



# Prime Contractor Issues Integrating Distributed Systems on Large Naval Platforms

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# Abstract



- Prime contractors have significant EM issues to manage when dealing with integrating distributed systems on large naval platforms of diverse COTS and MOTS EMC standards, integrating systems from different manufactures equipment distributed through multiple ships compartments of differing EM environments / construction.
- This involves a risk based EMC approach, for the intended EM environment early in the EMC design cycle, supported by functional testing during setting to work, systems acceptance and whole platform acceptance through sea trials.
- The challenge is to adequately define responsibilities between equipment manufacturer, system integrator and whole platform integrator (prime) for the overall EMC certification of the ship

# About the presenters



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Adrian Monk CEng,  
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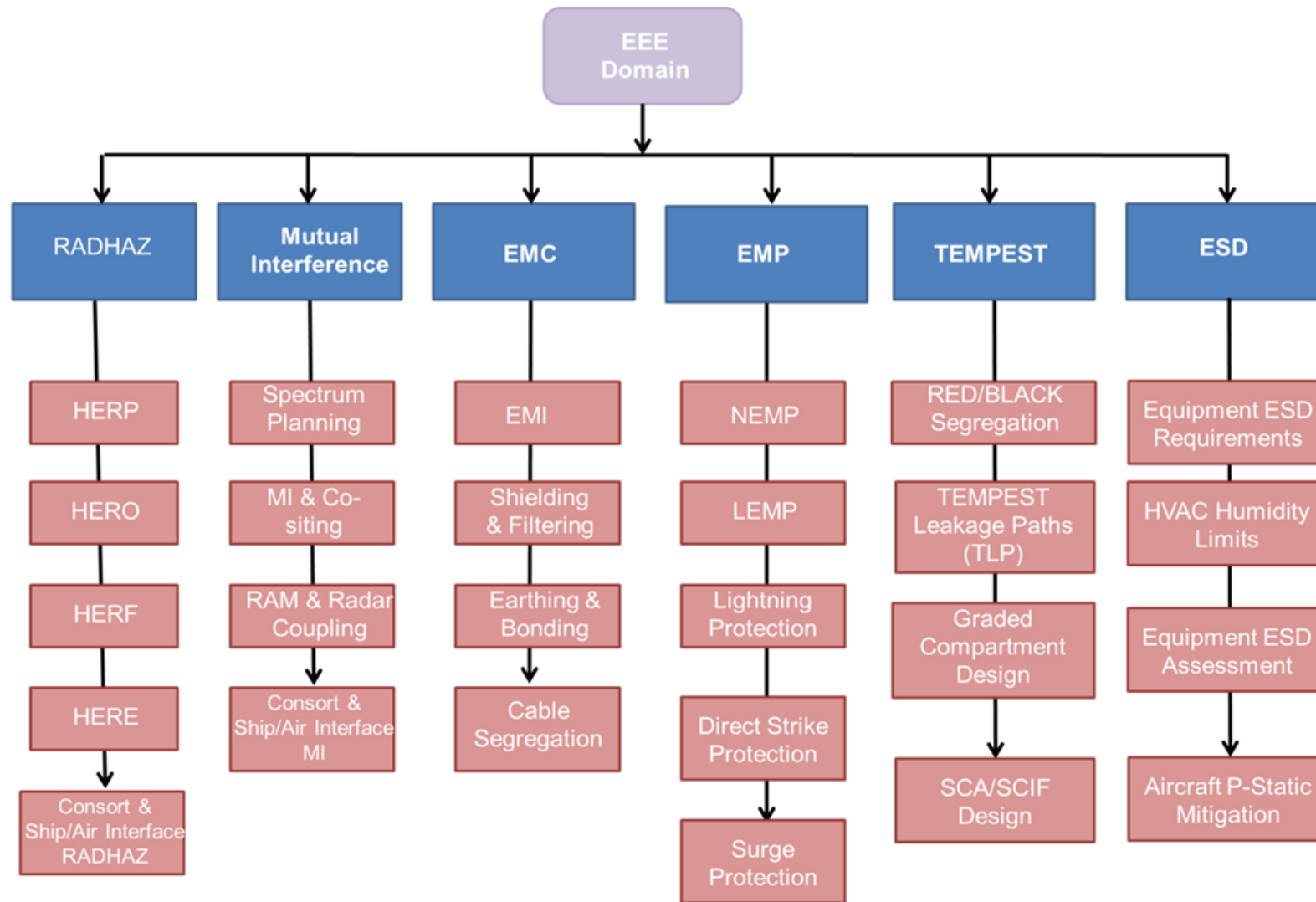
Daniel Nock  
MEng(Hons) EngTech  
TMIET



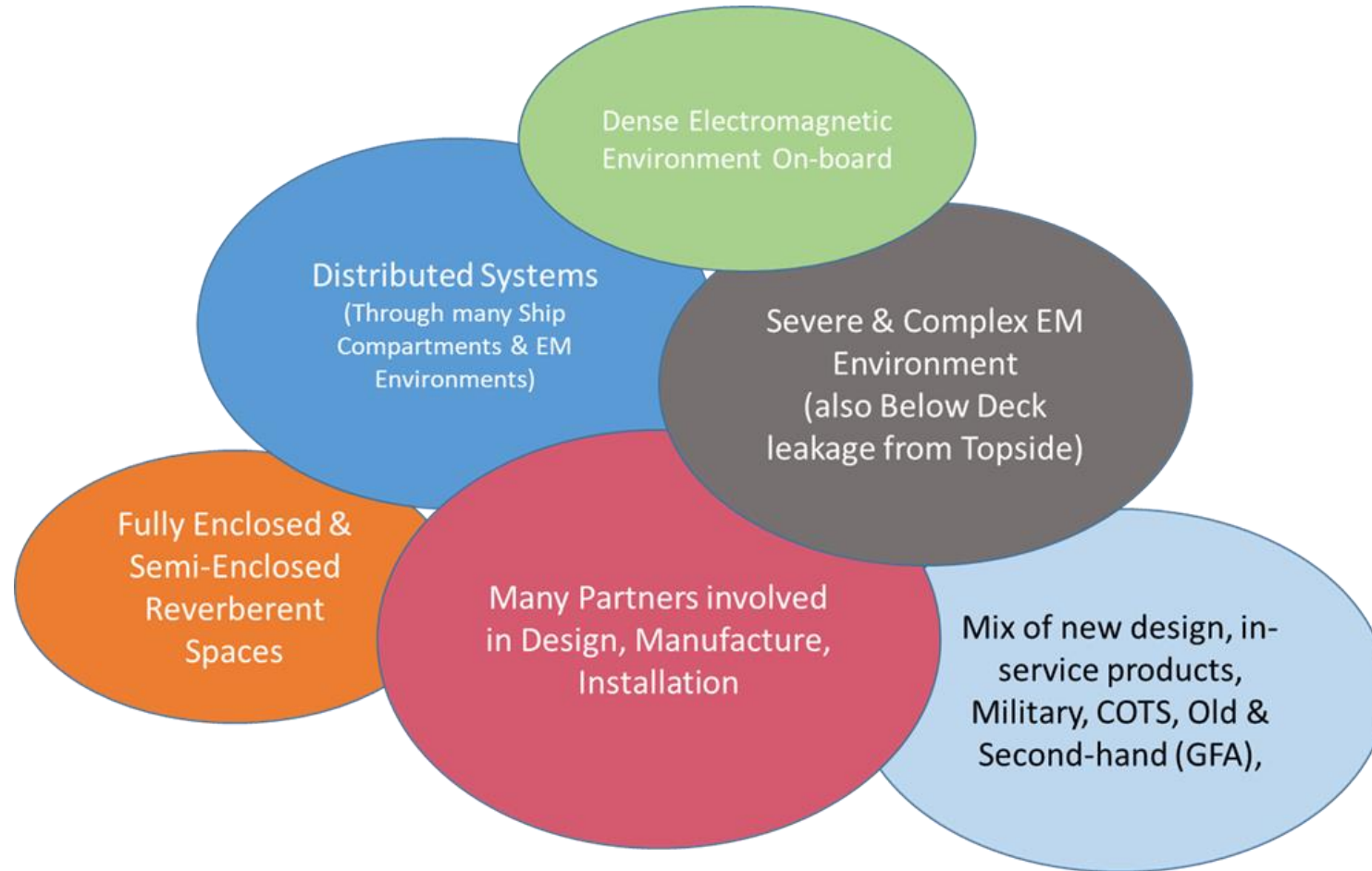
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The EEE Team have Ship Wide Responsibility for EMC, RADHAZ, Mutual Interference, ESD, EMP, Lightning & TEMPEST on BAE Systems Naval Ships platforms & facilities, in Design, Build and Acceptance events.

