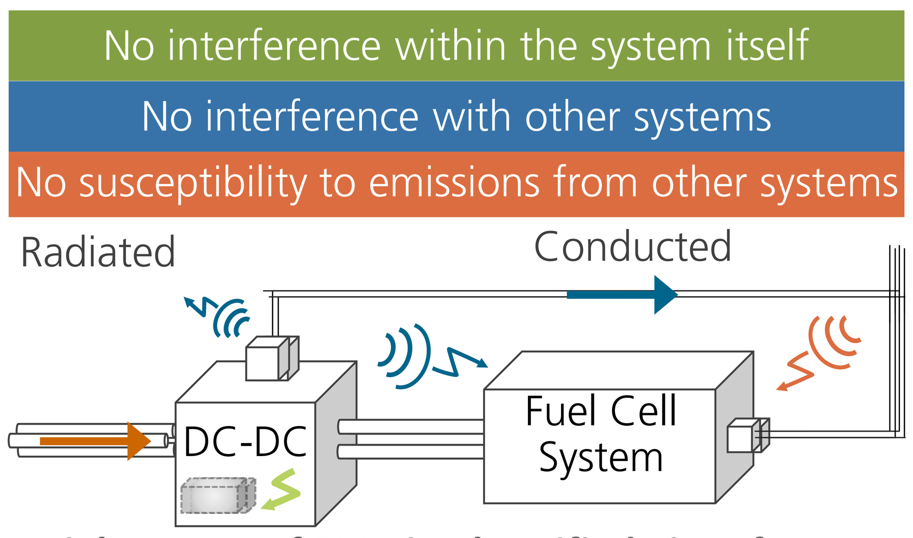
#ArchitectingAviation

INTERFACE ANALYSIS OF ELECTRIC DRIVETRAIN SYSTEMS : ELECTROMAGNETIC INTERFERENCES AND CERTIFICATION

Consideration of EMI in preliminary design phase of electric aircraft & evaluation of novel propulsion systems towards safety and certification

Electromagnetic Interference in Electrified Propulsion

An electromagnetic compatibility (EMC) analysis is carried out to identify the primary sources and sinks of electromagnetic interference (EMI) in preliminary design of the electric propulsion system.

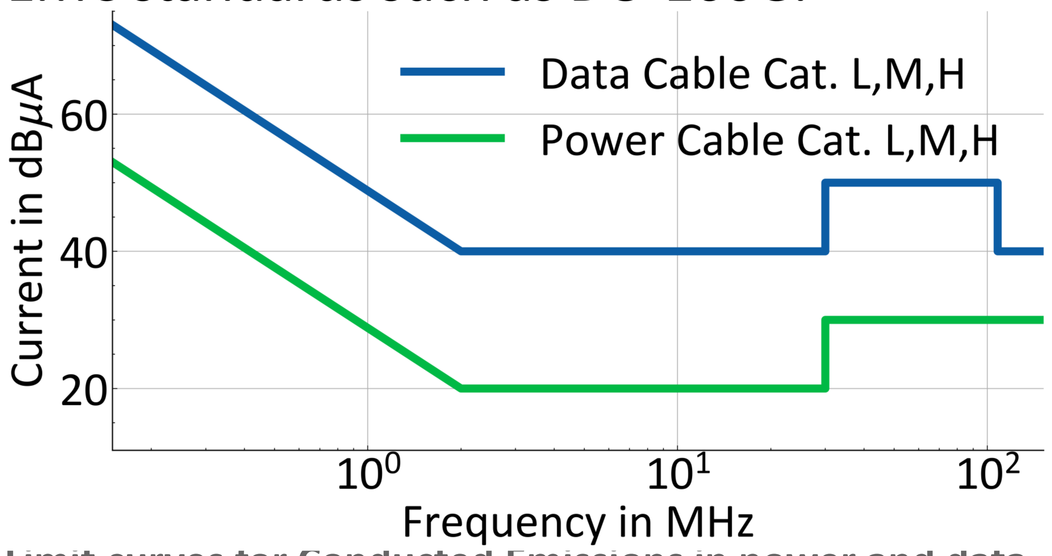


Essential aspects of EMC in electrified aircraft

EMI ANALYSIS STRUCTURE

- Component level analysis
- Propulsion system level analysis
- Aircraft level analysis

