Simulating the Digital Twin

Simcenter for Industrial Machinery

SIEMENS

The world is evolving...

SIEMENS

The world is evolving

From mechanical components to smart systems integrating mechanical, electrical, controls

From known material / production methods to mixed materials, novel production methods

From defined options to mass customization and personalization

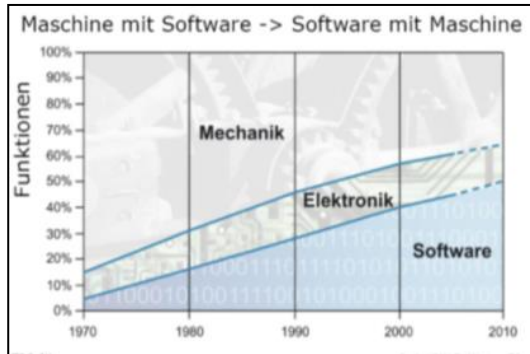**From internet connectivity to system of systems and internet of things**

SIEMENS

One constant. Addressing these engineering challenges …
… without compromising time-to-market, quality and cost

SIEMENS

Pressures on Industrial Machinery

SIEMENS

A transitioning industry

Maschine mit Software -> Software mit Maschine

PRODUCERS OF MACHINE TOOLS
MILLIONS OF U.S. DOLLARS

	COUNTRY	% CUTTING MACHINES	2013	2014
1.	China, P. Rep.	59%	$24,700.0	$23,800.0
2.	Germany	71%	15,268.7	12,957.2
3.	Japan	83%	11,333.6	12,831.6
4.	South Korea	74%	5,150.0	5,631.0
5.	Italy	51%	5,475.9	5,074.7
6.	United States	75%	4,956.1	4,900.4
7.	Taiwan	82%	4,537.0	4,700.0
8.	Switzerland	84%	3,242.8	3,111.7
9.	Austria	51%	1,217.0	1,101.2
10.	Spain	60%	1,285.1	1,083.0

Source: Gardner Research – World Machine Tool Output & Consumption Survey

Customization is the New Formula for Success in the Global Pharmaceutical Packaging Market

FROST & SULLIVAN

IndustryWeek Advancing the Business of Manufacturing

Mass Customization and the Factory of the Future
Manufacturing is now entering a new phase of customization-oriented production. Forcing this shift is a dramatic increase in the complexity of demand coming from consumers.

premium beauty news

Customization of perfume bottles, a trend of the times

Every manufacturer and supplier of electrical and electronic equipment conducting business in the European Union must comply with the RoHS2 in order to CE mark their products

machine design

Macroeconomic Impacts of Federal Regulation of the Manufacturing Sector

NERA ECONOMIC CONSULTING

From 1993 to 2000, the average number of major regulations was 36. This figure increased to an average of 45 per year from 2001 to 2008. Under the current presidential administration, **the average was 72 major regulations per year between 2009 and 2011.**

Massive complexity

- Complexity is the new norm
- Industry 4.0 is a key driver

Competitive pressures

- Pressures from new, low cost providers
- Multi-country operations

Customized products

- Mass amounts of customization expectation
- Customization-oriented production

Regulatory pressures

- Driving innovation to new levels
- Design products with their entire life cycle in mind

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What your customers care about

Energy efficiency
Optimize energy efficiency of machines systems and architectures

Reliability
Ensure accuracy, structural durability and avoid critical vibrations
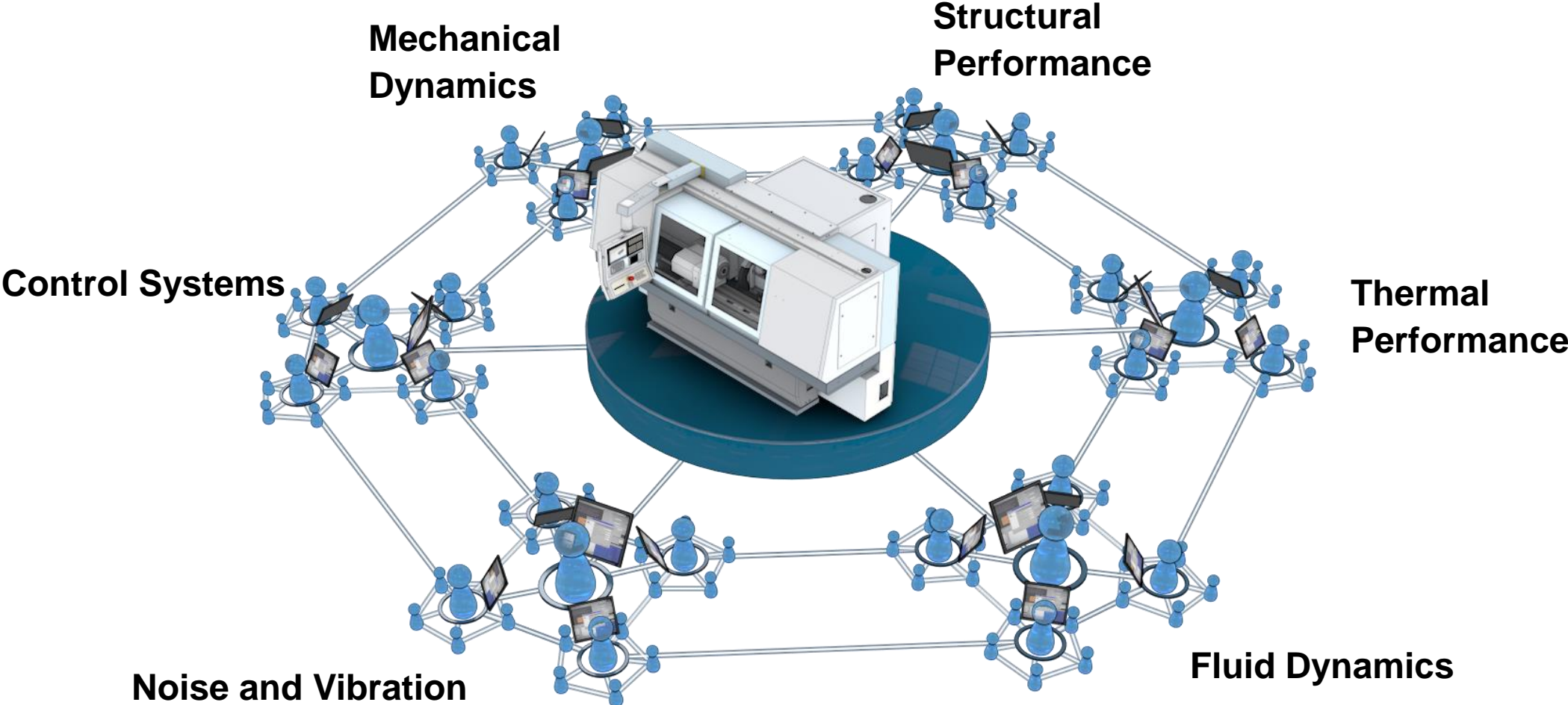
Performance
Ensure production throughput and ability to meet flexible needs

Smarter machines
Controls and mechatronics
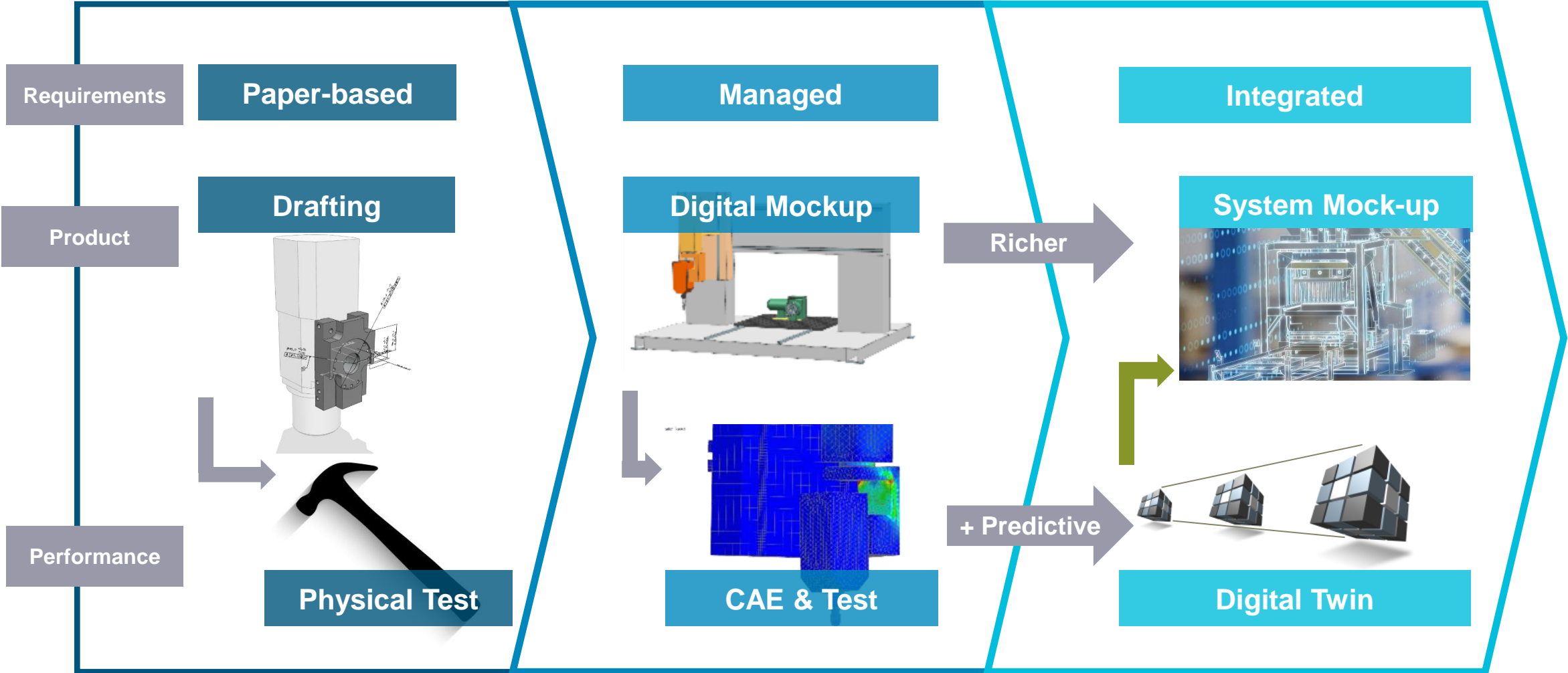
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The Multi-disciplinary World of Machines

