# Design Exploration and Cosimulation

*From traditional Design Optimization*
*to Multiphysics Design Exploration*

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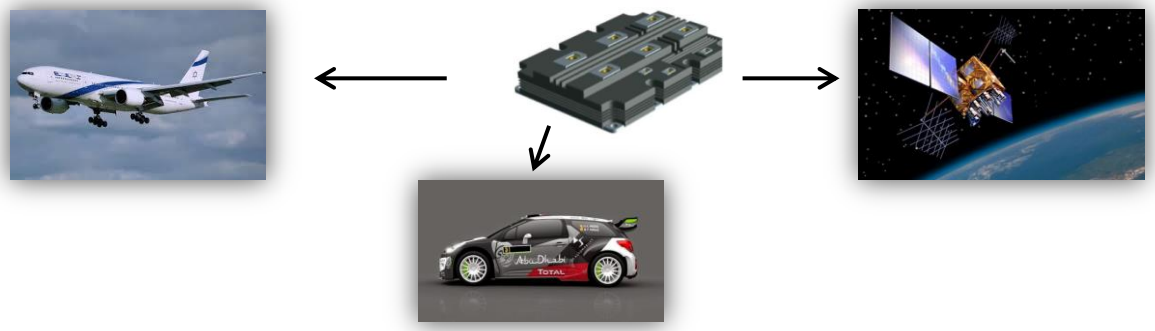
Let us start from an example…



A **power module** provides ***electrical*** power. It is submitted to ***thermal*** constraints. Which can damage the ***mechanical*** properties of the component, and therefore the power ***electrical*** function.

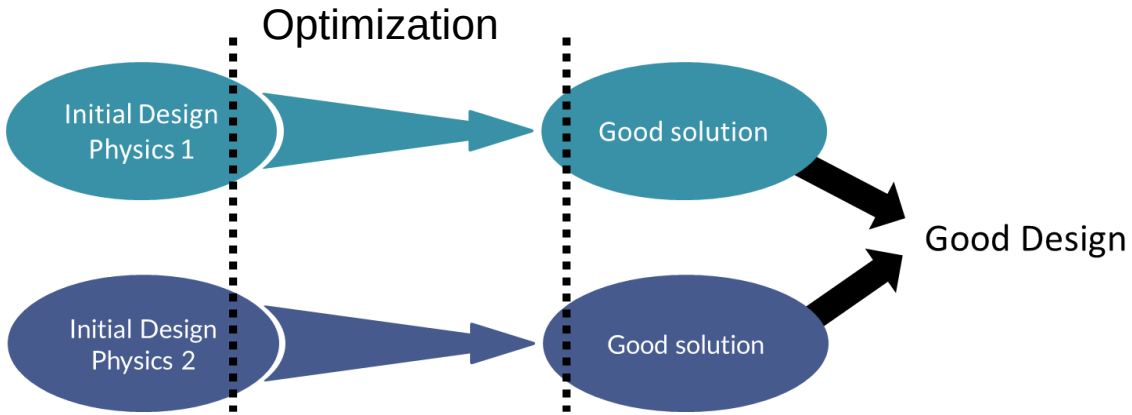
How can we compute its lifetime according those dependencies?

- Those physics are intimately coupled
- Reliability and performance are related
- Each manufactured power module has a different life

} Multiphysical design problem

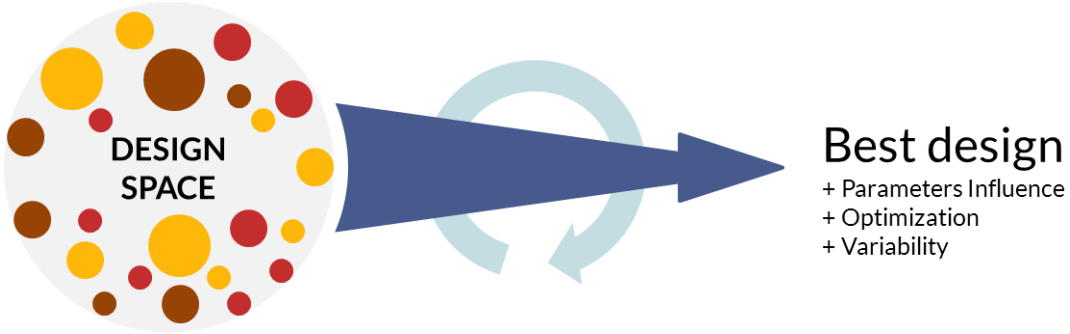
} Design optimization and variability analysis

