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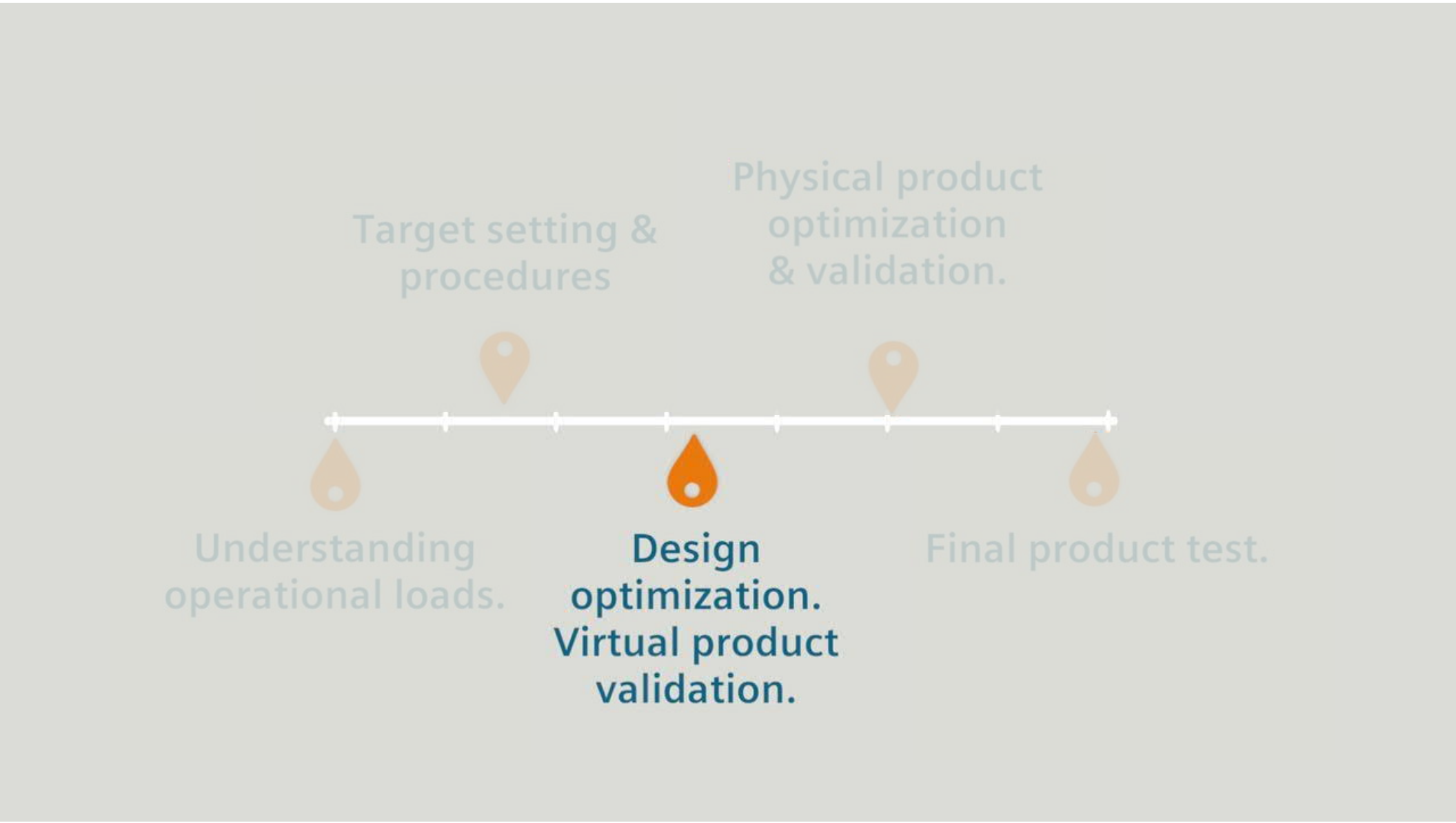
# Faster and more accurate strength and durability analysis using 3D simulation


Target setting & procedures
Physical product optimization & validation.
Understanding operational loads.
Design optimization. Virtual product validation.
Final product test.

## The Digital Twin allow to

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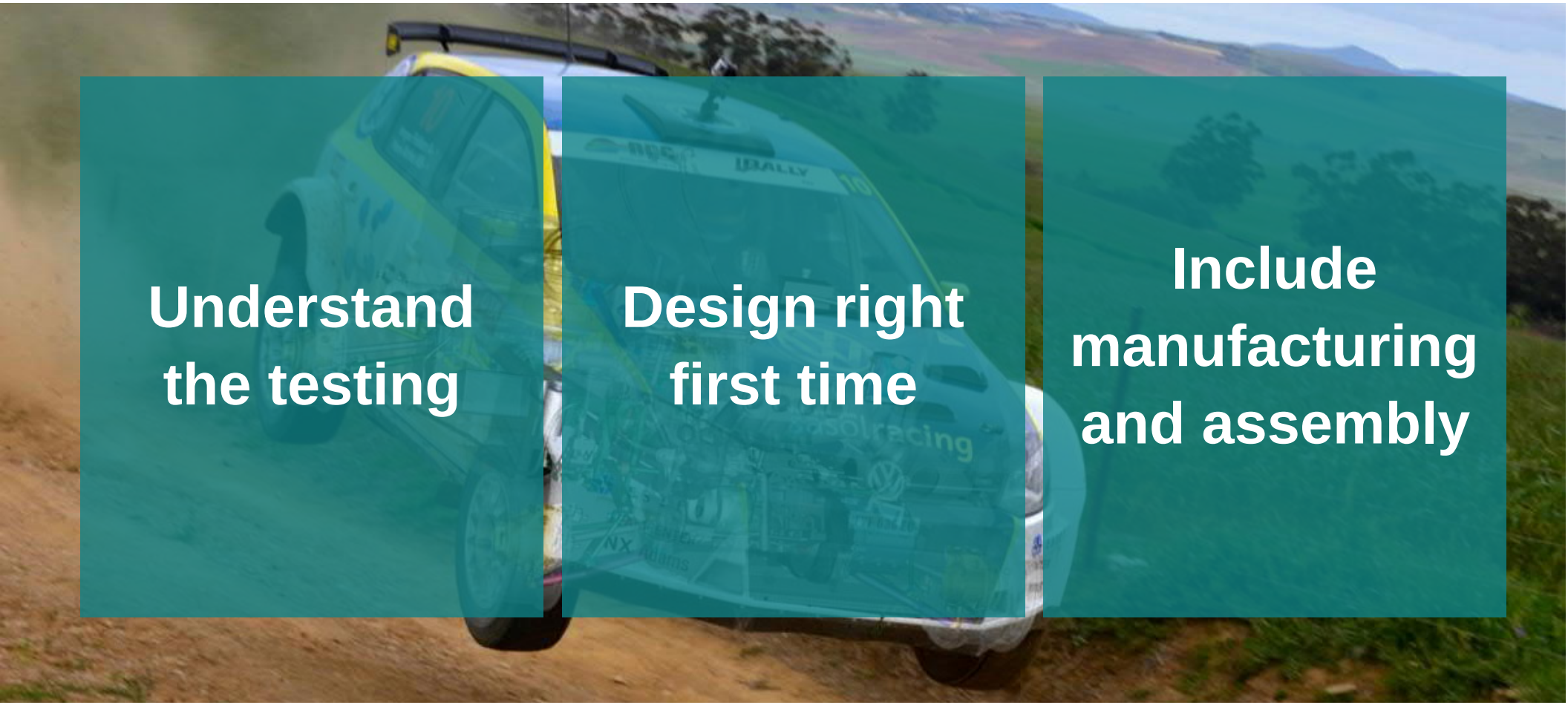