# EMC within EEE Domain on a Naval Platform

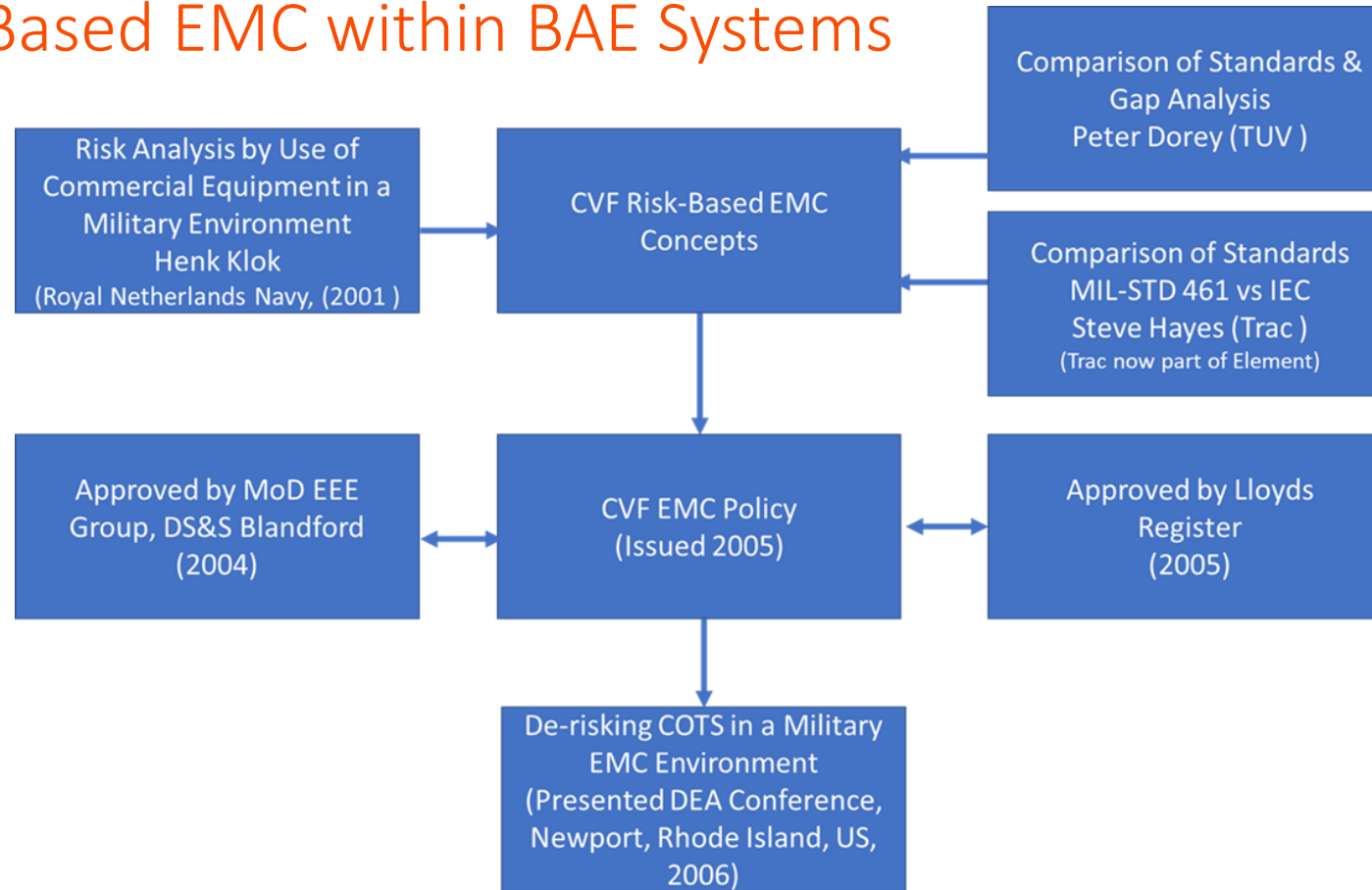


# Complexity of Management of Risk-Based EMC on a Naval Platform



Many aspects to be controlled and managed not normally associated with commercial system.