# Traditional Design Optimization




- Experts concentrate on their area of expertise from a known solution.
- Efficient approach.
- Take into account multiphysical constraints through textual of static constraints
- Does not take into account other possible design variable combinations

# Design Exploration

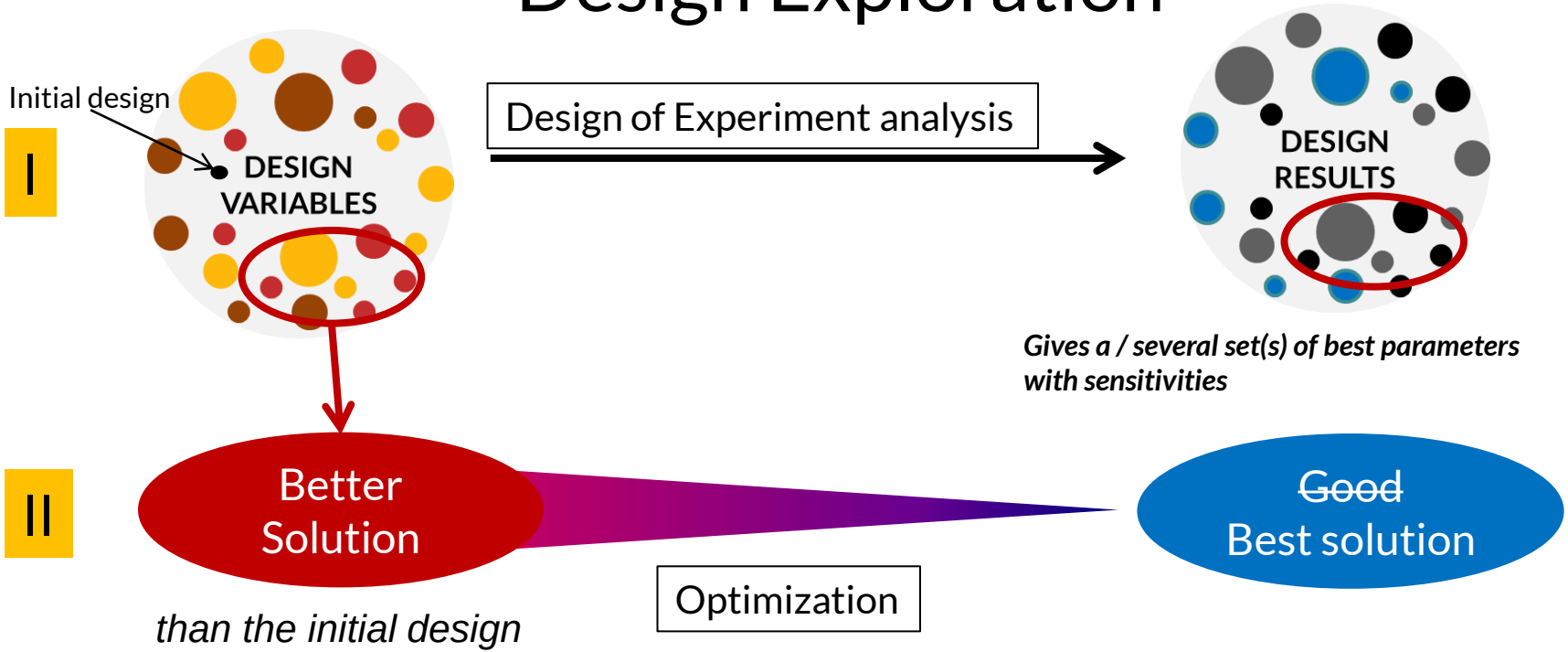



Takes into account all combinations of parameters to evaluate the outcome on the product performance

In this presentation, **Design Exploration** will include

- Design of Experiment : how will a set of parameter influence the performance (e.g. sensitivity analysis)
- Optimization : provided those sensitivities, how can I find the best combination
- Variability Analysis : what happens if my parameters value are variable in a defined range (manufacturing tolerance, performance loss in time…)

