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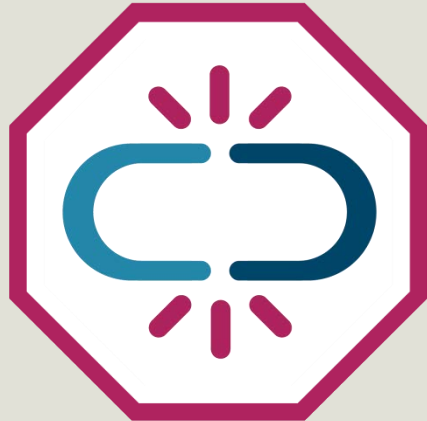
**Accelerate your CAE vehicle
structural analysis process**

Unrestricted

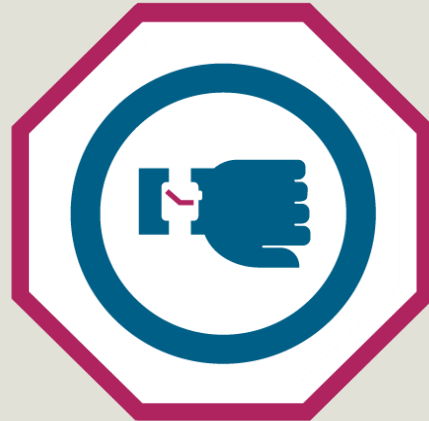
www.siemens.com/simcenter



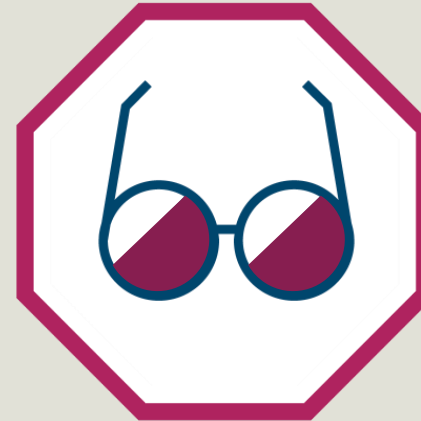
Issues faced by CAE departments



Disparate tools and inefficient workflows



Results out-of-synch with design



Limited visibility and business impact



Budget and resource constraints

“30% of analysts’ time was spent seeking or providing information and a further 32% was spent in discussions or meetings.”

Source
Rolls-Royce Aero-Engines, “How analysts spend their time (HASTT)” study

What do CAE departments need?

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✓ Single simulation platform integrating CAD and CAE

✓ Automation, Scalability and Openness

✓ Embedded, fast, accurate solvers to cover all disciplines with one model

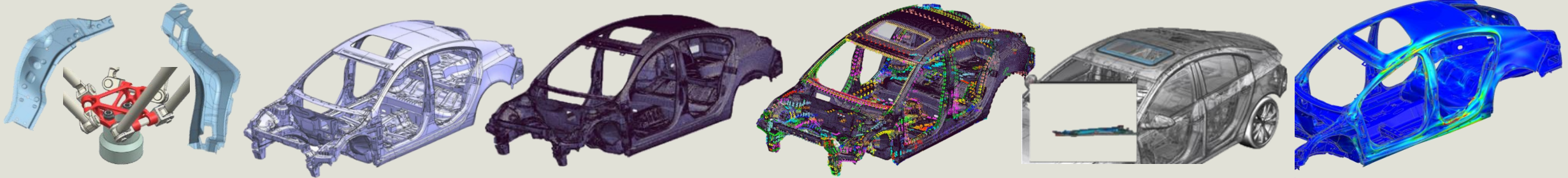
✓ Simulation Data Management

Simcenter Solutions to streamline Structural Analysis Process



Design

CAE



CAD

Model Preparation

CAE Simulation

Post-Processing

Disconnected from CAE

Manual and Error-Prone

Siloed, Disconnected



Too Late!

CAD

Model Preparation

CAE Simulation

Post-Proc.

CAD integration
In sync with CAE

Mesh / Assembly Automation
Application-specific
assemblies

Solvers Integration

Automated
Reporting

CAD data
management

Structure Management
and Automation

Tool and
Process
Management

Results
Communication

CAE process time reduction

- ✓ Get CAE results in sync with design updates
- ✓ Use CAE for optimization instead of validation
- ✓ Increase value of CAE work in vehicle development process



Simulation Process and Data Management

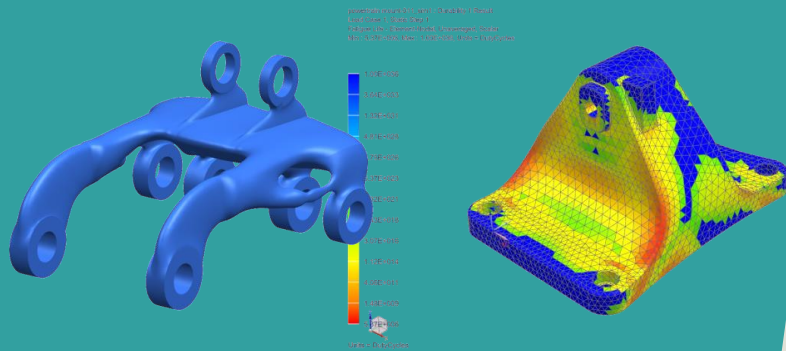
Simcenter Solutions to streamline Structural Analysis Process



Integrated Simulation Platform

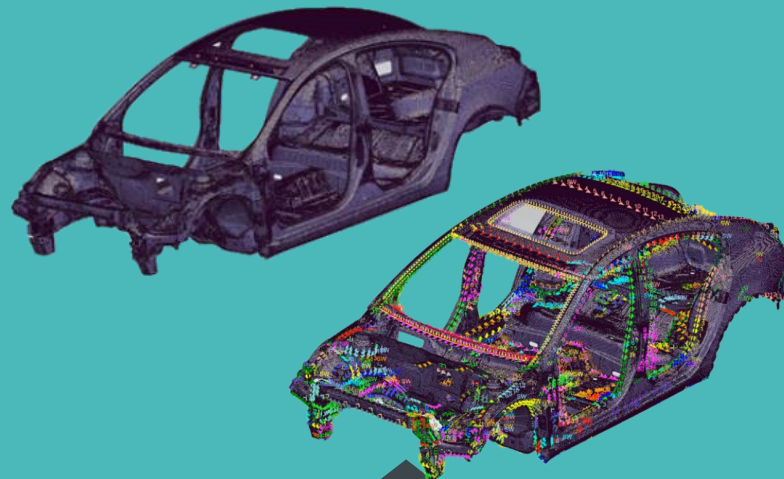
Simulation-Driven Design

Democratize CAE engineering in CAD departments to get optimal design early in the process



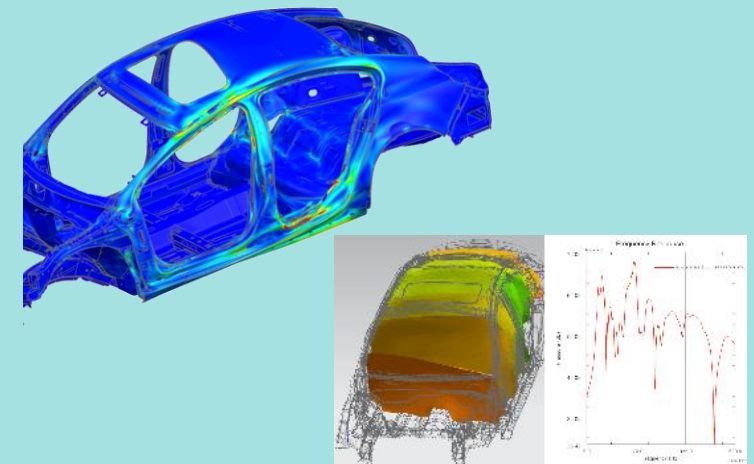
Model Build Automation

From CAD Bill-of-Material to BIW assembly FEM in days instead of weeks



Multi-Discipline Simulation

Integrate fast and accurate solvers to balance vehicle attributes

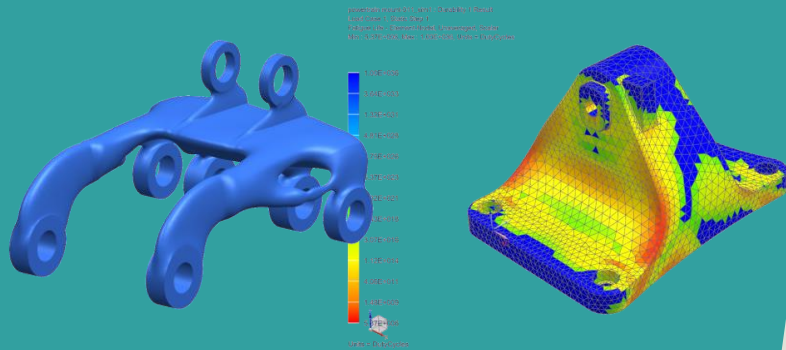


Simulation Process and Data Management

Integrated Simulation Platform

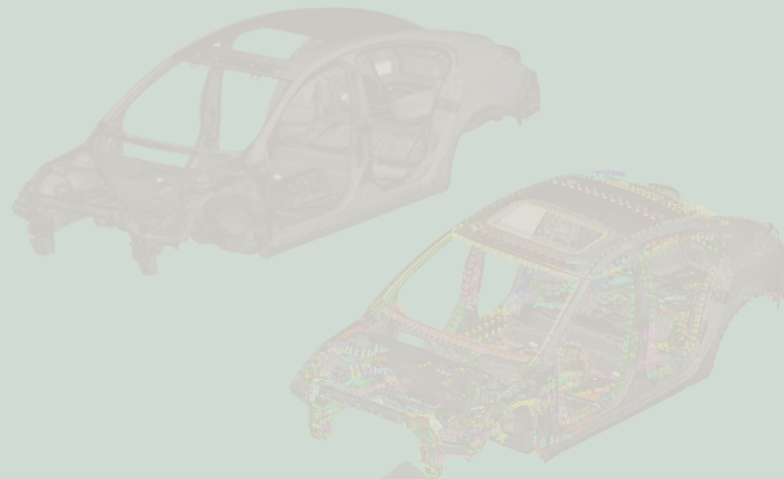
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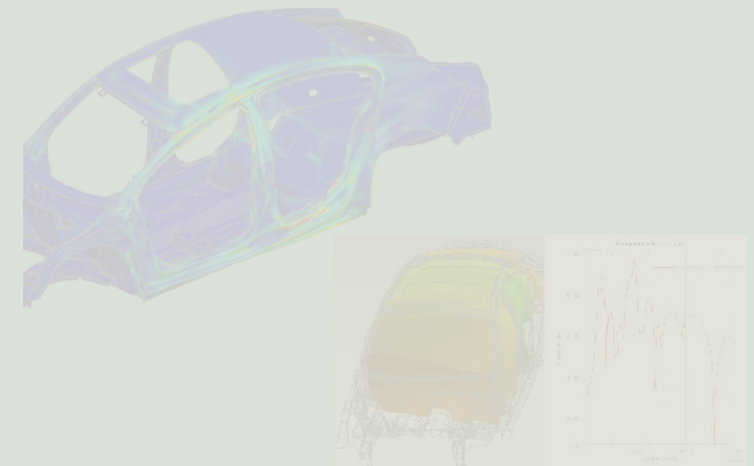
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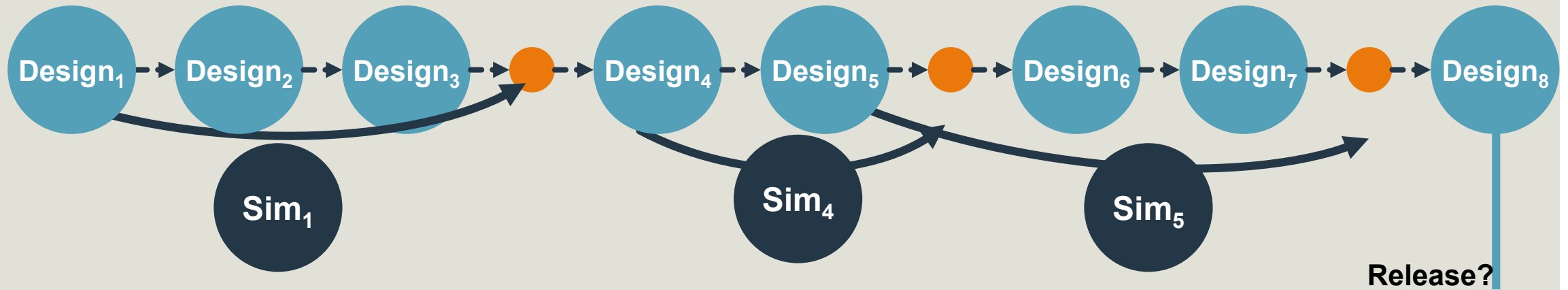
Integrate fast and accurate solvers to balance vehicle attributes