Mechanical Dynamics

Structural Performance

Control Systems

Thermal Performance

Noise and Vibration

Fluid Dynamics

SIEMENS

Addressing these challenges requires a new approach

Companies must evolve their product engineering practices to meet these new challenges or risk becoming obsolete

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Evolution of product engineering

Requirements	Paper-based	Managed	Integrated

Product — Drafting → Digital Mockup → **Richer** → System Mock-up

Performance — Physical Test → CAE & Test → **+ Predictive** → Digital Twin

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From Disconnected Models and Data …

Test data

3D SIMULATION

CFD SIMULATION

Simulation data

Customer Usage data

TEST

Historical data

1D SIMULATION

CONTROLS

SIEMENS
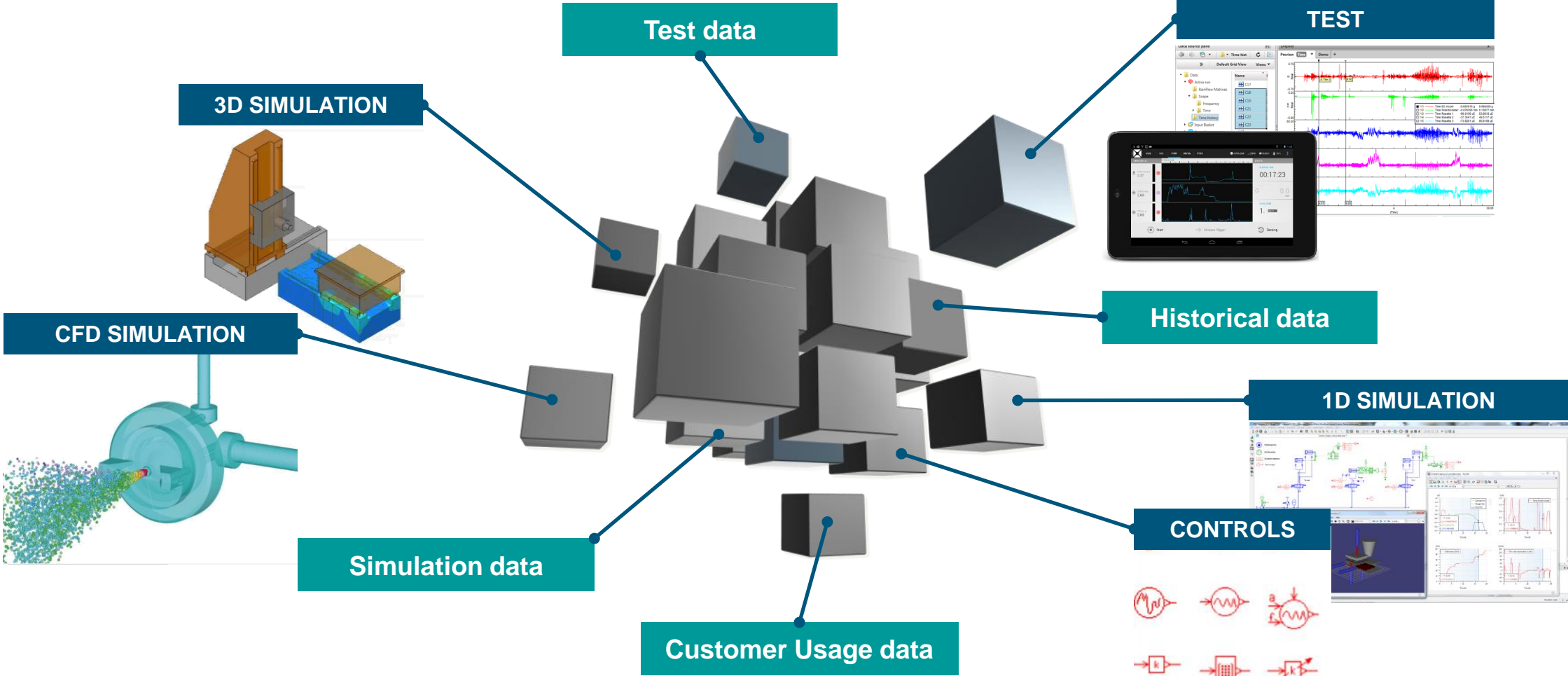
…to a performance Digital Twin

3D SIMULATION

CFD SIMULATION

Test data

Simulation data

Customer Usage data

TEST

Historical data

1D SIMULATION

CONTROLS

SIEMENS
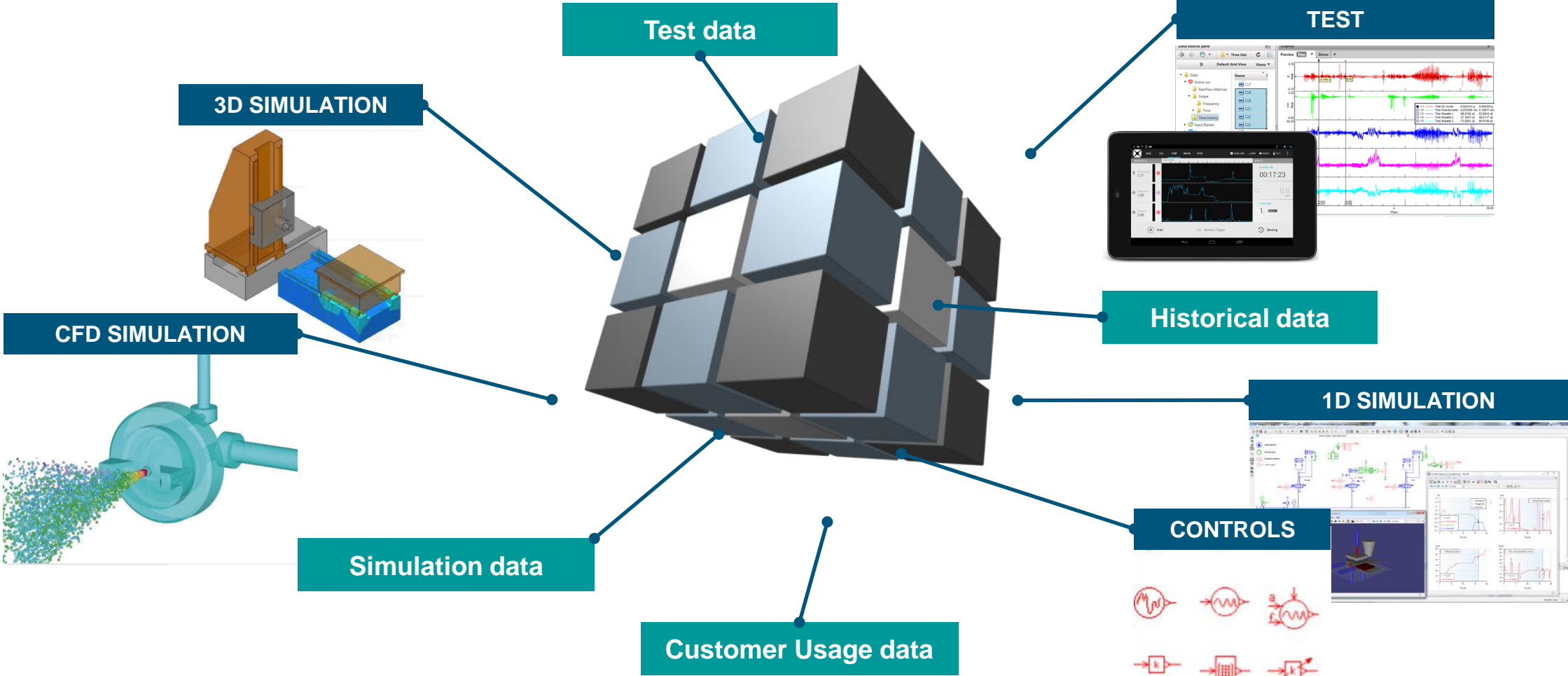
…enabling Predictive Engineering Analytics

Test data

3D SIMULATION

CFD SIMULATION

Simulation data

Customer Usage data

TEST

Historical data

1D SIMULATION

CONTROLS

SIEMENS
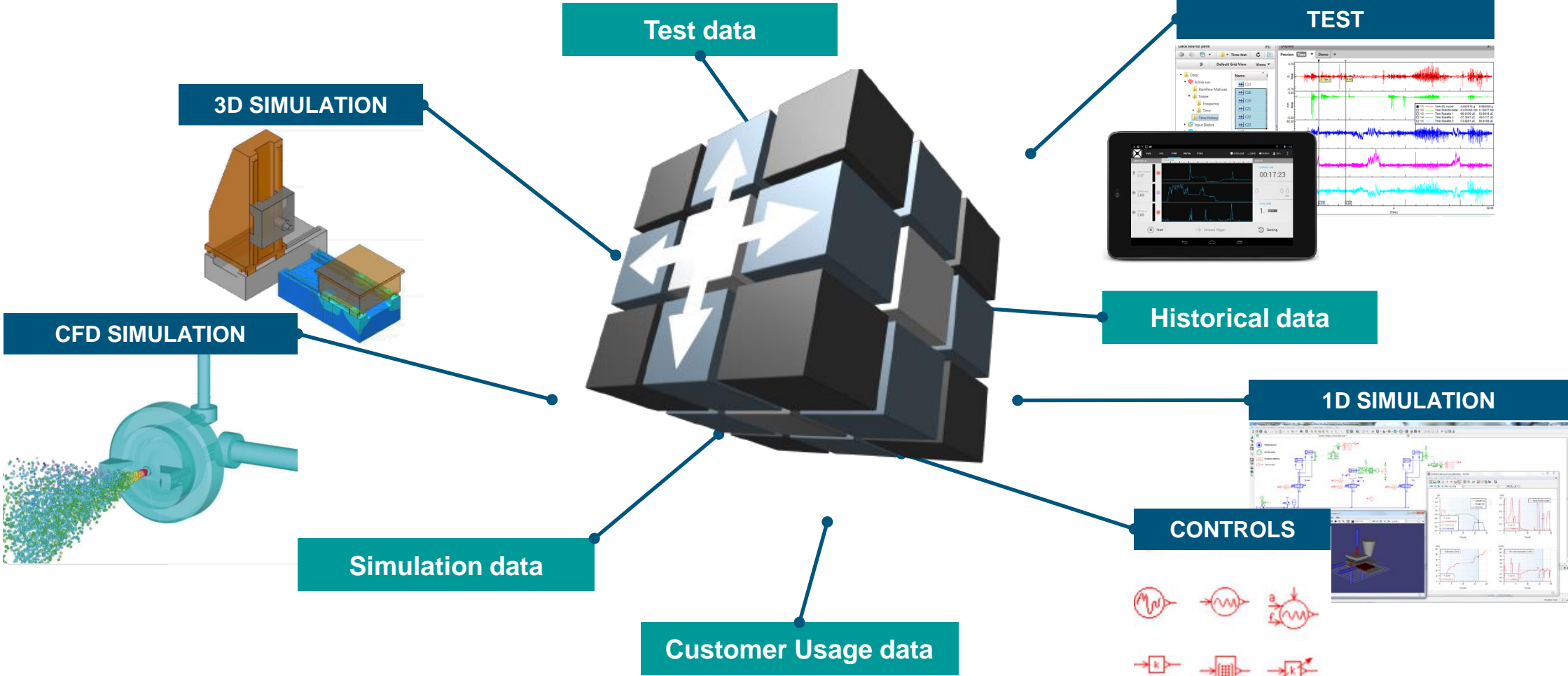
Predictive Engineering Analytics