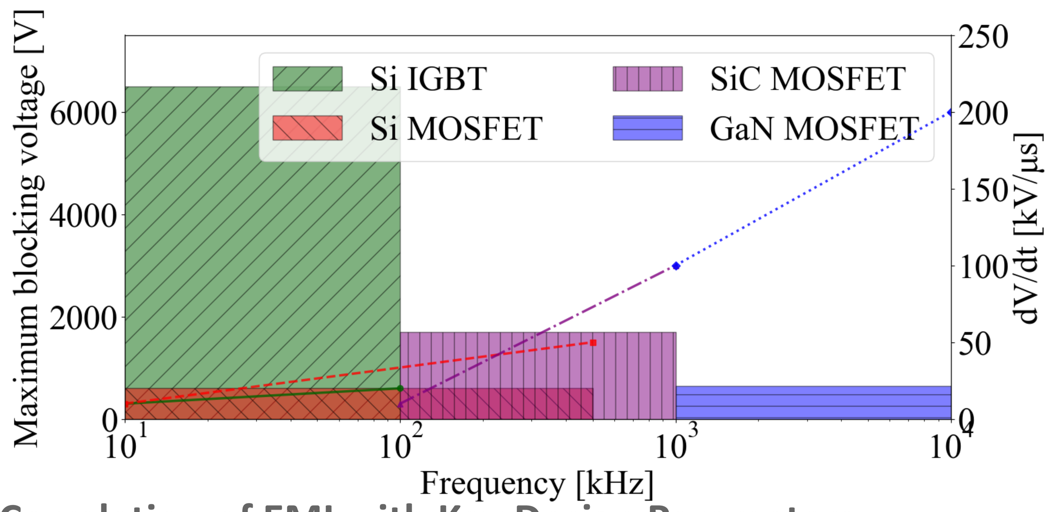
The analysis covers three system levels. The emissions and susceptibility of power converters are being evaluated at the component level based on its key design parameters. At the propulsion system level, interferences among propulsion system components are being assessed, with an emphasis on suitable mitigation strategies. At the aircraft level, the emission and susceptibility of the propulsion system components to avionics, peripheral systems, and external sources are being studied to ensure compliance with aviation EMC standards such as DO-160G.



Limit curves for Conducted Emissions in power and data cable according to ED-14G Sec. 21

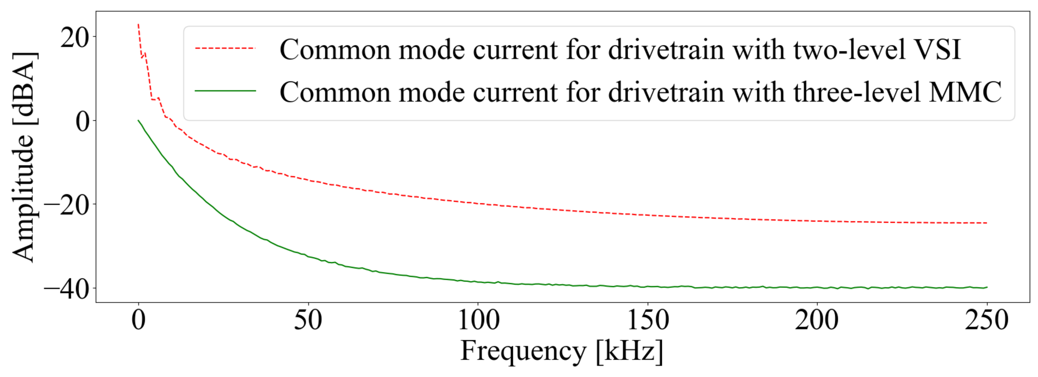
EMI IDENTIFICATION APPROACH

1. Propulsion system architecture evaluation
2. EMI correlation with key design parameters and trade-offs
3. Component selection and EMI impact assessment
4. Component placement and system integration



