Aerospace Product Engineering & Verification: The Digital Twin

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Agenda

- **Digital Twin Overview**
- **Case Study – The Digital Thread: Concurrent Safety**
- **Case Study – The Digital Twin: eAircraft**

Challenges in the Aviation Industry

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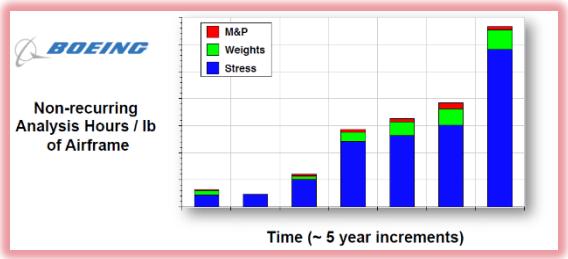
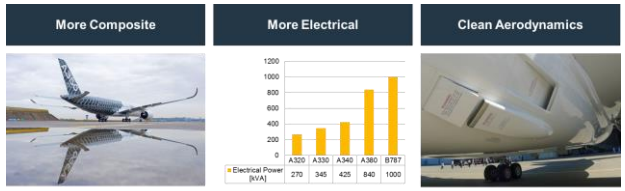
Structural Integration



	Designers	Analysts
Metal	5	1
Composites	1	2

Composites complicate significantly structural development, certification and production processes.

Thermal/Energy Management



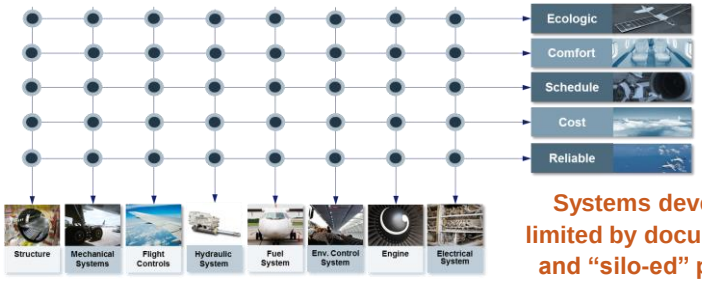
More Composites
Less Heat Dissipation through Structure

More Electrical Power
More Heat Generation

Reducing drag
Reduced Heat Dumping

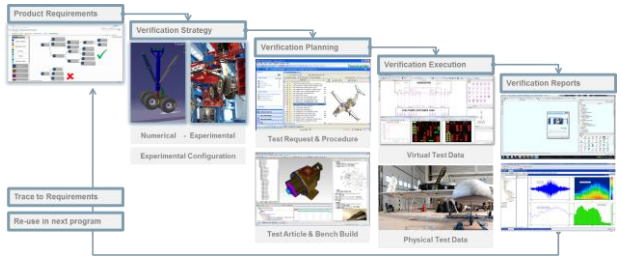
More Electric A/C leads to Thermal Management Issues.

Systems Integration



Systems development limited by document based and "silo-ed" processes.

Verification & Certification



Software – Structures - Systems Certification becomes unaffordable.

Critical Aerospace Value Streams

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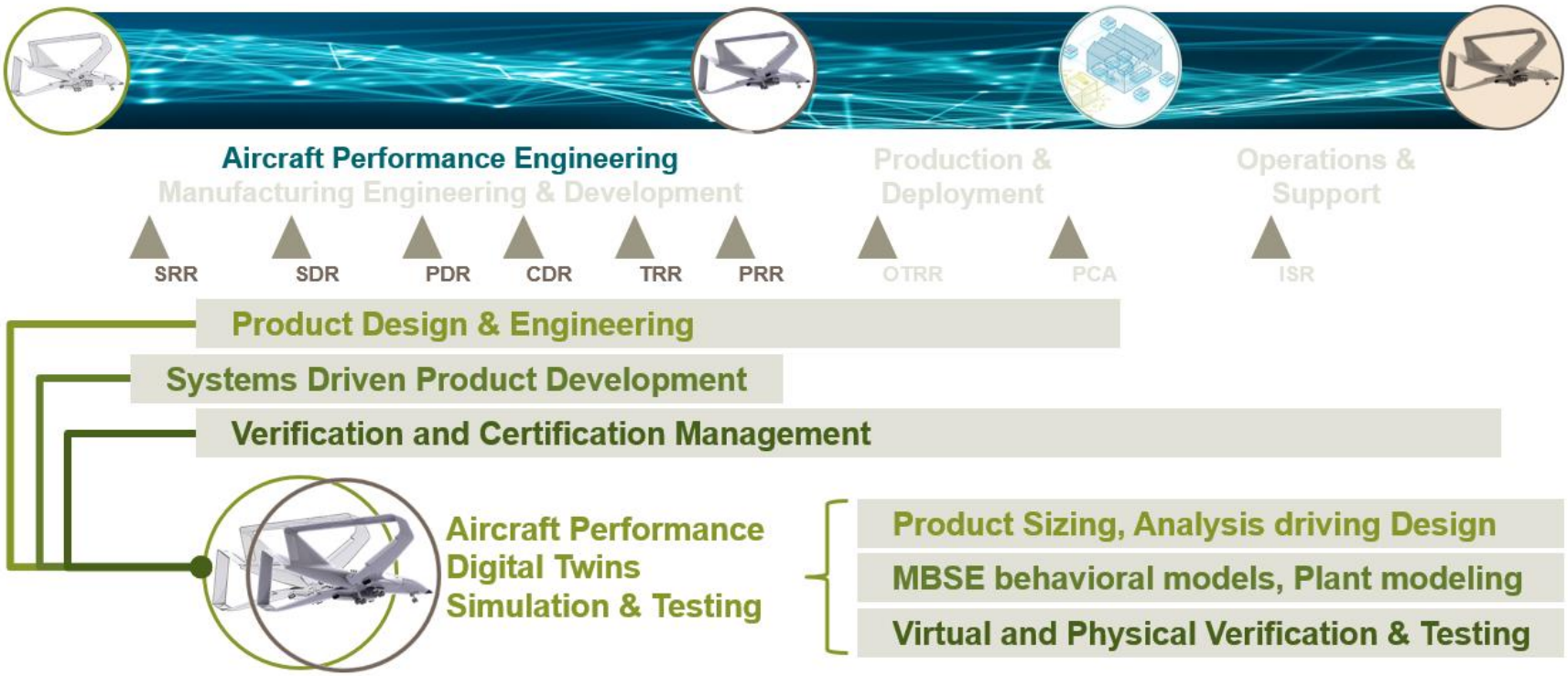