Move beyond verification to drive design decisions faster and with greater confidence

- Deliver multi-fidelity digital twins
- Simulate all critical system performance characteristics
- Evolve models to remain in sync with the product and environment
- Apply analytics and multidiscipline design exploration

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Predictive Engineering Analytics
Role in Systems-Driven Product Development

Systems-Driven Product Development

System Mockup

Predictive Engineering Analytics

1D

3D

Digital Twin

TEST

CFD
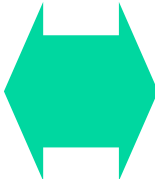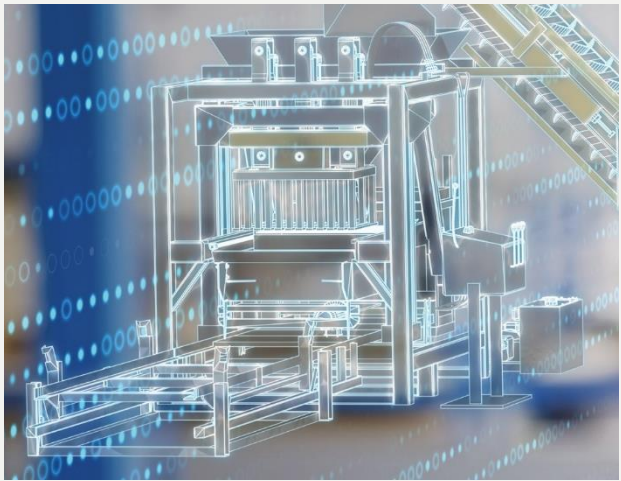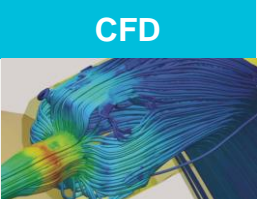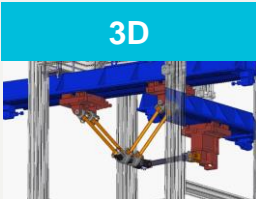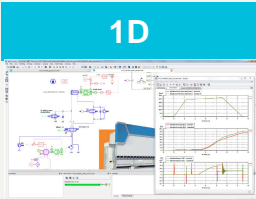
Exploration - Analytics - Reporting
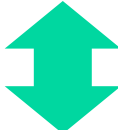
Managed in PLM Context - Multi-Domain Traceability, Change and Configuration

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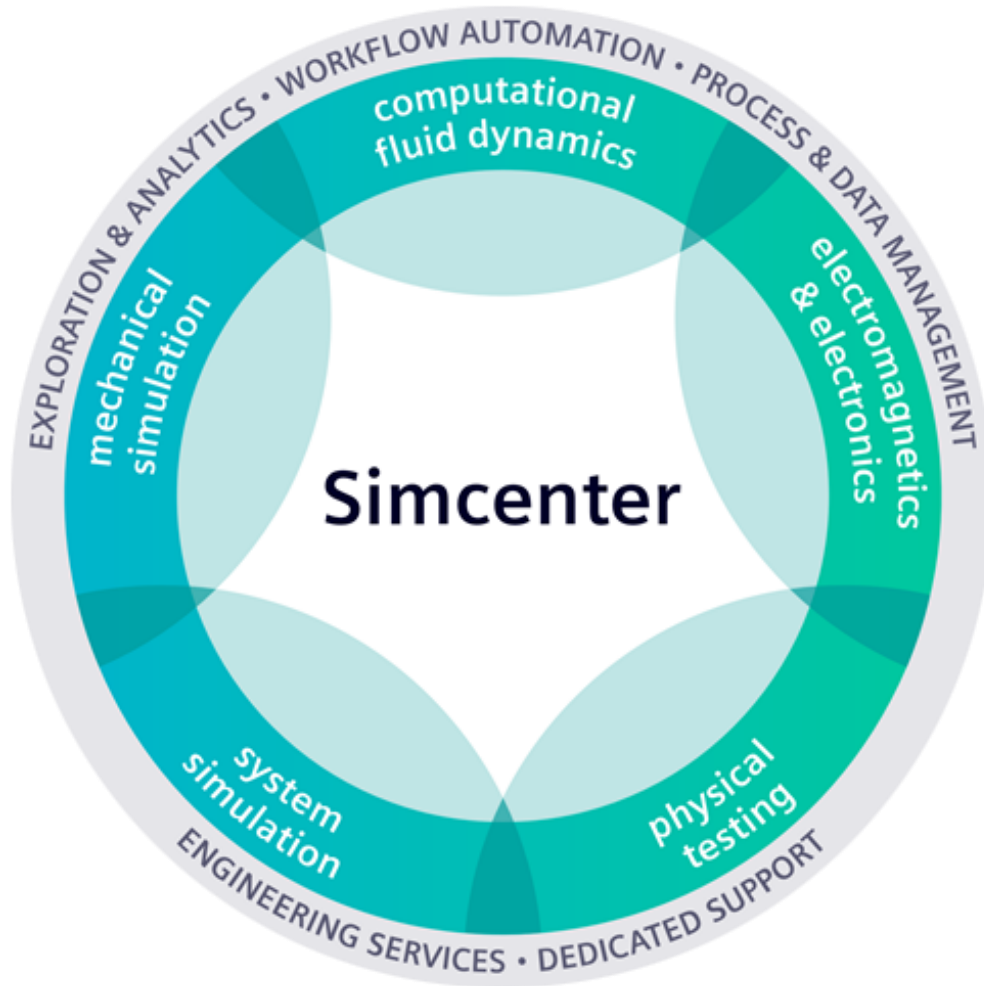
Simcenter™

Simcenter™ Portfolio for Predictive Engineering Analytics
Cornerstones for a future-proof engineering approach