# Origin of Risk-Based EMC within BAE Systems



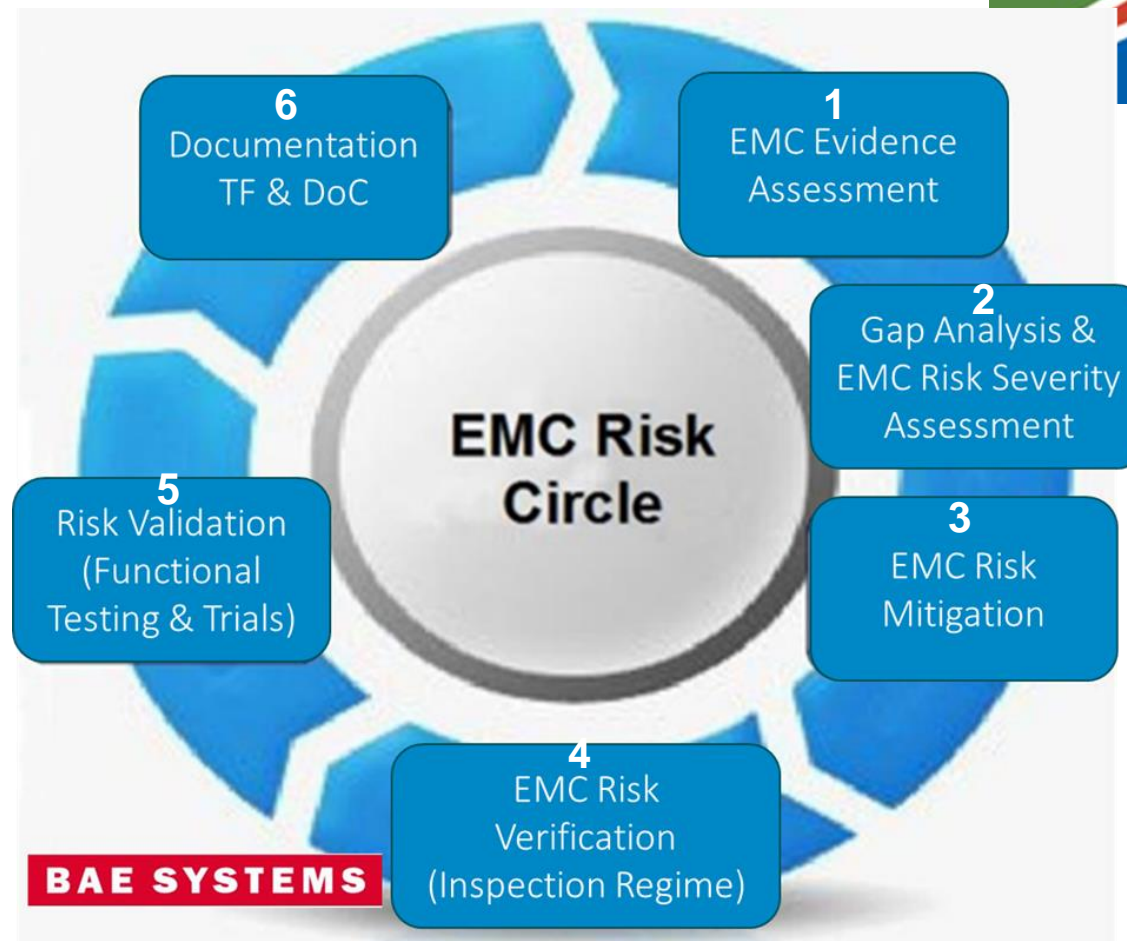
Approach started on CVF Project, in 2004, before it was 'mainstream' and 'approved' in DEF-STAN 59-411 and Lloyds Naval Rules [2]

HMS Queen Elizabeth First Warship to go through this process – Successful TEMPEST & EWEMIT Trials

[2] Lloyds Register, "Rules and regulations for the classification of Naval ships," 2017.

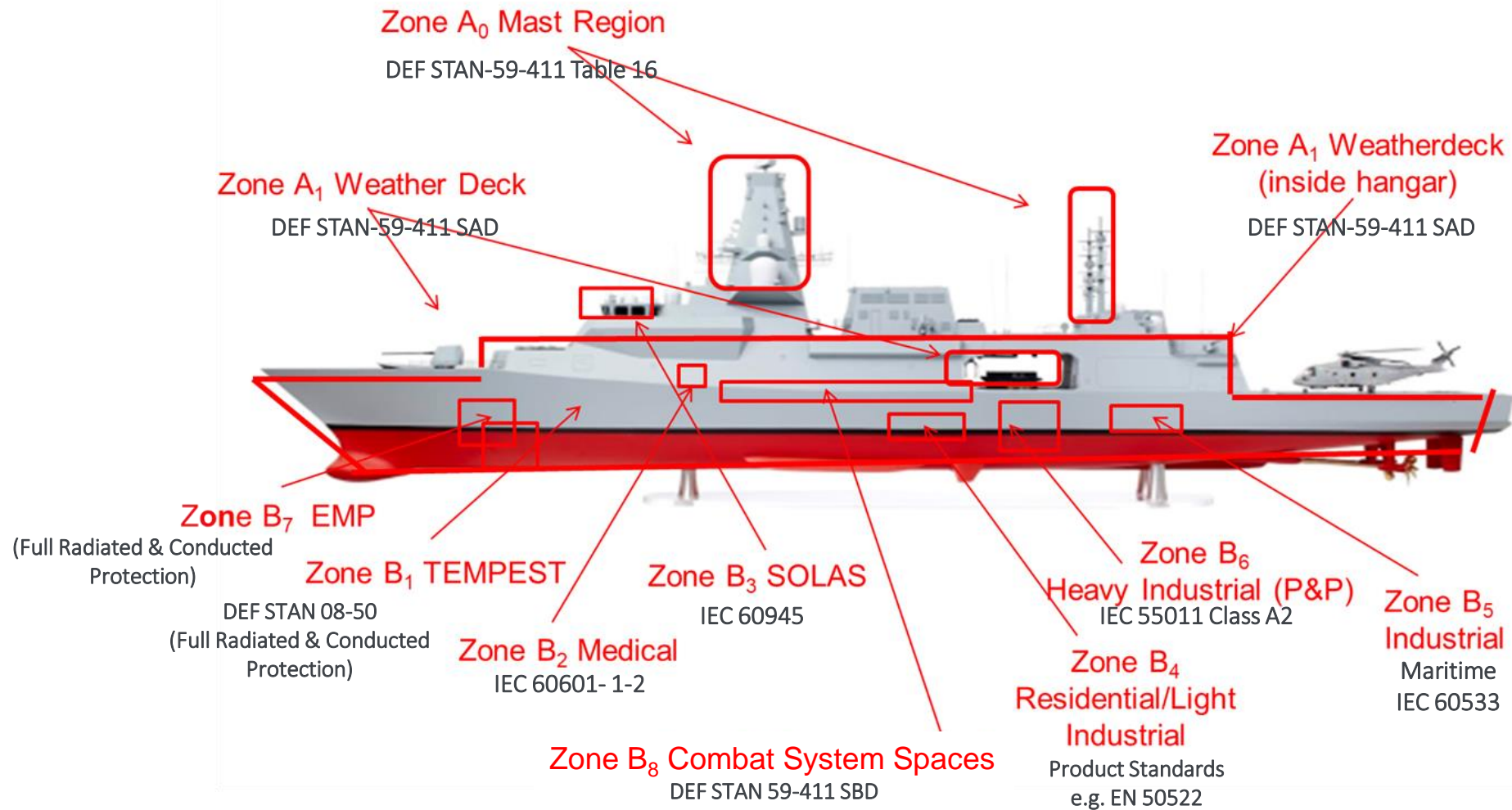
# EMC Risk Assessment – High Level Process

- EMC Evidence Assessment
  - Is EMC evidence Available, Reliable & Current?
  - Weak Evidence then no Gap Analysis go straight to mitigation
- Gap Analysis & EMC Risk Severity Assessment
  - Parameter-by-parameter assessment
  - Summary determines Mitigation
- EMC Risk Mitigation
  - EMC Protection Measures
  - Additional Testing
- EMC Risk Verification
  - Inspection Regime – Equipment & Compartments.
  - Compartments inspected multiple times as required.
- EMC Risk Validation
  - STW, Functional Testing & Trials
- Documentation , Technical File & DoC