System Driven Product Development

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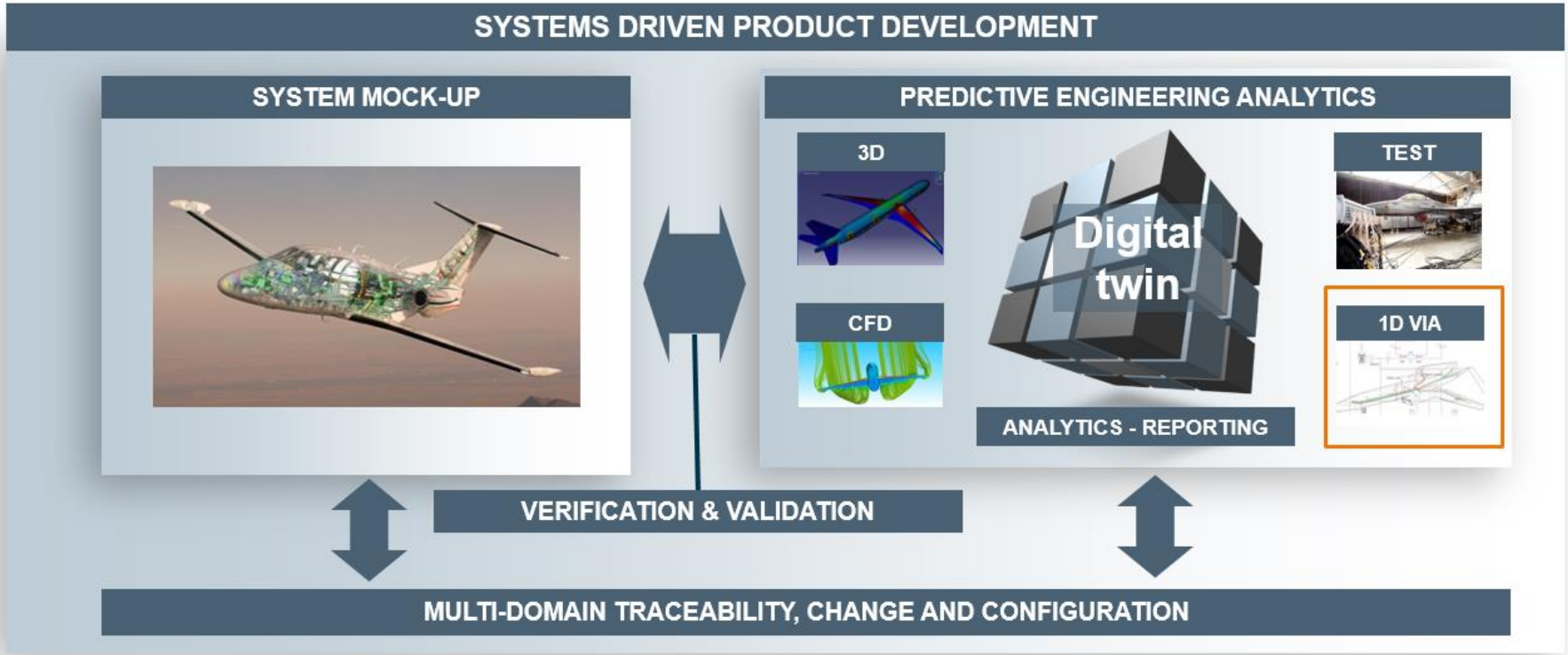

The Multi-Discipline Problem

- Domain Specialization separates expertise
  - Discipline-specific methods, data and technologies
- Best in Class Tools do not connect
  - Technology-focused optimizations for each discipline
- Project and Lifecycle goals are not aligned
  - Separate flows, processes and targets in each discipline
- Manufacturing Pressures cause shortcuts
  - Complete product needs

- It is not solely a Data problem
- It affects Process and Project as well as the People and the Product

The Requirements

- Changes to current practices should be minimal and incremental
- Every participant should have transparent access
- No changes should go unaddressed
- Incomplete work should be immediately noticeable
- Shared resources should be allocated effectively
- No work should be done twice (or more!)
- Every participant should access information in a familiar view
- Reporting upon what has been done should be no extra work

Enabling Systems Engineering

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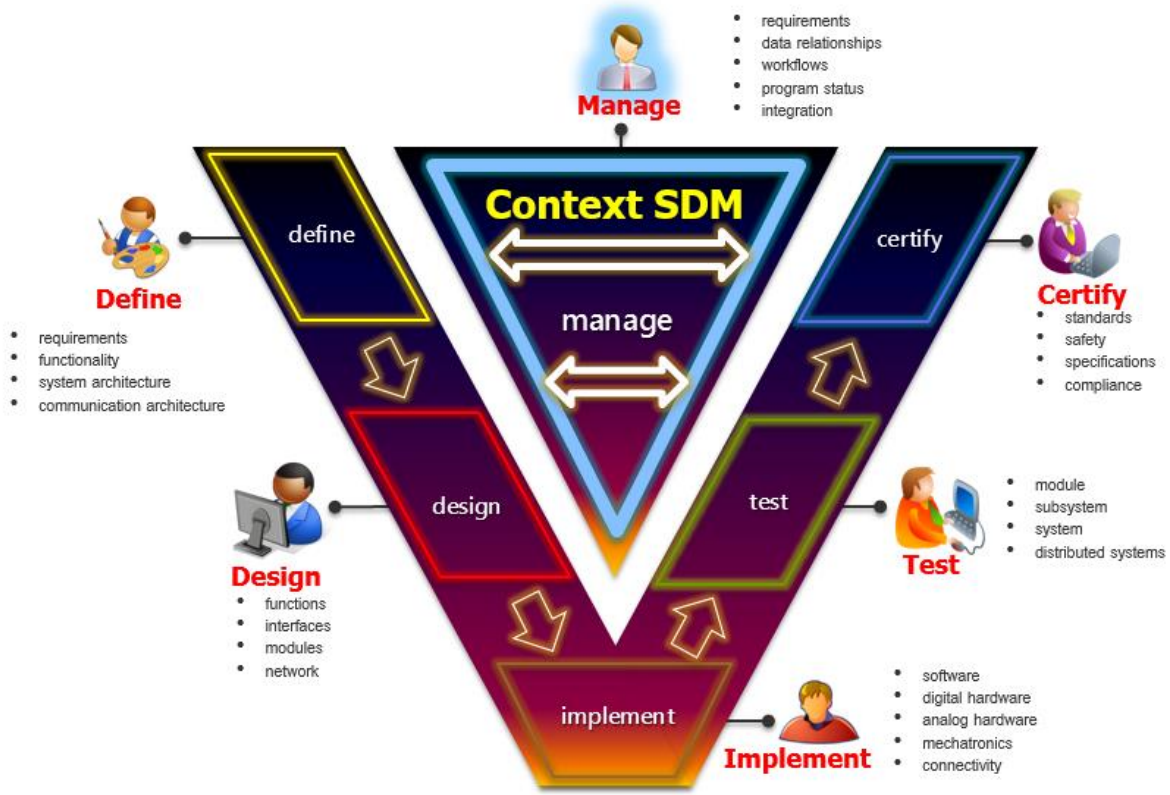