Covering full range of methods

Controls
1D
TEST
3D
CFD

Multi-discipline & multiphysics

Industry & engineering expertise

Analytics, reporting & exploration

Systems approach

R
F
L
P

Cloud

Licensing flexibility

Deployment flexibility

Openness & Scalability

Collaboration & workflow

User experience

SIEMENS

Common environment for engineering

Mechanical Dynamics

Structural Performance

Control Systems

Thermal Performance

Noise and Vibration

Fluid Dynamics

WORKFLOW AUTOMATION · PROCESS & DATA MANAGEMENT
EXPLORATION & ANALYTICS
ENGINEERING SERVICES · DEDICATED SUPPORT

computational fluid dynamics

electromagnetics & electronics

mechanical simulation

Simcenter

system simulation

physical testing

SIEMENS

Introducing the Simcenter portfolio

SIEMENS

Simcenter™ Portfolio for Predictive Engineering Analytics
Simcenter 3D, NX Nastran & Star CCM+
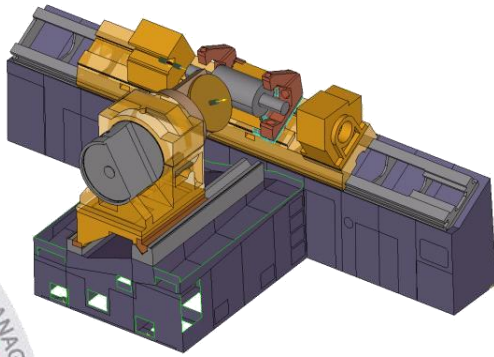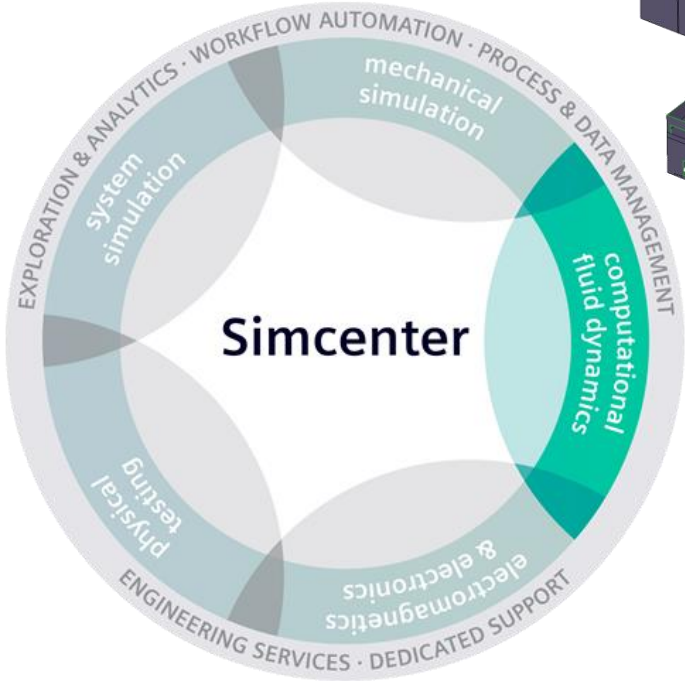
Simcenter 3D
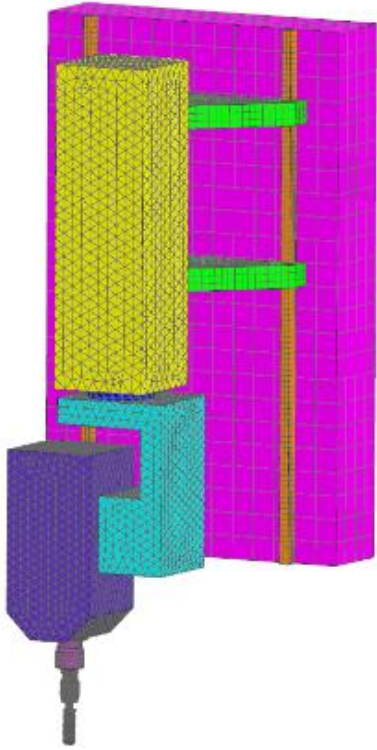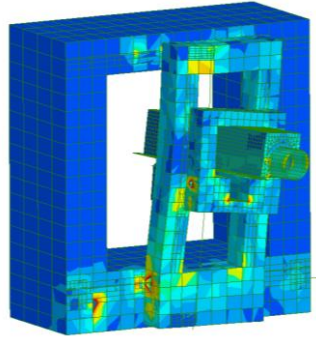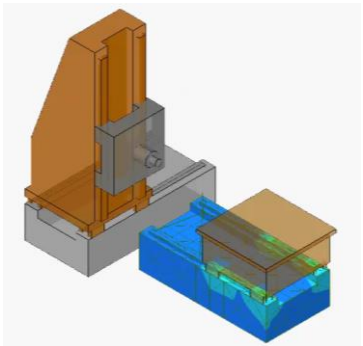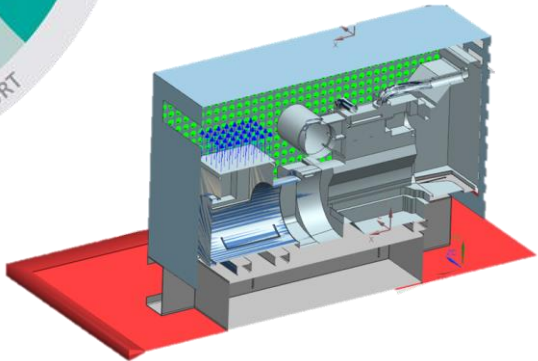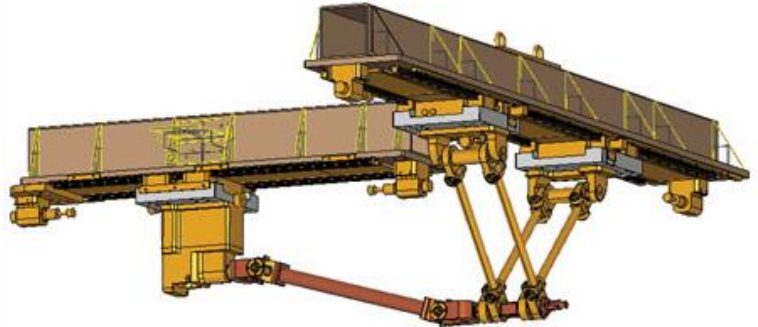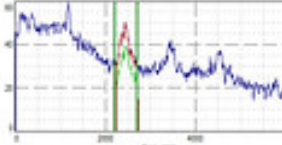
NX Nastran

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Simcenter™ Portfolio for Predictive Engineering Analytics
Simcenter 3D, NX Nastran & Star CCM+
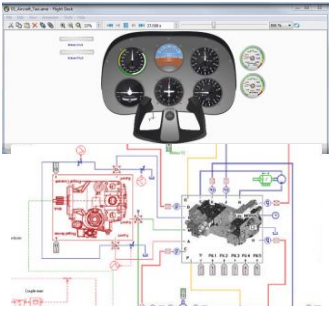
TEST-CAE Correlation