Gap Analysis is only one stage in the Process

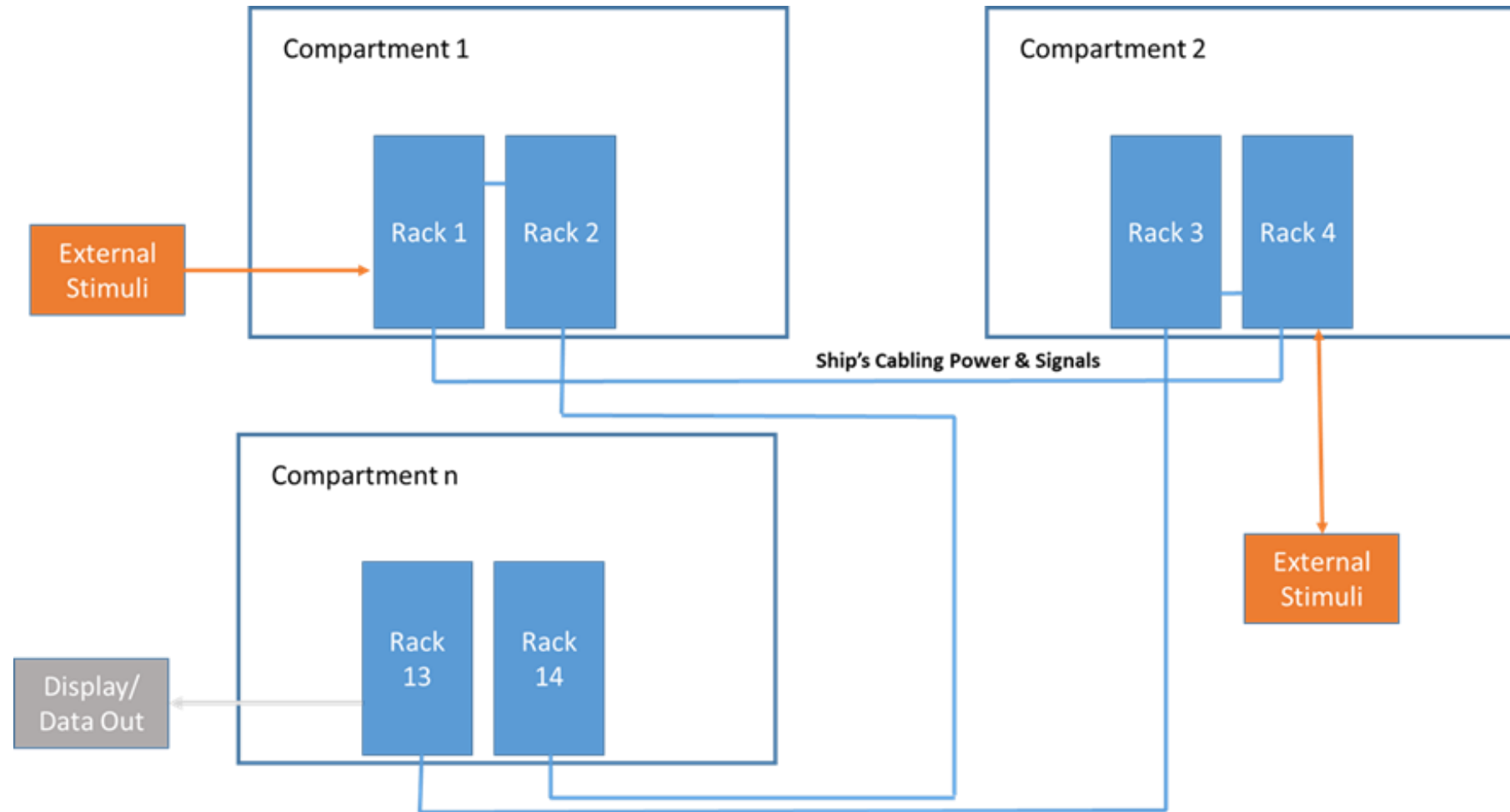
# EM Zoning of Ship Defines Areas of Different EM Environments



**NB: EM Zone Location for Zone Type Diagrammatic Purposes only**



# Complex Distributed System – Through Several EM Environments



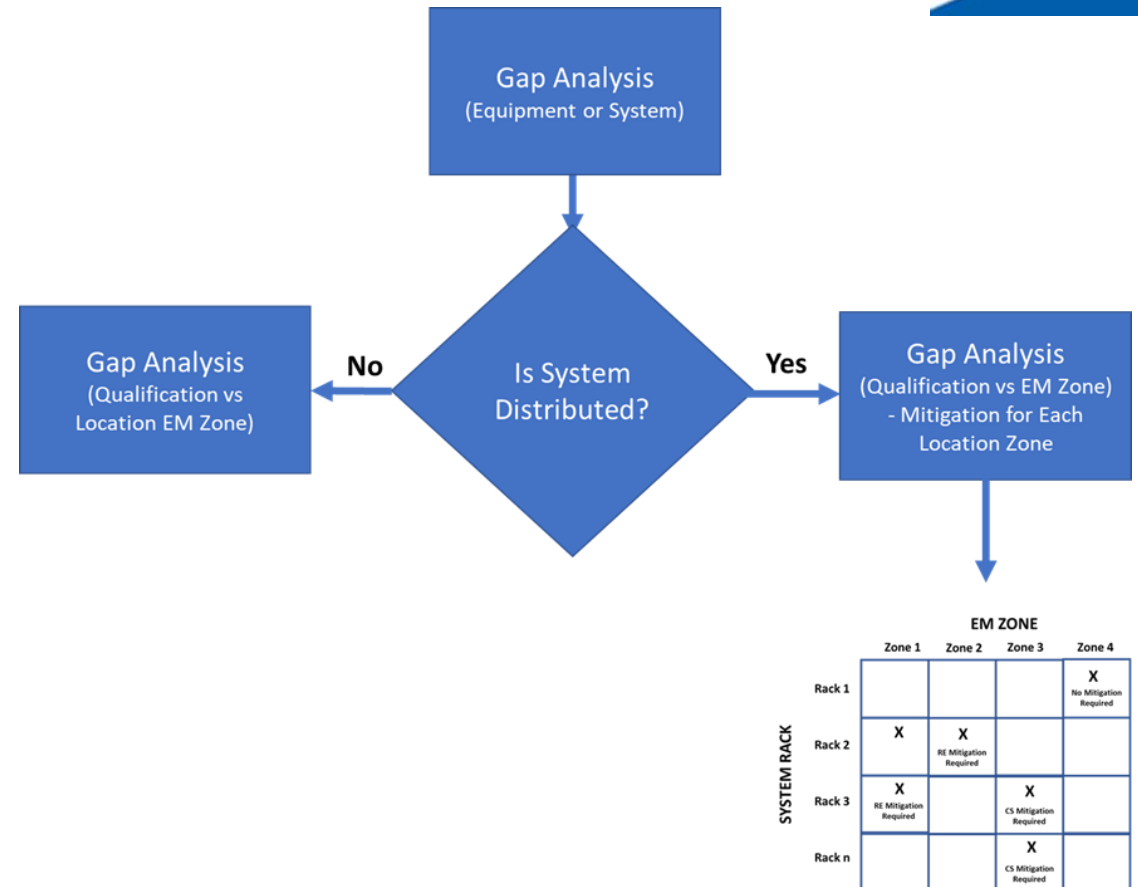
Many Racks Distributed through Several EM Environments

