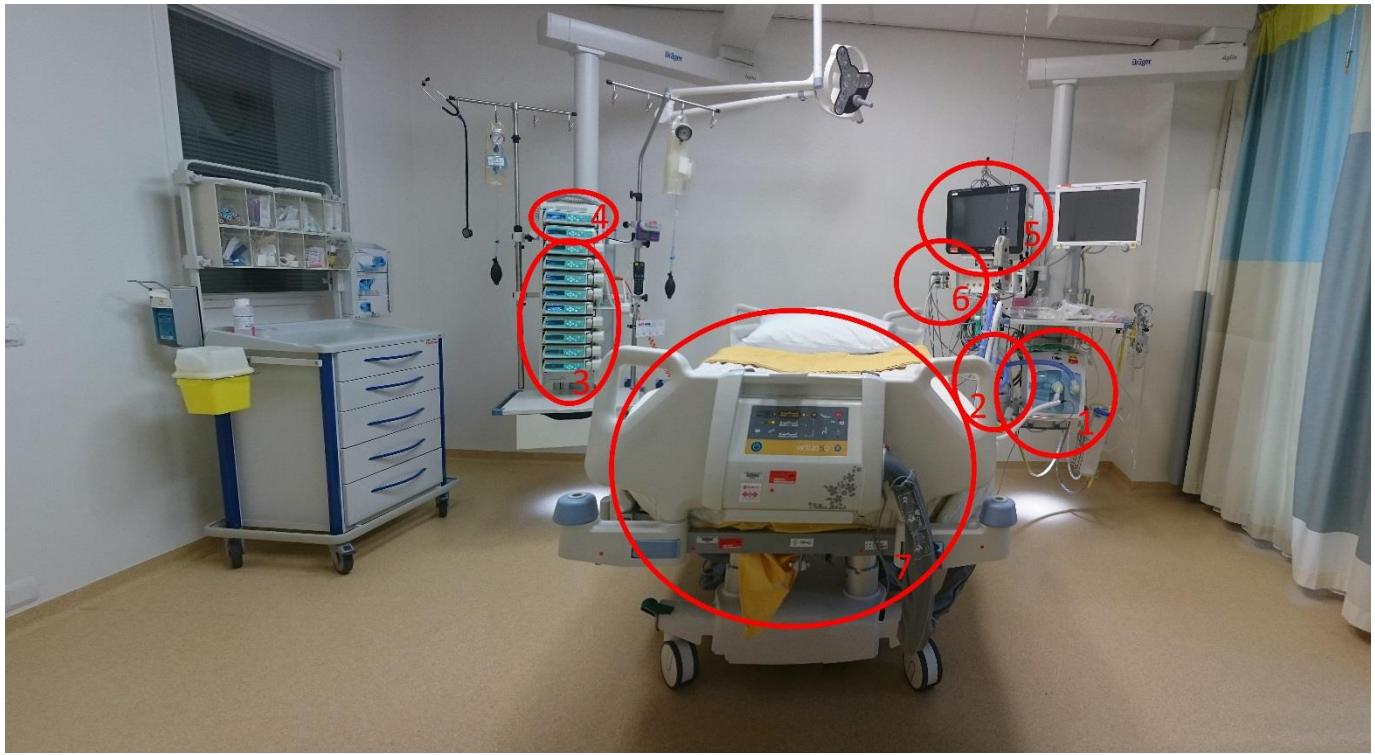
- Risk = Probability x Severity
- Probability
  - Emission of source
  - Susceptibility of victim
  - Accessibility of victim
- Severity
  - Consequence
  - Duration of dis-functioning
  - Visibility

		Severity		
		Critical	Serious	Negligible
Probability	Probable			
	Moderate			
	Minor			

Risk analysis, medical, neonatology

Silvo Jeunink, Master Thesis University of Twente: Electromagnetic sources in the hospital environment: risks analysis and measures for electro-magnetic compatibility (EMC)

Risk analysis, medical, IC



Silvo Jeunink, Master Thesis University of Twente: Electromagnetic sources in the hospital environment: risks analysis and measures for electro-magnetic compatibility (EMC)

Risk analysis, medical, results

- Difference in every source-victim pair, but in general:
- Probability
  - Related mostly to power of source
    - Walkie-Talkie: EMI Probable
    - Cell phone: EMI Probable
    - Computer, tablet: Minor
    - RFID: EMI Probable
- Severity
  - Related to function victim
    - Mostly critical or serious

		Severity		
		Critical	Serious	Negligible
Probability	Probable			
	Moderate			
	Minor			

