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AUDACE

# The AUDACE Collaborative Project

A joint innovation program between Thales, Valeo, SMEs & Research Labs on mechatronics devices reliability

Philippe POUGNET Reliability Expert

**Version 1 – December 6th 2012**

# Agenda

1. Introduction

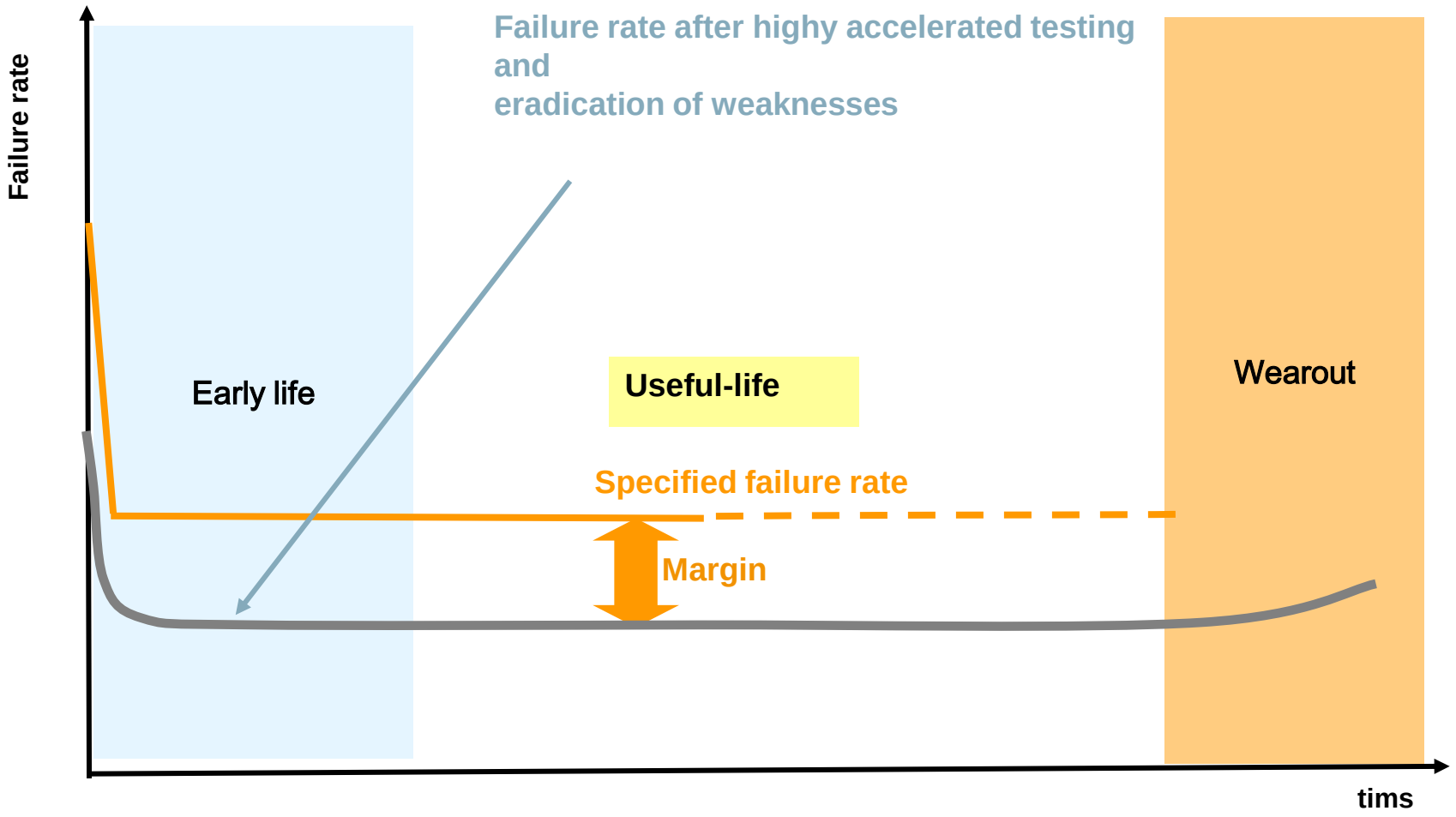
2. Project management

3 WorkPackages

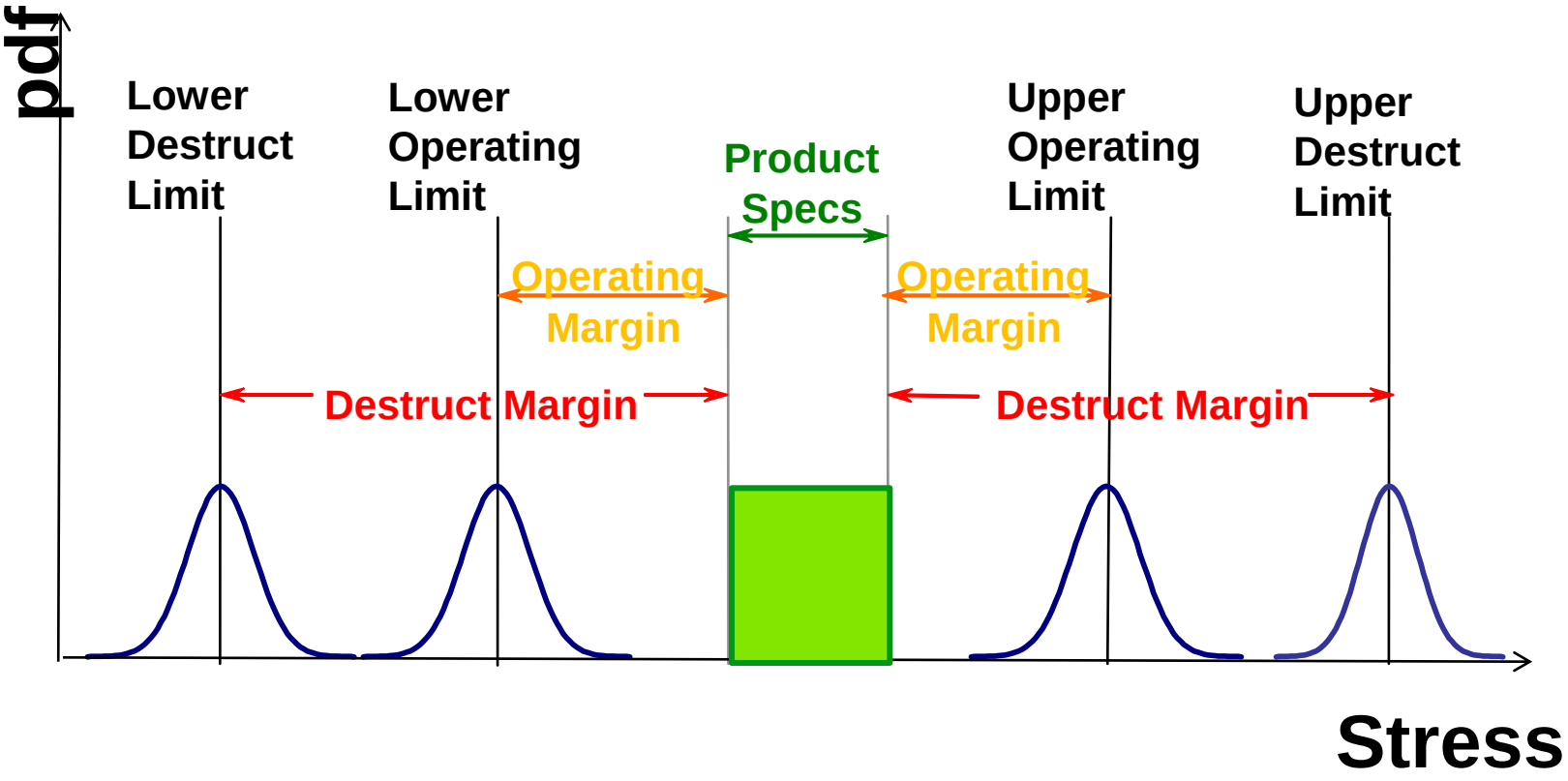
4 Conclusion

**Date + numérotation**

# Reliability targets



# Robustness Margins



# Audace

Project overview

# Project Description


## « Analyse des caUses de DéfaillAnces des Composants des systèmes mEcatroniques embarqués »

**A Mov'eo Cluster program**

**Budget : 8 790 k€**
**Public funding: 5 861k€**

**Duration : 48 mois**
**Start :…October 1st 2008……**

**Pilot : THALES, VALEO,**

**Partners : PRESTO, LIGERON, MB ELECTRONIQUE,**

**CEVAA, CETIM, UVSQ, UNIV ROUEN, INSA, ECIME, IRSEEM, ENSICAEN**

# Goals

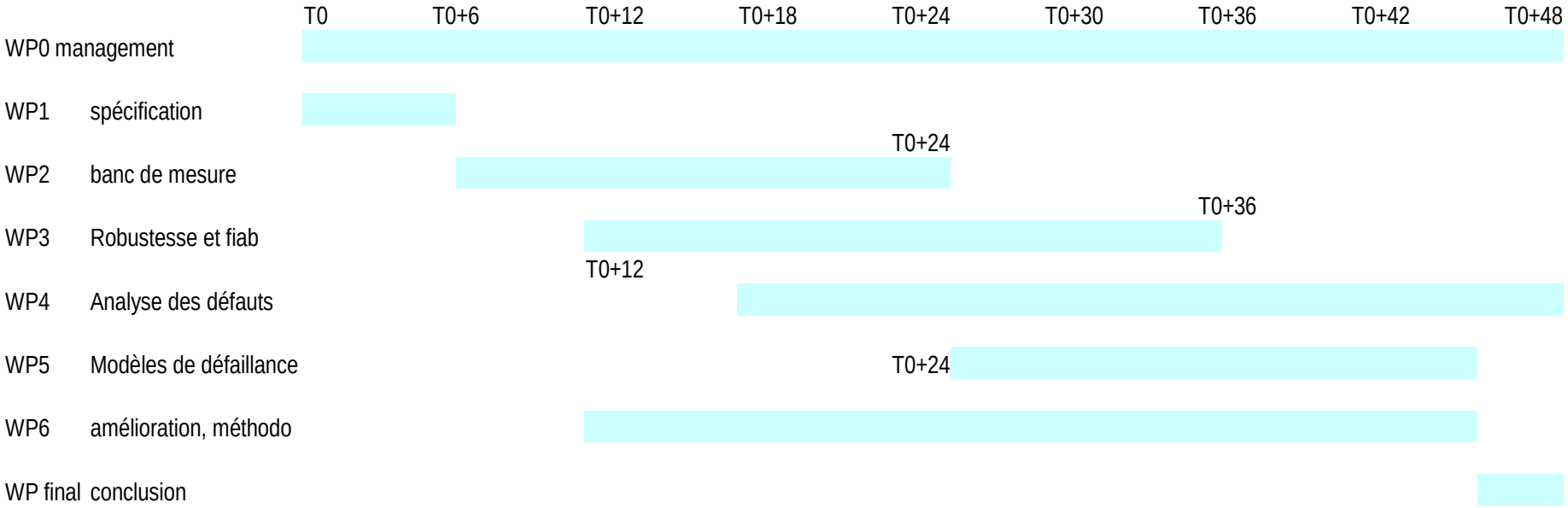
- **Develop a Reliability Engineering Methodology**
  - ➔ Reliability & Robustness Characterization Equipments
  - ➔ Methodologies
    - – Future products and technologies reliability ( PRO-ACTIVE)
    - – Analyze failures of existing products (RE-ACTIVE)
- **Launch a Test Platform**

# Work Packages

| WP1 | WP2 | WP3 | WP4 | WP5 | WP6 |
|---|---|---|---|---|---|
| Specifications | Stress effect Measurements | Robustness & Reliability | Defect Analysis | Failure models | Reliability Improvement Methodology |
| WP1.1 | WP2.1 | WP 3.1 | WP4.1 | WP5.1 | WP6.1 |
| Mission profile | Chip temperature | Super HAT Test bench | Physics measurements | Multiphysics modeling | Design architecture improvment |
| WP1.2 | WP2.2 | WP3.2 | WP4.2 | WP5.2 | WP6.2 |
| Qualification test | EM stress Test bench | Reliability Test bench | Package Constituants measurement | Predictive Reliability Models | Design Rules |
| WP1.3 | WP2.3 | WP3.3 | | | |
| Components & Systems of interest | Mechanical deformations | EOVS Test bench | | | |