# Gap Analysis for a Distributed System

## Distributed System RACK/ZONE Mitigation Matrix

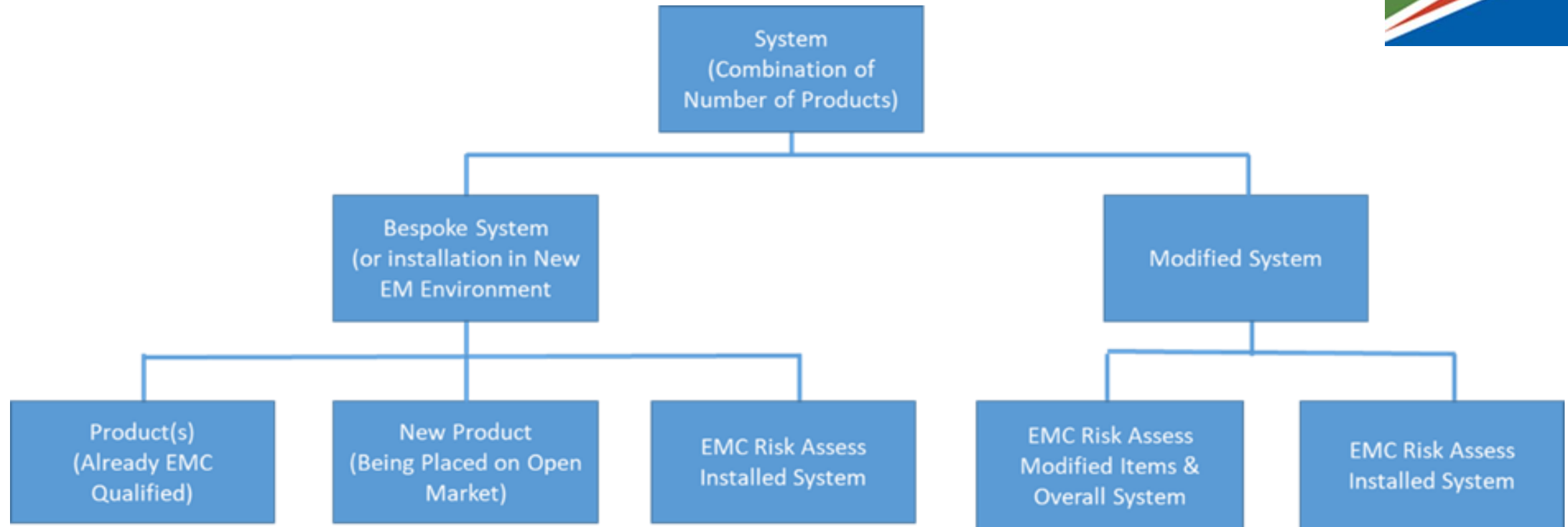
		EM ZONE			
		Zone 1	Zone 2	Zone 3	Zone 4
SYSTEM RACK	Rack 1				X No Mitigation Required
	Rack 2	X No Mitigation Required	X RE Mitigation Required		
	Rack 3	X RE Mitigation Required		X CS Mitigation Required	
	Rack n			X CS Mitigation Required	

Two Approaches: 1. Worst Case Mitigation for each Rack Type  
2. Mitigation Appropriate to EM Zone



Determine which racks are in which EM Environment, and resulting mitigation

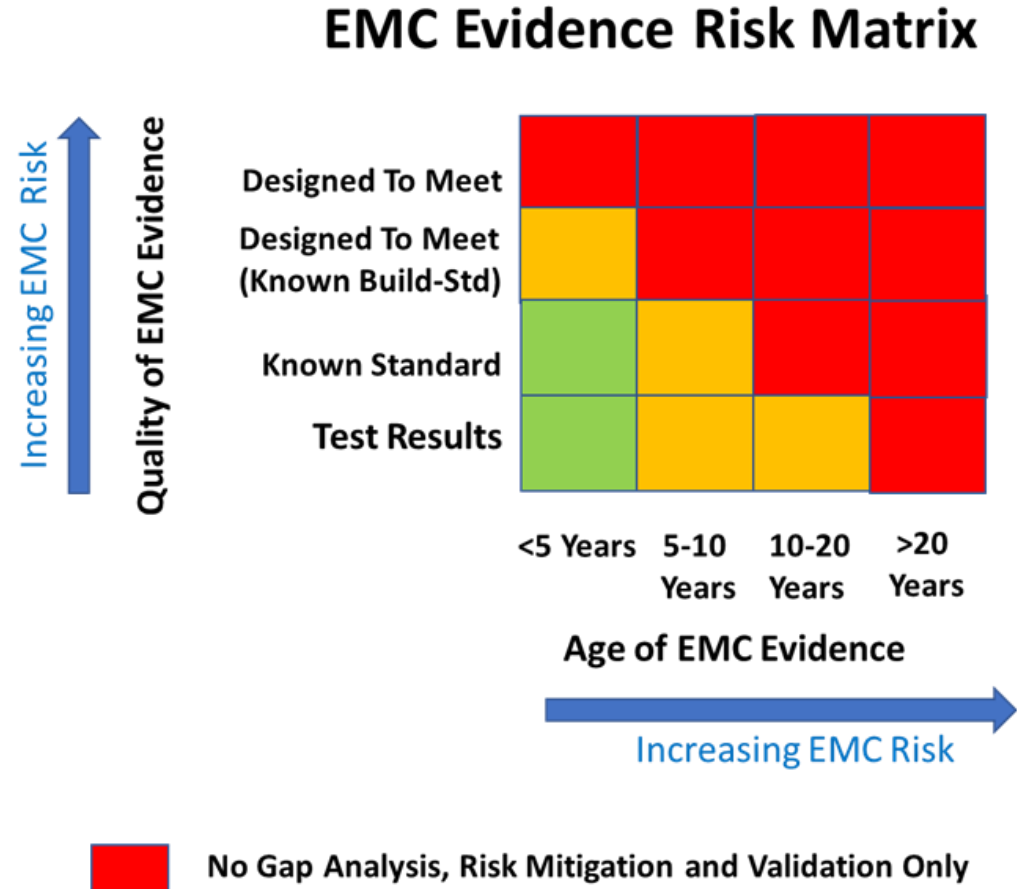
# Product, Bespoke and Modified System EMC Assessments



UKCA markings must only be placed on equipment by manufacturer - or their authorised representative