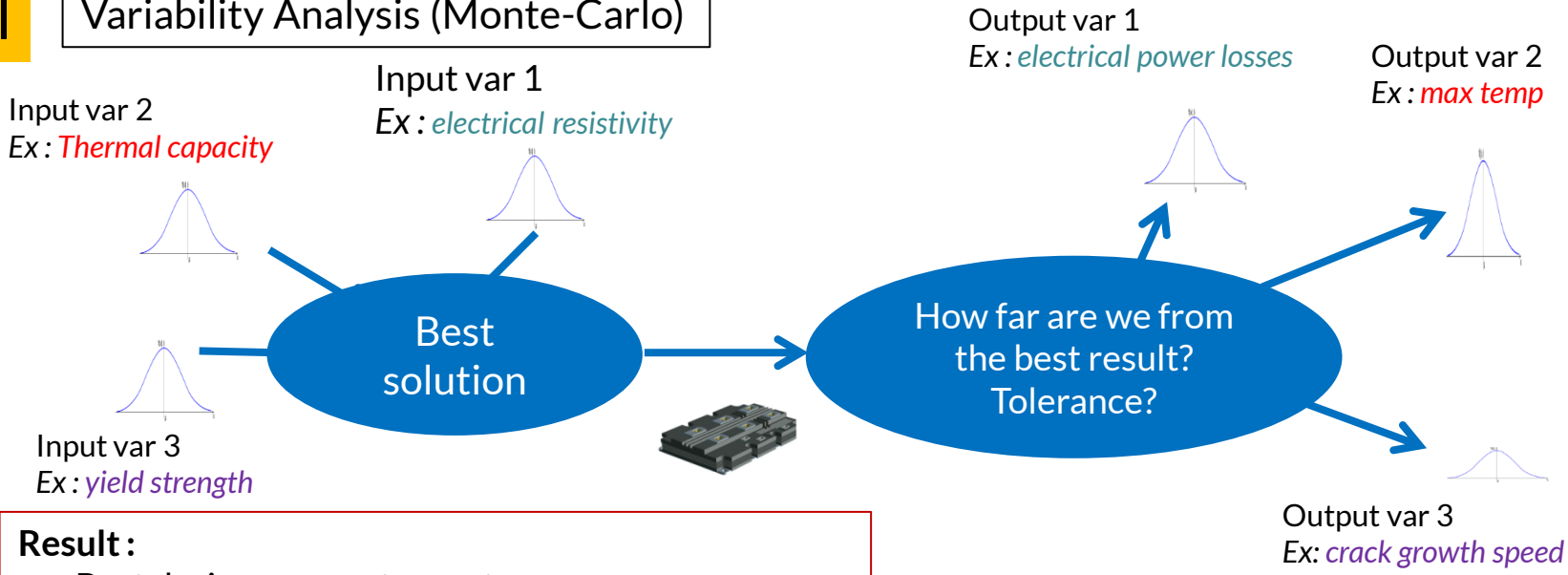
# Design Exploration



# Design Exploration

III

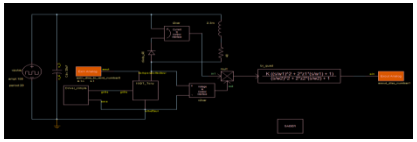
Variability Analysis (Monte-Carlo)




**Result :**

- Best design parameters set
- Does not depend on previous design calculations
- Within the acceptable range
- Variability