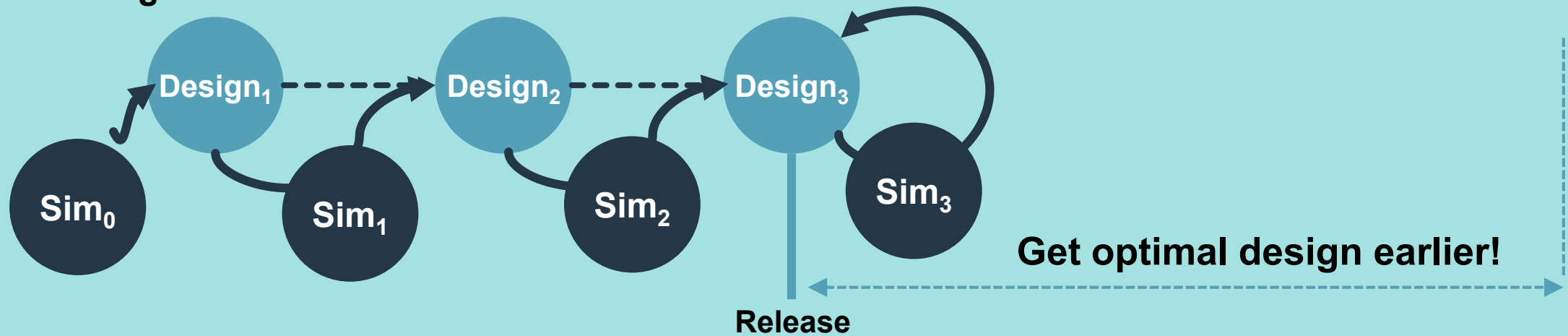
Simulation Process and Data Management

Frontload simulation

Typical CAD-CAE Process

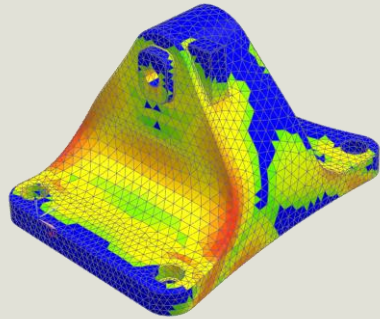


With design-embedded simulation

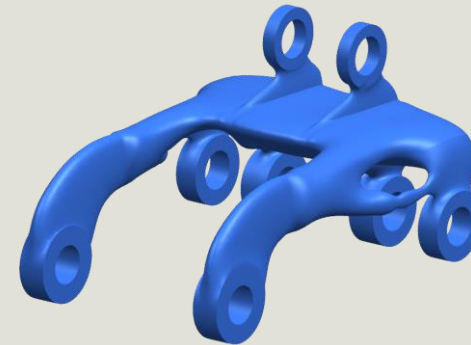


How to implement simulation driven design?

powertrain mount-011_sim1 : Durability 1 Result
Load Case 1, Static Step 1
Fatigue Life - Element Model, Unaveraged, Scalar
Min : 5.37E+006, Max : 1.00E+036, Units = DutyCycles



Simplified, Guided Simulation



Topology optimization

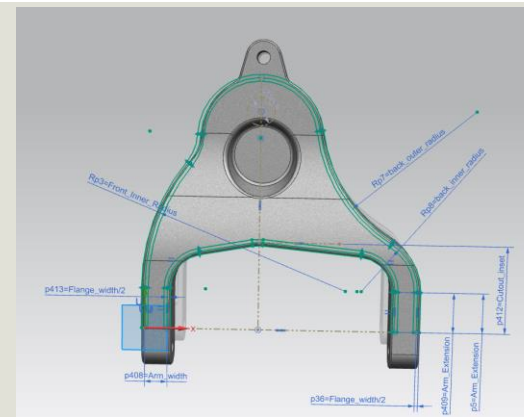
Specialists and Simulation Experts

- Capture best practices
- Author automated processes

Designers / Design Engineers

- Consume automated processes
- Guided through analysis
- Immediate, qualitative feedback on design performance

Automation of Process and Best Practices



Design Space Exploration

Hendrick Motorsports

Deliver high-performing, durable components in time for the next race

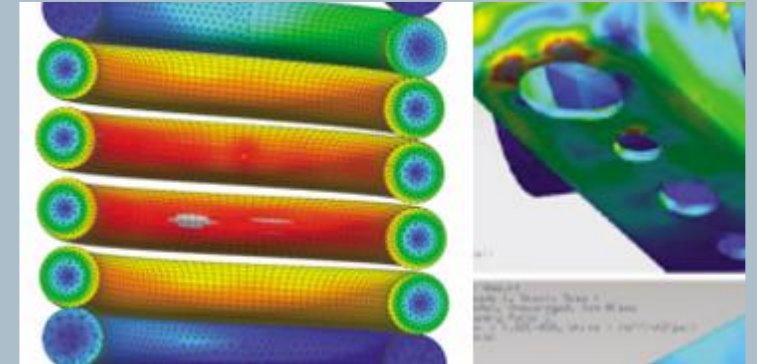


- Developed understanding of underlying physical behavior that caused failures
- Rapidly designed and analyzed multiple solutions
- Delivered high-performing, durable components in time for the next race

Providing the tools for victory



Precisely engineered



Valve spring stress & yield on suspension

- Integrated NX design and Simcenter 3D analysis environment
- Rapid and automatic updating of analysis models for faster design-analysis iterations

“The ability to turn designs into real hard parts is critical for us and the Simcenter 3D suite helps support every facet of that.”

Jim Wall, Director, Engine Engineering

Simcenter Solutions to streamline Structural Analysis Process



Integrated Simulation Platform

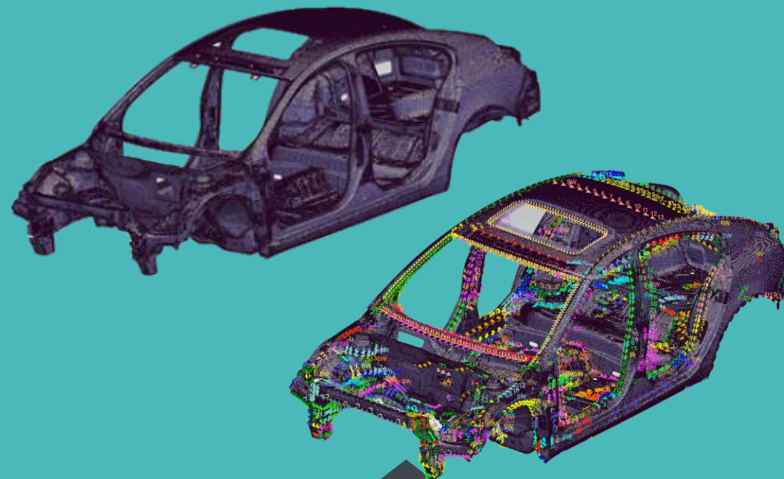
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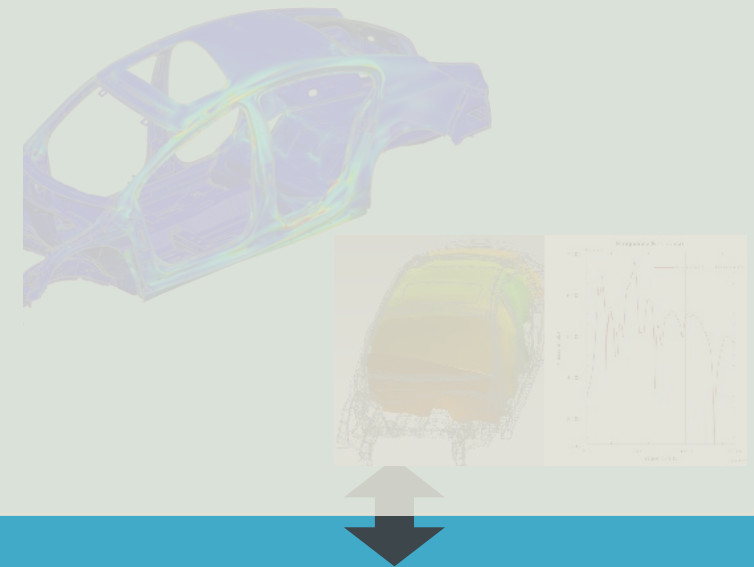
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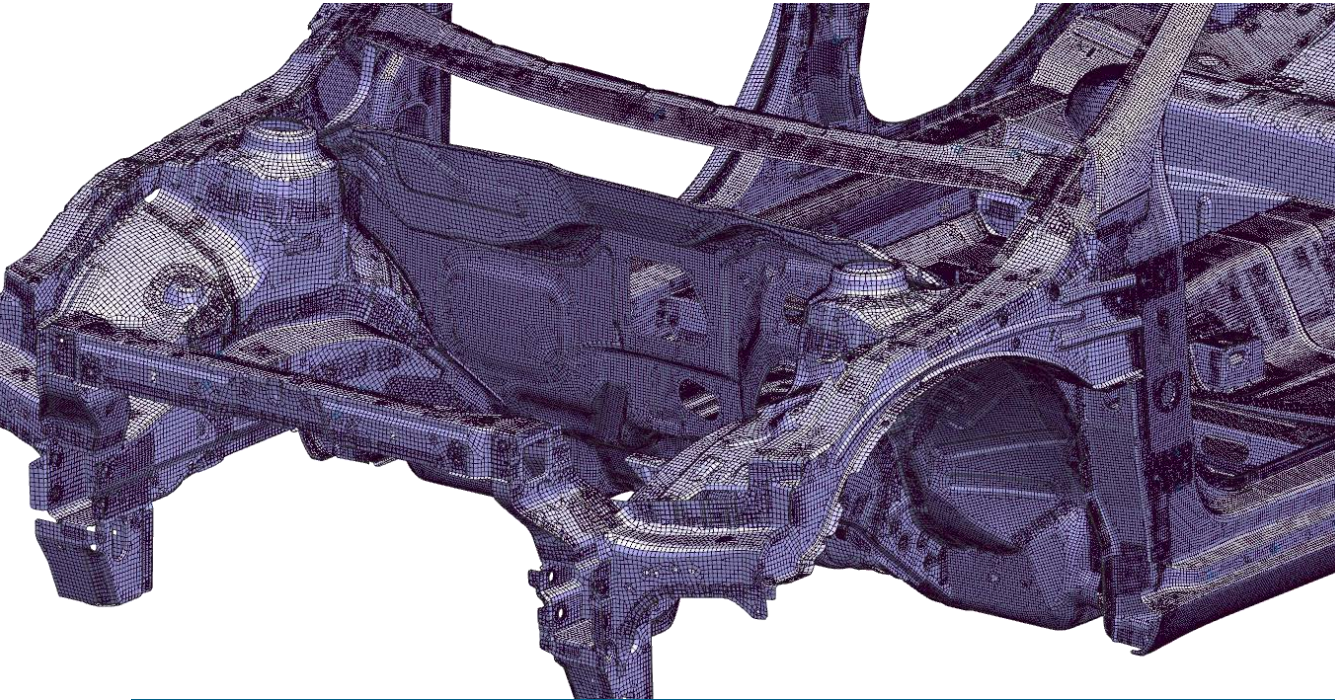
Integrate fast and accurate solvers to balance vehicle attributes