# Assessing Quality of Available EMC Evidence

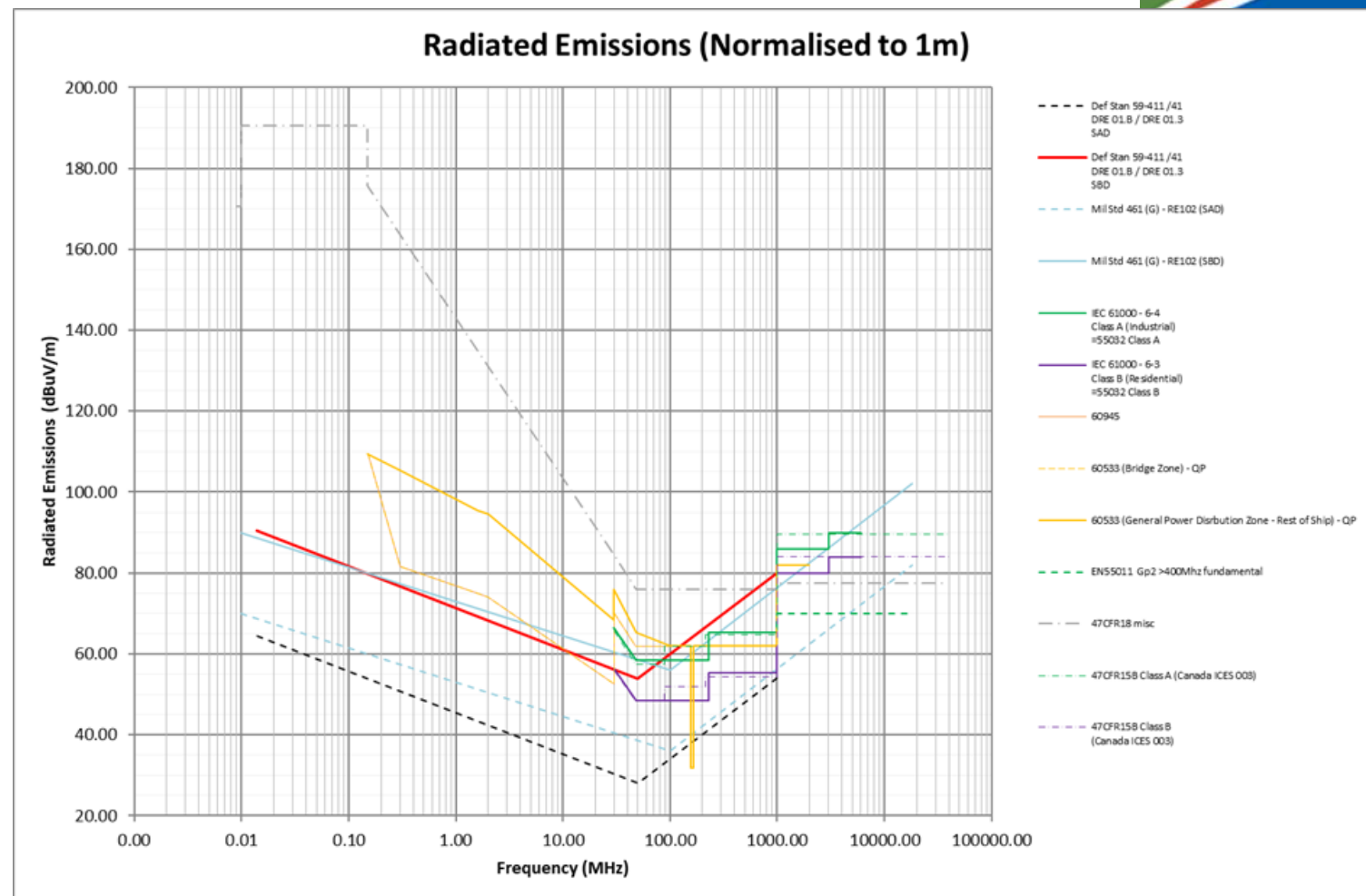
- Detailed review of all EMC evidence is required.
- Outcome of this review will determine way forward.
- Refurbishment for EMC protection measures may be required.



Not all our equipment is new, not all is tested, some has no EMC evidence at all!

# Normalisation of Standards

- Normalisation of Standards Essential for Comparison
- Based on Process Developed by Peter Dorey of TUV.



# Radiated Emissions Gap Risk Comparison Table

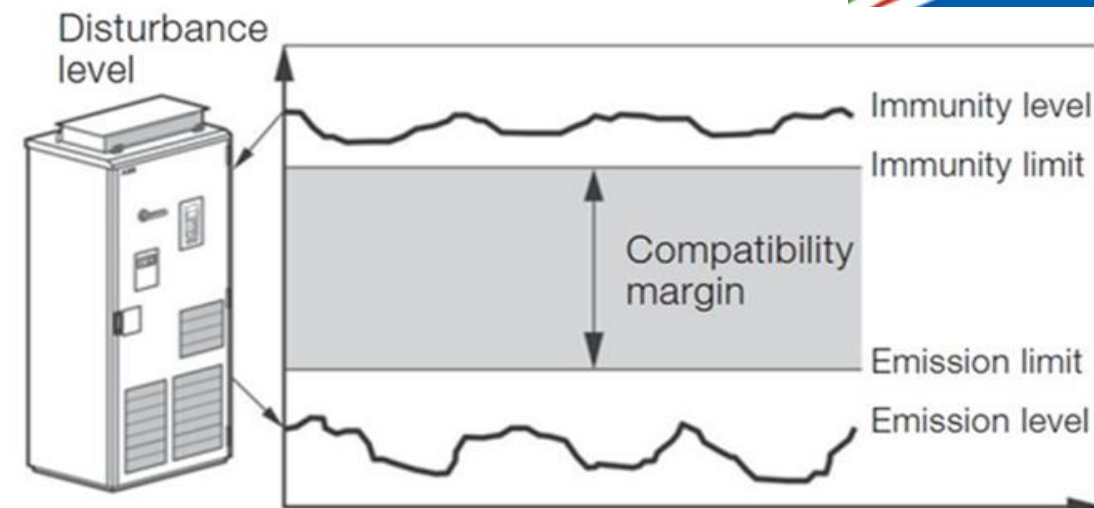
Radiated Emission Risk Comparison

Wanted		Offered																	
		Def Stan 59-411/41 - All Ships DRE 02.B/02.3	Mil Std 461 (G) - RE101 (All)	EN55011 2011 Class A Group 2	EN55011 2011 Class B Group 2	EN55011 2007/2009 Class A & B Group 1	Def Stan 59-411/41 SAD - DRE 01.B/01.3	Def Stan 59-411/41 SBD - DRE 01.B/01.3	Mil Std 461 (G) - RE102 (SAD)	Mil Std 461 (G) - RE102 (SBD)	IEC 61000 - 6-4 Class A (Industrial)	IEC 61000 - 6-3 Class B (Residential)	47CFR15B Class B	47CFR15B Class A	47CFR18Misc	60945	60533 - Bridge Zone	60533 - Rest of Ship	
Magnetic (dBpT)	Def Stan 59-411/41 - All Ships DRE	Green	Red	Red	Red	Red	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Mil Std 461 (G) - RE101 (All)	Red	Green	Red	Red	Red	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	EN55011 2011 Class A Group 2	Yellow	Yellow	Green	Green	Green	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	EN55011 2011 Class B Group 2	Yellow	Yellow	Red	Green	Green	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	EN55011 2007/2009 Class A & B Group 1	Yellow	Yellow	Red	Yellow	Green	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Electric (dBuV/m)	Def Stan 59-411/41 SAD - DRE 01.B/01.3	N/A	N/A	N/A	N/A	N/A	Green	Red	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
	Def Stan 59-411/41 SBD - DRE 01.B/01.3	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Green	Yellow	Red	Red	Red	Red	Red	Red	Red	Red
	Mil Std 461 (G) - RE102 (SAD)	N/A	N/A	N/A	N/A	N/A	Yellow	Red	Green	Red	Red	Red	Red	Red	Red	Red	Green	Yellow	Red
	Mil Std 461 (G) - RE102 (SBD)	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Green	Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red
	IEC 61000 - 6-4 Class A (Industrial)	N/A	N/A	N/A	N/A	N/A	Green	Yellow	Green	Green	Green	Yellow	Red	Red	Red	Red	Red	Red	Red
	IEC 61000 - 6-3 Class B (Residential)	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Green	Red	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow
	47CFR15B Class B	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Green	Red	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	47CFR15B Class A	N/A	N/A	N/A	N/A	N/A	Green	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	47CFR18Misc	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Green	Yellow	Green	Green	Yellow	Green	Green	Green	Green	Green
	60945 (SOLAS)	N/A	N/A	N/A	N/A	N/A	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Red	Red	Green	Green	Red
	60533 - Bridge Zone	N/A	N/A	N/A	N/A	N/A	Yellow	Red	Yellow	Red	Yellow	Yellow	Yellow	Red	Red	Red	Green	Green	Red
	60533 - Rest of Ship	N/A	N/A	N/A	N/A	N/A	Green	Red	Green	Red	Yellow	Yellow	Yellow	Red	Red	Red	Green	Green	Green