Correlation of EMI with Key Design Parameters

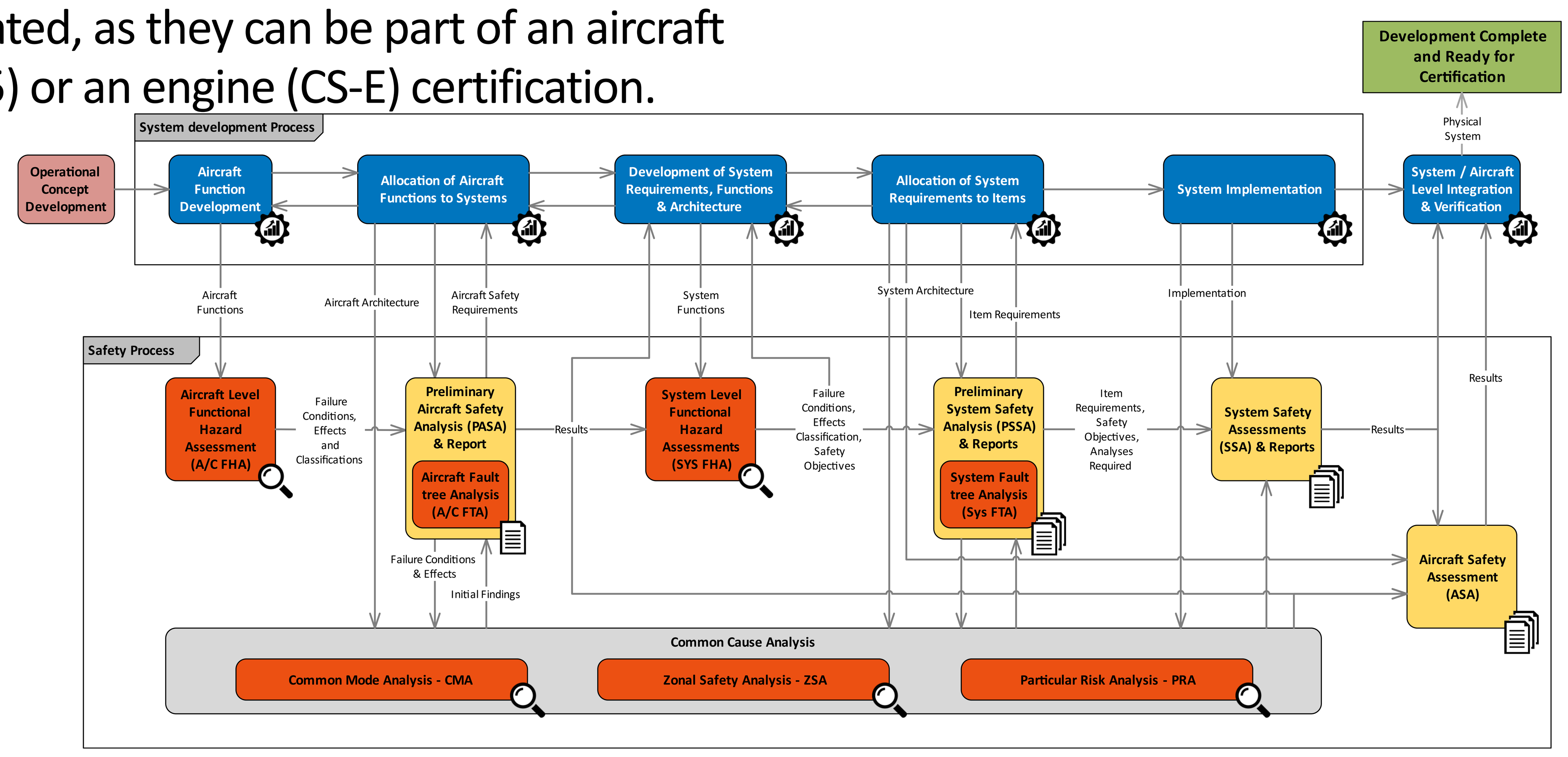
The correlation of EMI with key design parameters is shown in the figure above. A comparison of four types of semiconductor devices has been carried out based on blocking voltages and the rate of change of voltage dV/dt — highlighting the trade-offs between switching losses and EMI due to high frequency. The comparison of common-mode (CM) current by two different inverter topologies for the motor drive system is show in the figure below. Using the three-level modular multilevel converter (MMC) instead of a two-level voltage source inverter (VSI) the CM current can be reduced.