**Understand & Control Failure Mechanisms**

# Time Plan



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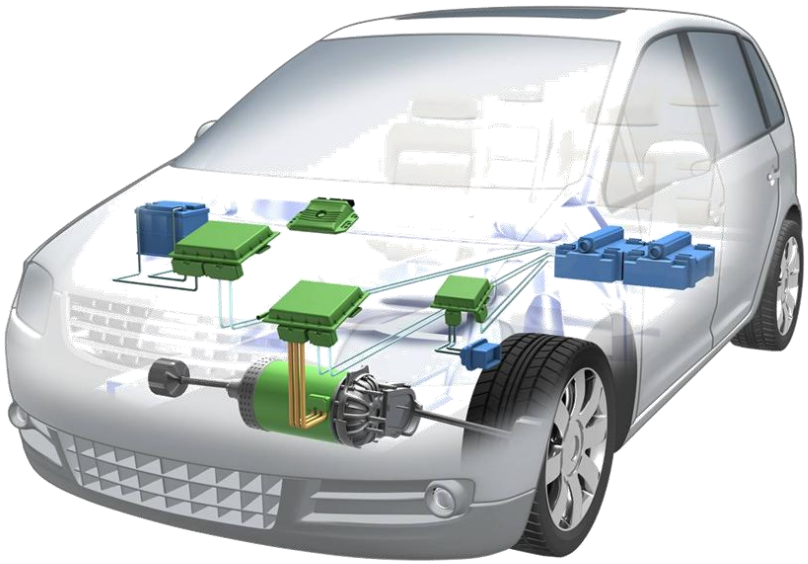
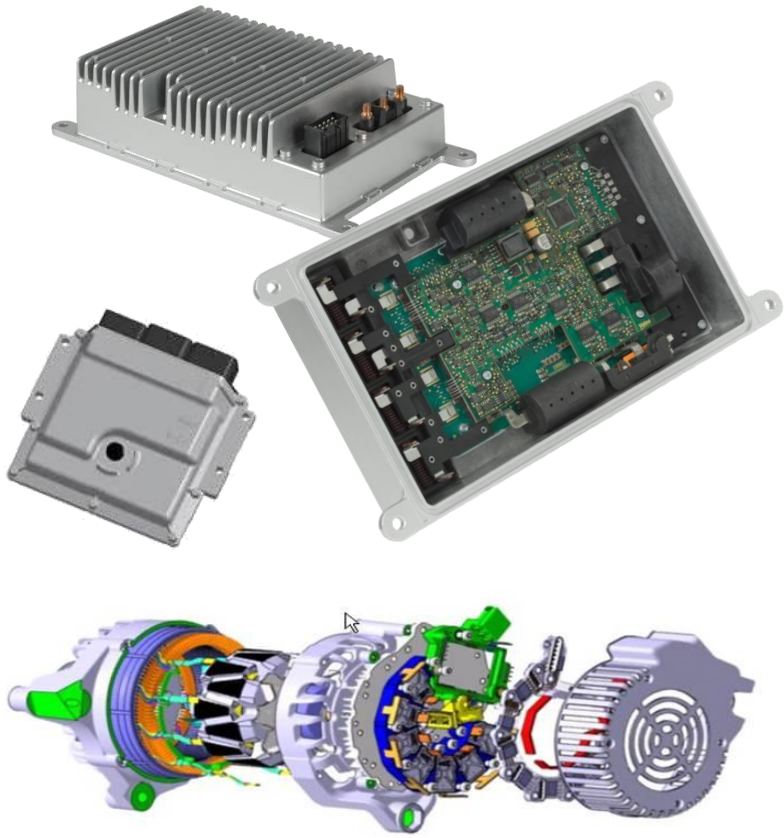
# Audace WP1

## Demonstrators

# Reliability of innovative embedded mechatronic devices





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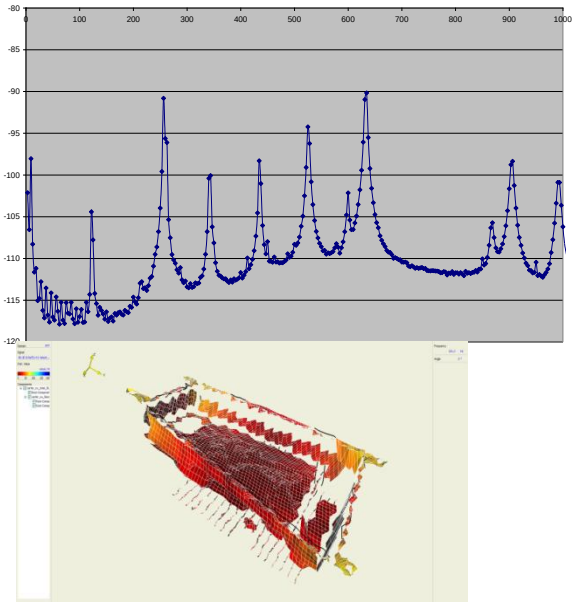
# Audace WP2