**Understand the testing**

**Design right first time**

**Include manufacturing and assembly**

## The Digital Twin allow to

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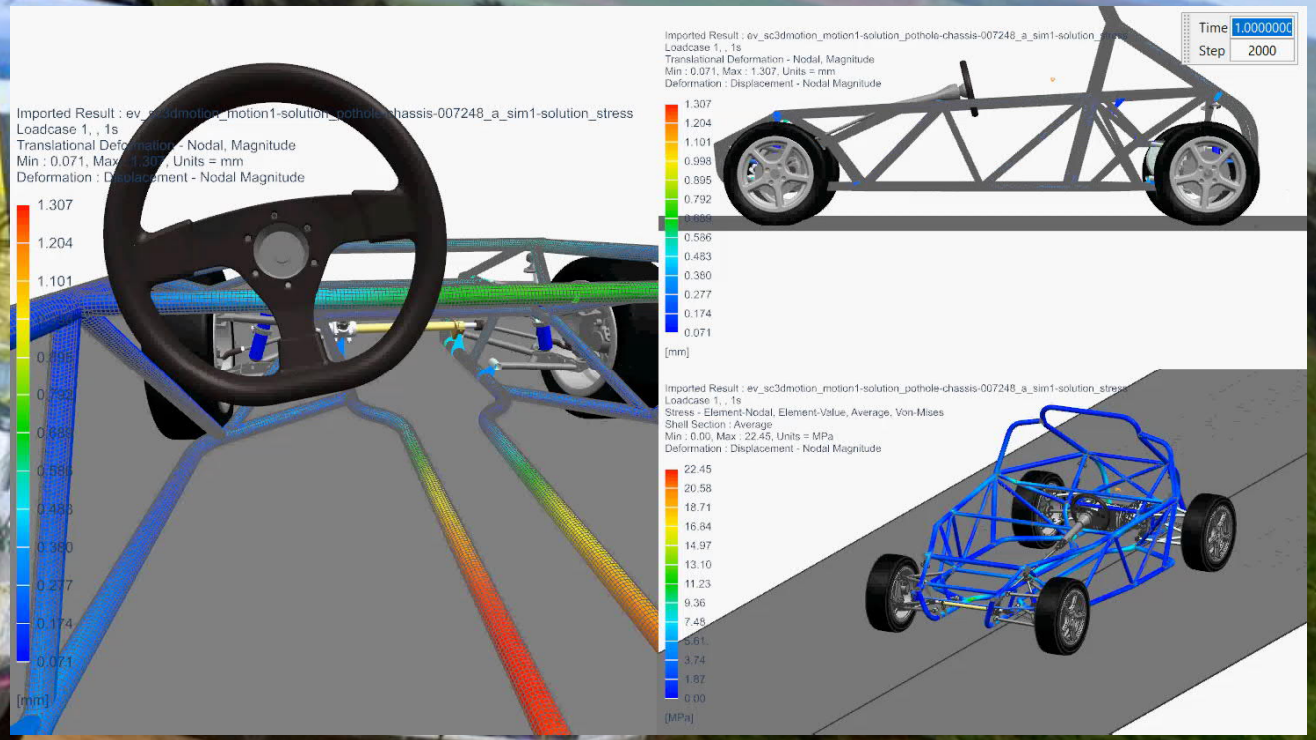
# Understand the testing



# Define Durability Load Data Analysis Tasks

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Input source-1: Test

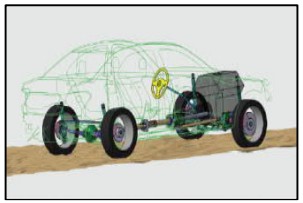
Roads
Measure
Test engineer

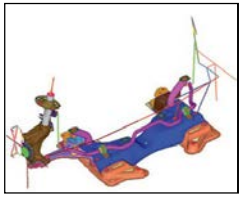


Roads/Office
Validate
Test engineer

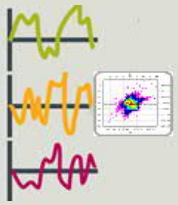
Input source-2: Simulation

Office
Simulation
Simulation engineer





Office
Analysis
Report & share



Test schedule creation

Test engineer

# Road Load Data Prediction

## Earlier access to real-world vehicle loads

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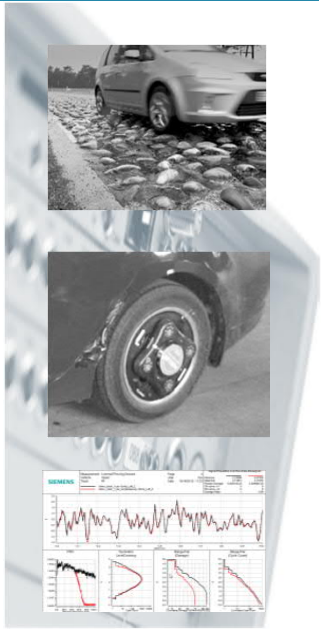
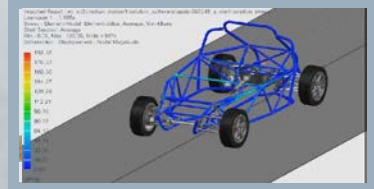
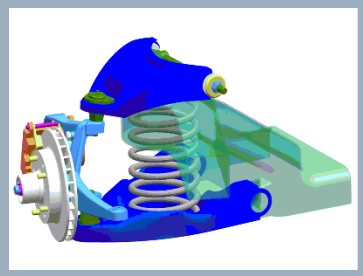
**Road Load Data Acquisition**



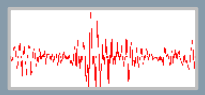
**Road Load Data Prediction**



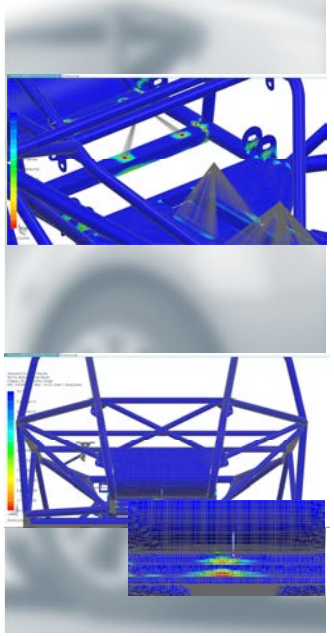
**Full Vehicle Simulation**
- Hybrid Road
- Digital road



**Component Simulation**
- Test Rig in Simulation
- Subsystem simulation



**Fatigue Analysis**



# Fiat Group Automobiles S.P.A.

## Using Simcenter Simulation & Test to verify and validate durability virtually

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- **Reduced margin of error in real loads between 8 and 15 percent**
- **Reduced overdesign by performing simulation prior to building a prototype**
- **Diminished costs by developing equivalency between two proving grounds**

