axe technologique

HIGH RELIABILITY ENERGY
Center of Competence

Centre Français Fiabilité

Bridging Emerging Technologies to Harsh Environment Operation !

SAINT EXUPÉRY

ElectroMagnetic Compatibility (EMC)
for Emerging Technology in Harsh Environment

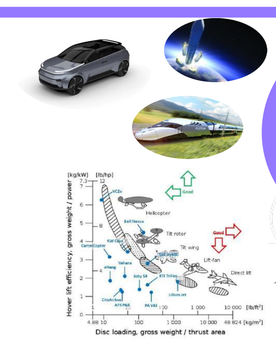
GENERAL CONTEXT

Increasing deployment of Emerging Technologies :
- Electrical engine (Vtol, Aircraft, car)
- Wireless communication & detection (5G / wifi6 / ILS / radar)
- Very High Power management (>MW , Breakthrough technology e.g. Wideband Gap)

New constraints :
- Increasing Power/voltage/current → trade of : Weight/Volume, Fiability
- Electrical function densification (Flying Taxi, VTOL)
- Coexisting of critical functions (5G/ILS, WIFI on Aircraft, sensor/radar…)
- Environment hardening (T,RH, Rad...)

Specifics EMC issues :
- Obsolescence management (Fukushima, Si crisis (COVID)) → second sourcing, re-qualification without test
- Cost VS reliability trade-off → Design optimisation (virtual prototyping)
- Multiple large scale and complex problem (large scale geometries, wide frequency band and strongly coupled)
- Lack of information → uncertainty management

- **Investigation** tools development (experimental, software)
- Virtual **prototyping** approach
- **Co-simulation** environment (multi-approaches : 1D, 3D, 3D)
- **Capitalization** (Knowledge, database of model)



ECO-SYSTEM

Industrials partners / end users

vitesco TECHNOLOGIES · ACTIA · AIRBUS CRT · AIRBUS DEFENCE & SPACE · LIEBHERR Aerospace · Continental The Future in Motion · ThalesAlenia Space a Thales / Leonardo company · NEXIO · SAFRAN AEROSPACE-DEFENCE-SECURITY · AIRBUS

EMC Characterisation · EMC phenomena analysis · Modelling approaches · Investigation Tools (calibration, automation) · EMC · SAINT EXUPÉRY · Simulation tools · Evolution of qualification standard tests

Analysis · Testing

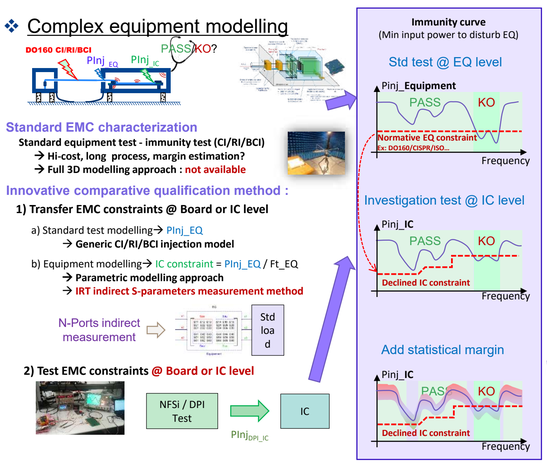
Laboratory/ intuitional partners

LAAS CNRS · INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE · SATIE · ceatech · IETR · Laplace · DGA · technische universität dortmund · ims BORDEAUX · cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

MAIN ACHIEVEMENTS

IRT Pre-qualification / obsolescence management Approach

❖ Complex equipment modelling



Standard EMC characterization

Standard equipment test - immunity test (CI/RI/BCI)
→ Hi-cost, long process, margin estimation?
→ Full 3D modelling approach : not available

Innovative comparative qualification method :

1) Transfer EMC constraints @ Board or IC level

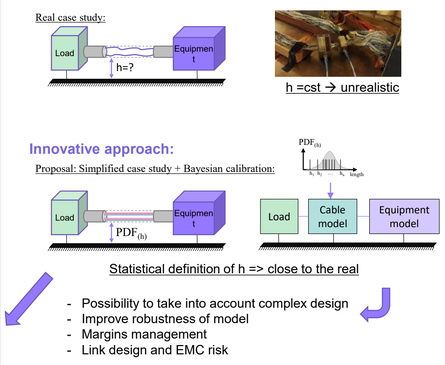
a) Standard test modelling→ $Pinj_{EQ}$
→ Generic CI/RI/BCI injection model

b) Equipment modelling→ IC constraint = $Pinj_{EQ}$ / Ft_{EQ}
→ Parametric modelling approach
→ IRT indirect S-parameters measurement method

2) Test EMC constraints @ Board or IC level

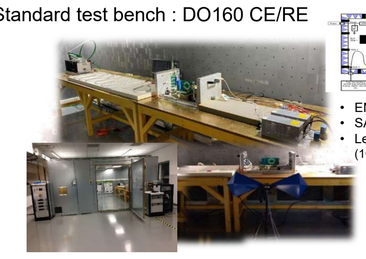
$PInj_{DPI_IC}$

❖ Statistical modeling of uncertainly



- Possibility to take into account complex design
- Improve robustness of model
- Margins management
- Link design and EMC risk