Simulation Process and Data Management

Assembly Model Build

Typical Process and Challenges



Retrieve up-to-date CAD data

Import CAD data into CAE environment

Adapt geometry to CAE

Generate a high quality mesh for every component

Select components, connect them

Share large models with analysts

Large amount of non-managed data
Too much manual work
→ ***Models are coming too late***

Model Build Automation Proposed Workflow

Integrated Simulation Platform

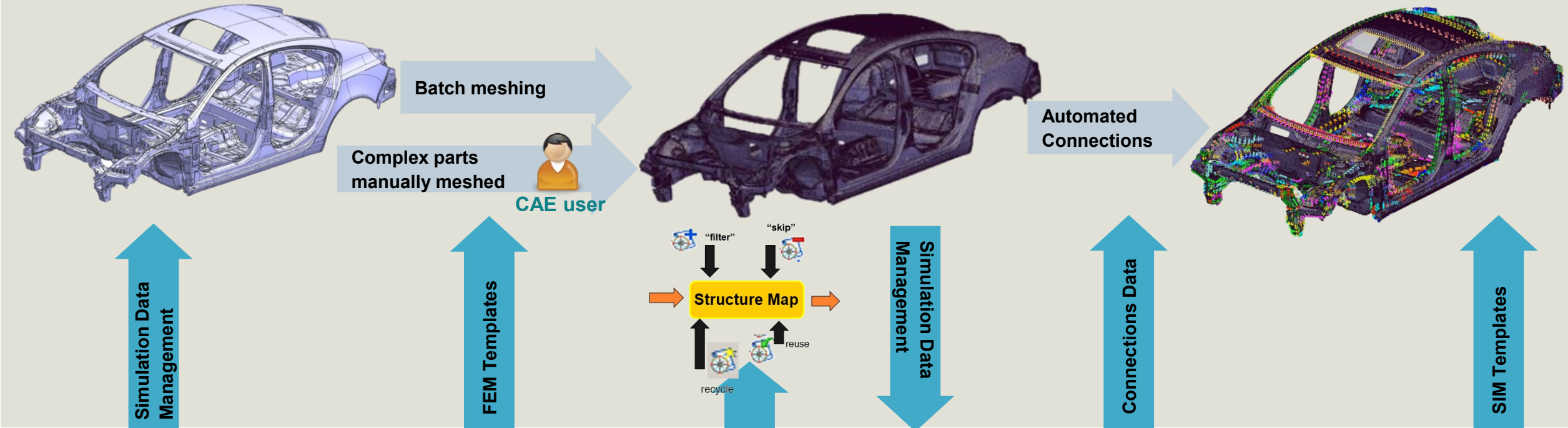
CAD Bill of Material

Components FE Models

FEM Bill of Material

Assembly Model Build

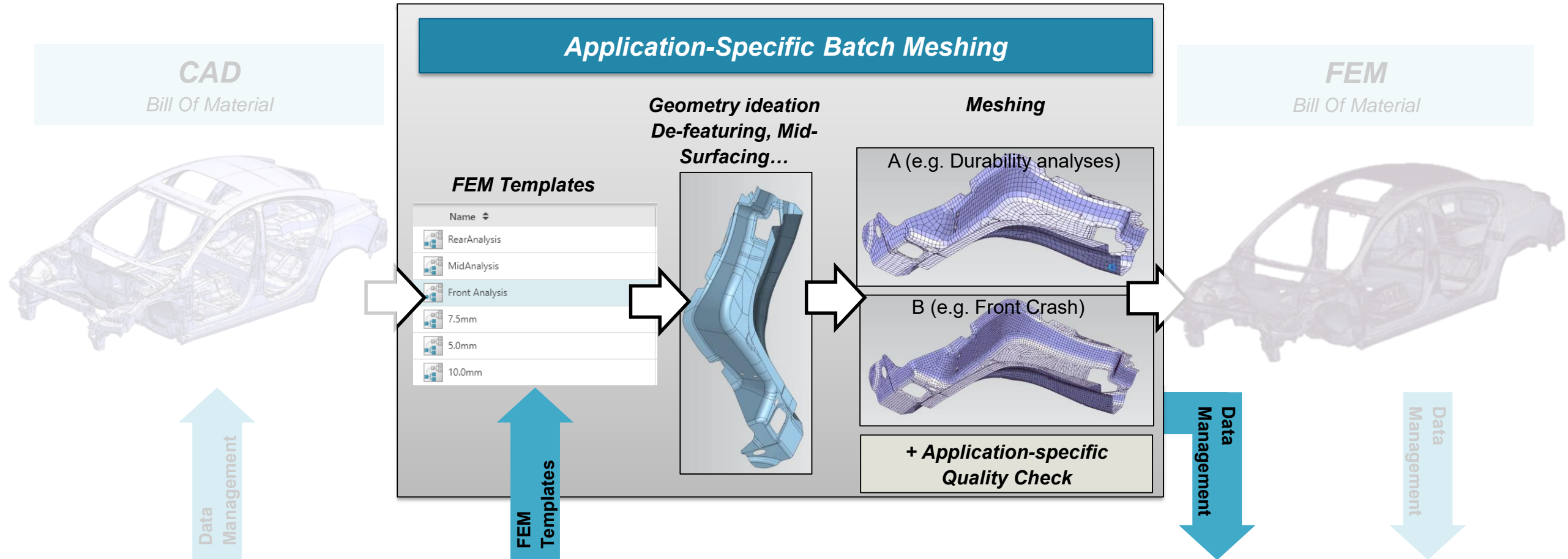
Loads & Boundary Conditions



Simulation Process and Data Management

Batch Meshing Workflow Automation

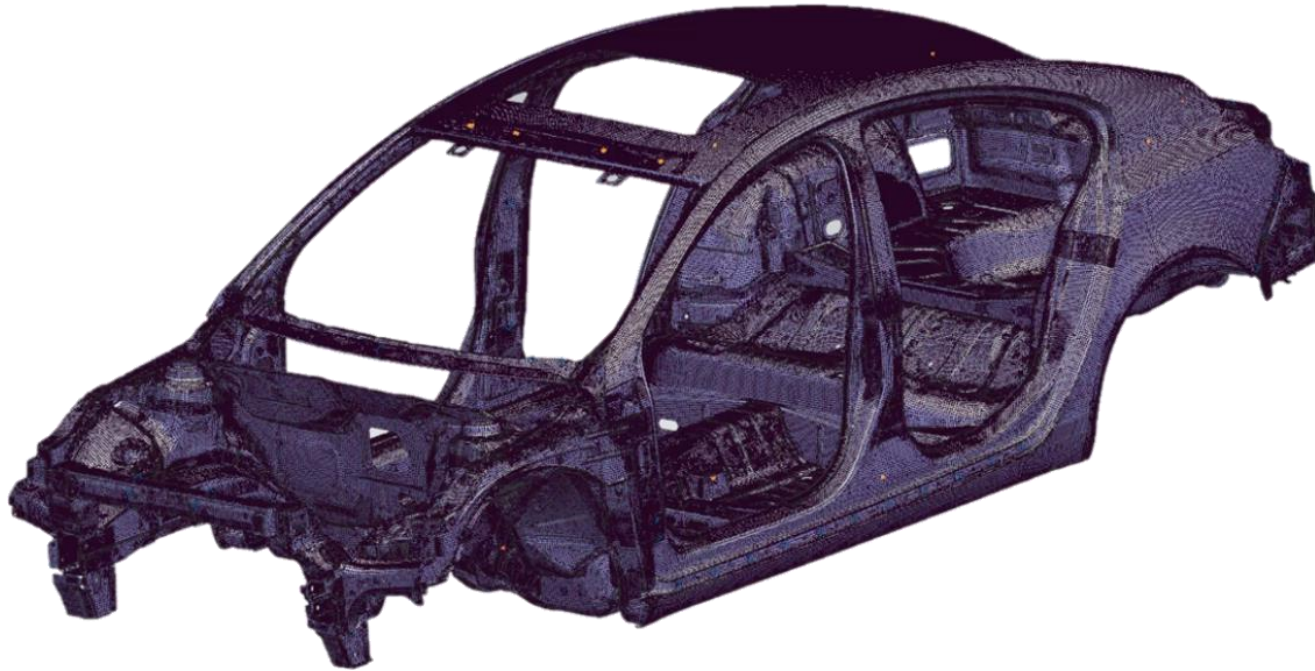
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Simulation Process and Data Management

Batch Meshing

Application: Full Body in White model with 250+ components



- **Different FEM templates (mesh size, elements types...)** depending on target applications and components locations
- **Meshing Quality**
 - *95 to 98% of components meshed automatically with sufficient quality for target application*
 - *Remaining 2 to 5% of components efficiently revisited by CAE user*

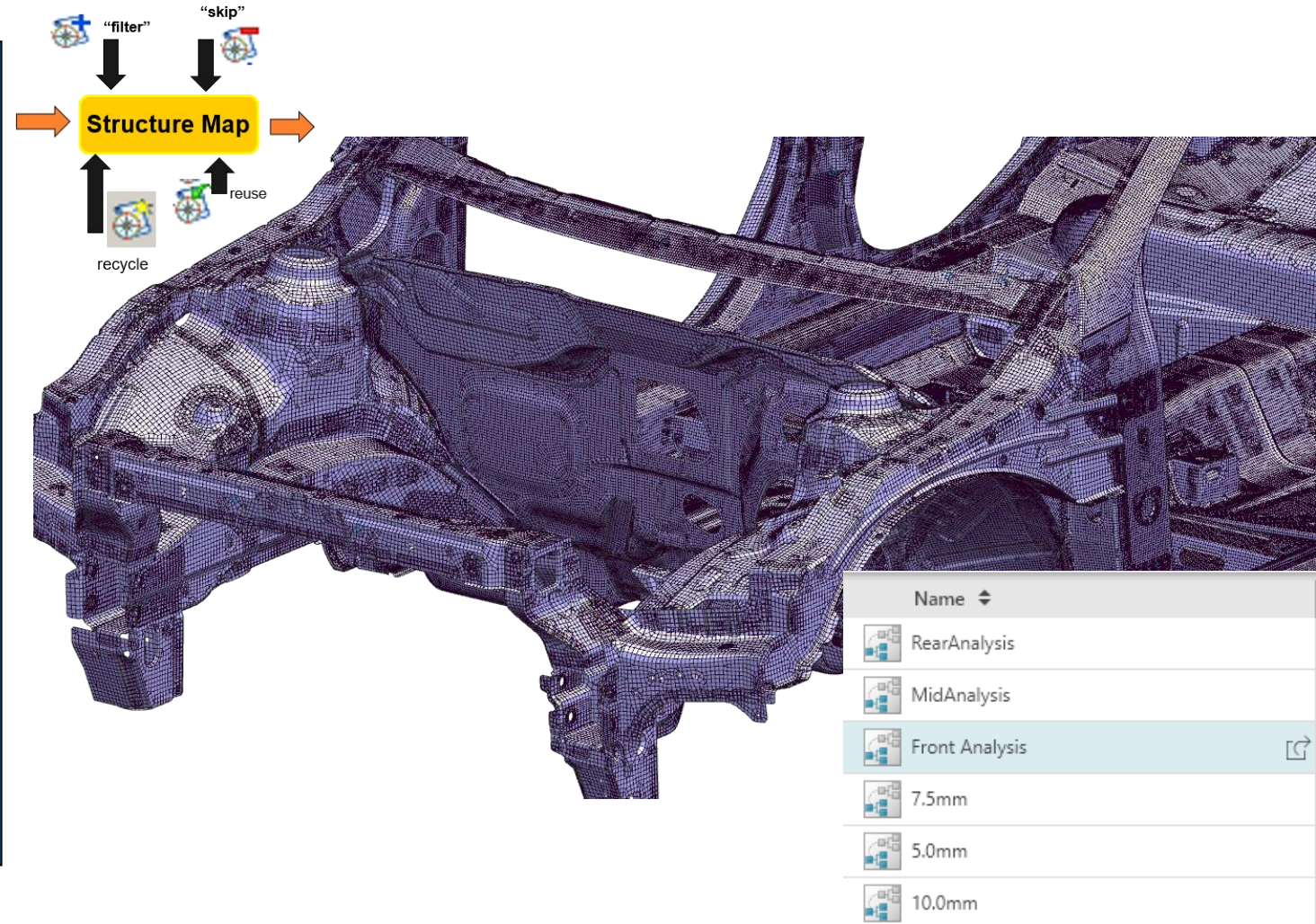
- ✓ **Very good mesh quality generated from automated template, thanks to geometry de-featuring and high quality mesh**
- ✓ **Very limited user interaction: few components to be re-visited by user**