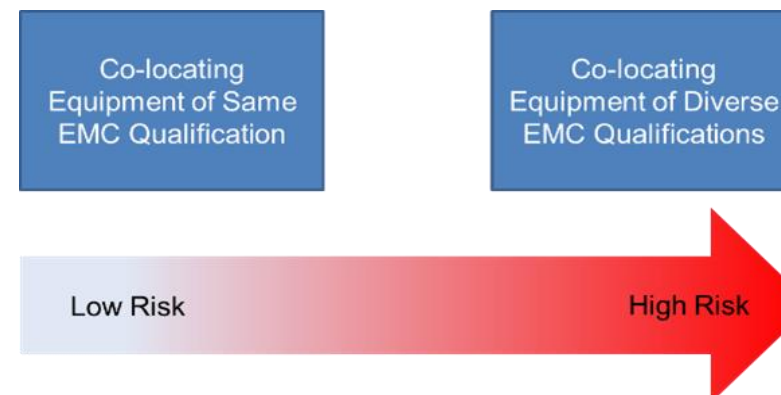
■ Cat 1 - Acceptable  
■ Cat 2 - Mitigation or Risk Capture  
■ Cat 3 - Mitigation Required

# Mitigating the EMC Risk

- Matching Standards to EM Environment
- Matching Emission and Immunity Standards
- Installation
- EMC Protection Measures (Filtering, Grounding & Shielding)
- Installation Techniques
- Re-packaging
- Additional Screening and / or Filtering
- Additional Qualification / Testing
- Physical Separation
- Compartment Interference Matrices (separating noisy from susceptible equipment).

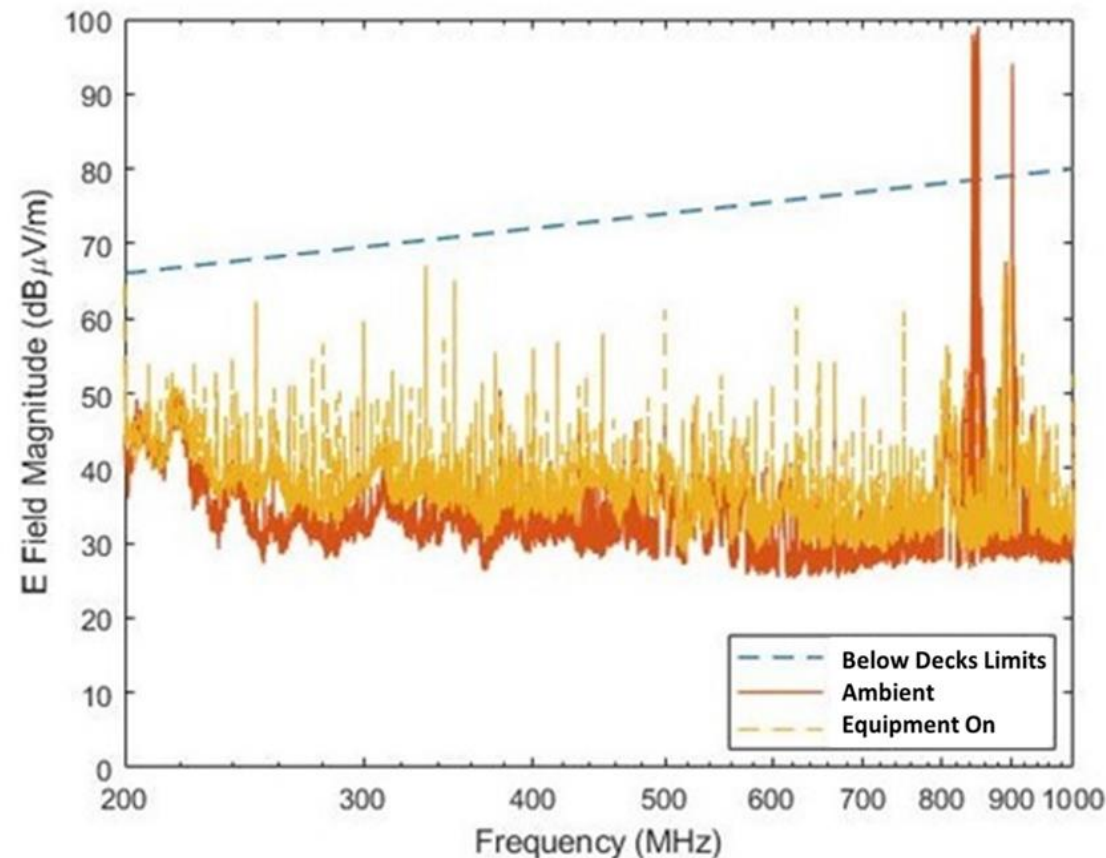


EMC Mitigation by Preserving the EMC Margin



## Below Decks Zones – Defined by Dominant EMC Standard

- In Combat Systems compartments this is DEF STAN 59-411, in Bridge this is SOLAS.
- EM environment is multi-frequency that cannot be replicated by EMC testing.
- EMC Standards (apart from medical devices standard -IEC 60601-1-2 Edition 4 ) do not allow for radio transmissions.
- Deliberate Transmission such as Bluetooth, WiFi & GSM can exceed SBD RE limits.
- So Risk-Based EMC is essential.