Structures

Noise & Vibration

Thermal
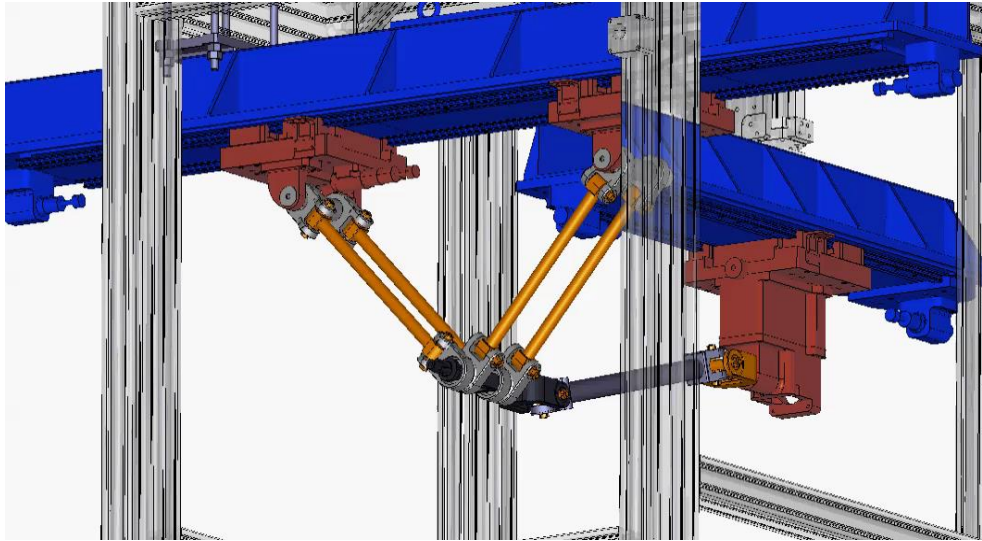
Motion

Flow

Durability

Optimization

1D – 3D Co-Simulation

Multi-Physics
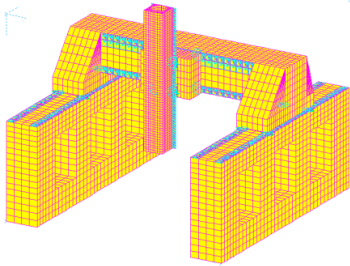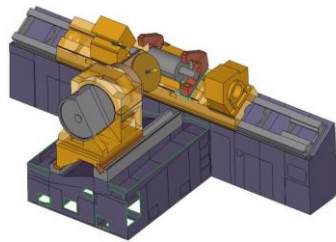
Linear FEM	Non-Linear FEM	BEM	Multi-body	Fatigue	Thermal	CFD
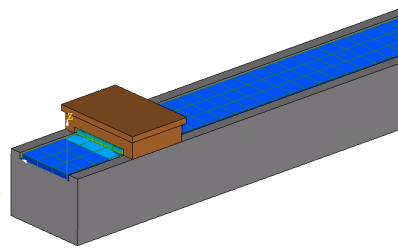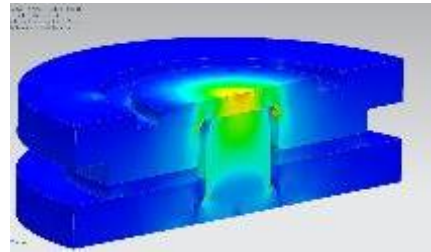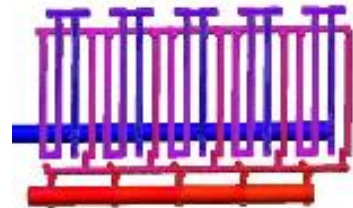
SIEMENS
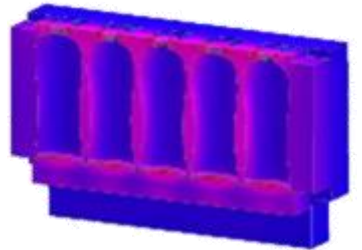
Simcenter™ Portfolio for Predictive Engineering Analytics
LMS Imagine.Lab
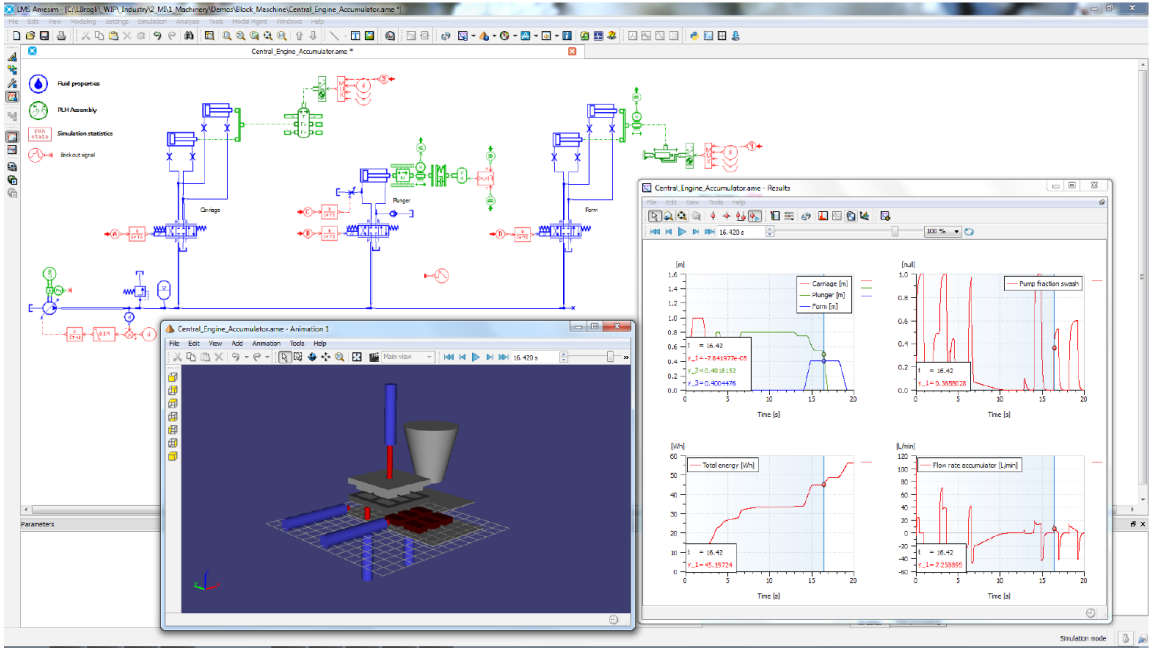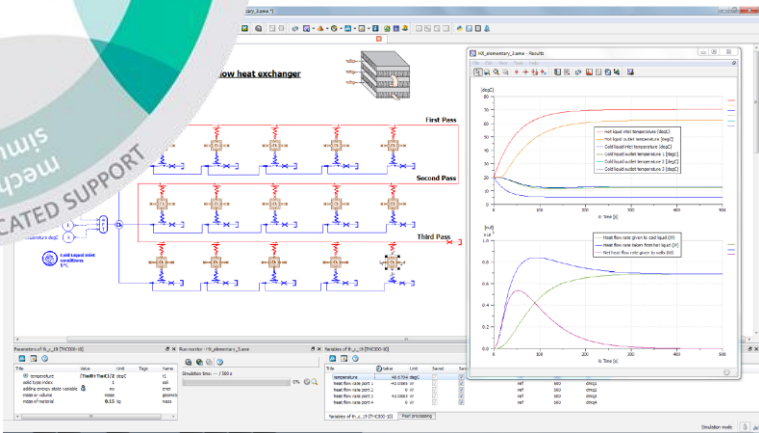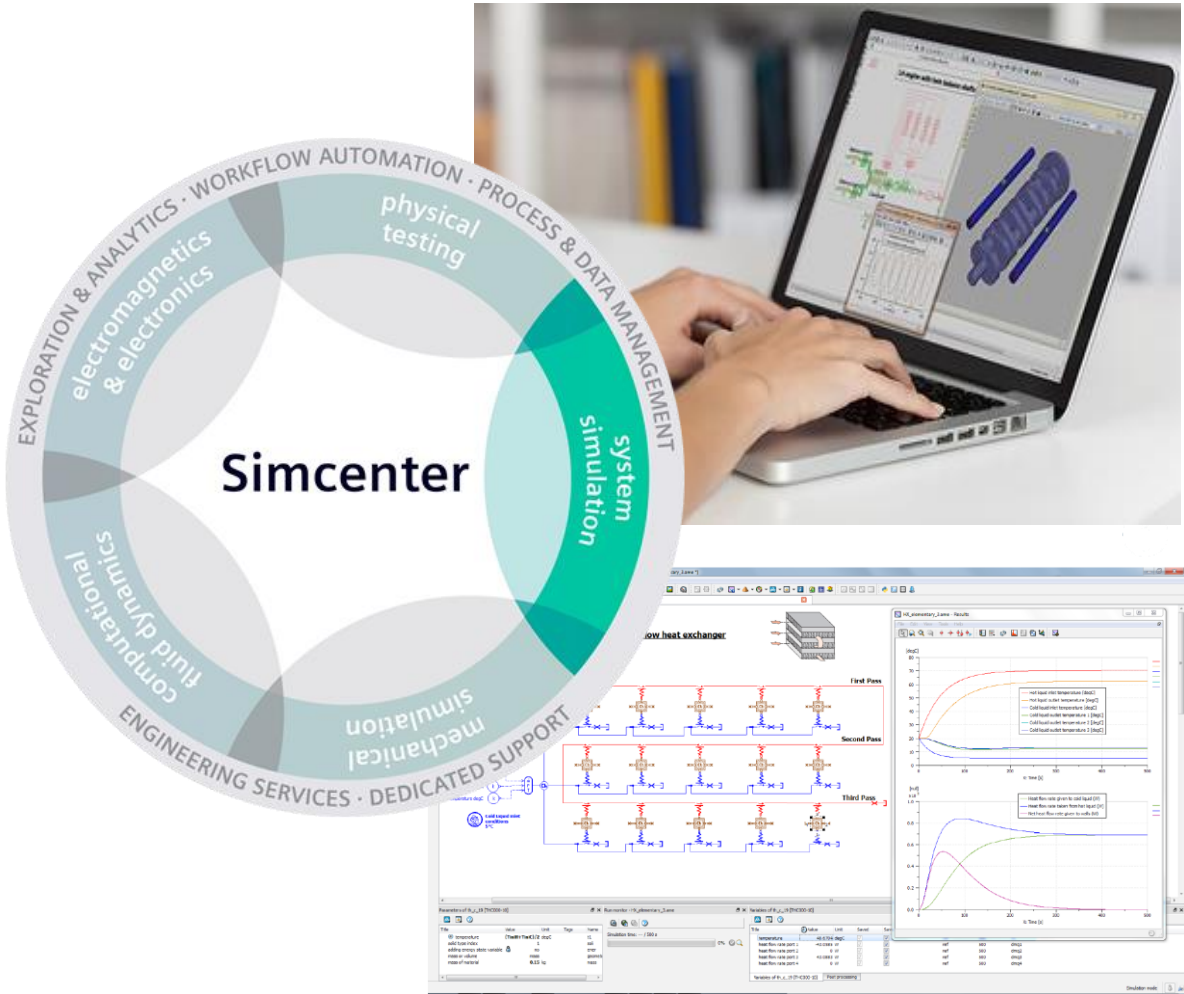
**LMS Imagine.Lab
Amesim**

**LMS Imagine.Lab
System Synthesis**

SIEMENS

Simcenter™ Portfolio for Predictive Engineering Analytics
## LMS Imagine.Lab

Model-Based System Testing

Industry specific

Thermal Systems

Electrical Systems

Pumps & Compressors

Electro-Hydraulic Valves

Fluid Actuation Systems

Heat Exchangers

Heat Pumps / Refrigerators

Pre-Design

Systems Sizing & Integration

Performance Balancing

Controls Validation
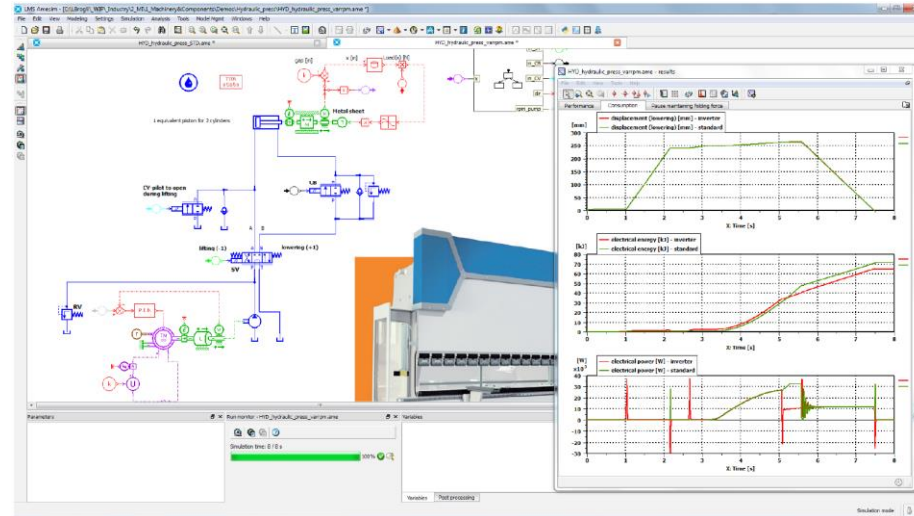
Scalable Simulation

Connecting "Mechanical" – "Controls"

Model reduction for real-time

Co-Simulation

Open & Customizable

>30 Libraries

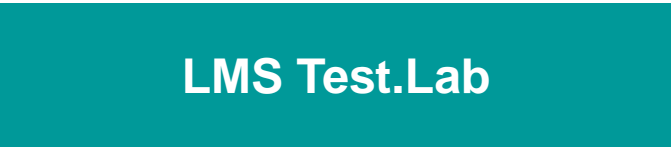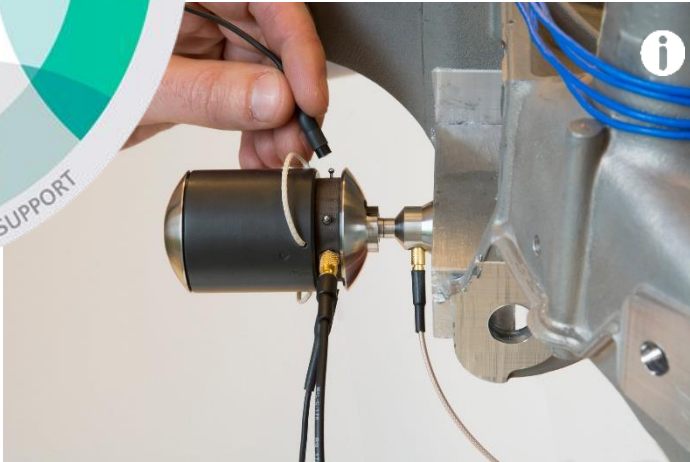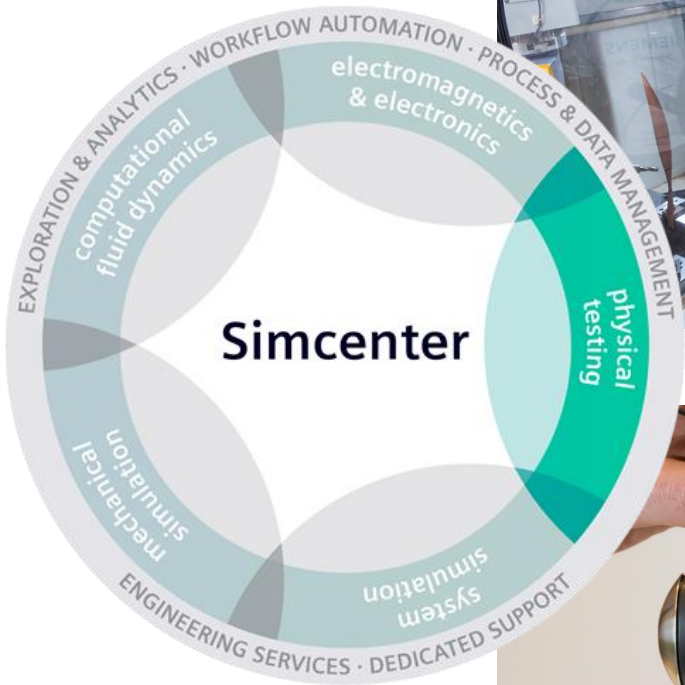**>4,000 Multi-physics Models**
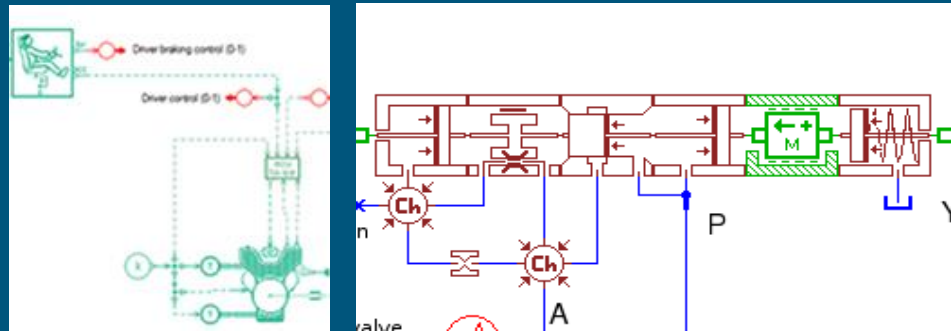
Hydraulics Pneumatics Thermal Electrical Mechanical Signals
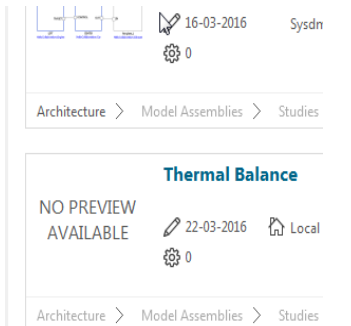
Process & Data Management