### Conducting complete fatigue analysis

**Proving grounds in Turin, Italy**

**Virtual prediction and use experimental data for model validation**

- Long-term partnership between Fiat and Siemens PLM Software
- The ability of Siemens PLM Software to deliver customized solutions

**"Although we can't measure the improvement because we previously didn't use virtual data, the results that we have received by using both Simcenter products are absolutely excellent."**

Marco Spinelli, Head of the Chassis CAE Department

# Ford Otosan

## Cut time to reproduce 1.2 million kilometers of customer usage

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- **Reproduced 1.2 million kilometers of customer usage in a condensed proving ground test period**
- **Developed 4-week accelerated rig test to represent 1.2 million kilometers of customer usage**
- **Provided opportunity to optimize cost and weight**

### Conducting customer correlated procedures

**Customer correlated proving ground test**

**Cabin rig test to represent 1.2 million kilometers**

- Qualify and quantify the durability potential of vehicle loads with innovative analysis
- Replace time-consuming and costly tests by deriving compressed load time histories with an equivalent damage potential for uniaxial and multi-axial loading conditions

**"We selected Siemens PLM Software for its capabilities and experience in durability field testing, load data analysis and test schedule development for virtual simulation and durability track and rig testing."**

Vehicle Durability Supervisor

## The Digital Twin allow to

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# Model the real world

## The digital twin using real life load data

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**Model the real world**

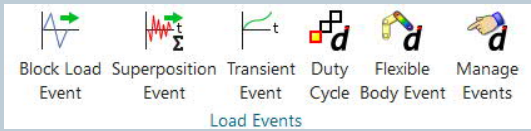
**Interoperability**

**Efficient Durability Modelling**

**Get the results at fingertip**

### Challenge

- Get real load data
- Get a realistic digital twin
- Durability loads in simulation can be represented in multiple ways




### Key Points to enable the process

- Access to any load data format, and FE data
- From simple block loads to hundreds of load channels and FE cases
- Transient events
- Complex duty cycles

# Model the real world

## The digital twin using real life load data

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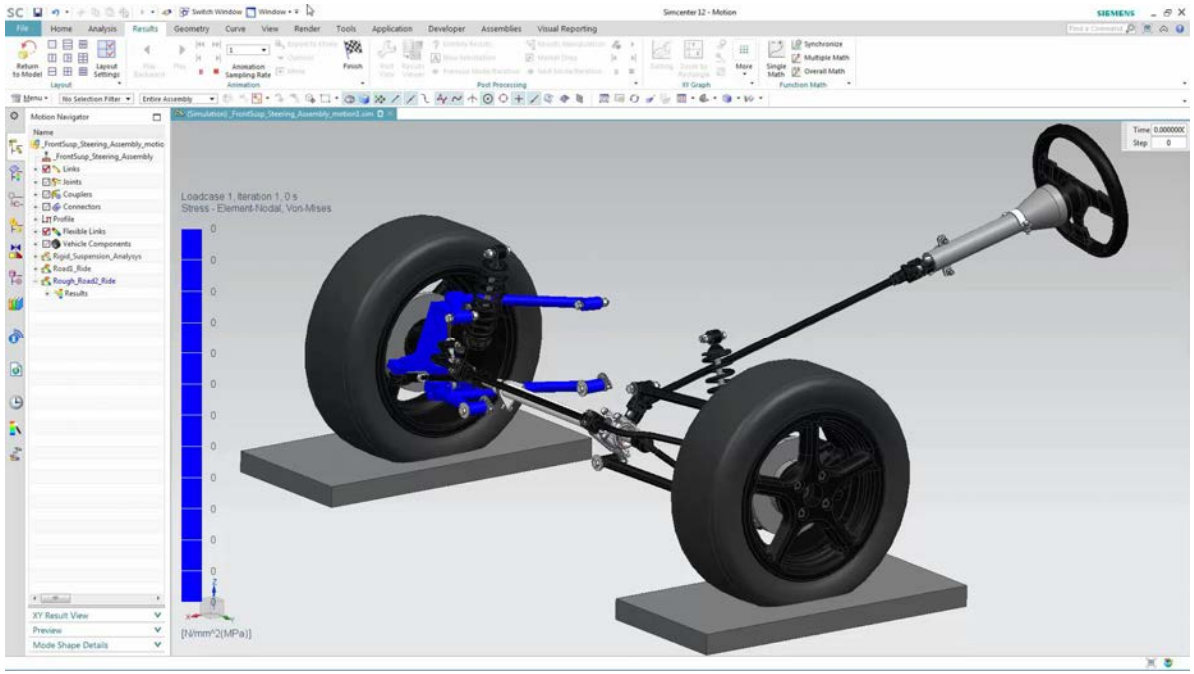
- **Model the real world**
- **Interoperability**
- **Efficient Durability Modelling**
- **Get the results at fingertip**




**The digital twin using real life load data**

# Interoperability

## Get the correct loads – use the current results

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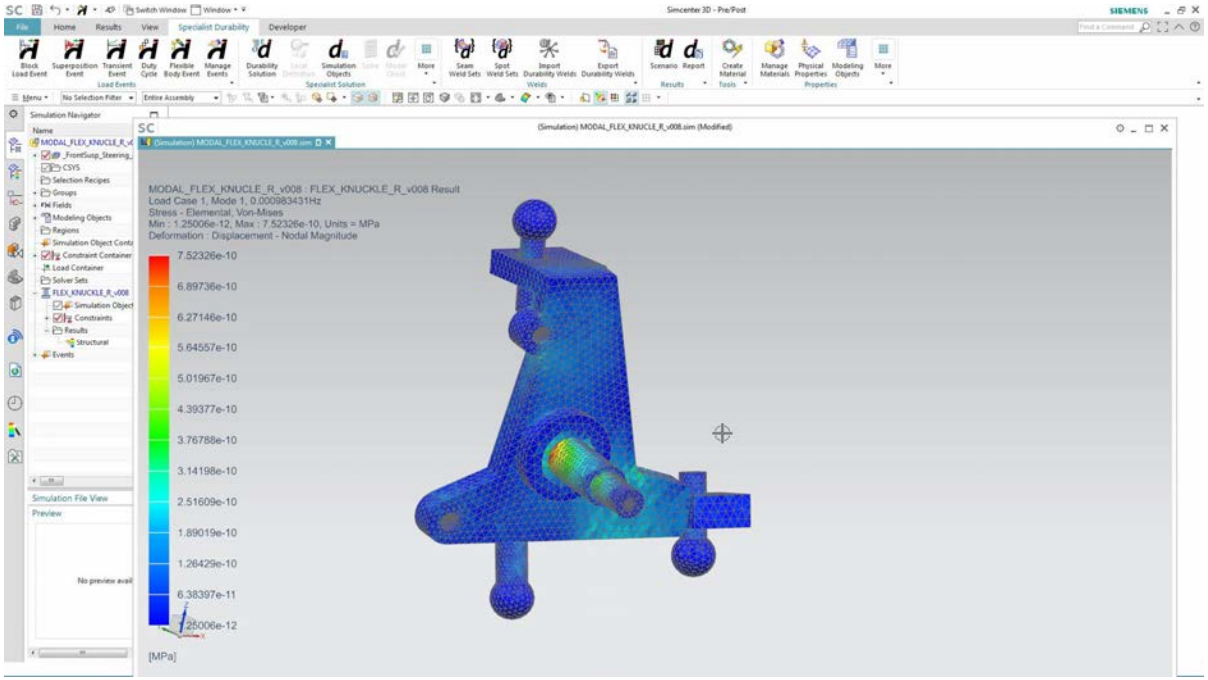
- Model the real world
- Interoperability
- Efficient Durability Modelling
- Get the results at fingertip