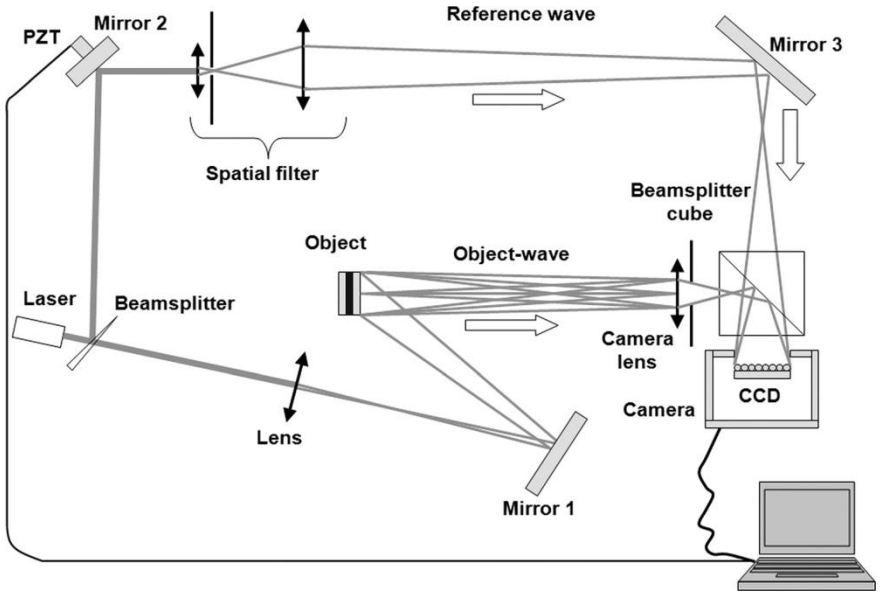
## Identify the failure modes

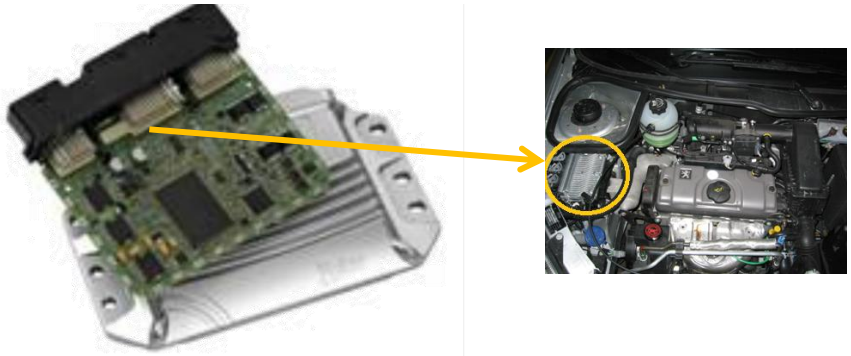
# Modal Analysis Test Bench: Laser Vibrometry

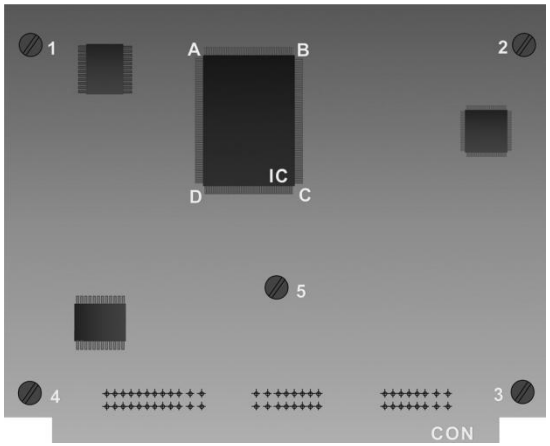
- **Main features:**
  - non contact optical technique (components, assembled circuit boards)
  - High density mesh measurements
  - Rapid response time
  - Identifies Eigen frequencies and Eigen modes and FRF



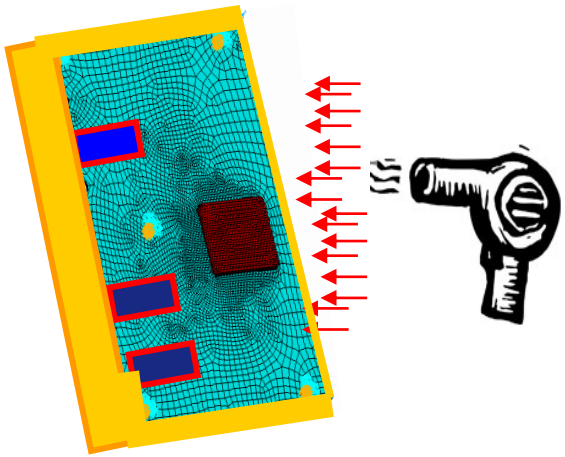
# Phase-stepped Laser Speckle Interferometry