Assembly Models Templates

Define CAE structure maps to repeatedly generate assemblies with the right data

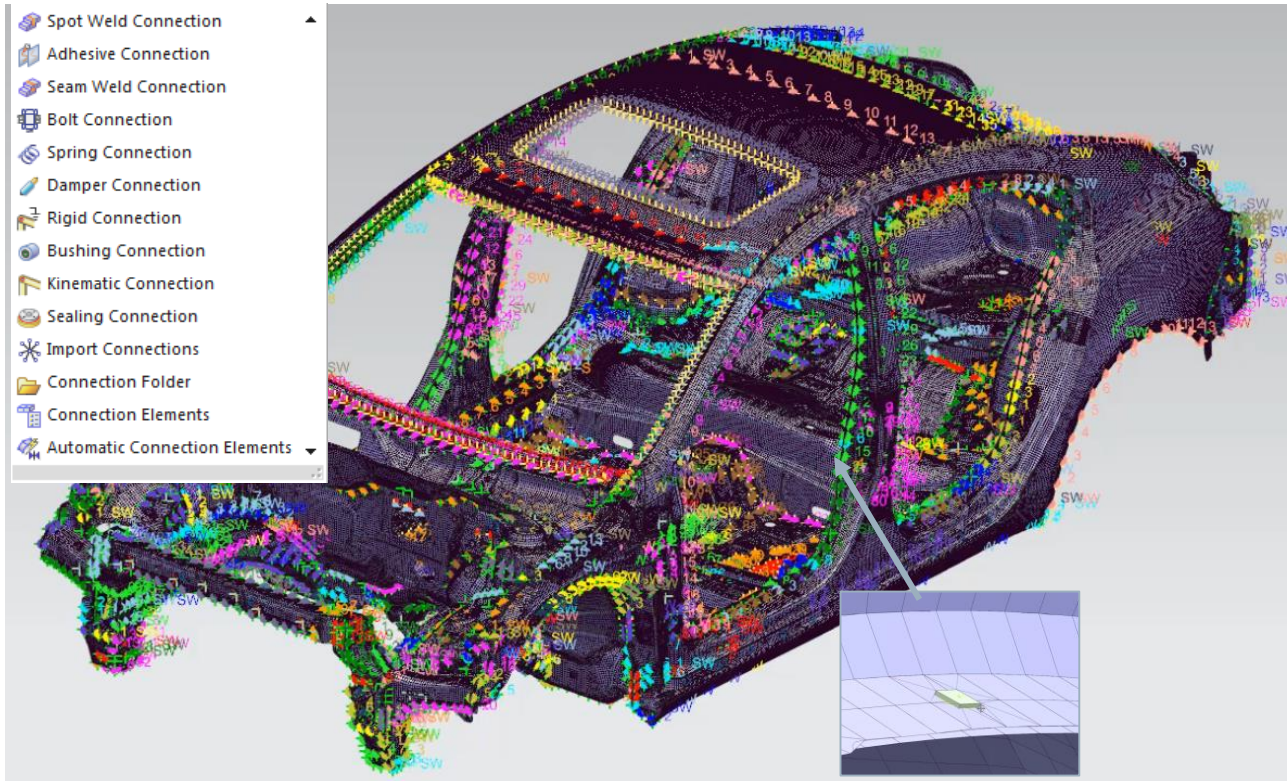
CAE Structure Maps: Template to automatically build CAE assemblies based upon rules

- Select, Skip, Re-use, Filter components from the FEM Bill-of-Material, depending on application
- Skip sub-assembly nodes of the CAD assembly
- Automatically generate CAE models for missing components or filter them out to exclude them



CAE Assembly automation and connections

Assembly Connection Modeling



Challenge

- Bodies typically contain 200+ components connected with various types of connections
- Typically thousands of connections locations

Solution

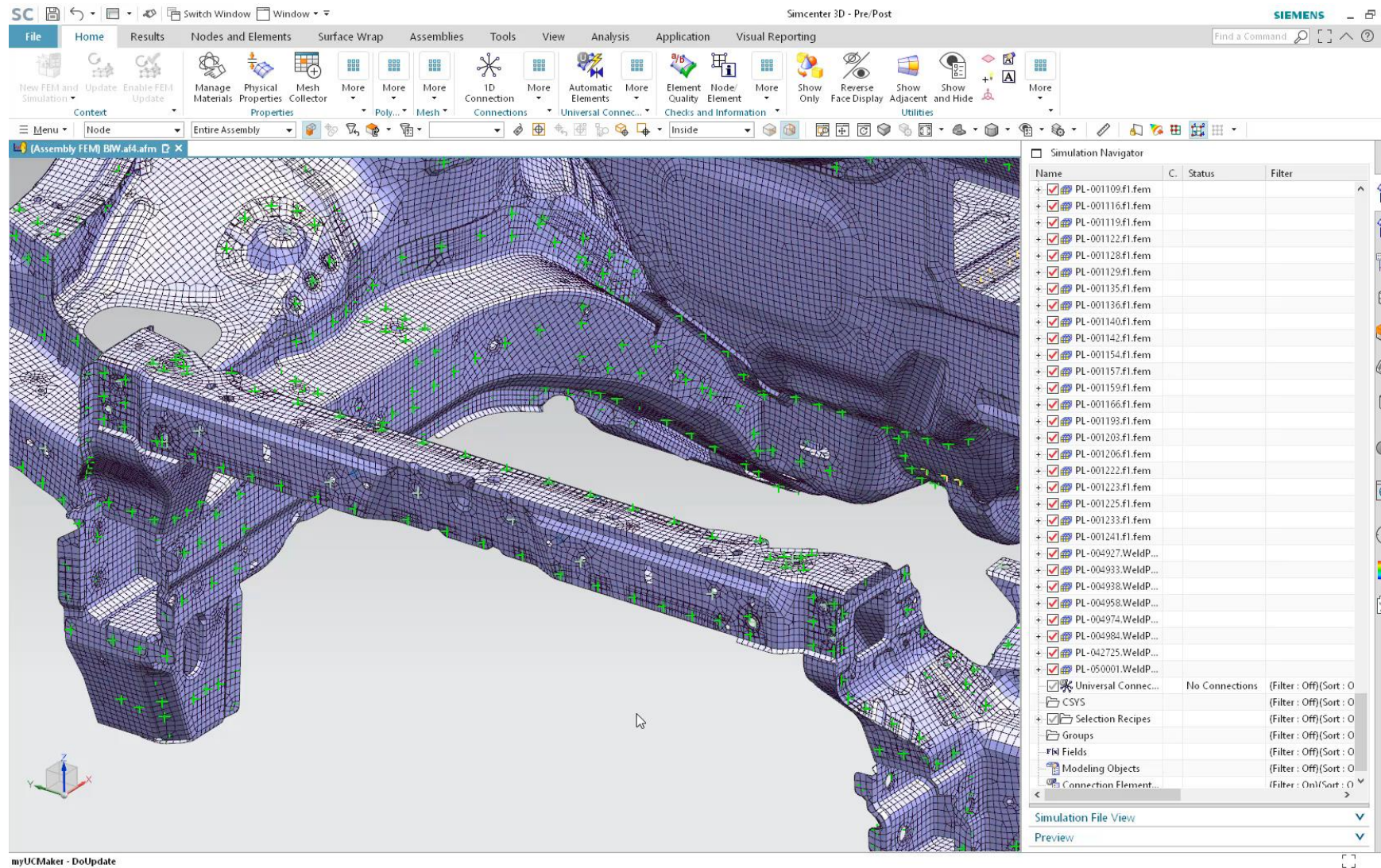
- Automated CAD-associative generation of connections of various types
- Multi-solver and attributes support

- ✓ Drastic reduction of spent time (from days to seconds)
- ✓ No human mistake (automation)

CAE Assembly automation and connections

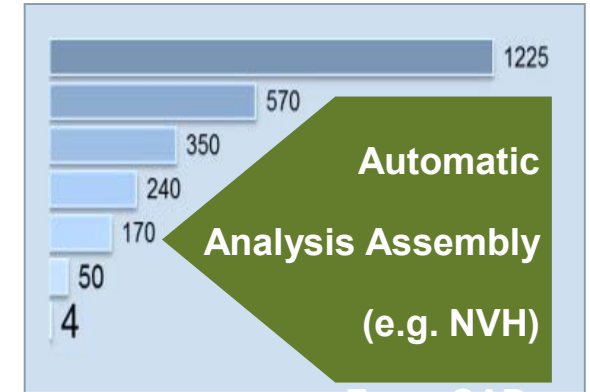
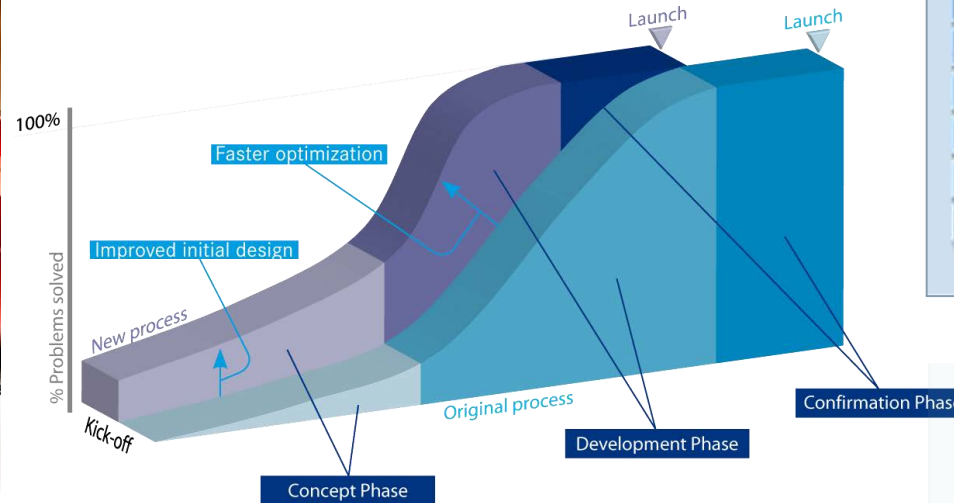
Assembly Connection Modeling

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Siemens 3D Simulation

Mitsubishi Motors Corporation (MMC): Record Model Build Times



- Creation of Vehicle “Digital Twin”
- Minimize time required for model creation
- Automate CAE model creation from CAD
- Accelerate design improvement process
- Increase model quality and reliability

“Mitsubishi compressed the development cycle and realized a major leap forward in shortening time to market and lowering cost & managed to save a full prototype cycle, without a single compromise on the final vehicle quality”

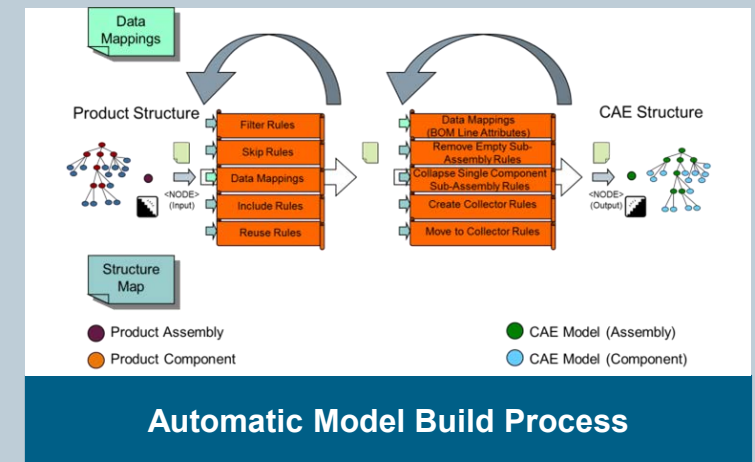
Hiroataka Shiozaki - Mitsubishi Motors Corporation

Ford Motor Company

Automating the Model Build Process



Efficient, Global CAE Simulation Management Implementation in Place



8X Performance increase of key steps:

- Initial “overhead” for CAE simulation management of BIW CAE model became close to zero
- Overhead costs was more than offset by downstream benefits

- Full integration with PDM solution, minimal extra IT effort
- Use of out-of-the-box un-customized solutions wherever possible
- CAE Software integration provides user efficiency gains compared to original solution

“...Siemens ... was a natural choice as the vendor of our PDM system. We had the idea of full integration from the start... [Siemens] gave us the benefit we expect from this integrated, enterprise solution.”