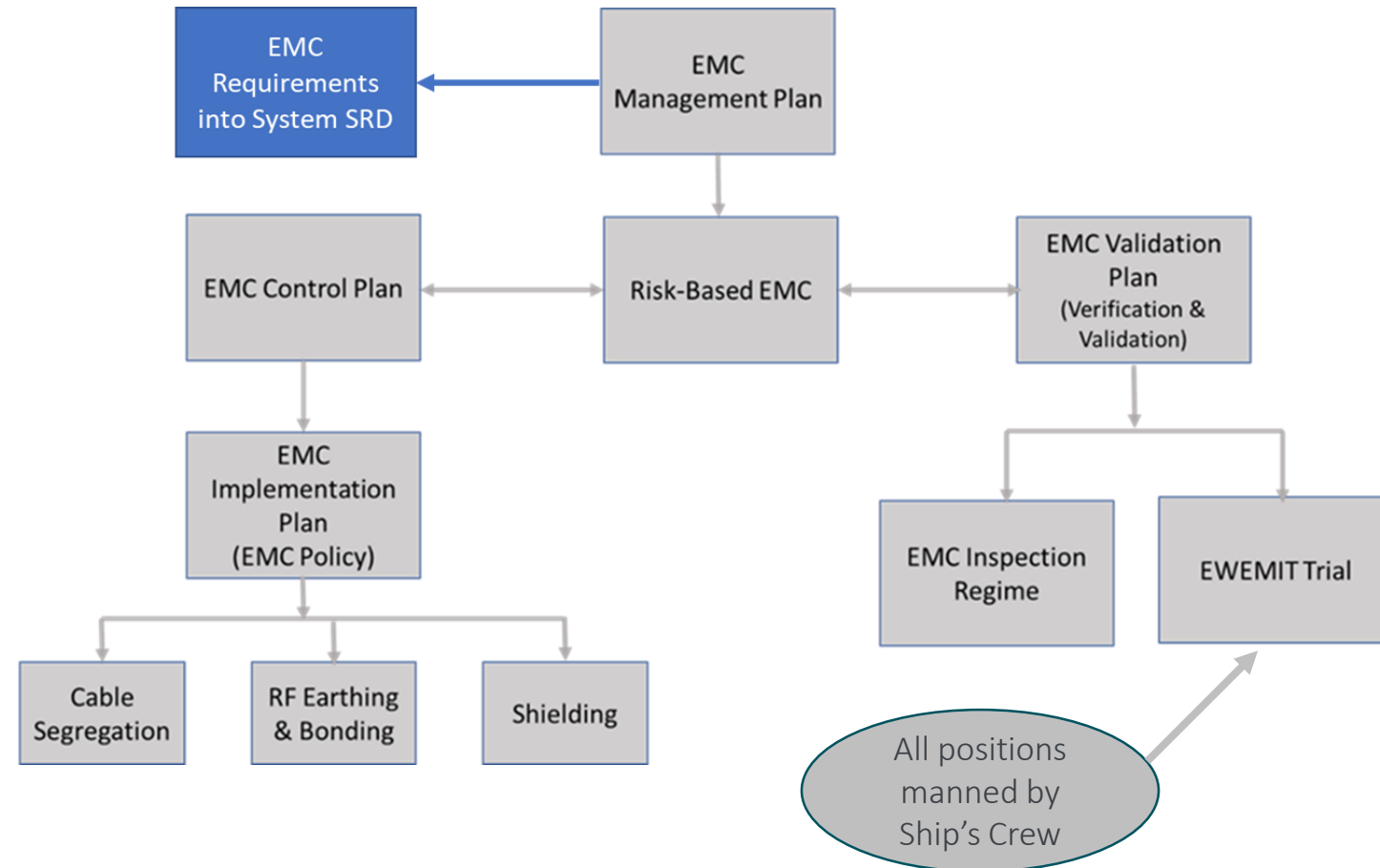


Not always representative: cumulative resonances, deliberate transmissions: Bluetooth, WiFi & GSM

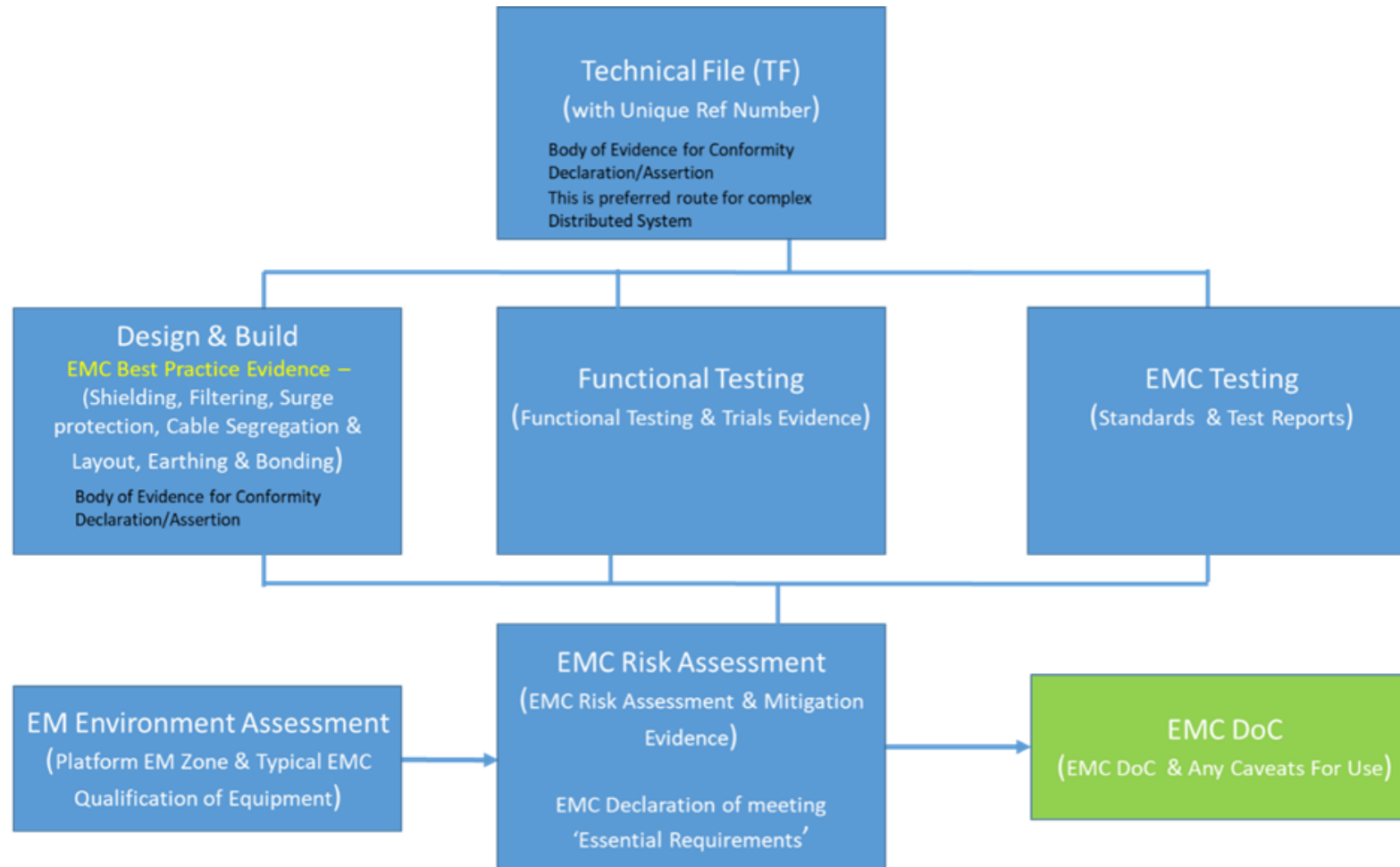


# Risk Based EMC – Complex Platform EMC Design Rules Validated & System Installation by Functional Testing & EWEMIT Trial

- Overall Platform EMC control is achieved via the EMC Management Plan
- EMC Control Plan is all about controlling identified EMC risks and defining measures to minimise EMC risks.
- EMC Policy states “what needs to be done to prevent interference”, but also states in detail “how this should be done”.
- EMC Validation and Verification Plan consists of two parts:
  - Verification part, performed during construction phase (EMC Inspection Regime)
  - Validation part, performed during Setting-To-Work (STW), Harbour Acceptance Trials (HAT) and Sea Acceptance Trials (SAT), including Enhanced Weapons Electromagnetic Mutual Interference Trial (EWEMIT).



# Risk-Based EMC Documentation, Verification and Validation



# Summary

Thank You – Any questions?