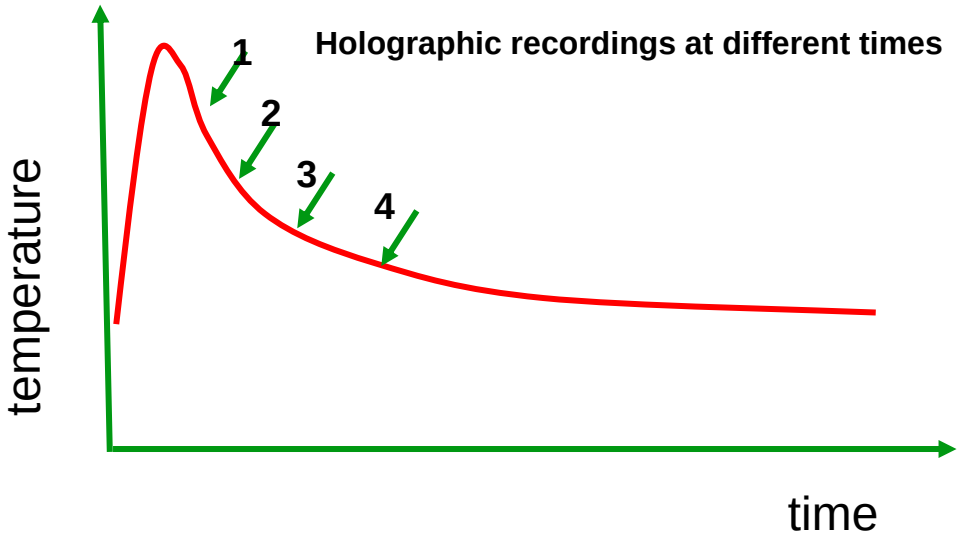




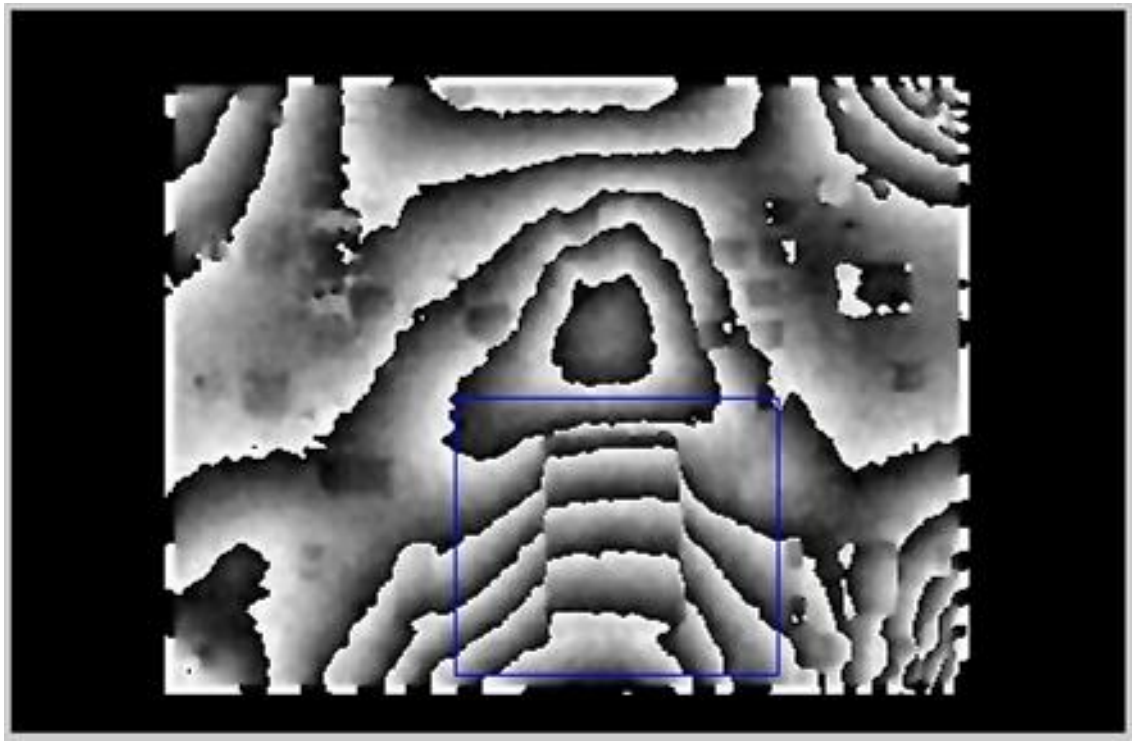
# Phase stepped Laser Speckle Interferometry

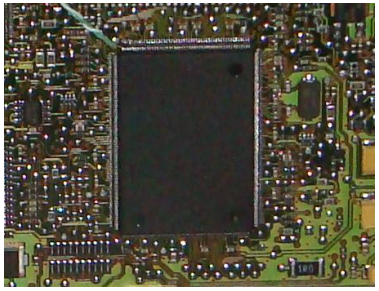


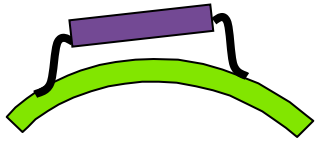



**Thermally induced deformation**

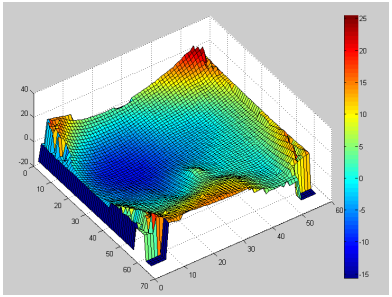
# Phase-stepped Laser Speckle Interferometry

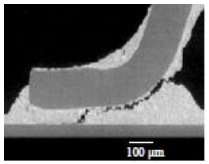






**Full field out of plane deformations**





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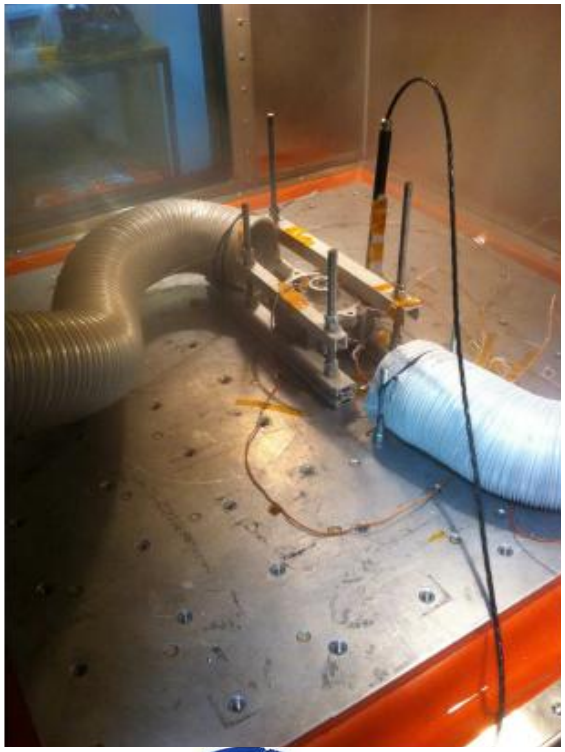
# Audace WP3