Dr. Ulrich Fox, Manager Mesh Development Group

Simcenter Solutions to streamline Structural Analysis Process



Integrated Simulation Platform

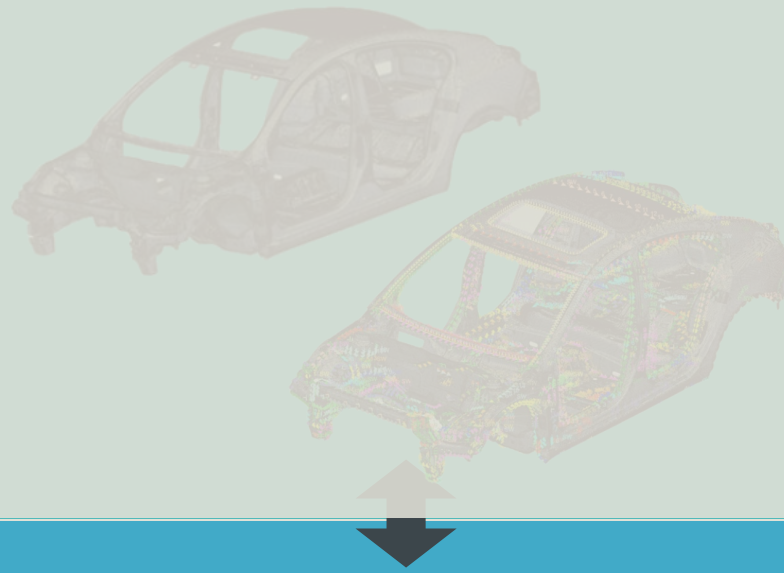
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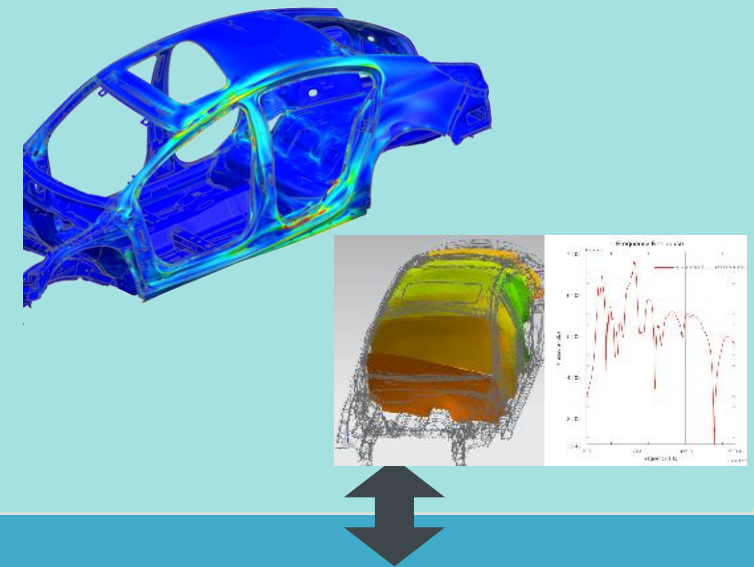
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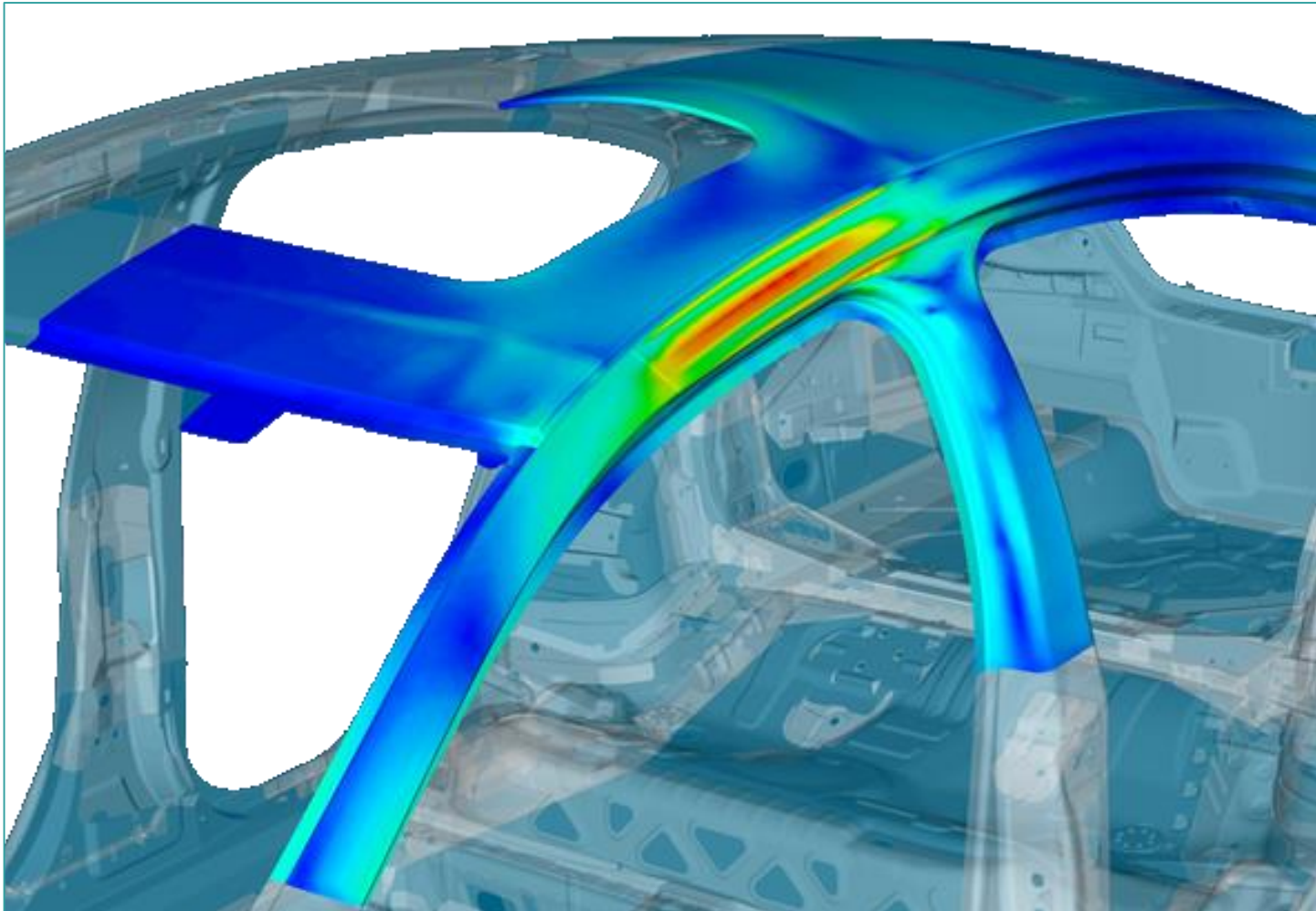
Integrate fast and accurate solvers to balance vehicle attributes



Simulation Process and Data Management

Vehicle Structural Analysis Challenges

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Typical Applications involving
Multiple physics

Different platforms and solvers
typically used across departments

Solver performance and convergence

Solver Selection (Static, Dynamic...)
and Parameters

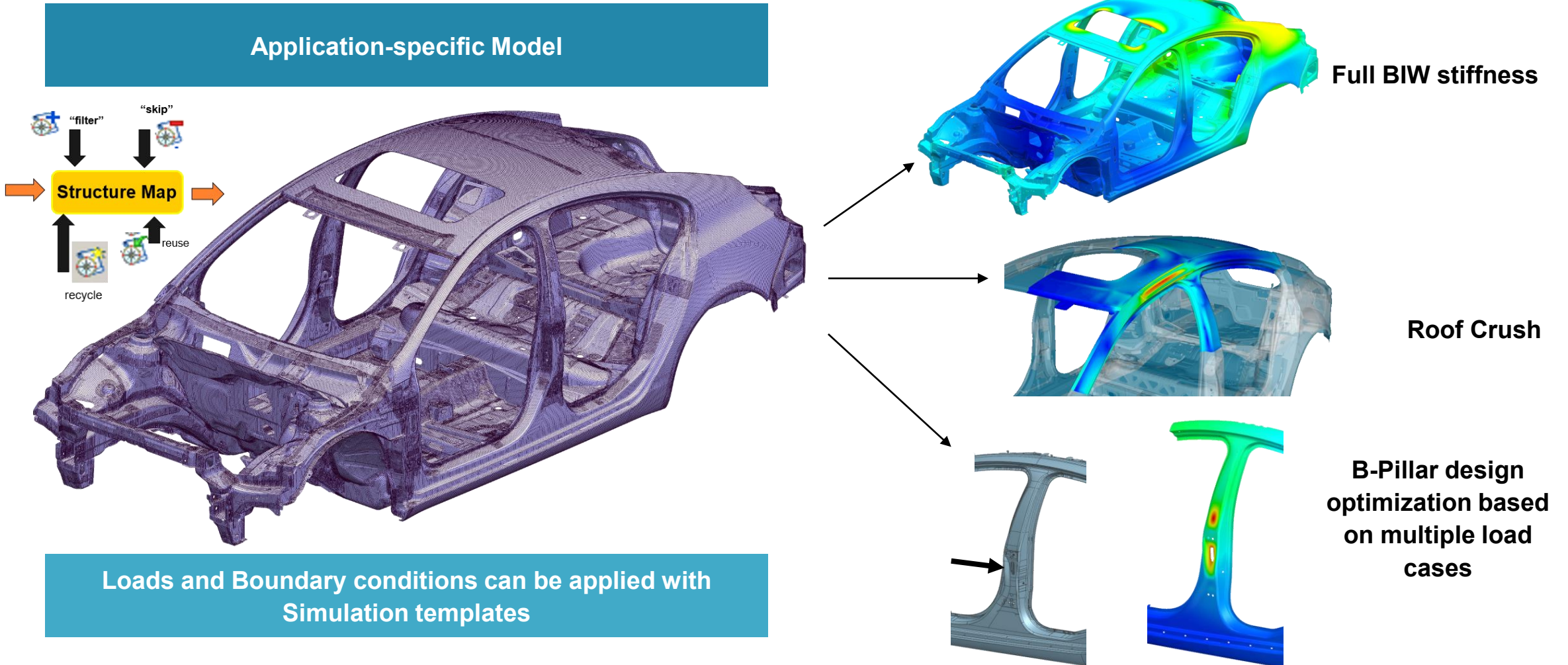
Many types of nonlinear materials in
vehicle structure