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Simcenter™ Portfolio for Predictive Engineering Analytics
LMS Test.Lab & LMS SCADAS

LMS Test.Lab

LMS SCADAS

SIEMENS

Simcenter™ Portfolio for Predictive Engineering Analytics
LMS Test.Lab & LMS SCADAS

Model-Based System Testing
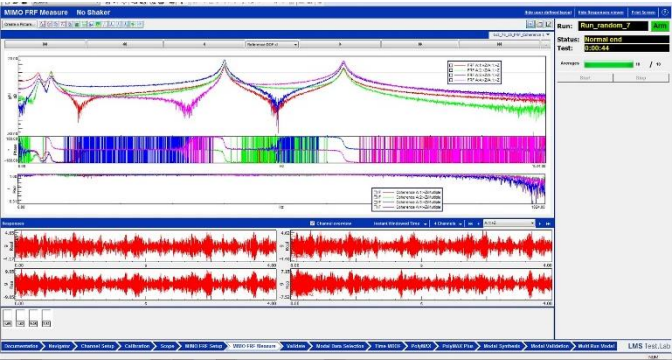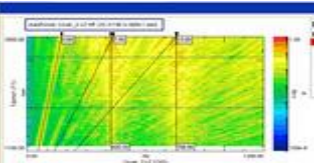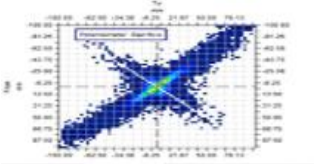
Structures

Noise & Vibration
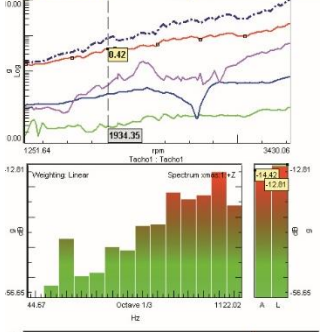
Rotating

Durability

Vibration control

TEST-CAE Correlation

ANALOG

- Microphones
- Stress , strain
- Displacement
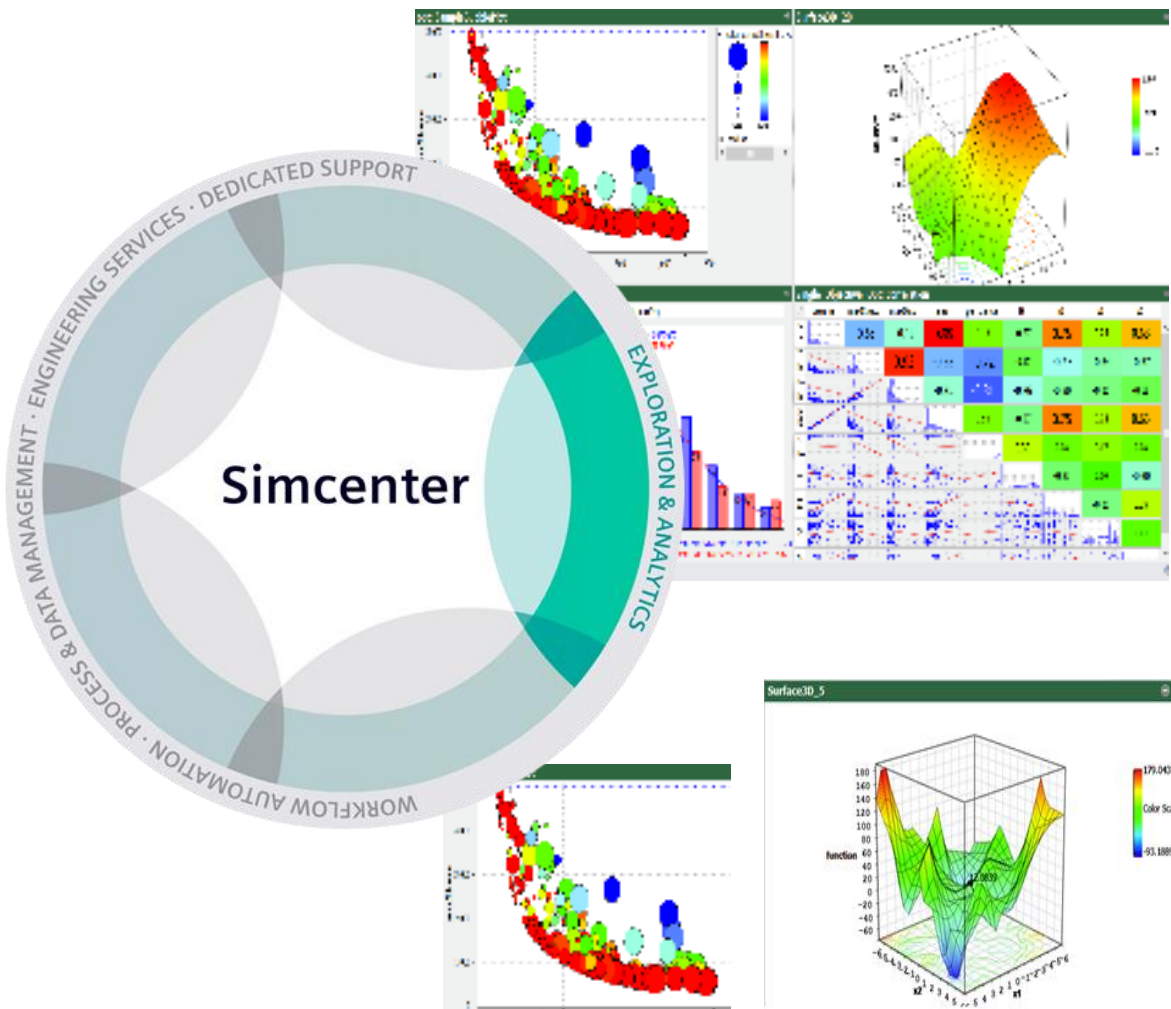- Force, Torque, Load, pressure
- Tacho, TTL,
- Temperature, Current

DIGITAL
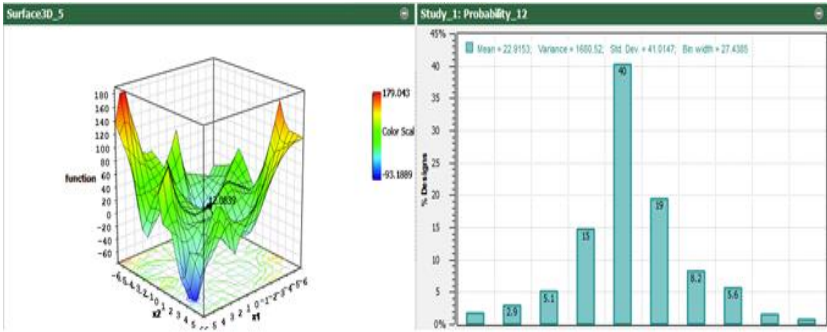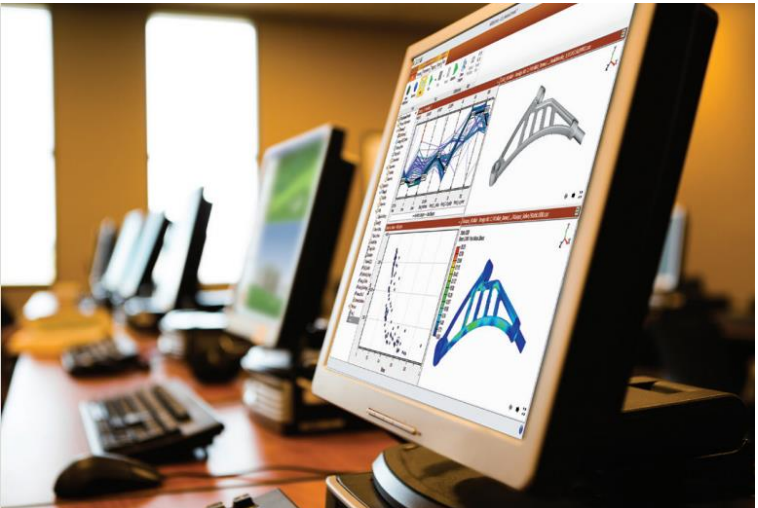
- GPS
- Video
- CAN-bus
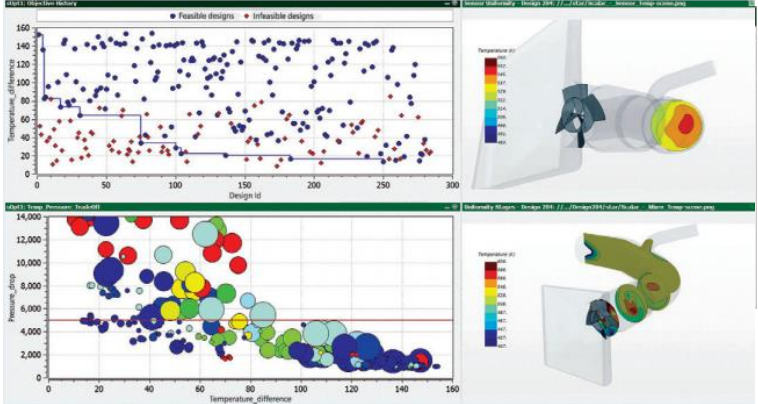- Flexray
- Ethercat