**Work with one digital twin – Get the right data**

# Efficient Durability Modelling

## Complex Durability Setup – easy and efficient

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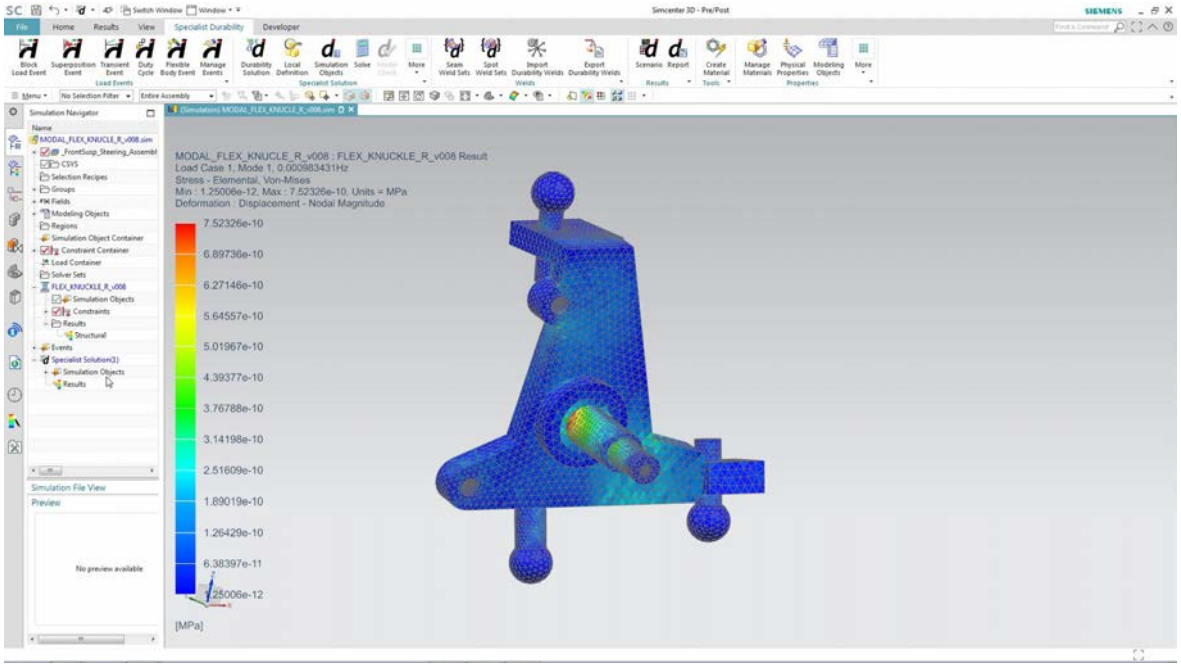
- Model the real world
- Interoperability
- **Efficient Durability Modelling**
- Get the results at fingertip




**Complex Durability Setup – easy and efficient**

## Get the results at fingertip

Know the reasons of fatigue and build better designs

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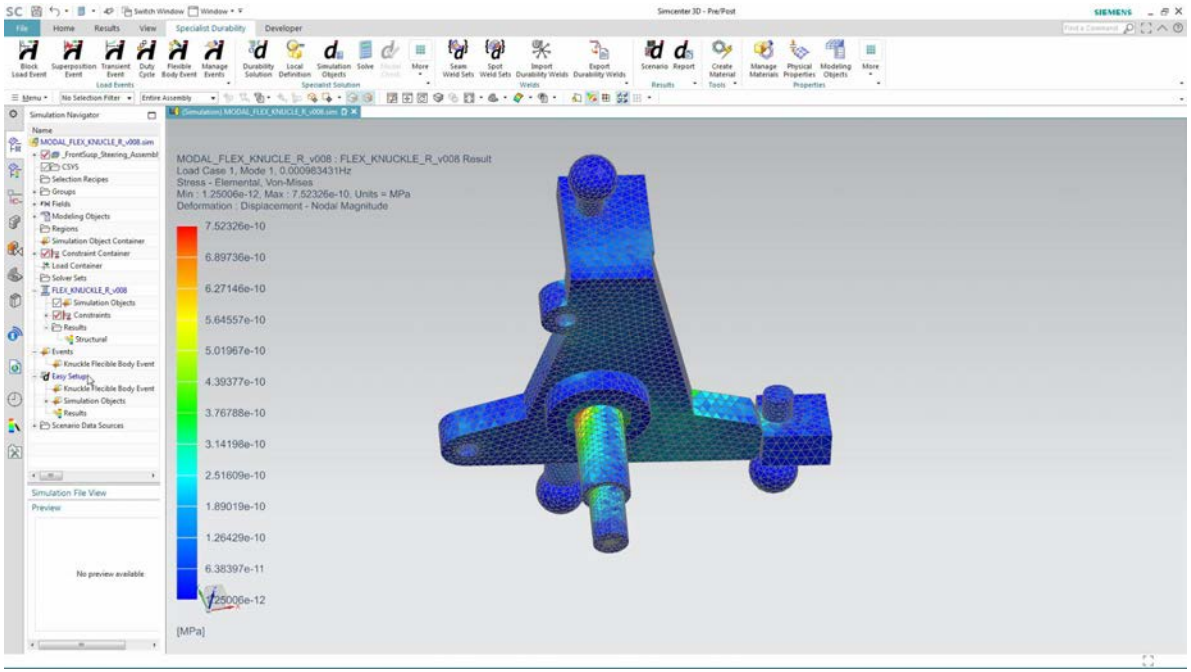
- Model the real world
- Interoperability
- Efficient Durability Modelling
- Get the results at fingertip




**Know the reasons of fatigue and build better designs**

# Fatigue analysis of a chassis part

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| | |
|---|---|
| **Model the real world** | **The digital twin using real life load data** |
| **Interoperability** | **Work with one digital twin – Get the right data** |
| **Efficient Durability Modelling** | **Complex Durability Setup – easy and efficient** |
| **Get the results at fingertip** | **Know the reasons of fatigue and build better designs** |

## The Digital Twin allow to

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## Challenge

Geometry and Behavior of a (Seam) Weld … Not that simple

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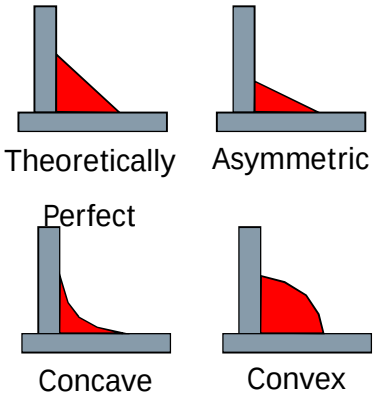
Simplified Cross-Sections




?