Connected System Architecture

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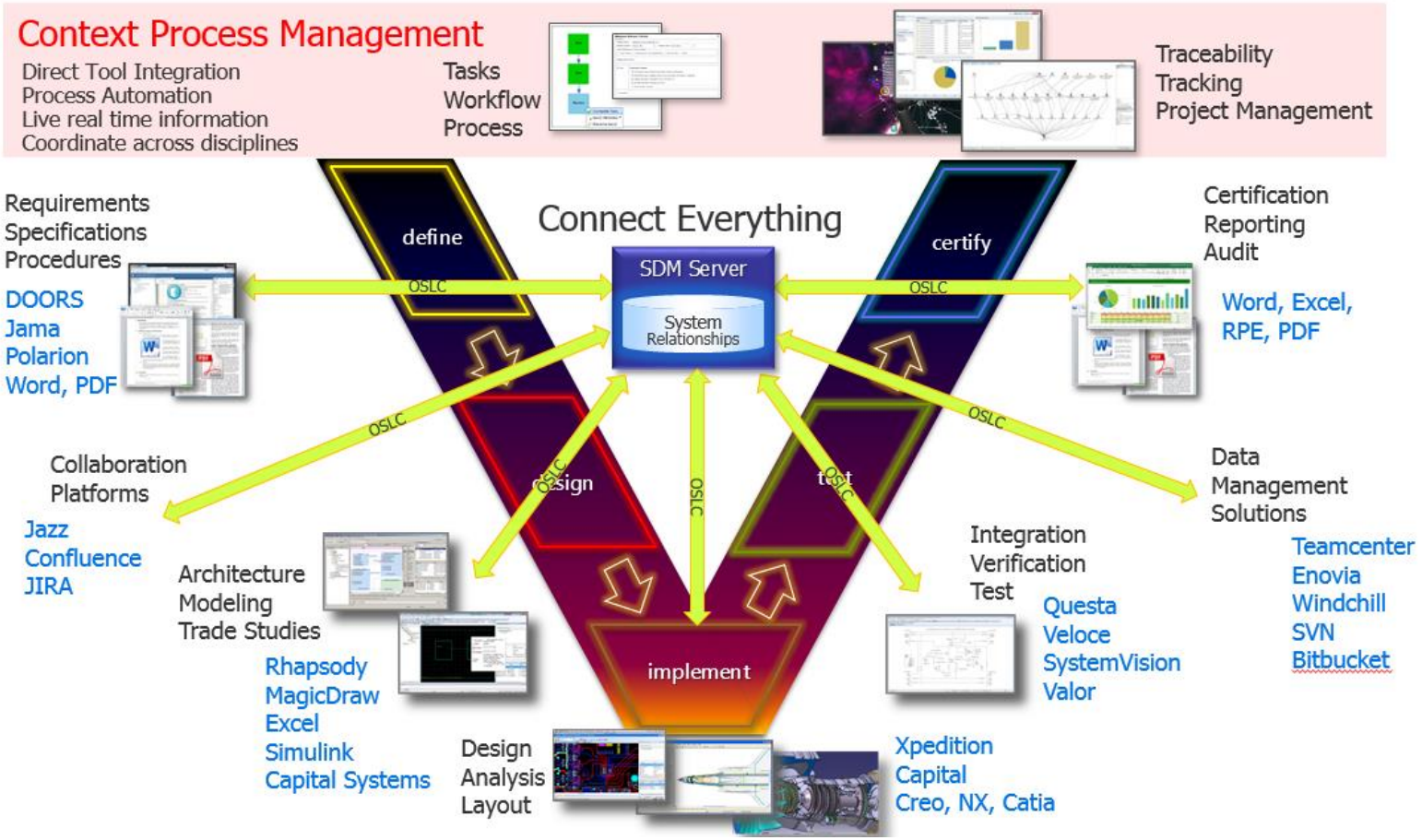


So What?

- The project manager gets…
  - — Visibility, control and status

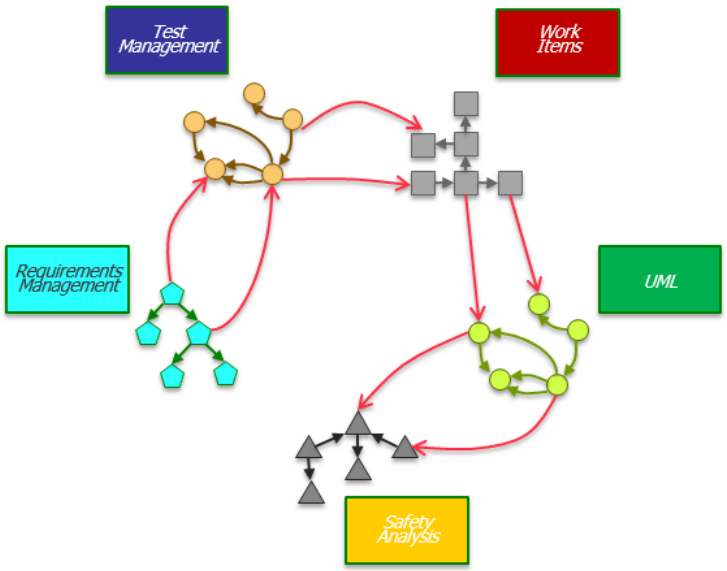
- Each designer gets…
  - — Access to relevant information

- The safety analyst gets…
  - — Traceability and audit

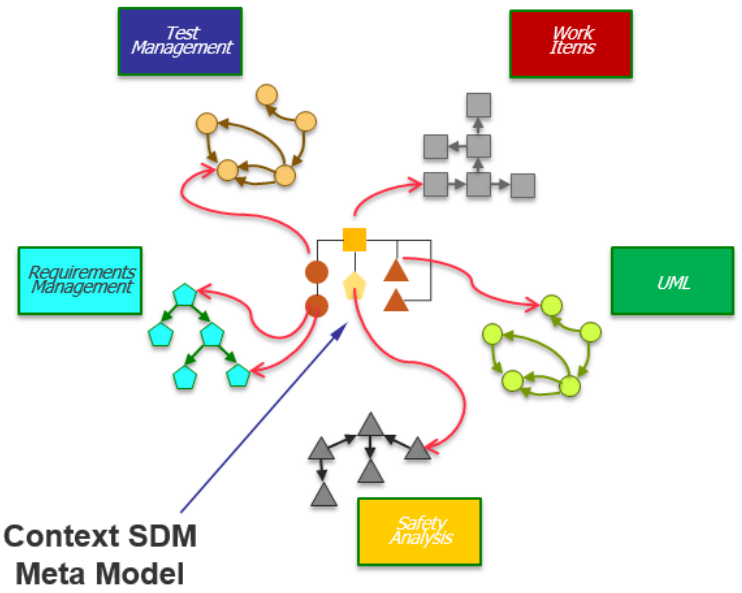
- The requirements engineers get…
  - — Complete and current data