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Simcenter™ Portfolio for Predictive Engineering Analytics
HEEDS – Multidisciplinary design exploration

HEEDS

SIEMENS

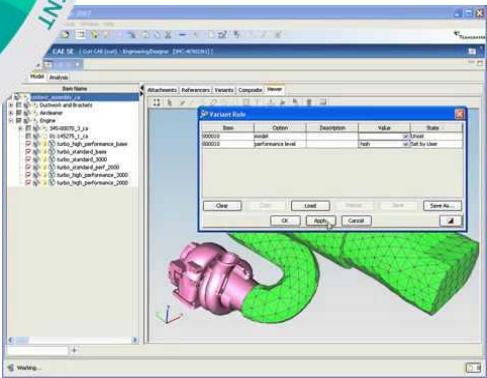# Simcenter™ Portfolio for Predictive Engineering Analytics
Teamcenter – Model & data management

Systems Engineering

Teamcenter

SIEMENS

Engineering services – LMS & CD-adapco
Experience and global talent for valued customer partnerships

CD-adapco Engineering

LMS Engineering

SIEMENS

Engineering services – LMS & CD-adapco
Experience and global talent for valued customer partnerships

Troubleshooting

Co-development

Technology transfer

Engineering process transformation
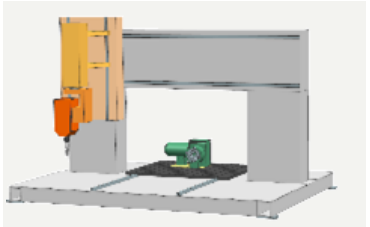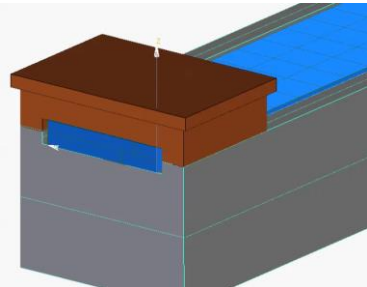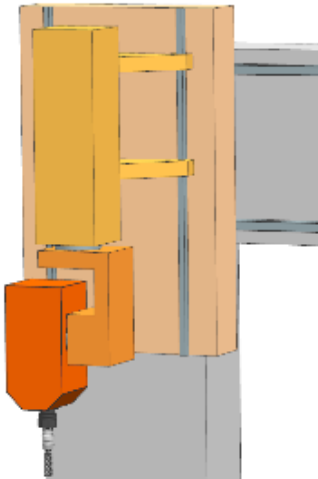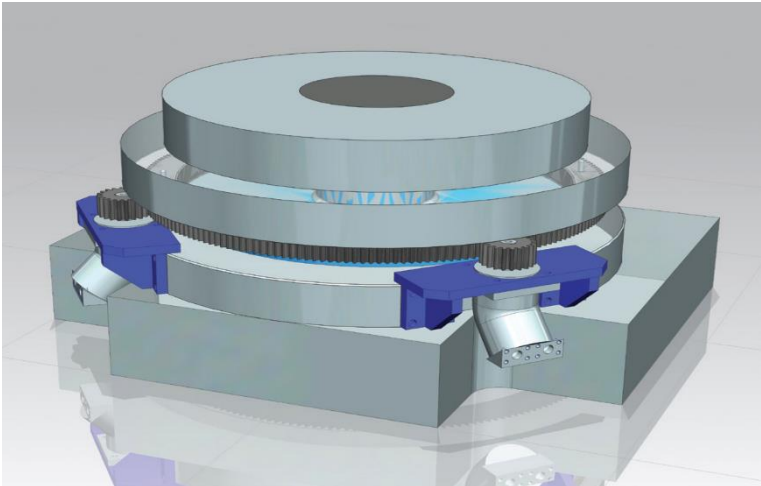
Performance Engineering

Noise & Vibration

Durability

Mechatronics development

CFD

SIEMENS

Validate your products exceed customers' expectations

Energy efficiency
Optimize energy efficiency of machines systems and architectures

Reliability
Ensure accuracy, structural durability and avoid critical vibrations

Performance
Ensure production throughput and ability to meet flexible needs

Smarter machines
Controls and mechatronics

EXPLORATION & ANALYTICS • WORKFLOW AUTOMATION • PROCESS & DATA MANAGEMENT

computational fluid dynamics

mechanical simulation

electromagnetics & electronics
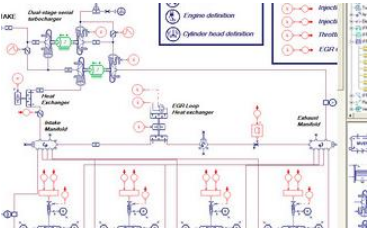
Simcenter

system simulation

physical testing

ENGINEERING SERVICES • DEDICATED SUPPORT

SIEMENS

Pinacol
Launching a highly energy-efficient loom thanks to LMS Imagine Lab Amesim

Energy efficiency

- **Designed the "most energy-efficient weaving looms on the market"**
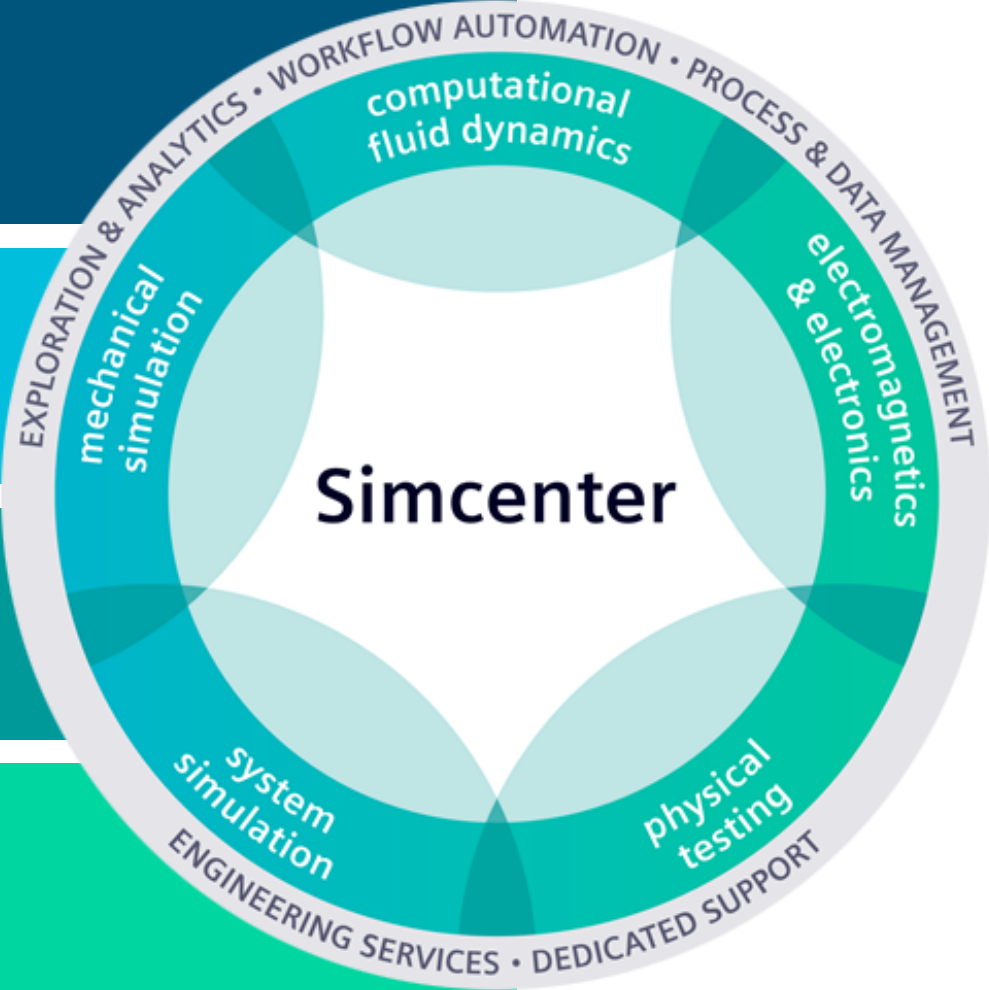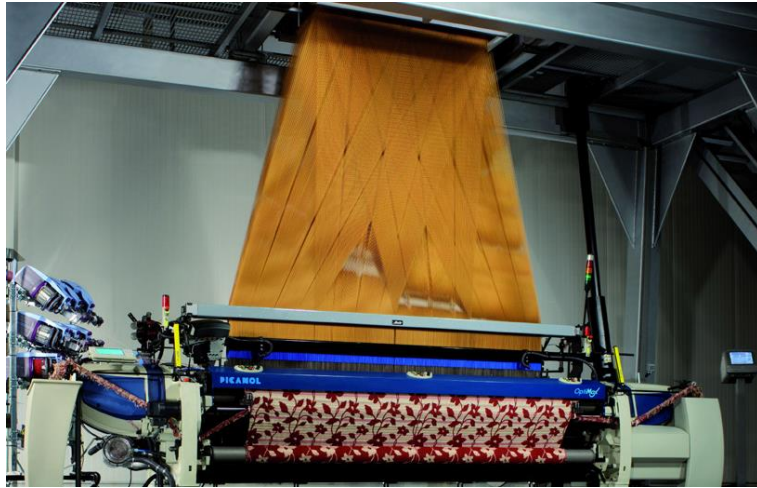- **Balanced performance, durability, noise and vibration parameters while minimizing energy consumption**
- **Implemented advanced model-based system engineering**