Reality...

**Weld Geometry: Penetration, Convexity, Continuity, Grinding**

**How to model – as not known before the assembling and scattering**

## Challenge
Geometry and Behavior of a (Seam) Weld … Not that simple

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Reality...

**Other influences**

| | |
|---|---|
| **Chemistry:** | Carbon, Manganese, Hydrogen |
| **Temperature:** | Weld, Preheat, Cooling |
| **Base Material:** | Porosity, Composition |
| **Heat Affected Zone:** | Uniformity, Property Degradation (Ductility) |
| **Microcracking:** | at perimeter of Weld |
| **Residual Stress:** | after cooling |
| **Part Geometry:** | Surface Finish, Alignment, Warpage |

**Need for a simplified but still accurate approach**

# Seam Weld Analysis
## Traditional methodologies

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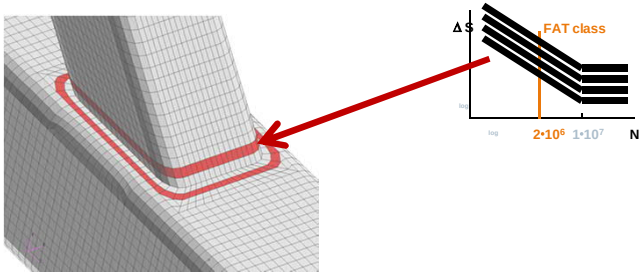
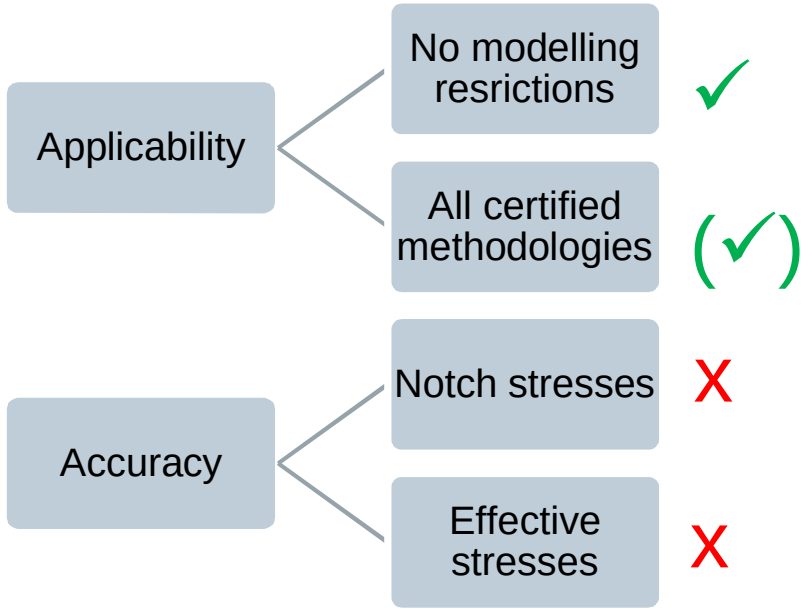
**Nominal Stress**

Traditional approach
In several certification processes
Read/measure stress in distance to weld – Compare results with prescribed SN curves




**High safety factors**
**Expensive and heavy over design**

# Seam Weld Analysis
## Traditional methodologies

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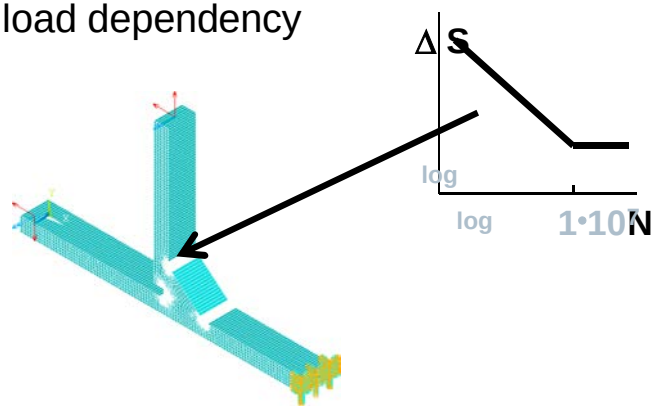
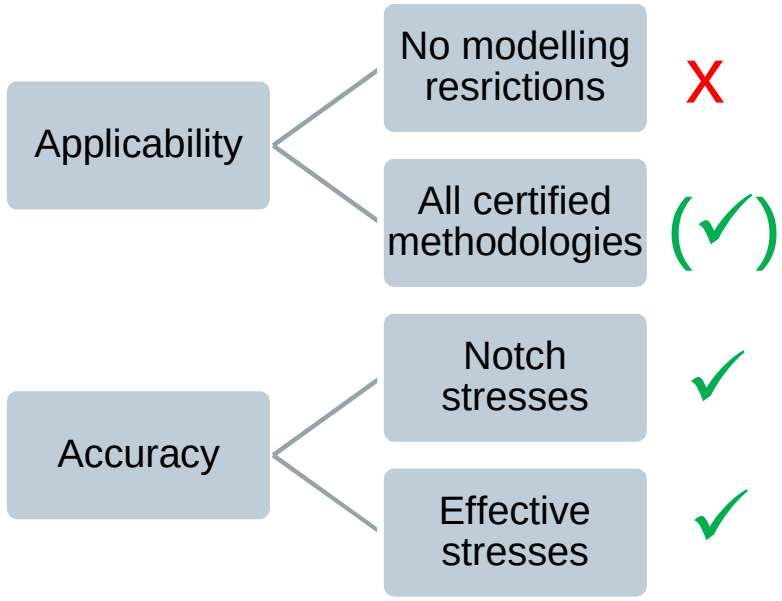
**Notch Stress**

Use local stress values
In IIW guidelines
High accuracy
Includes local geometry effects and load dependency




**High effort**
**Not applicable to large structures**

# Seam Weld Analysis

## Accurate and efficient solution

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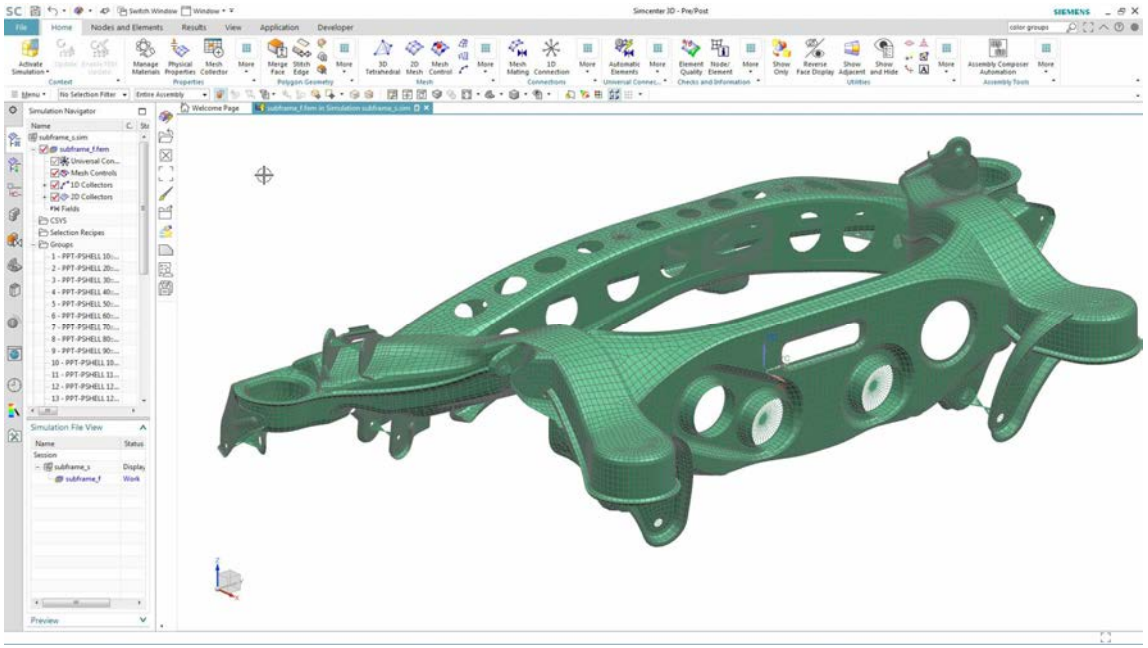