- The systems engineer and the customer get…
  - — The right product, at the right time

The Value of the OSLC-Based Architecture



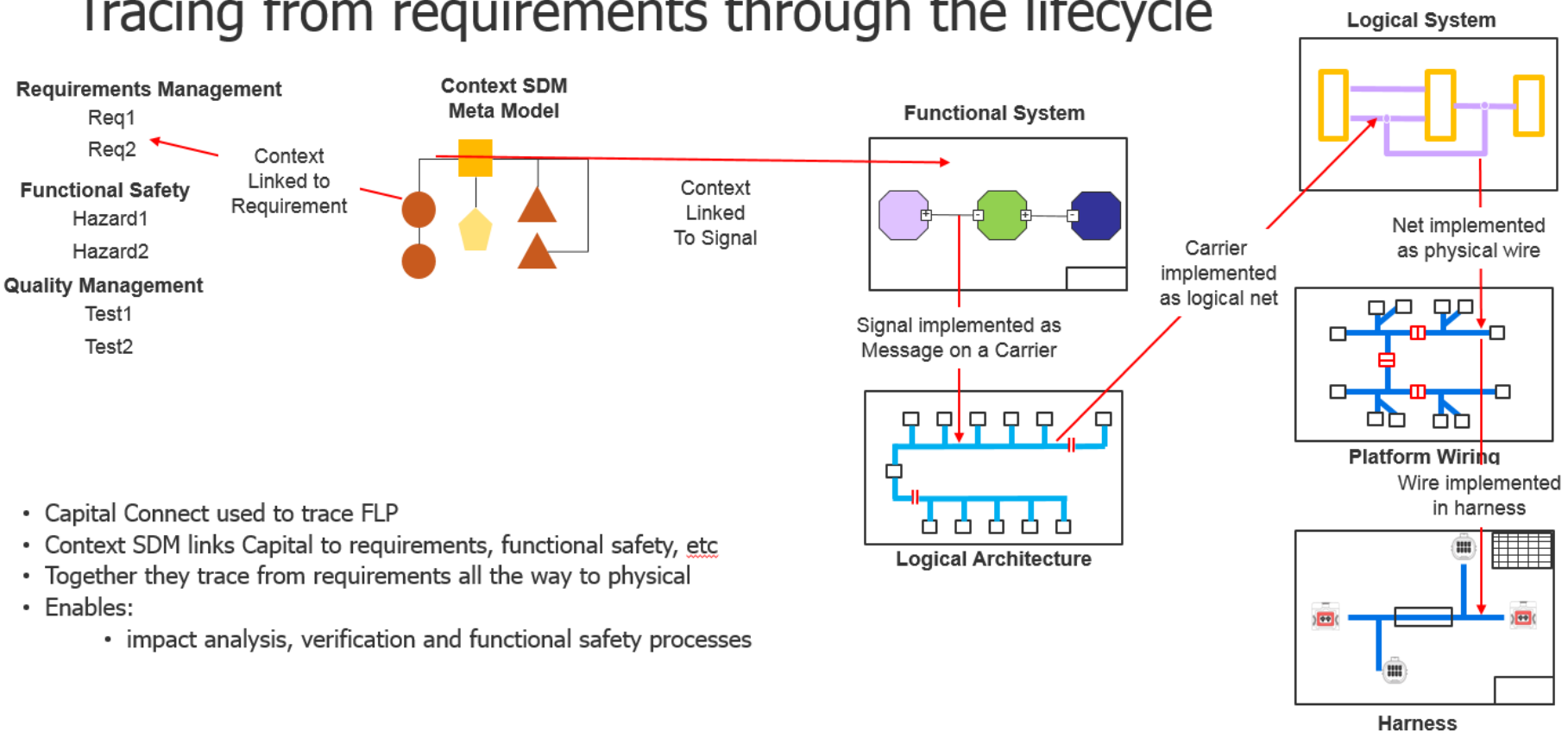
Regular OSLC



Context SDM OSLC

RFLP – Digital Thread In Action

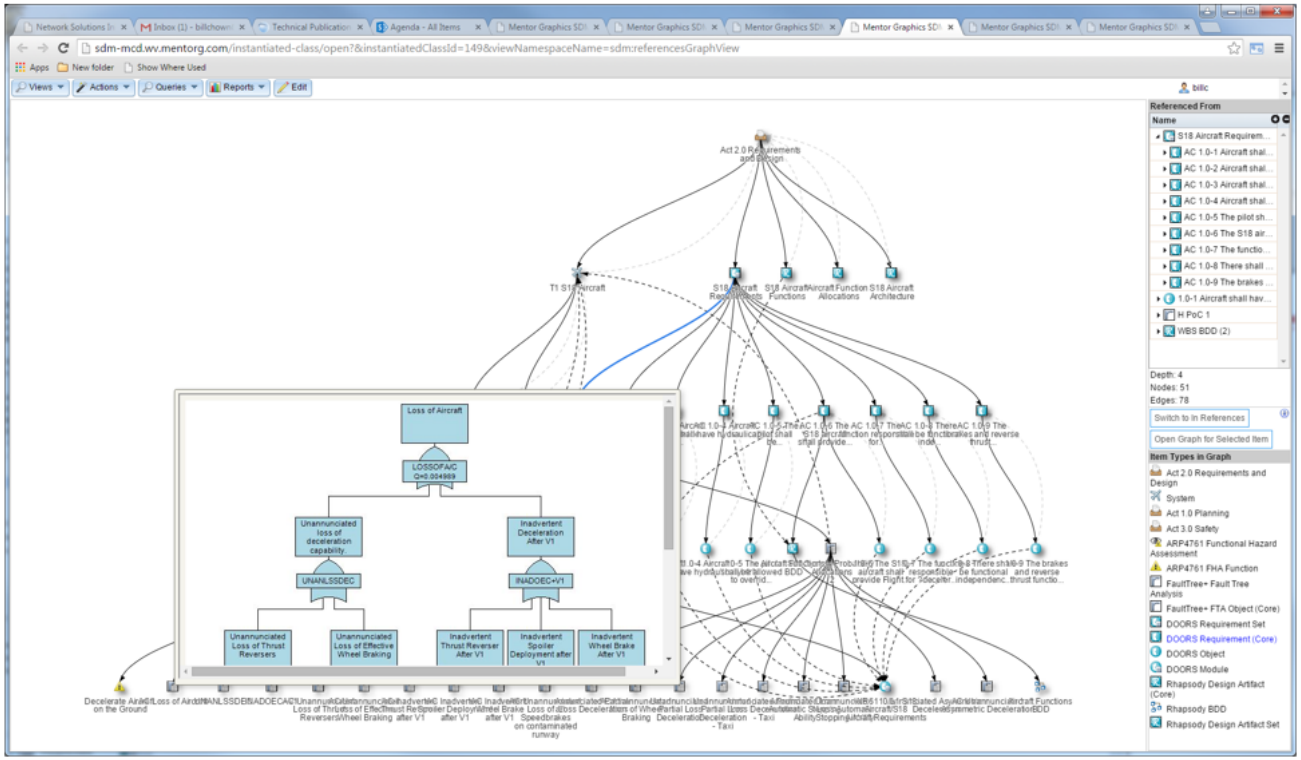
Tracing from requirements through the lifecycle