Optimizing the design towards energy performance
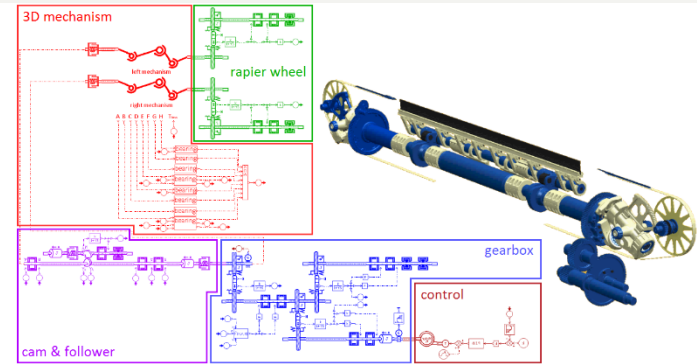
Co-simulation with LMS Virtual.Lab Motion
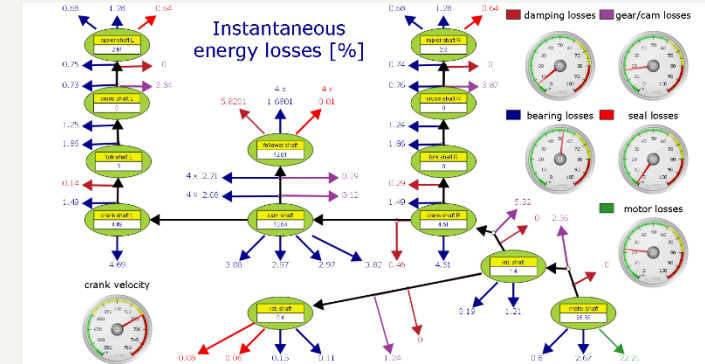
Flow chart of instantaneous energy losses

- Support the scalable optimization of energy flows
- Use energy efficiency and total cost of ownership as key performance criteria

"A platform like LMS Amesim offers extensive libraries of components that also connect to describe complete multiphysics systems, a prerequisite for advanced model-based system engineering."
Kristof Roelstraete, Manager Research and Development

SIEMENS

GEA Grasso
Reducing significanly compressor testing time

Reliability

- **Improved efficiency by reducing the number of testing systems from 3 to 1**
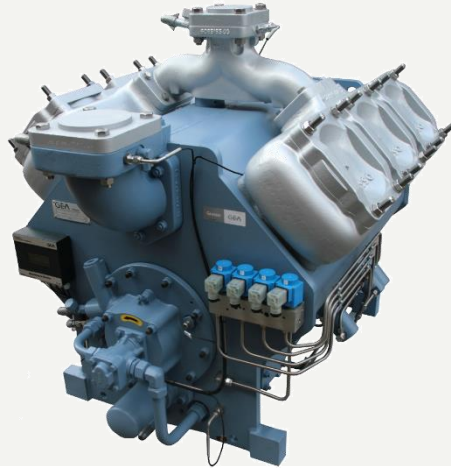- **Reached an important NVH signoff point in less than 50 percent of the time**

Seeking a user-friendly and efficient system

"Vibrations will become increasingly important in the future due to new building designs. For instance, buildings with flexible steel construction or machine rooms that are situated above an office can easily radiate noise, so keeping compressor vibrations to a minimum is crucial for us."
Hans Vermeer, Manager, Testing Department

Reducing heat

Finding the source

- Develop a more integrated and flexible data acquisition and analyzer system
- Implement user-friendly, efficient and advanced compressor noise and vibration testing solution

"Thanks to LMS Test.Xpress, we were able to increase our testing efficiency and managed to reach an important NVH signoff point in less than 50 percent of the time it would have taken before."
Hans Vermeer, Manager, Testing Department
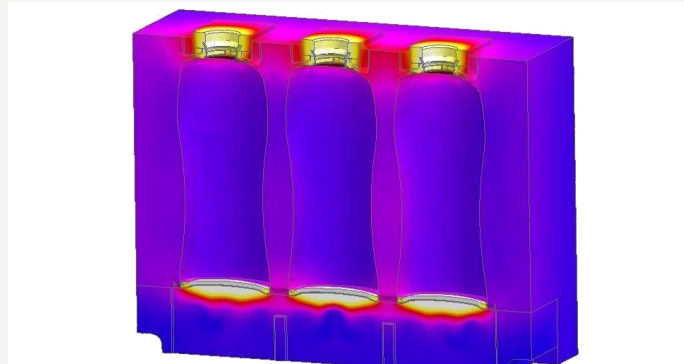
SIEMENS

Graham Packaging
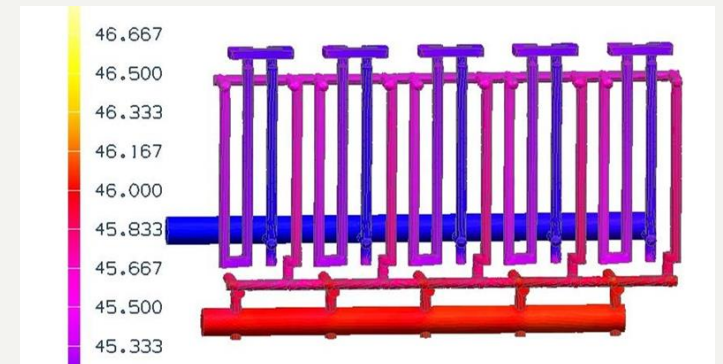## Reduced cycle time by 20 percent

Performance

- **Reduced 6 weeks of testing to 1 week of simulation**
- **Reduced cycle times by 20 percent**
- **Reduced neck inserts from 2 or 3 revisions to 0 or 1 revision**

Improve mold cooling performance with Simcenter

Thermal analysis of mold cavity

Thermal / flow analysis through cooling channels

- Coupled thermal and flow analysis to simulate mold cooling process
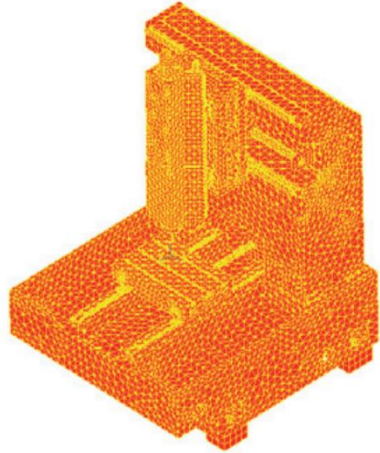- Ability to quickly edit imported geometry to prepare the model for simulation

"Just the mold side, we've saved $2 million dollars by cutting costs and reducing the number of recuts."
Travis Hunter - Design Engineer and Lead Analyst

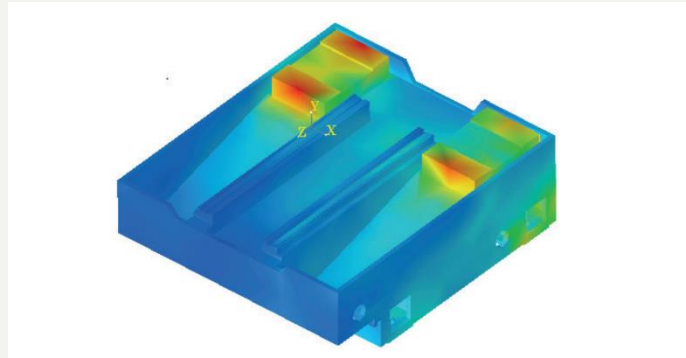**SIEMENS**

Shenyang Machine Tool
Reducing simulation time by over 50 percent
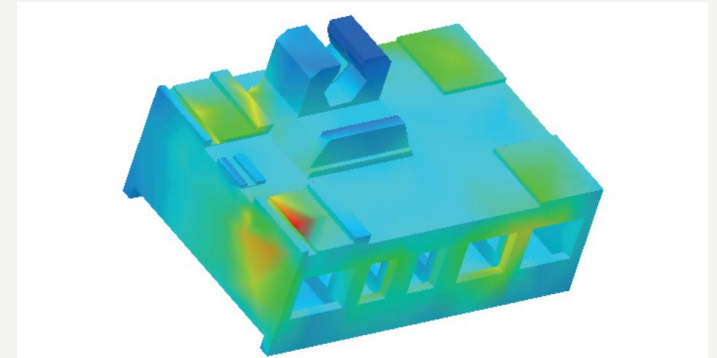
Smarter machines

- **Reduced simulation time during development by 50 percent**
- **Optimized the structure for smooth operation**
- **Implemented a method that can detect potential risks early in the development cycle**

NL dynamic analysis to design smooth-operating and robust machines

Advanced finite element analysis with multibody simulation

Efficient capabilities for building the mechanism model

- Analyze component stresses with nonlinear dynamic simulation
- Deploy a solution that can be used to perform coupled electromechanical analysis

"By combining the high-end, nonlinear mechanical solution LMS Samcef with the electrical simulation in LMS Amesim and controls technology, we have all the components in place to help us develop the next-generation machines."
Zhao Feng, Design Engineer Research and Development

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Simcenter™ Portfolio for Predictive Engineering Analytics

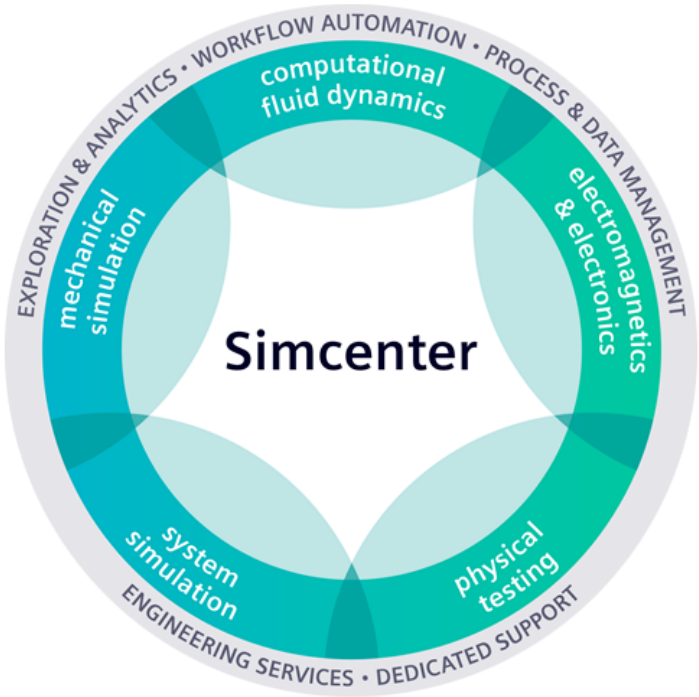**Evolving product engineering to help you meet new challenges**

Predictive Engineering Analytics

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