CM current (in dBA) in frequency spectrum

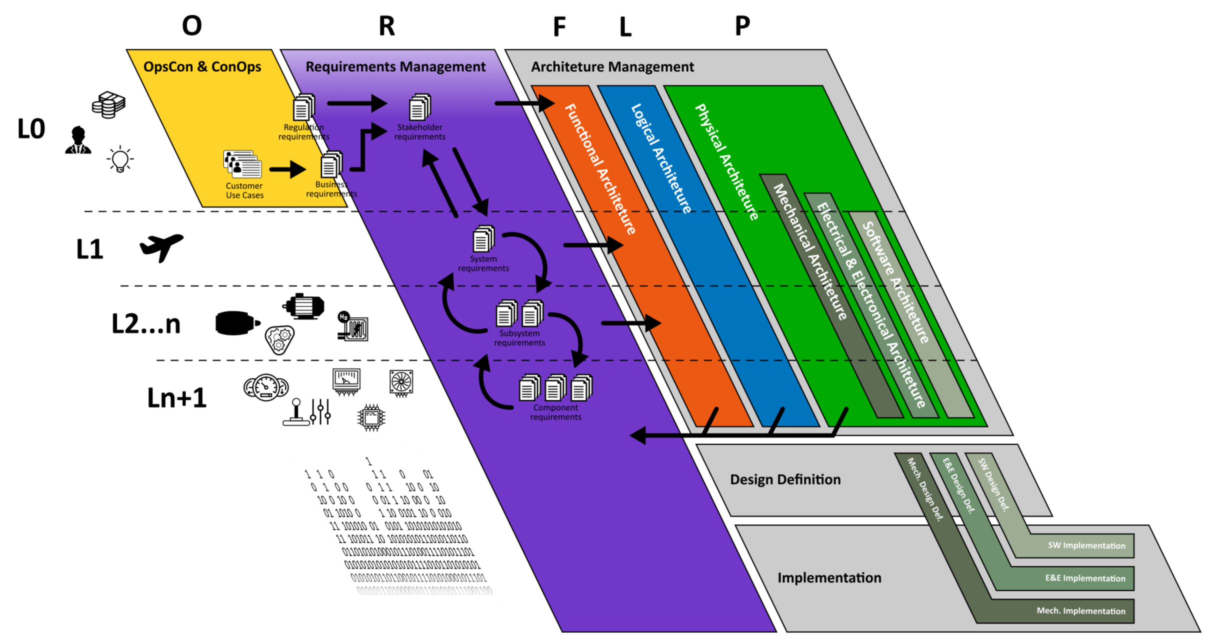
System Safety and Certification

Novel electric propulsion systems cause different behavior on safety and reliability than conventional turbine engines. This behavior characteristics have to be analyzed and specified. In addition, the certifiability of the new electrified drivetrain must be assessed. Therefore, the way of certification of the several subsystems and components has to be evaluated, as they can be part of an aircraft (CS-25) or an engine (CS-E) certification.



Regulatory Framework for System Safety and development Process acc. ARP 4754 and 4761

Based on initial requirements and aircraft functions a hazard analysis as well as a risk assessment must be performed. The safety methods according ARP 4754 and 4761 will be used in the overall context. The effect of Failure conditions combined with the corresponding failure rate enable a quantitative risk categorization.



MBSE Viewpoints and V-Modell

Logical dependencies between Components and subsystems will be assessed from a safety point of view in a top down analysis. For safety analysis methods a model based approach combining all, the requirements, the functional and the logical viewpoint into one safety model will be developed .

Certification analysation

On the way to a permit-to-fly or a future type certificate, it is necessary to

- perform detailed safety analyses,
- prepare extensive risk assessments,
- deduce suitable safety requirements

and extend the existing certification specifications with regard to electrified drivetrain technologies in aviation.

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