- Capital Connect used to trace FLP
- Context SDM links Capital to requirements, functional safety, etc
- Together they trace from requirements all the way to physical
- Enables:
  - impact analysis, verification and functional safety processes

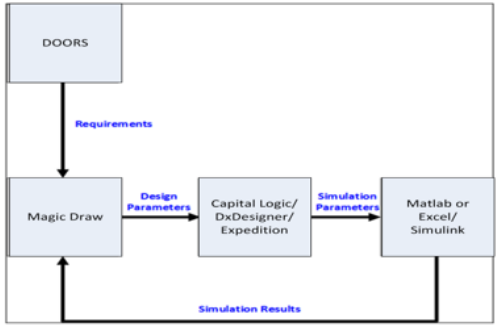
Analyze – Change Impact

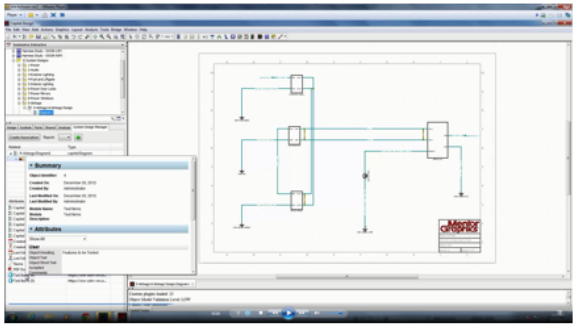
- View relationships to determine impact of intended changes
- Select items for full details
- Traverse to any level of detail
- Trace all dependencies



Example Use Case

- Power transmission and voltage loss
  - Generator – transmission – system load
- Multi-tool environment
  - Requirements – Architecture – Implementation
- Primary data path
- Associated specifications and analysis
- Traceability and Management oversight
- Integrated interoperability in each part of the flow





The Digital Twin: eAircraft Example

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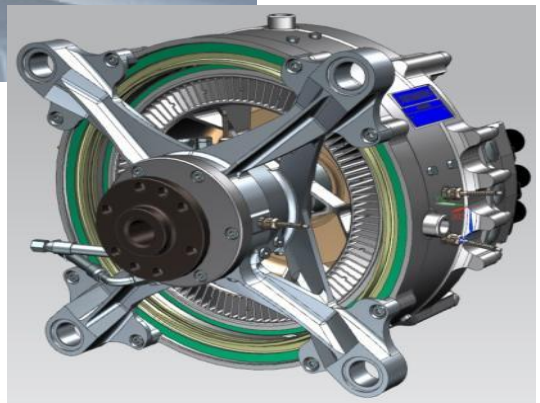

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Siemens Propulsion 260 kW Direct Drive electric motor - designed for aircraft propulsion

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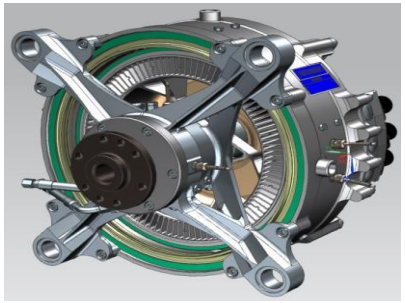
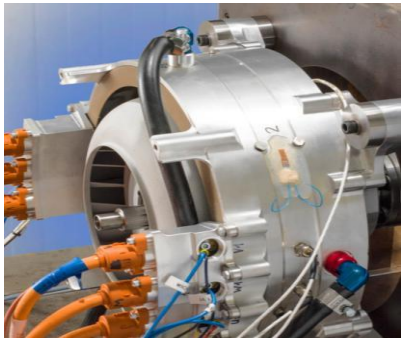
- **SAFE** **Two electrically independent winding systems for internal redundancy**
- **POWERFUL** **260 kW continuous power at 2500 RPM eliminating the need for a reduction gear**
- **EFFICIENT** **η = 95% at cruise power**
- **LIGHTWEIGHT** **50 kg mass → power density 5,2 kW/kg, unique for a direct drive e-motor in this power range**
- **ROBUST** **High coolant inlet temperature of 90 ºC**
- **EASY TO INTEGRATE** **Integrated propeller bearing**