# Multiphysics and dependencies

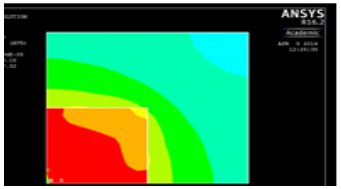


*Electrical model*

**Parameters**
Electrical :
- Resistivity
- Inductances
- Voltage source
- IGBT parameters
- …

Thermal
- Temperature

**Results**
Power output
Power losses
Voltage and current at each pin

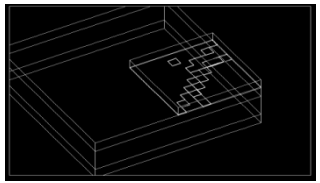



*Thermal model*

**Parameters**
Ref. temperature
Thermal resistivity
Thermal conductivity
Power losses

**Results**
Temperature at each point
- Thermal stress

lax temp



*Mechanical model*

**Parameters**
Elastic modulus
Yield strength
Thermal loadings

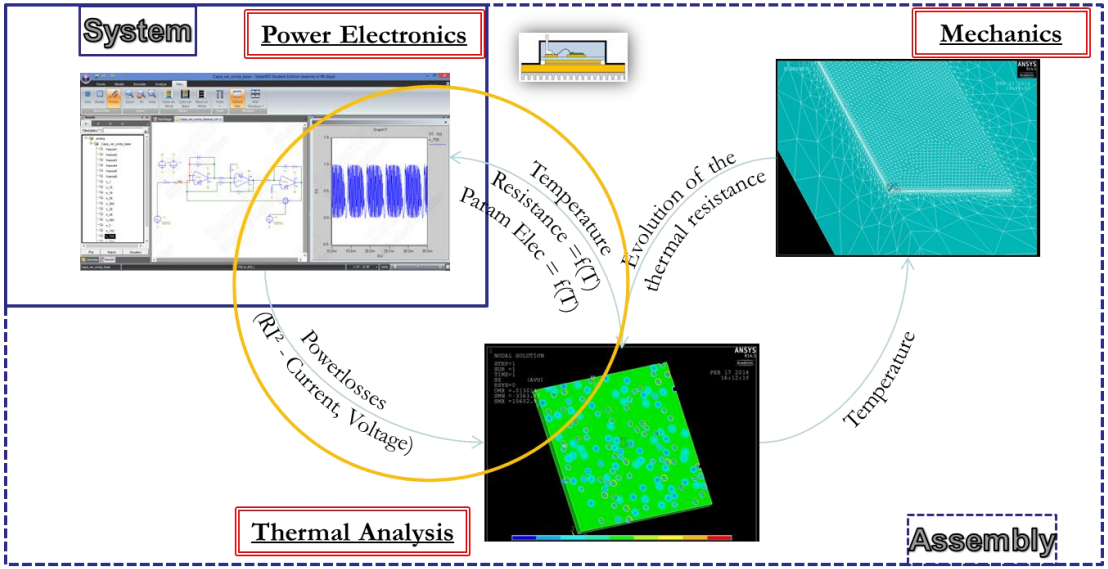
**Results**
Displacement
Stress
Thermal resistivity
Damage

# Multiphysics and cosimulation

- Engineers need to share IP
- Every engineer has their favorite environment
- Each physics has their characteristic time
- Several engineers should be able to share their data at the same time
  - And respect IP policies
  - Even if working from remote location