**Combine the accuracy of the notch stress approach with ease of use of traditional nominal stress methods**

- Applicability
  - No modelling resrictions ✓
  - All certified methodologies ✓
- Accuracy
  - Notch stresses ✓
  - Effective stresses ✓
- Robust definition
  - Weld definition ✓
  - Weld detection ✓

# Magneti Marelli Sistemi Sospensioni

## Enhancing strength and durability of suspension structural components

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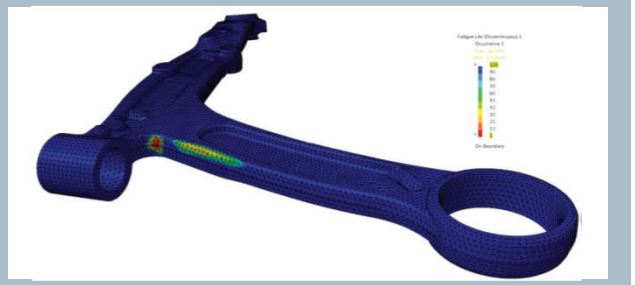
- **Enhanced strength and durability of components**
- **Optimized design before developing a prototype**
- **Enabled company to accurately predict the lifespan of components and assemblies**

**Using Simcenter solutions for durability analysis**



- Validate more design variants for fatigue life within shorter development cycles
- Use durability analysis to simulate performance of large and complex systems

**“What we appreciate about the Simcenter solution is reliability of the results. With the Simcenter solutions, for the first time we were able to accurately correlate with the bench test results”**

Andrea Santini, Head of CAE and Innovation

## The Digital Twin allow to

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# Challenges
## Materials and Manufacturing and Weight

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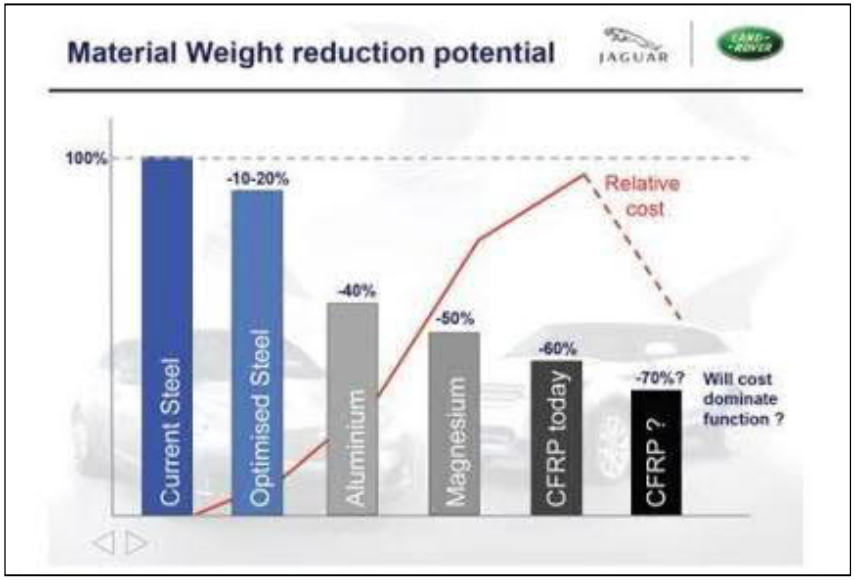
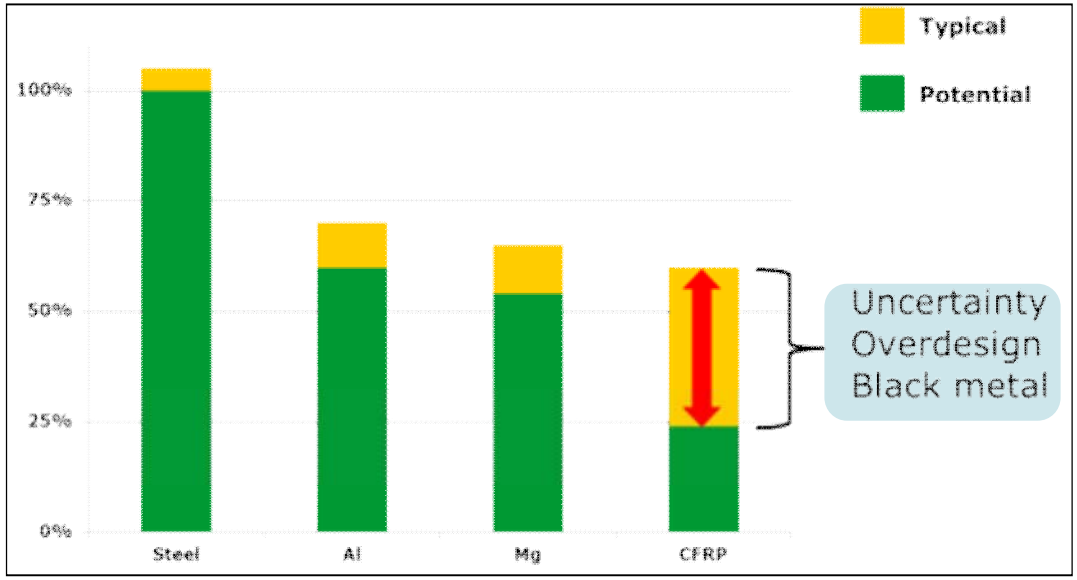
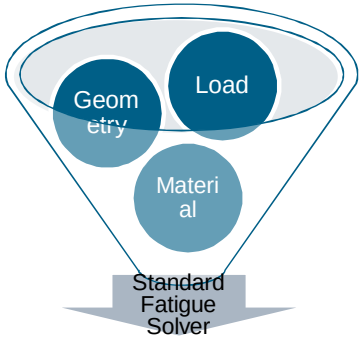
- New materials
  - New challenges
    - Need new methods