Case Study: Siemens world record setting motor- SP260D in the Extra 330LE

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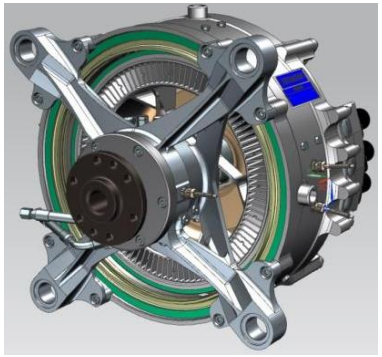
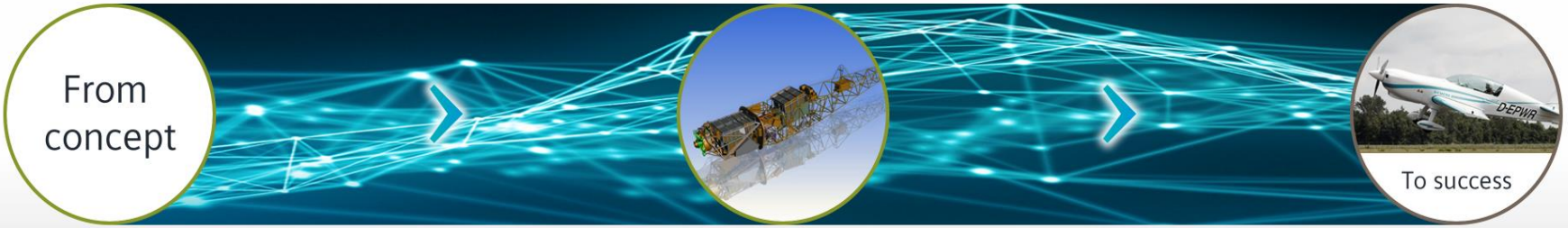
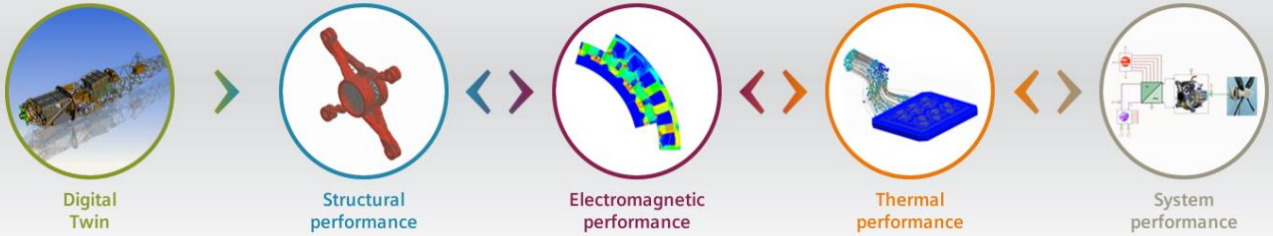


- July 2016: Extra 330 LE Maiden flight and first time all electric, quarter MW output airborne
- Nov 2016: Extra 330LE electric plane set new world record for time to climb: 3000 meters in 4 min 22 seconds//11.5 meters per second
- April 2017 :Extra 330LE electric plane breaks world speed record- 210 mph on straight course
- April 2017 : World first electric glider tow

SIEMENS
Ingenuity for life

The Siemens eAircraft world-record propulsion system – performance optimization using digital twin technology





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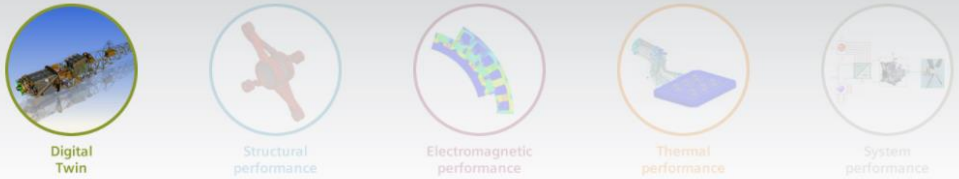


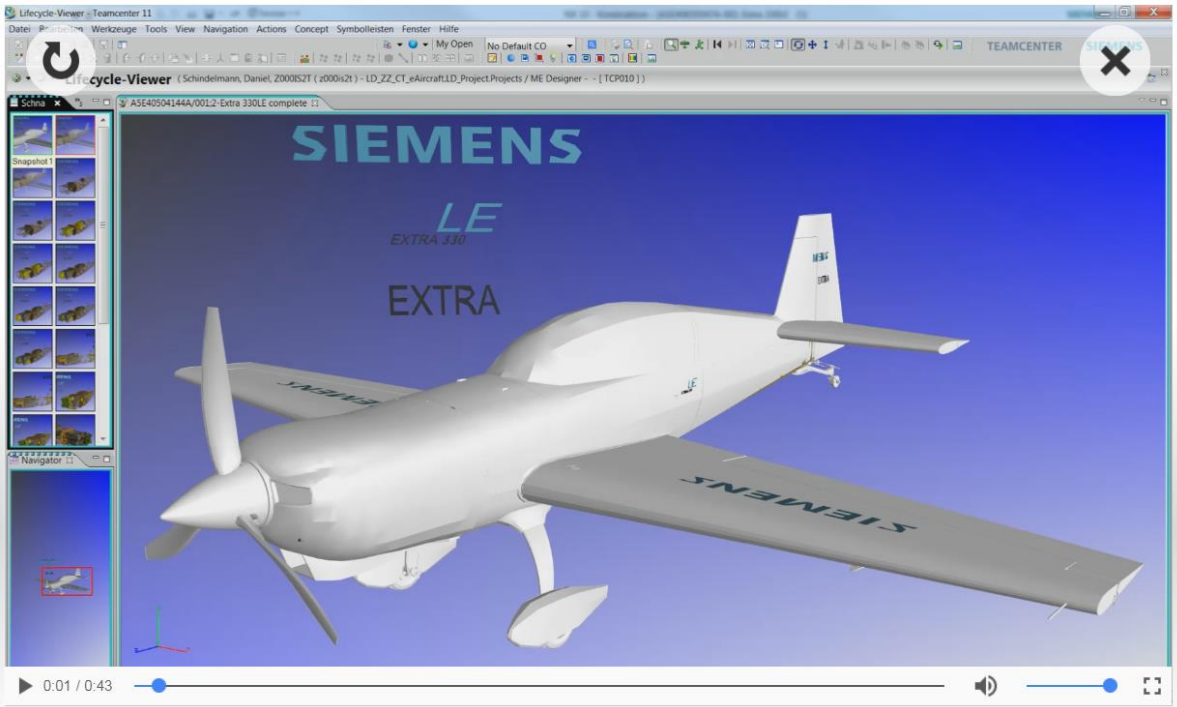
Digital twin setup:
... Basis for rapid development cycles

Digital twin of the complete system:

- motor
- inverter
- batteries
- cabeling
- structure

Each Individual component is created in detail and connected to the system.

Enables rapid iterations across all disciplines.



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Digital Twin | **Structural performance** | Electromagnetic performance | Thermal performance | System performance