Process for Optimization

Body design with structural analysis

Examples

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LOHR Industry

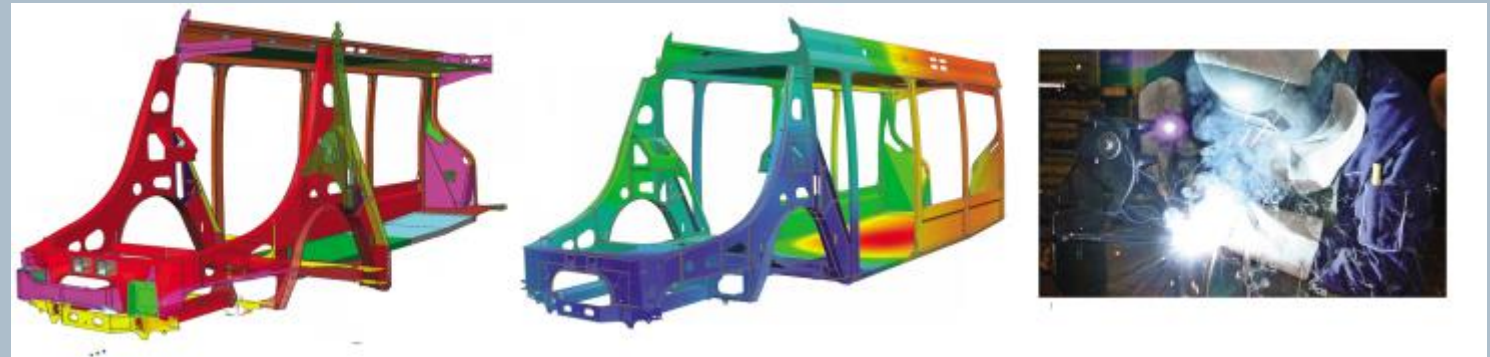
Ensuring product quality and integrity

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- **Successfully entered new target market**
- **Realized 60 percent time savings in model preparation**
- **Accelerated workflows through real-time design and approval**

Accelerating analysis for large welded assemblies



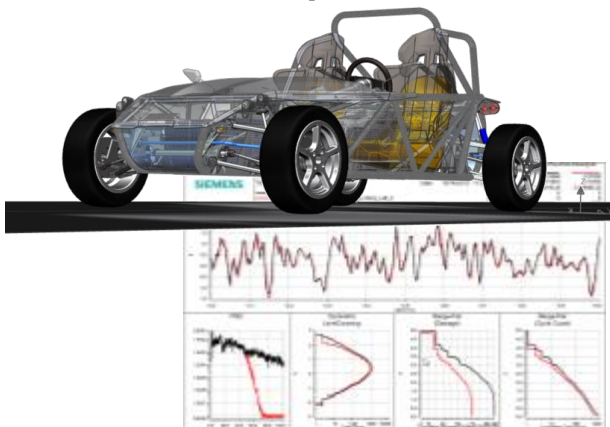
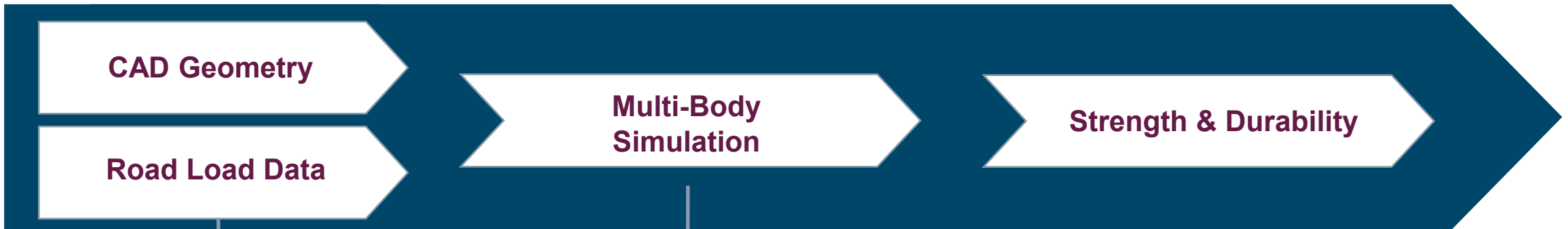
- Integrated NX and Simcenter environment for design and simulation
- Full 3D mathematical modeling and wider use of CAE to ensure product integrity

“We spend about 75 percent of the simulation time in model preparation. Using the automated process enabled by NX and Simcenter 3D, we cut about 60 percent of the model preparation time.”

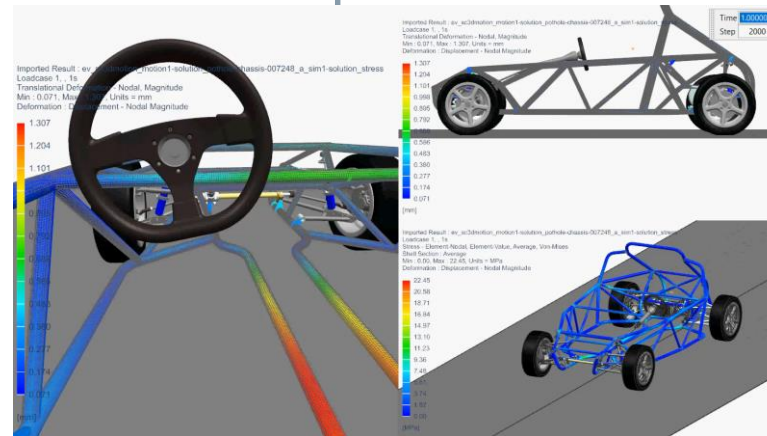
Patrice Klein, Simulation Manager, LOHR

Chassis Strength and Durability

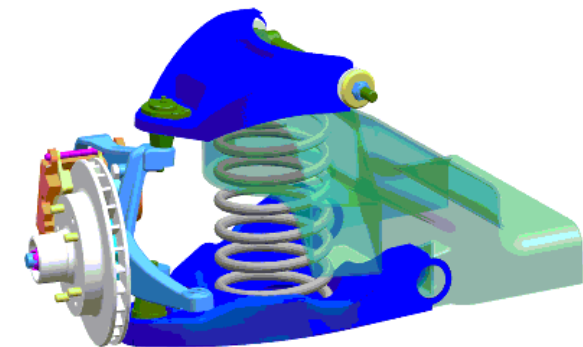
Example: Pot Hole or Sidewalk



Structural model (Rigid + Flexible) and measured road load data



Motion loads Prediction

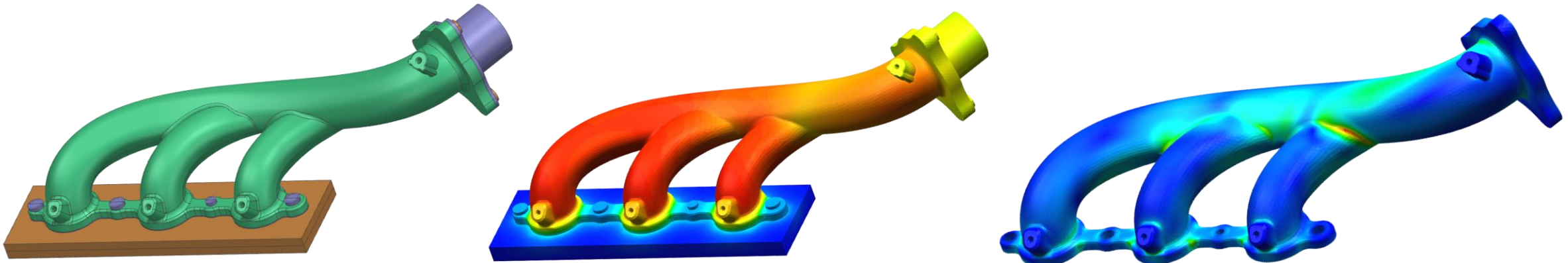


Strength & Durability

Fast Optimizations

Powertrain applications

Prevent fatigue of exhaust manifold due to temperature stress



FE Model for CFD (incl. boundaries) and for CAE

Derive Heat Transfer Coefficient and Temperature

Transient simulation → Temp. & Pressure distribution

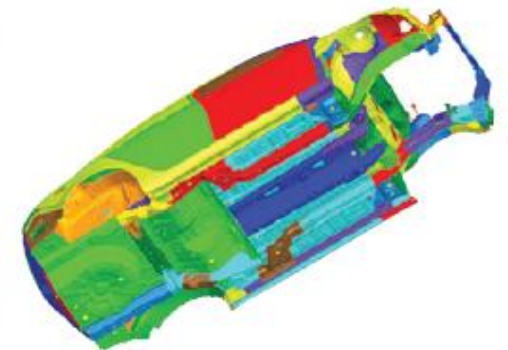
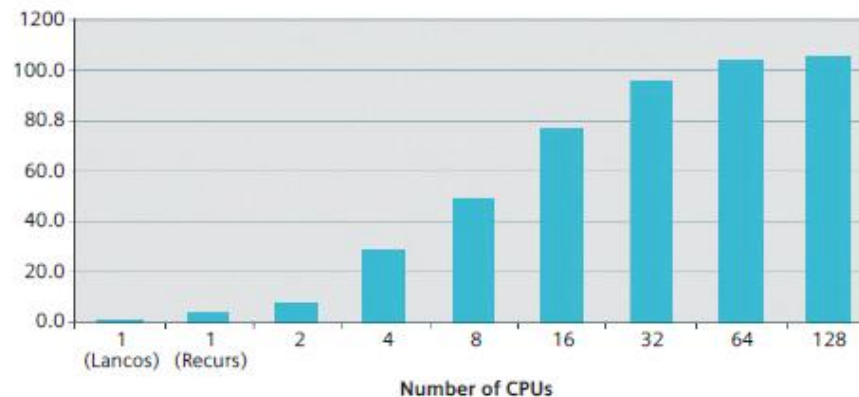
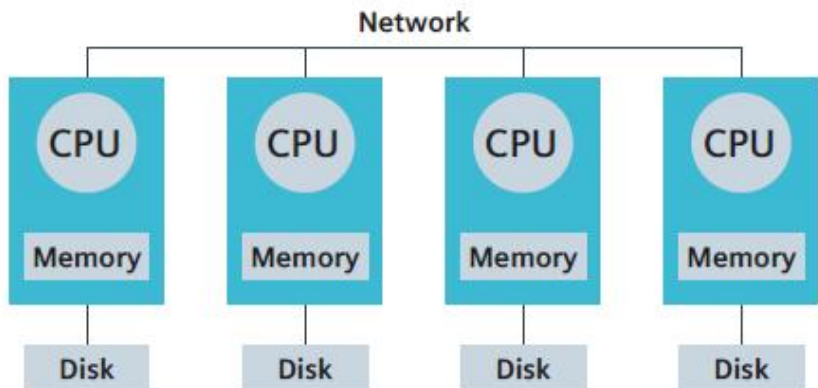
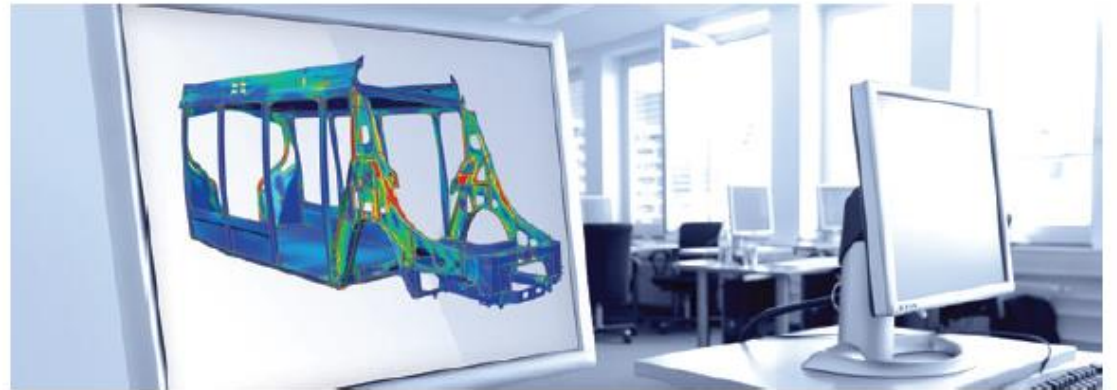
Stress / Fatigue maps
Lifetime prediction