Risk management, medical

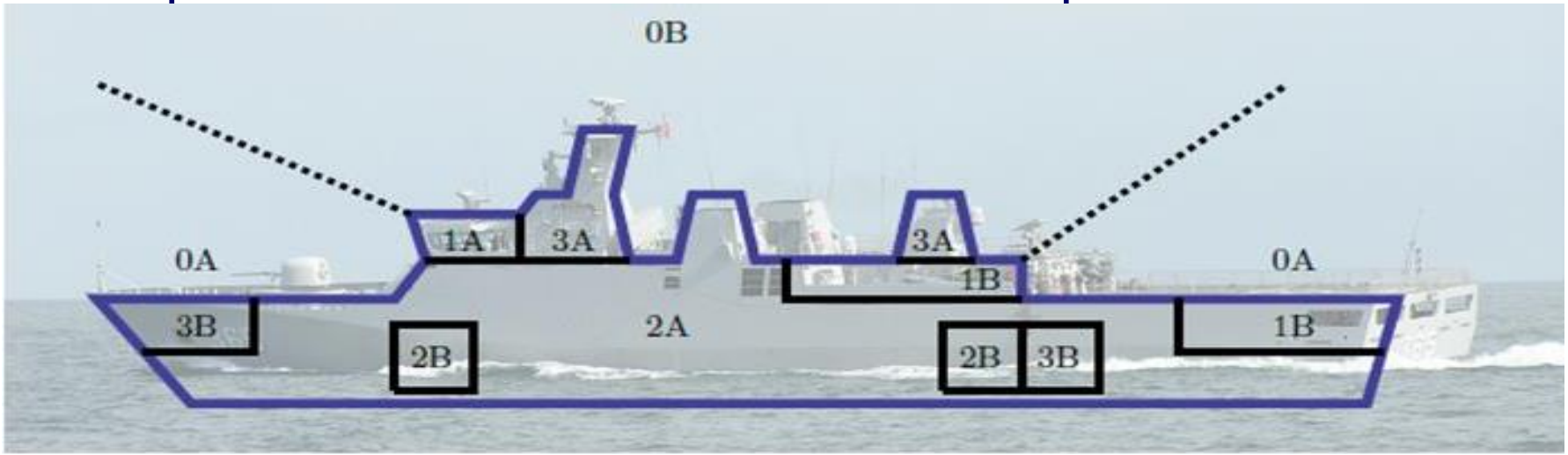
- Proposed policy for this case:
  - Walkie-Talkie: 1 m separation
    - Because of calculated and measured interference
    - With an extra safety margin
  - Cell phone: 50 cm separation
    - Calculated
  - Computer/tablet/etc.: 0 cm separation
    - Chance of EMI is negligible
  - RFID: 1 m separation
    - Mostly because of measured interference to ECG
    - Readers are installed on fixed places

Example for naval ship

- EMC Management (what, when, who)
- EMC Control (risk management)
- EMC Implementation (how)
- EMC Verification (check)

EMC Control

➡ Topics to deal with in the EMC control plan

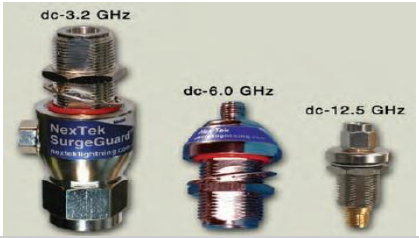


0A: General outer deck
0B: Antenna zone
1A: Bridge and similar
1B: Hangar and similar
2A: General inner deck
2B: Industrial area
3A: Special zone sensitive
3B: Special zone disturbing

EMC Implementation

- EMC-Multi Cable Transits

- EMP-protection



- Doors / hatches

EMC Zone protection measures

- Exposed cables

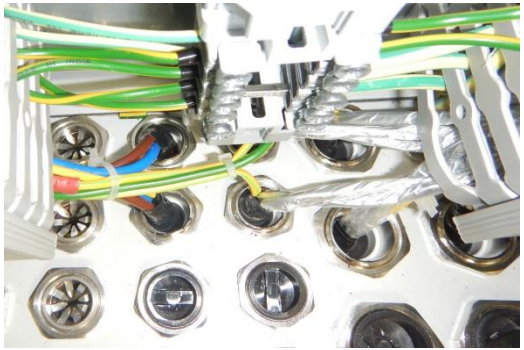
- Waveguides

- Honeycomb / wire mesh / netting

EMC Verification

Proper Conservation

During building phase



Proper work methods

Earthing check
R < 2,5 mΩ or 10 mΩ

Proper materials

EMC Verification

Conclusion

- Rule-based is nice for single EMI issues and simple equipment
- Complex systems EMC: risk-based approach necessary (and according to the EC Blue Guide even mandatory)
- Risk-based EMC is just proper EMC engineering:
  - EMC Management (what, when, who)
  - EMC Control (risk management)
  - EMC Implementation (how)
  - EMC Verification (check)

EMC EUROPE 2018

AMSTERDAM