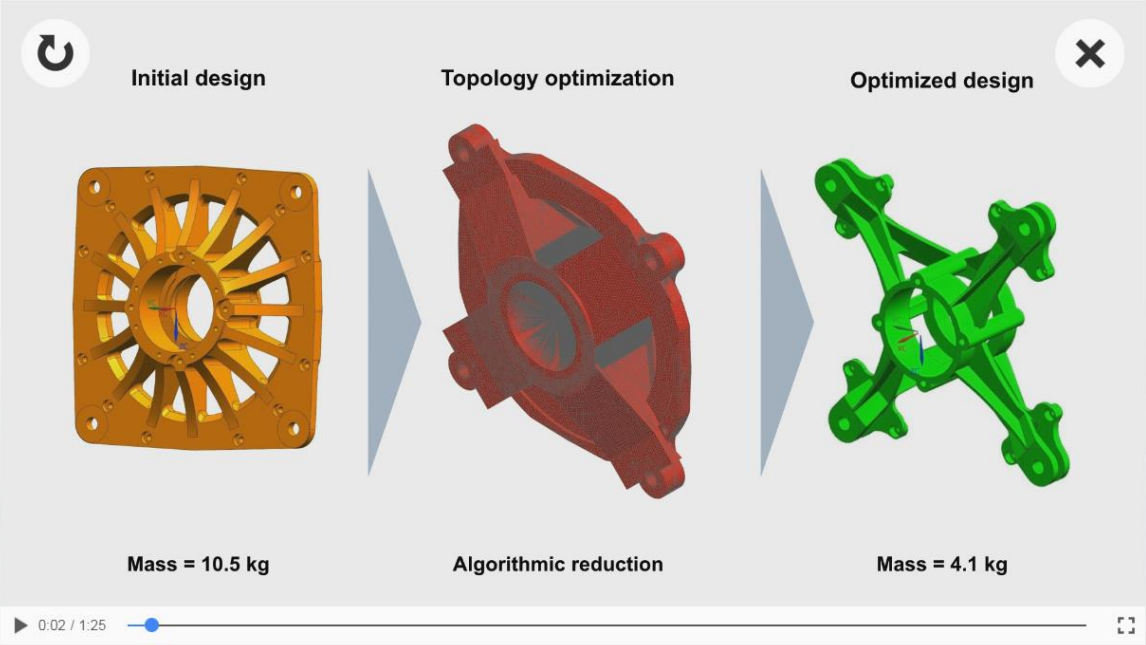
Structural performance engineering:
... Maximizing power to weight ratios

Structural optimization: Improved power/weight ratios

Maintaining

- mechanical strength
- reliability
- safety

Automated structural optimization using linear and non-linear algorithms.



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Digital Twin | **Structural performance** | Electromagnetic performance | Thermal performance | System performance

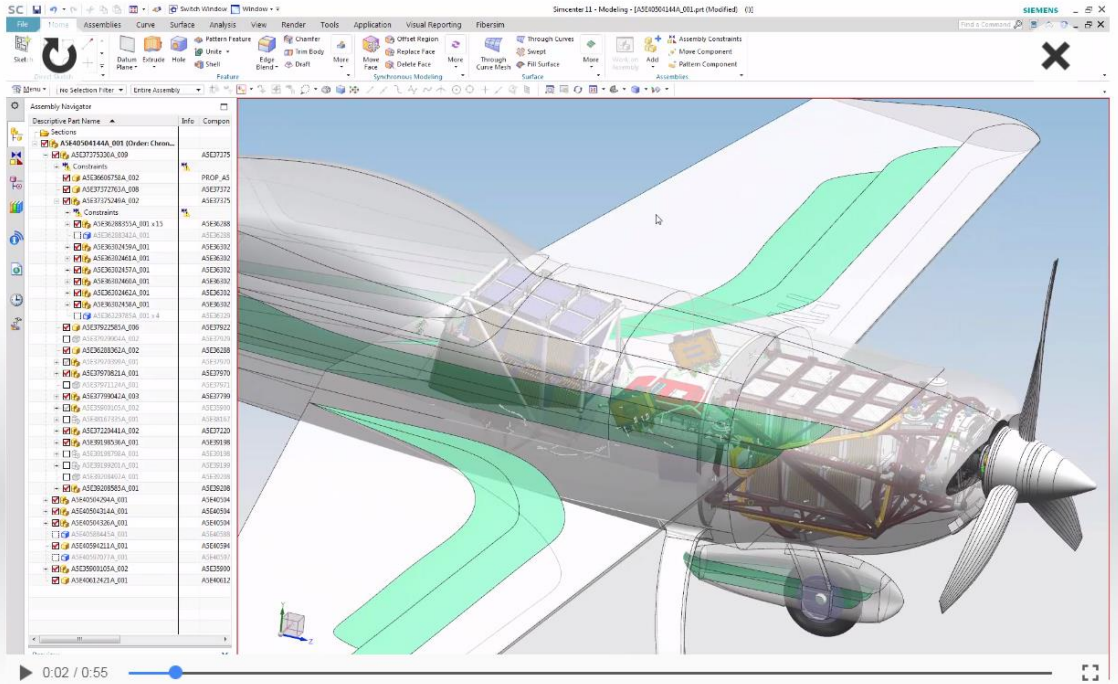
Structural performance engineering:
... Analysis of static and dynamic loads according to mission profiles

Testing loads under flight conditions

- material stresses
- deformations
- vibrations

Digital twin and integrated data models in teamcenter enable fast adjustments and updated calculations.

System optimization in exchange with electromagnetic and thermal analyses.



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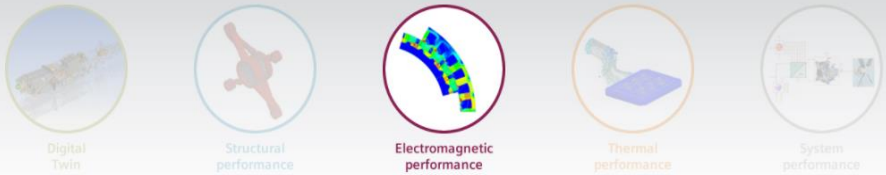


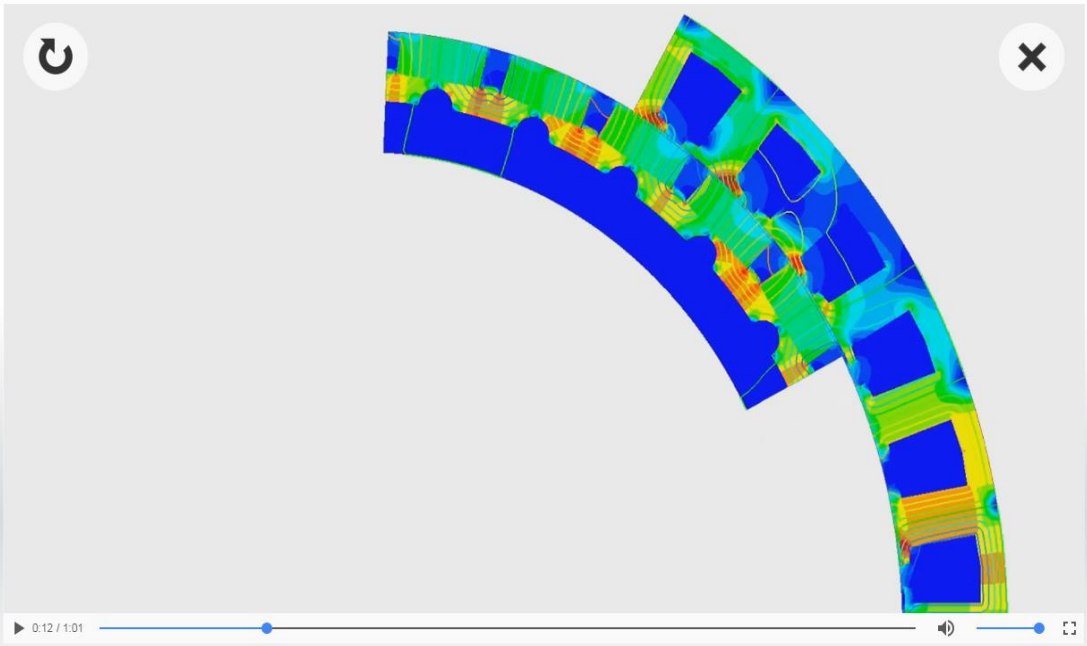
Optimized electromagnetics:
... Getting the ideal motor core