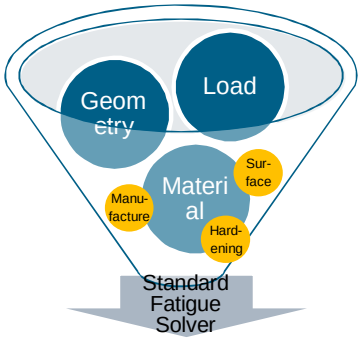




Source Mark White, JLR, Global Automotive Lightweight materials Conference, London, 2012

# Industry challenges
## Traditional idea fatigue simulation




Fatigue Results




Fatigue Results

Influence new materials and manufacturing processes are simplified

**Large safety factors**

**Over design**

# Production processes define material behavior

## Composites - examples

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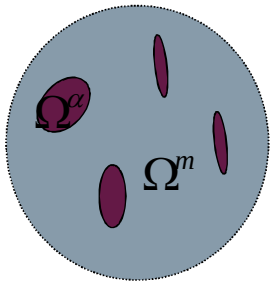
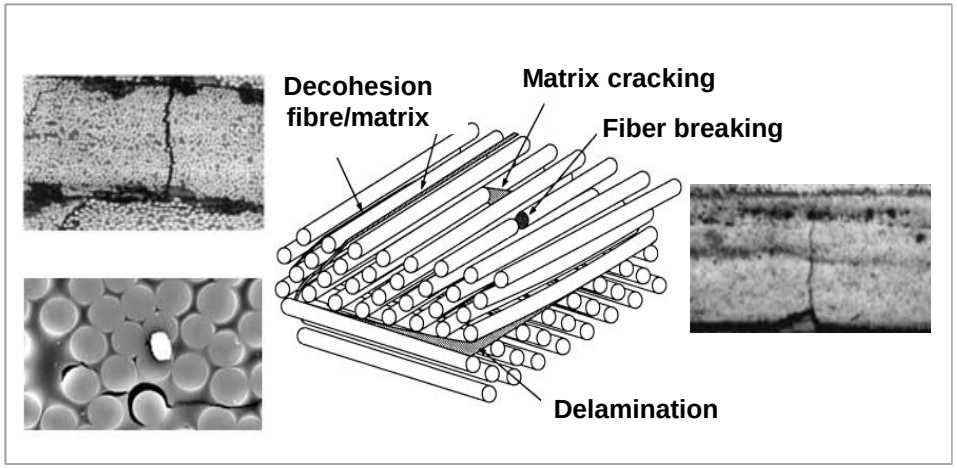
**Injection molding of random fiber re-enforces plastic**

Production process leads to locally statistically distributed fibers.




**UD or woven composites** not only fatigue behavior depends on manufacturing, but also damage modelling depends on different damage modes and materials.




**Using worst case apporaches leads to over design**

# Production processes define material behavior

## Additive manufacturing

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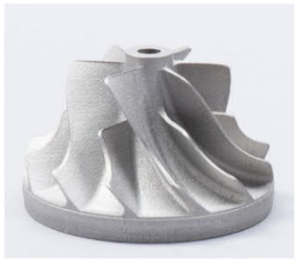
### Challenge

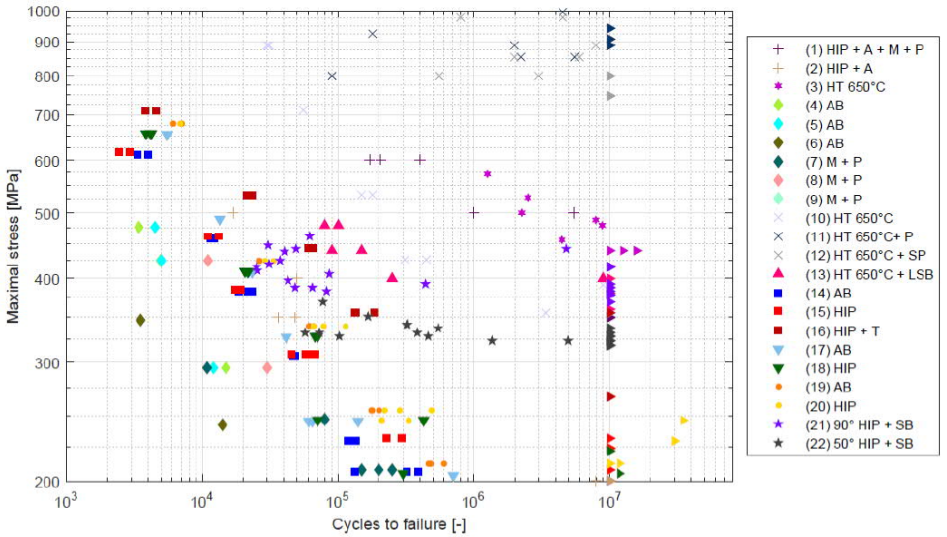
Fatigue behavior of 3D printed parts depends on many process parameters.

### Solution

- Isolate the influence of the parameters
- Simulation of the process to get the parameters



Literature Study – Fatigue Behavior of Ti6Al4V




- Different Stress Conditions
- Different Geometries
- Different Post treatments
- Different Build Orientations
- Different microstructures
- Different surface roughness

KU LEUVEN

9

## Ready for experts
Open Solver - Used in research and customer projects

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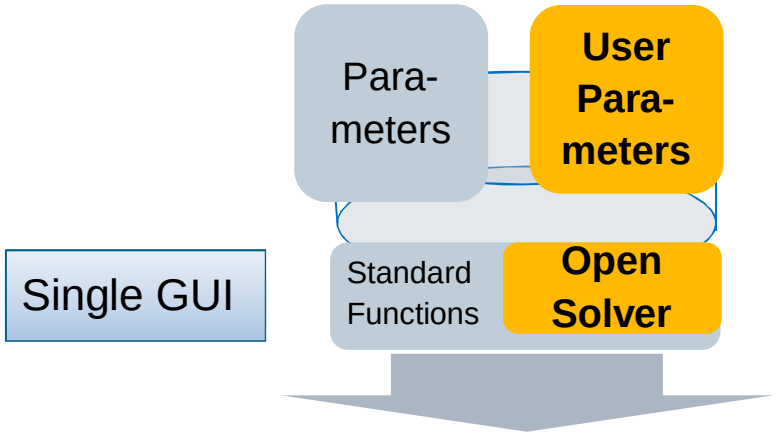
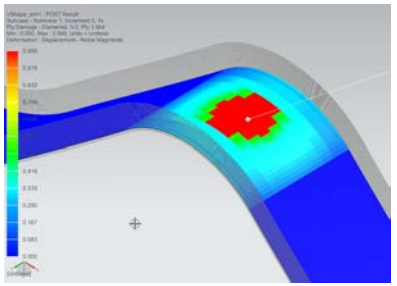
**Open Solver**
- One GUI
- One Pre and Post
- All interfaces to load and FE

- User defined methods
- User defined parameters



**Open but easy to apply for the end user**
**No overdesign**

# Honda R&D Co., Ltd.

## Innovation for progressive damage analysis in composite design

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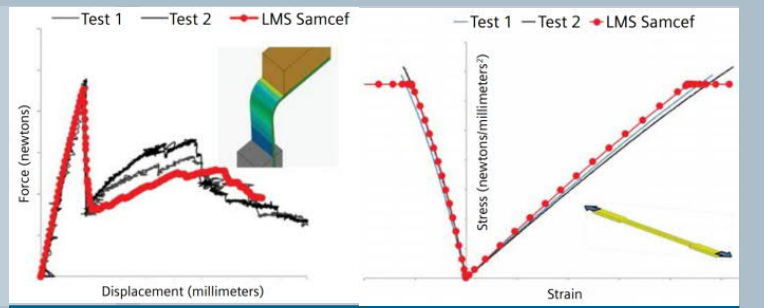
- **Predictive damage models at the coupon level and at composite subsystem design concept level**
- **Development of the parameter identification procedure, based on a limited amount of physical tests on coupons**