## Robustness Margins characterization

## Lifetime characterization in operating conditions

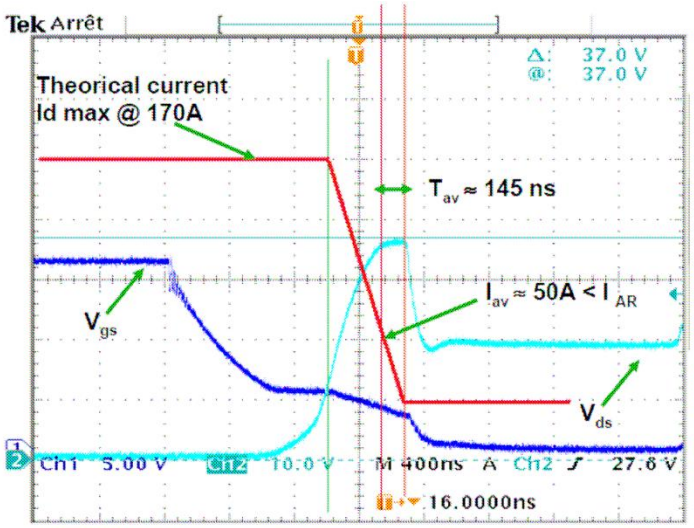
# SUPER HAT



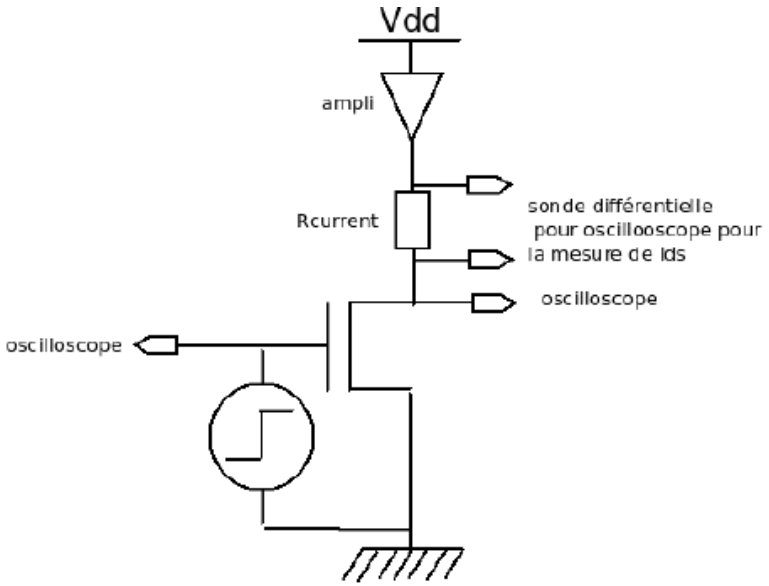

## Highly Accelerated Testing + Humidity

- Thermal environment
  - -100°C / 200°C
  - 60°C/mn
- Vibration environment
  - Random vibratons
  - 0 to 50 Grms between 10 Hz and 10 kHz
- Humid environment
- Combination of stresses

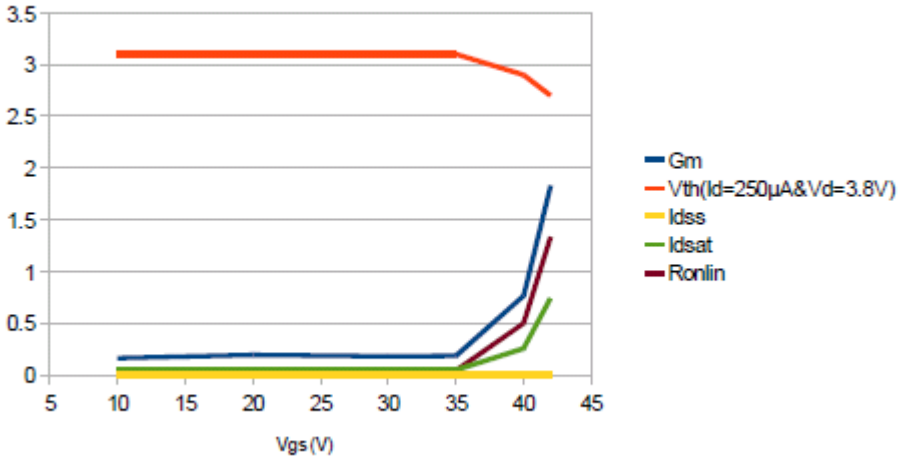
# EOVS test bench




**Vgs, Vds, Ids waveforms**

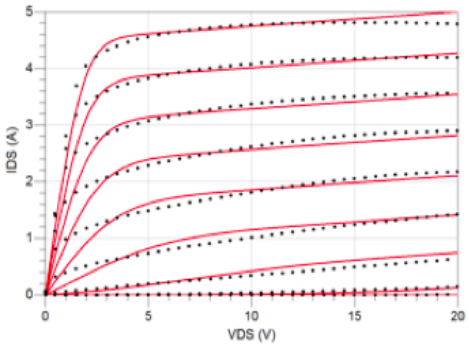


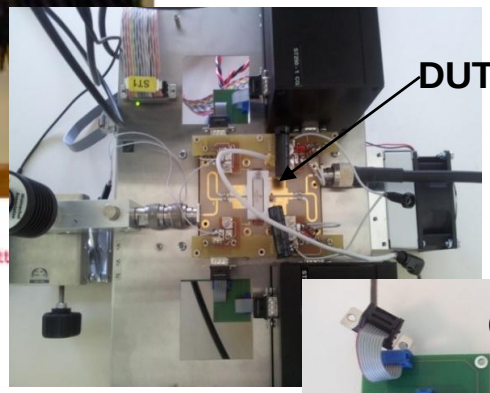

**Transient power generator**
**Ids = f(Vds)**



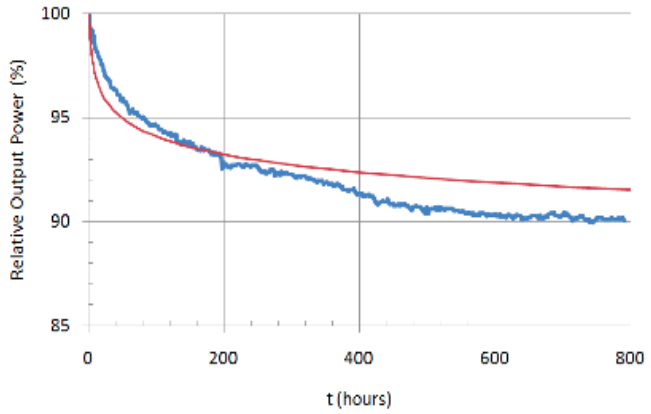
# Test benches: Pulsed RF HTOL & CW RF + EM