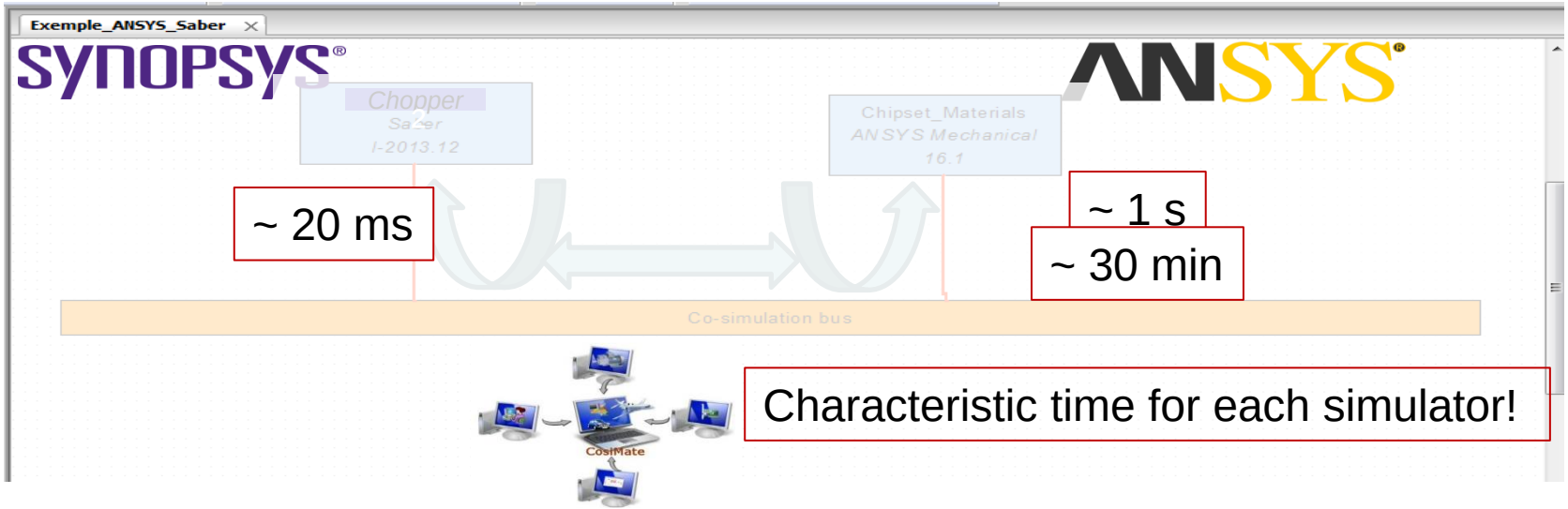
# Multiphysics and cosimulation

## Cosimulation is the solution to those pains

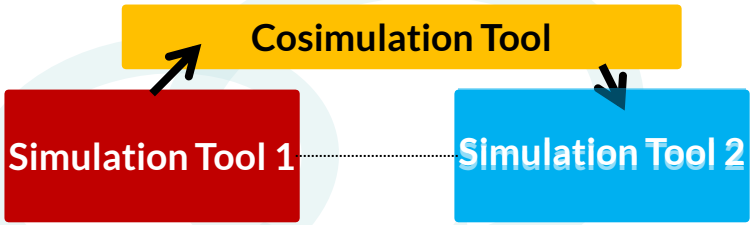



*Power module cosimulation example – courtesy Safran*

# Bus based cosimulation



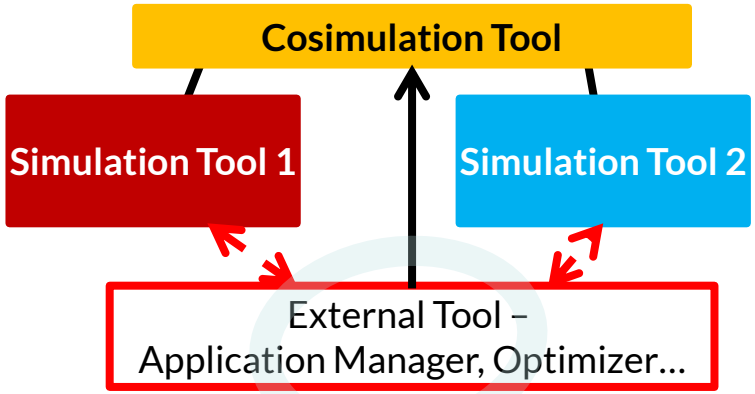

# Integration and management



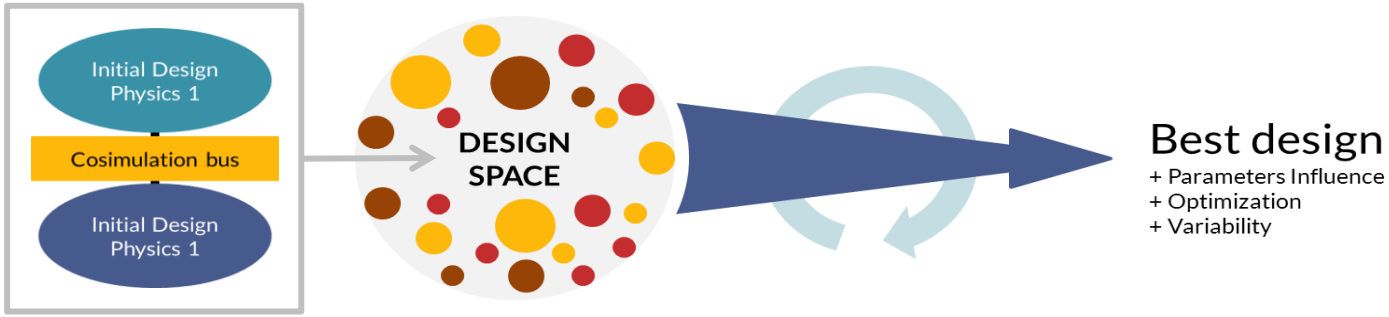

**User view** : simulation tool 1 (ST1)

ST1 contains the design parameters

ST1 sends start and stop signal to the cosimulation bus which handles ST2




**User view** :
The external tool manages the design parameters and results
It starts the cosimulation bus which starts the ST's



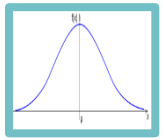

**Multiphysical cosimulation platform**
*Multi tools / versions / components*
*Collaborative engineering*

We have seen how to build a platform for Design Exploration and Multiphysics

- Identify important design parameters
- Optimize
- Assess variability
- Take into account multiphysical interdependencies