**Target: reaching 50 percent weight reduction by 2020 or 2030**

**Damage of a specimen after test**




**Innovative methodology for progressive damage analysis of composites**

- Simcenter Samcef non-linear finite element solvers for accurate modelling
- Simcenter Engineering Services for composite damage model identification

**"Not only at Honda, but many engineers in this field think that we can still make vehicles that have a 50 percent lighter body structure using composites while maintaining the mechanical properties of the replaced metallic parts."**

Yuta Urushiyama, Composite body innovation programs Honda R&D Co., Ltd.

# Simcenter for Vehicle Performance Engineering

## Vehicle Strength & Durability

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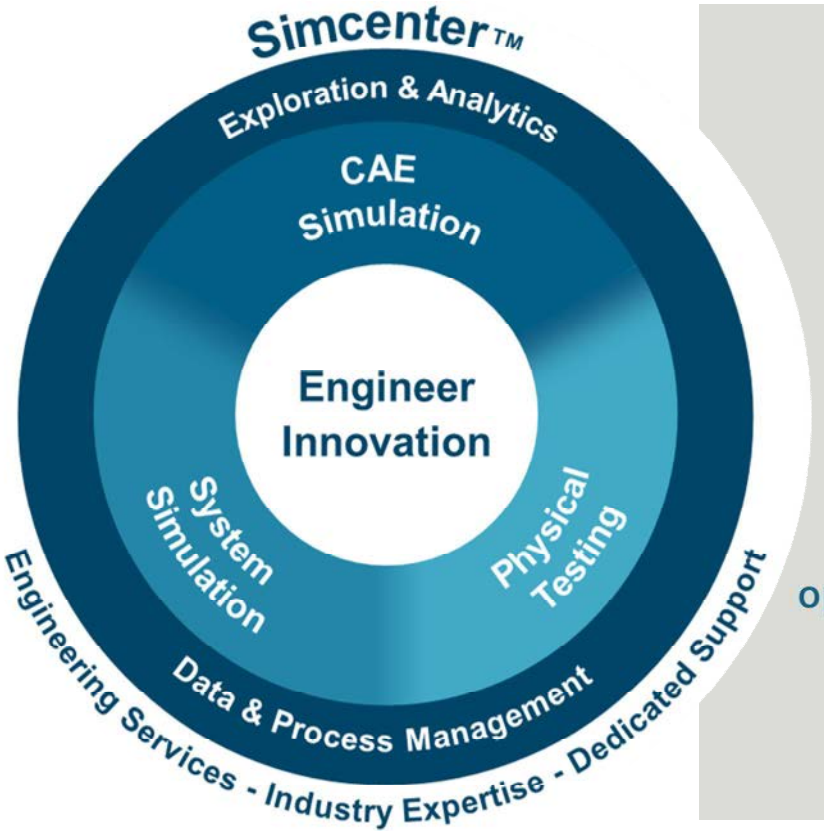


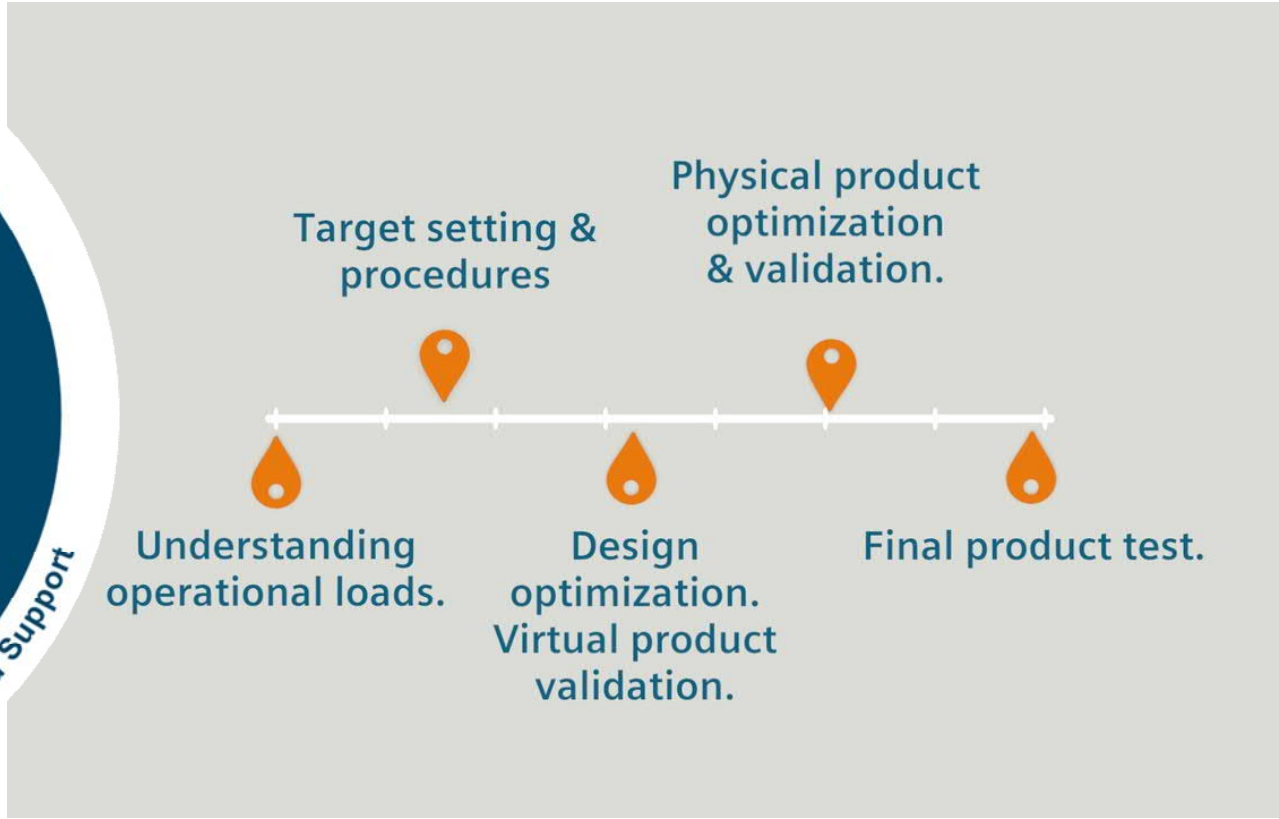

# The new era of durability engineering
# Deliver lighter, stronger and more durable vehicles

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## Simcenter solutions

- end-to-end durability engineering approach
- accelerate time to market
- balance weight, strength & durability
- avoid vehicle recalls
- meet customer's expectations.

# Thank you! Want to know more?

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## Read more

## Explore, share and learn

## Watch videos


## Contact the expert