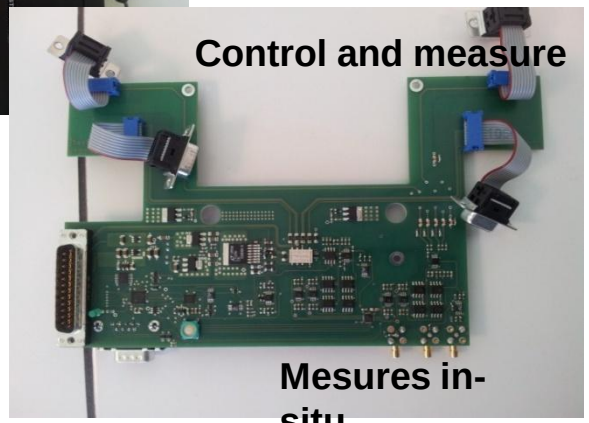

**ID(VD) simulé et mesuré**




**Puissance de sortie simulée et mesurée**



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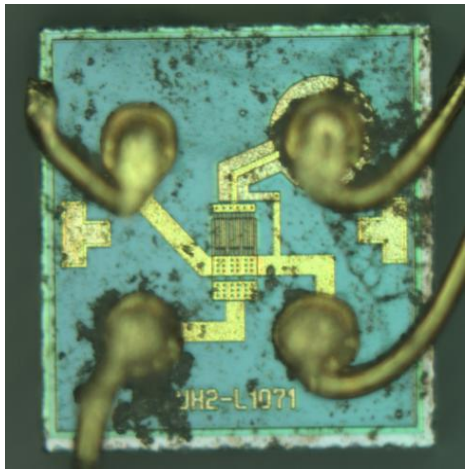
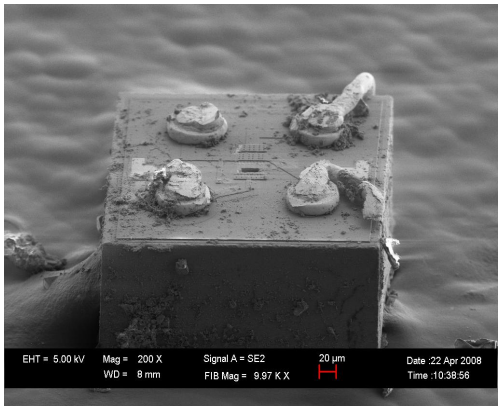
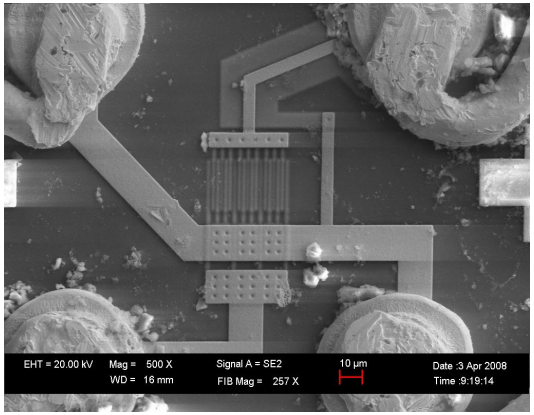
# Audace WP4