Fast Optimizations

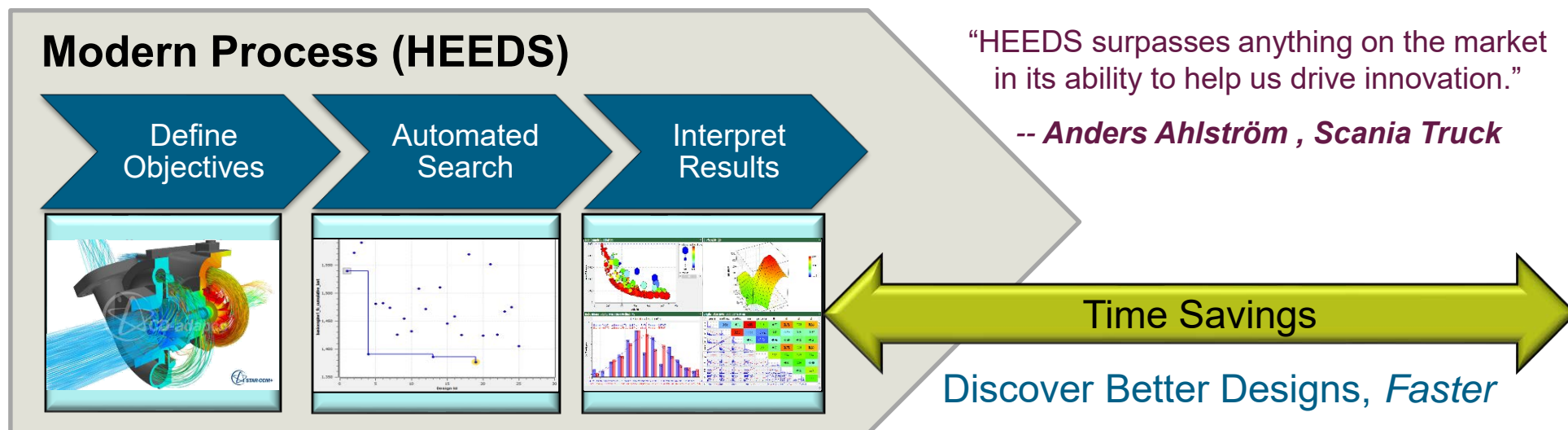
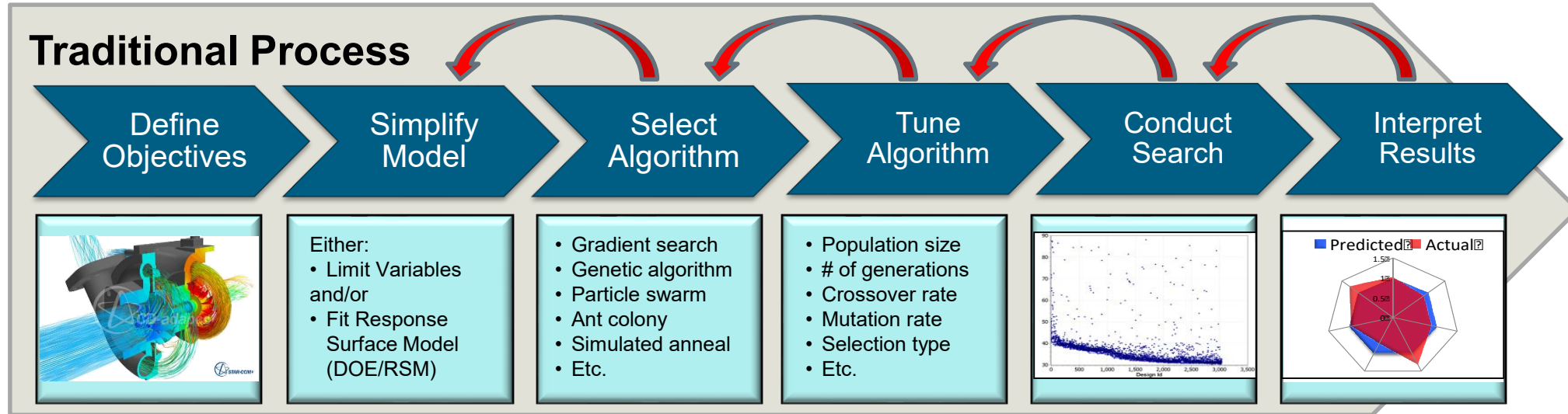
Solve large models efficiently

- Simcenter Nastran DMP: Parallel processing using distributed memory
- Can be used in combination with SMP
- Available for Static, modal eigen-value, modal dynamic response, direct frequency, and nonlinear solvers

More cores provide faster solution



Accelerate Structural analysis process with Design Space Exploration



Simcenter Nonlinear solvers

Material laws

Linear and nonlinear elasticity

- Isotropic, Orthotropic, Anisotropic

Plasticity

- Temperature-dependency
- Bilinear, Multi-Linear
- Isotropic, kinematic or mixed hardening

Hyper-elasticity

- Mooney Rivlin, Ogden, Foam
- Mullins effect (damage)
- Prony series (viscoelasticity)

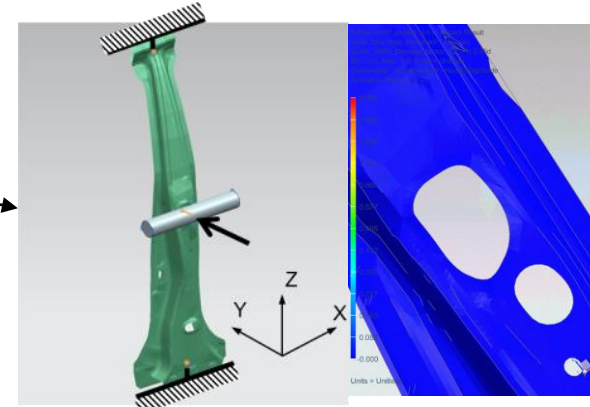
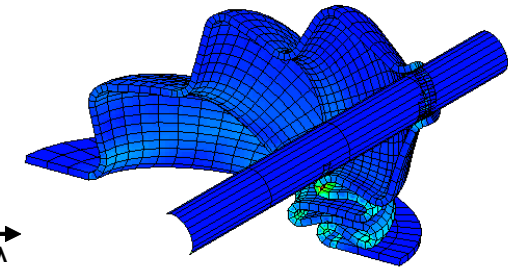
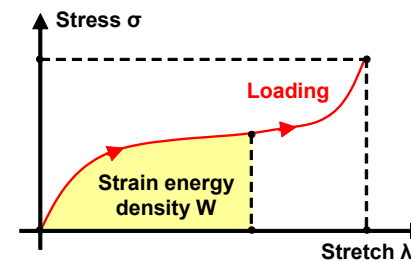
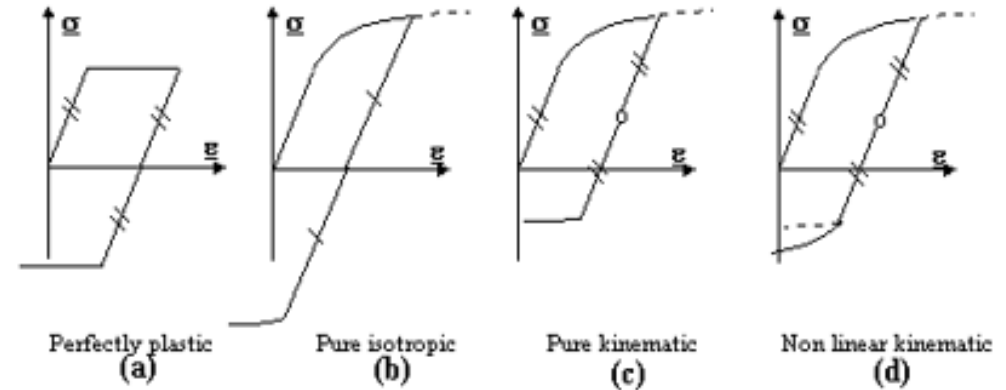
Gasket

Creep

Composite – continuous fibers

- Classic failure models
- Progressive ply damage
- Ply delamination
- Curing

User Defined Material

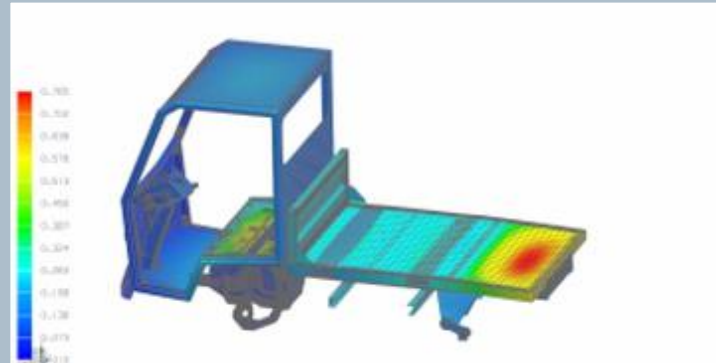


Services Précicad

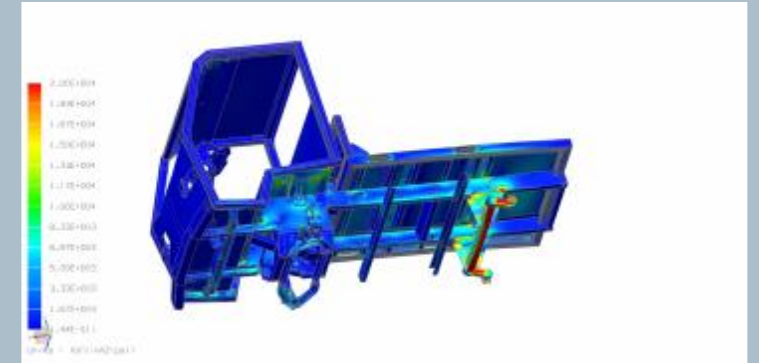
New aluminum electric utility transport



Optimized for strength, weight, production costs and ease of recycling



Cargo deflection analysis



Cargo stress contour

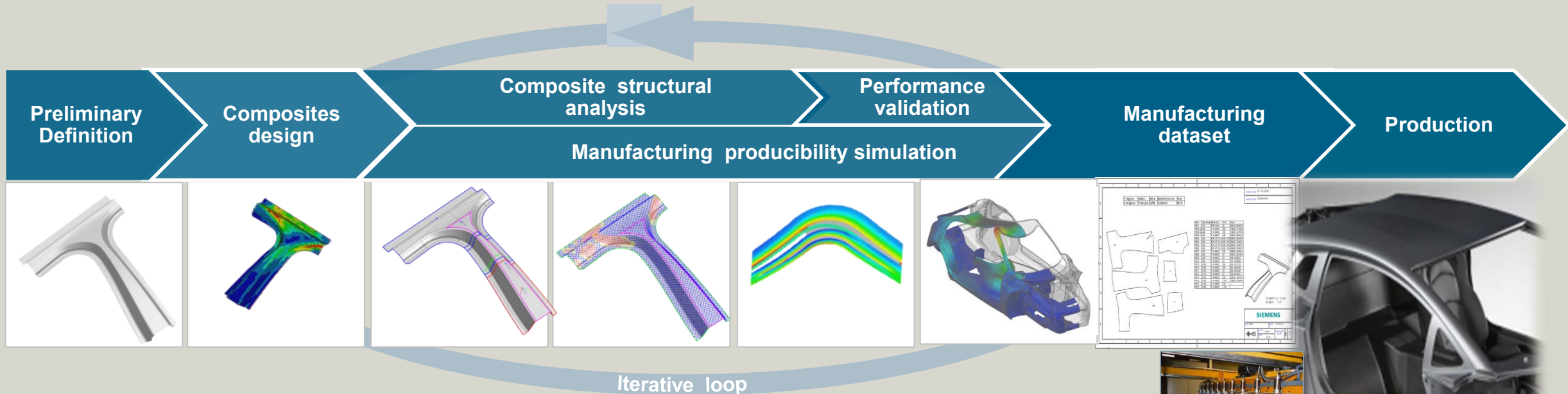
- First prototype ready in six months
- Lower weight contributing to longer operation time per battery charge
- 60 percent fewer welds means lower production costs
- 1,500-pound carrying capacity exceeded original requirements

- Ability to import SolidWorks geometry into Simcenter 3D
- Rapid FEA pre-processing

“Simcenter 3D is really fast and, in the same day, we could do many iterations.”