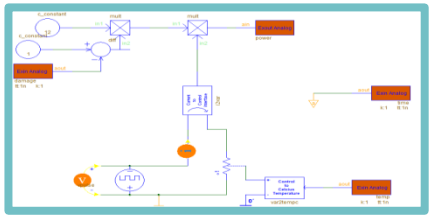
# Setup

## Reduced model

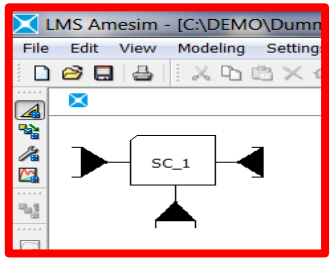


Variables parameters :
Power supply
- Manufacturing defects
- Measurements precision…

Electrical model – SaberRD

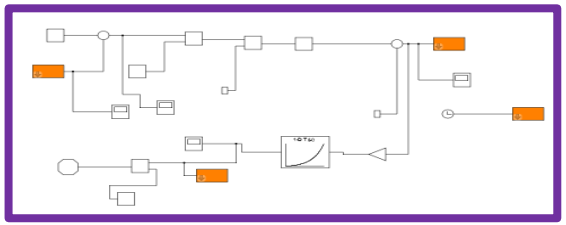


Thermal model – Amesim

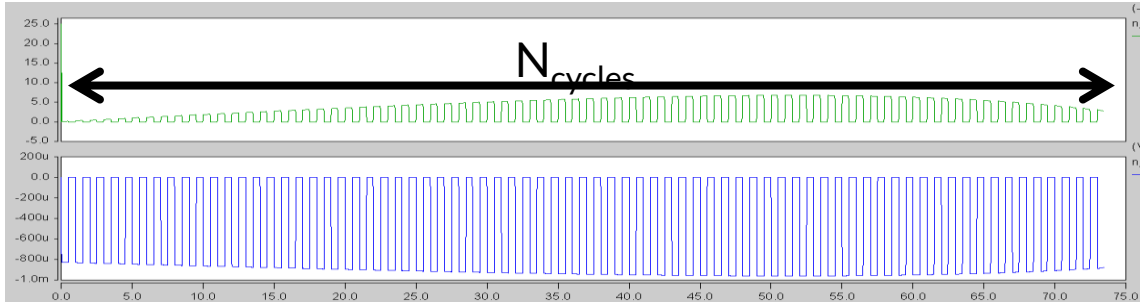



**Cosimulation bus**

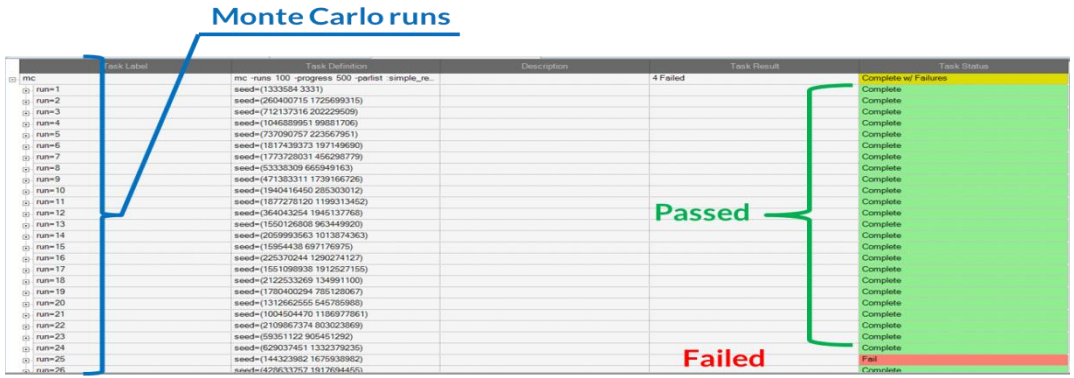
Damage model – Simulink



# Results




For one run -> one lifetime




Criterion:
Is the simulated lifetime sufficient regarding the specifications?
$N_{cycles} > N_{spec}$?

# CONCLUSION

Recent engineering methods such as Design Exploration and Cosimulation enable engineers to

- Share IP
- Do more multiphysical simulation effortless
- Assess any configuration early in the design cycle
- Explore alternative designs


EventDriven
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Engineering
Coupling
Model
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Virtualizer
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VHDL
Engine
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Modelica
FiniteElements
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MultiPhysics
SystemSynthesis
MSC.Adam
ModelCenter
Thermal
MBSE
Optimization
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C/C++
CarSim
FMI
Saber
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Rhapsody
Autonomie
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Cosimulation
SysDM
Simulink
MultiBody
DigitalTwin
MultiToolsIntegration
DistributedSimulation
CrossDomainSimulation
ContinuousEngineering

# THANK YOU