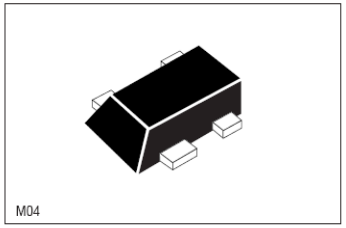
## Failure Analysis

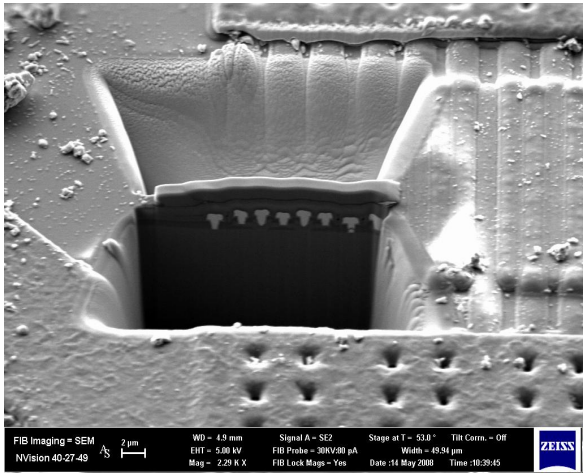
# Failure Analysis

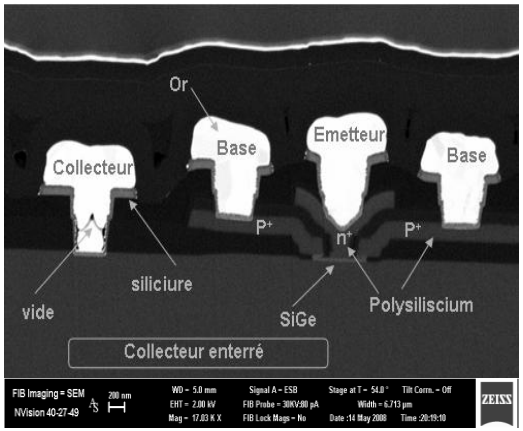


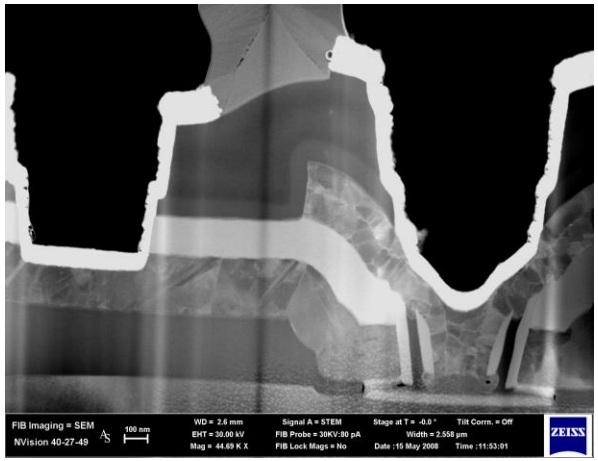


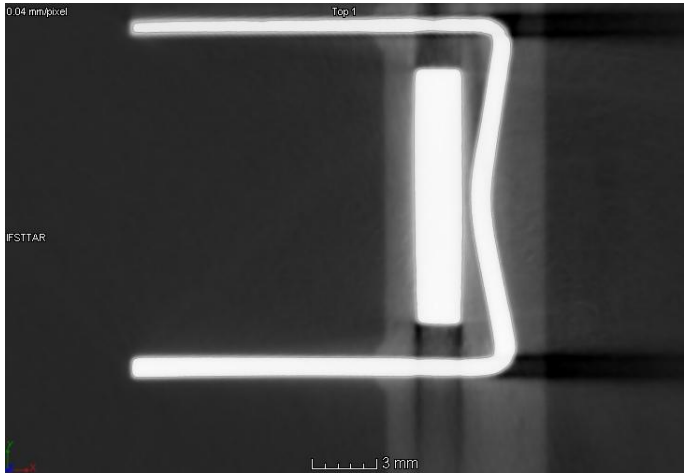



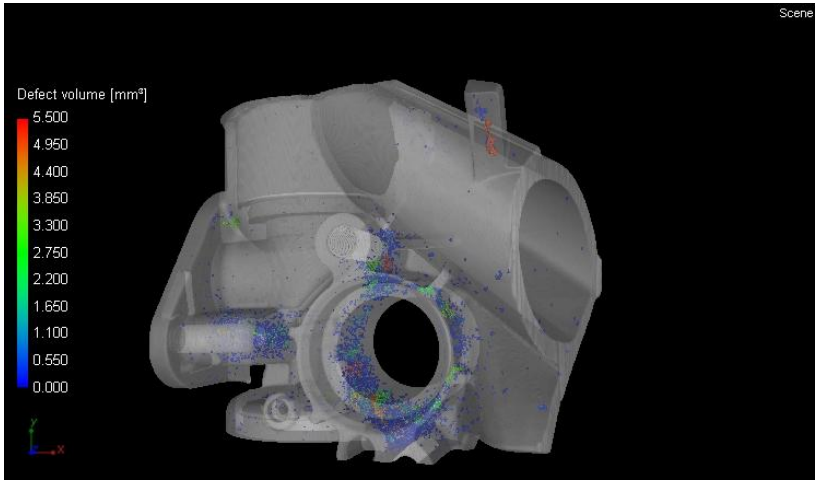



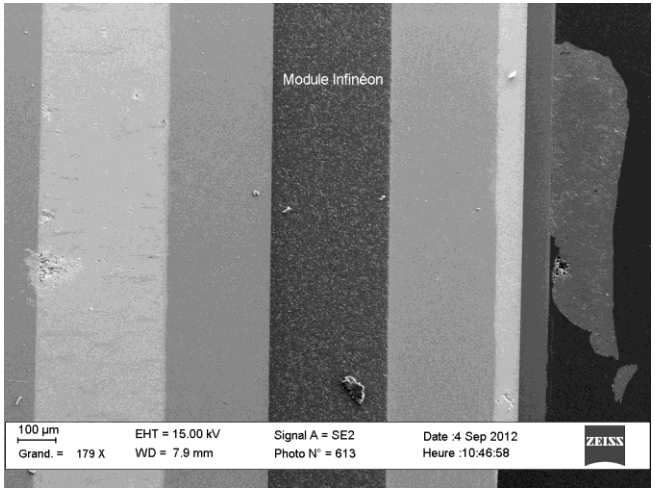



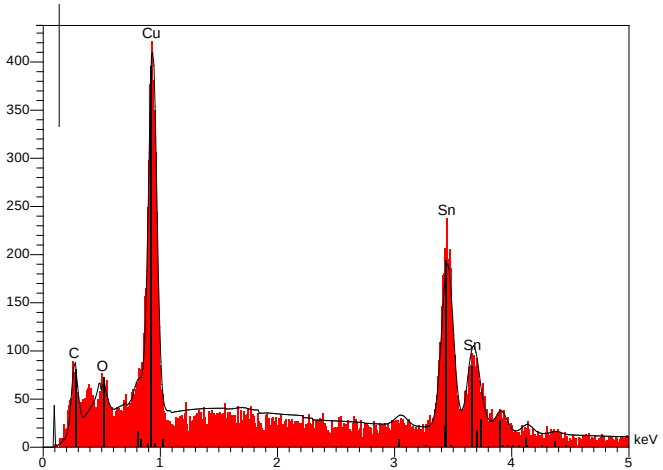



# Failure Analysis



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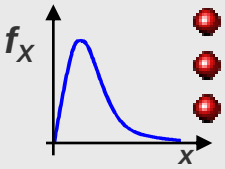
# Audace WP5 & WP6

## Modelling & Simulation

## Optimization

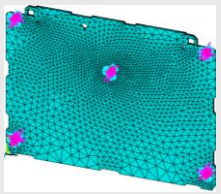
# A Probabilistic Approach to Robustness

**Uncertainties or variability**




- Materiel properties
- Geometry
- Thermal loading

**Mechanical model**

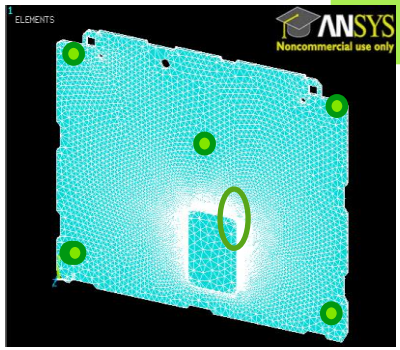


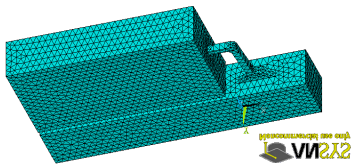
- FEM
- Fatigue…

**Response surface method**

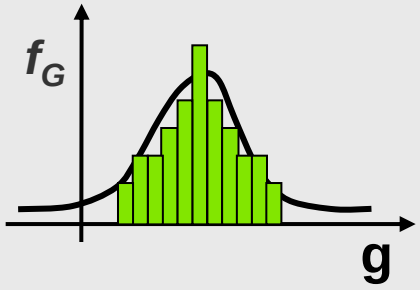
$$\tilde{\varepsilon}_p = c + \sum_{i=1}^{n} b_i x_i + \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} x_i x_j$$

**Mechanical -reliability coupling Monte Carlo Simulations with Latin Hypercube sampling**

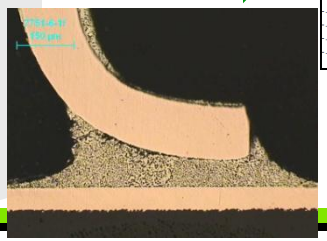


**Response distribution**




**Sensitivity analysis**



# Conclusion

1. A collaborative research program addressing the reliability failure mechanisms of mechatronic devices

2. A design methodology that insures the realization of reliability goals

3. A Test Platform proposing solutions to reliability issues

# Thank you for your attention!


*Enabling a better automotive world*