Stephane Arsenault, Head of FEA Department

Open, Specialized Solutions that address the Challenges of Composites Development



- ✓ **End-to-end solutions from design to analysis to manufacturing**
- ✓ **Open architecture supporting best-in-class engineering tools**

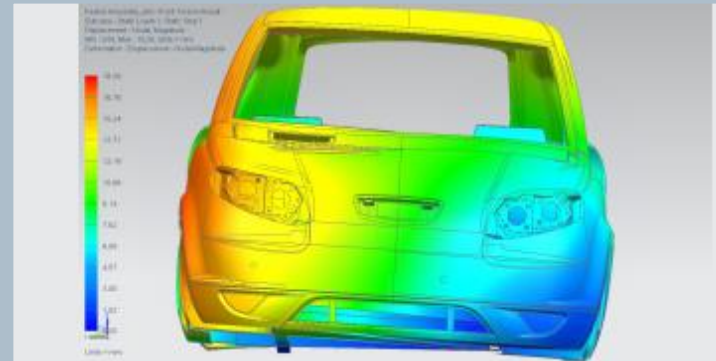
Composites Innovation Centre

Advanced composites-based vehicle using NX & Simcenter



- Component weight reduction exceeding 40 percent
- Faster creation of analysis models
- Accurate representation and analysis of laminate composite structures
- Compliance with federal safety standards

Rapidly evaluate design alternatives in half the time



Front torsion evaluation



Fabricated vehicle hood

- Powerful geometry editing and clean up capabilities
- Robust laminate composite modeling capabilities

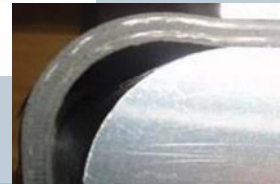
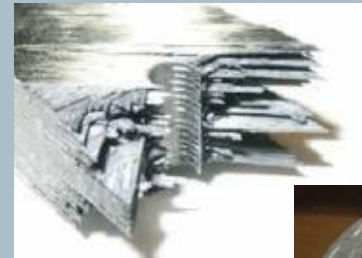
“With composites there are so many options, and so a flexible interface that allows you to quickly specify and experiment with a variety of parameters is essential. Use of Simcenter 3D Laminate Composites enables precisely that.”

Alastair Komus, Principal Engineer

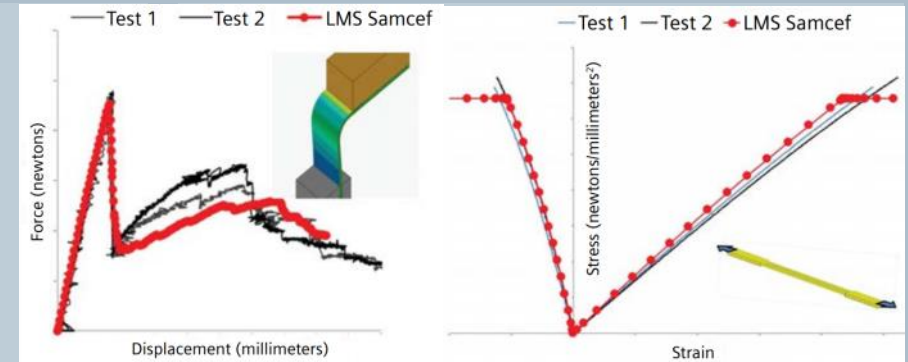


- Predictive damage models at the coupon level and at composite subsystem design concept level
- Development of the parameter identification procedure, based on a limited amount of physical tests on coupons

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 solver for accurate modelling
- Simcenter Engineering Services for composite damage model identification

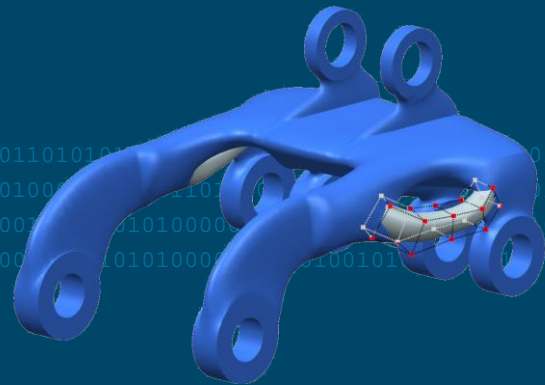
“Not only at Honda, but many engineers in this field think that we can still make vehicles that have a 50 percent lighter body structure using composites while maintaining the mechanical properties of the replaced metallic parts.”

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

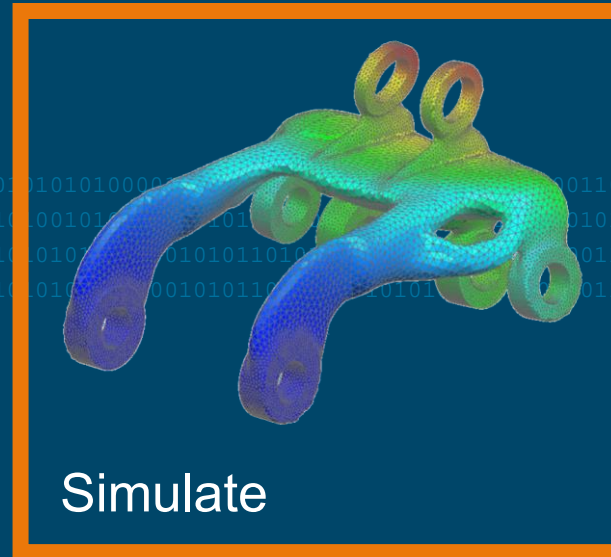
One integrated end-to-end system for industrializing additive



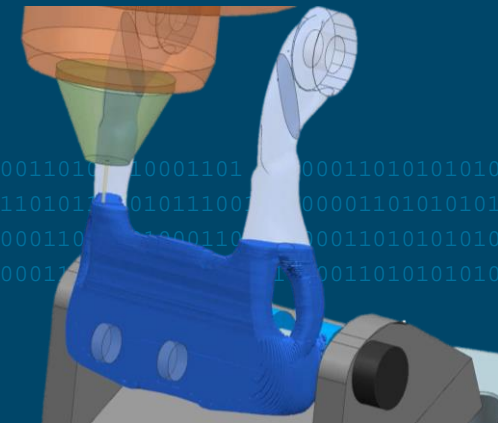
Smart model-driven process



Design



Simulate



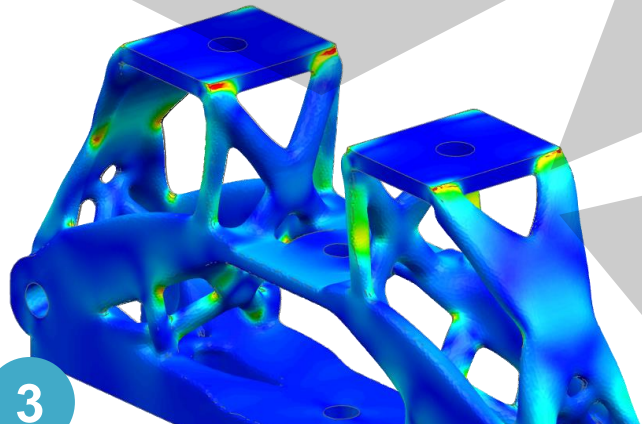
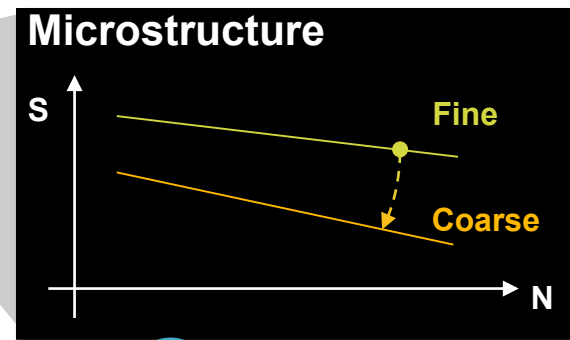
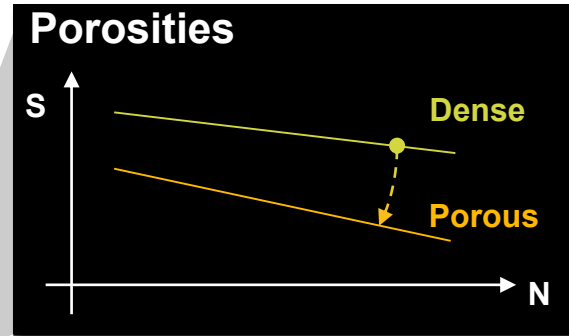
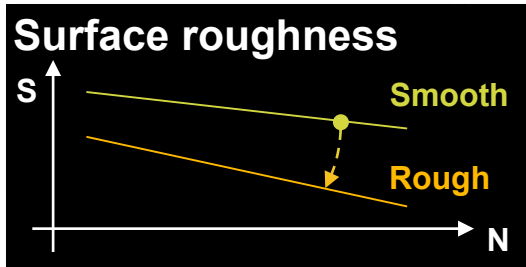
3D Print

Data Management and Shop Floor Connectivity

Siemens Production Software and MES Systems

Partnerships

Machine Learning (ML) Enhanced Fatigue Analysis



ML-enhanced Durability Solver for AM in Simcenter 3D

Additive manufacturing process induced fatigue influencing factors

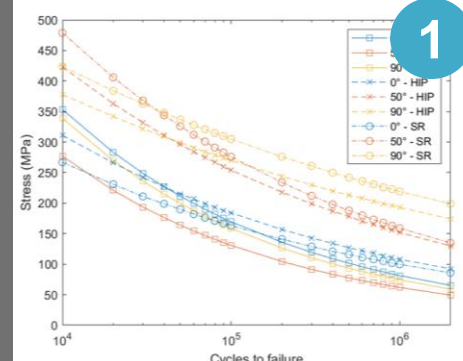
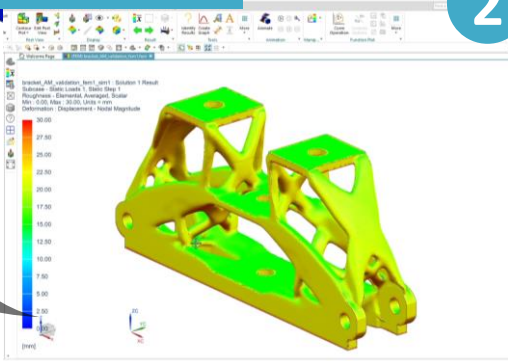
- Less controlled than for conventional manufacturing
- Highly dependent on geometry
- Exhibit a local nature

- ➔ Impossible to test for all combinations
- ➔ Challenging to predict fatigue performance

Simcenter 3D Solution

2 Prediction of fatigue influencing factors

- Surface roughness
- Porosities
- Microstructure



1 Smart Database

- Machine Learning predicts SN curve for any combination
- No a-priori assumptions
- Small training dataset

How to accelerate vehicle structural analysis process?

Takeaways



- ✓ **Model Preparation and multi-discipline simulation in one integrated platform**
- ✓ **Simulation Data Management, Customization and Automation to deal with large assemblies such as Body in White or full vehicle models**
- ✓ **Scalable, accurate and efficient Structural Analyses to predict product Performance under all operating conditions**
- ✓ **Accurate prediction of Strength and Durability of new materials to develop lighter, yet stronger components**



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Questions?