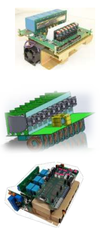
❖ Standard test bench : DO160 CE/RE



- EMI : 9k – 3GHz
- SA : 9k – 7GHz
- Lecroy HDO8108A (1GHz, 8ch, 10GS/s)

❖ Power drives demonstrators

	Chaine 15kVA SiC	
Moteur	Moteur VCS Liebherr Aerospace (15kVA)	Moteur Nidec (50kVA)
Génératrice	Génératrice Parker	Moteur Nidec (50kVA)
Onduleur	Onduleur SiC 3 phases, 1 bras par phase	Onduleur SiC , 1 bras GaN **3 bras et 3 niveau**
Câble DC	AWG 8 - EN2267-008A090P non blindé	AWG 4 - EN2267-009A220P non blindé
Câble AC	Idem DC, 3 fils torsadés, 10 mètres, non blindé	AWG 4 - EN2267-009C220P, 10 mètres, non blindé



❖ Investigation platform:

❑ NFSe / NFSi (in development)
- 9k – 7GHz / 9k – 1GHz
- Precision : 50µm
- Speed 3D measurement
- DUT
  - 400x400x350 mm
  - 50Kg
- DUT auto-location (in progress)

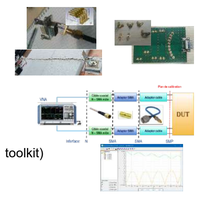
❑ Direst Power Injection (DPI):
- 9k – 1GHz
- 100W (10kHz-1GHz)

❖ Impedance measurement platform

❑ Equipments:
- VNA - R&S ZNB (100kHz – 4.5GHz)
- VNA - Keysight 8753ES (30khz-6Ghz)
- Impedance meter - E4990A (20Hz-120MHz)

❑ Passive impedance characterisation (Measurement and modelling tools)
- Passive components
- Connectors
- Cable/harness
- PCB

Modelling Tools
- Calibration & De-embedding tools (SMP/Wfl/Own toolkit)
- ICEM model extraction tools (FPGA)
- Statistical management of uncertainty (Scilab)



ROADMAP

Black box modelling (reuse) : time vs Frequency; Multi physics approaches, High power converter, Harness modelling, Radiated coupling

Hybrid modelling/simulation environment

Multi domain optimisation (multi constraints)

Statistical EMC (uncertainty propamanagement, IA algorithm)

- EMC/Mass optimization:
  - Active filtering (injector, coupling path, close loop regulation algorithm)
  - Material development (wireless charging)
- EMC/Efficiency optimization → Multilevel High power module; component/PCB embedded

- Health Monitoring

Measurement tools development
- New capture devices (SA vs EMI vs real time SA vs Scope) Time vs Freq
- Sensor development (sensibility, ultra wide band, non-intrusive…)
- Adapt standard for new systems (ex: relevancy of RSIL?)
- **Reliable**, **repeatability**, no-time consuming, Metrology management, **Margin control**, New constraints integration, Automation

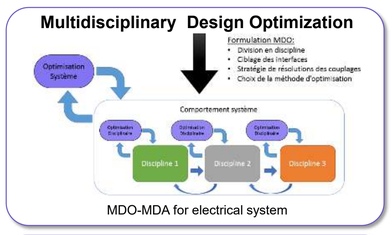
Investigation tools specification
Specific methodology for R&T : NFSe, NFSi

Standard test update
- new constraints integration
- Fiability, repeatability

Qualification protocols (Standardisation / Normalisation)

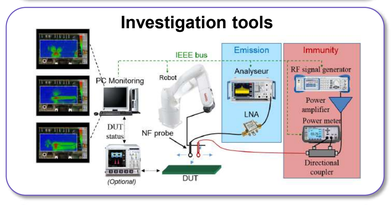
2021 · 2024 · 2027

Multidisciplinary Design Optimization

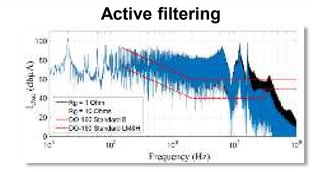


MDO-MDA for electrical system

Investigation tools



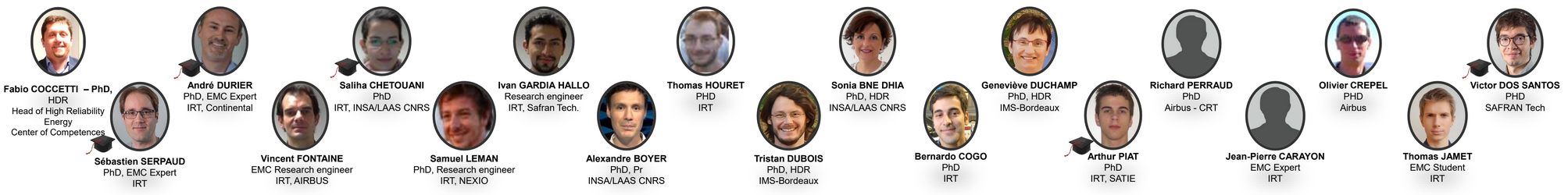
Active filtering



EMC filter design tools & modeling

IEC · afnor · ISO · DO-160

TEAM & ACKNOWLEDGEMENTs



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