Optimizing the electromagnetic design

- analyzing the magnetic field
- losses
- electromagnetically induced stresses

Basis for performance and safety of the motor.

System optimization in exchange with structural and thermal analyses.



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Digital Twin | Structural performance | Electromagnetic performance | Thermal performance | System performance

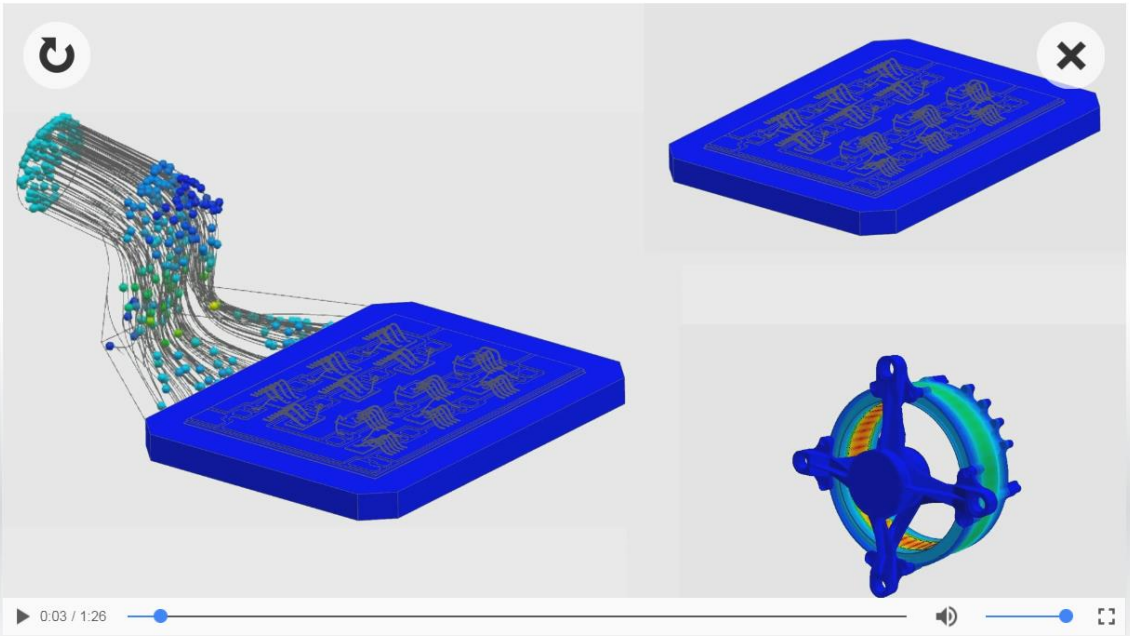
Optimizing themal loads:
... Optimal balance between power and efficiency

Thermal optimization

- heat flows
- cooling system design
- material analyses

Detailed modelling of heating, liquid- and airflows enables design of required cooling system.

System optimization in exchange with structural and electromagnetic analyses.



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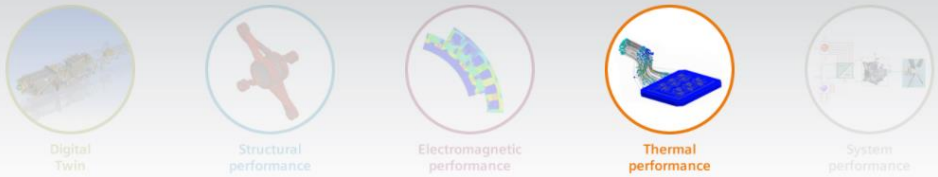

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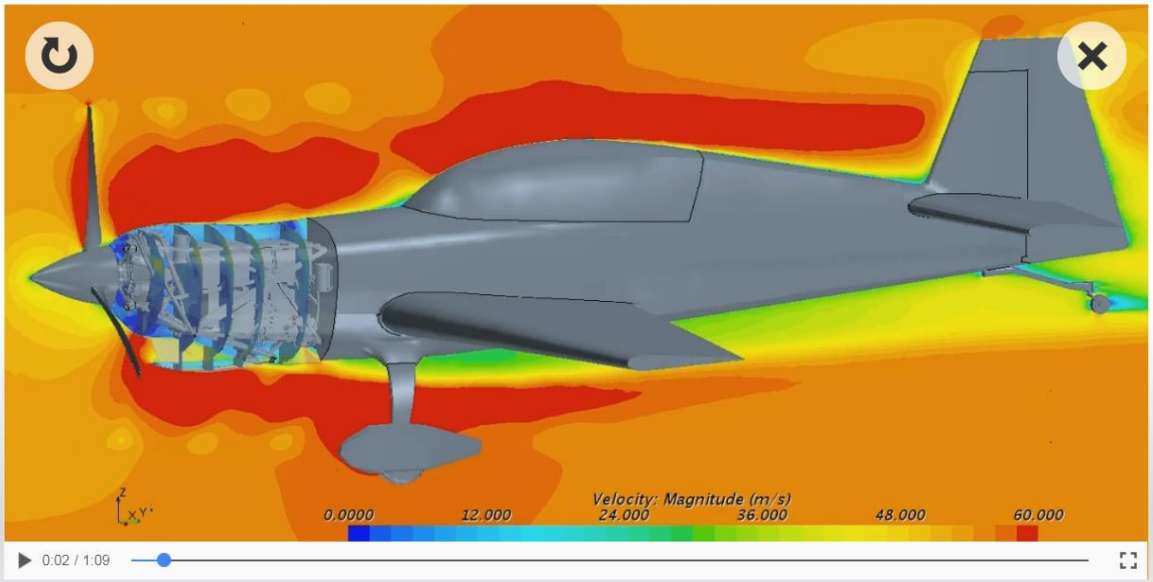

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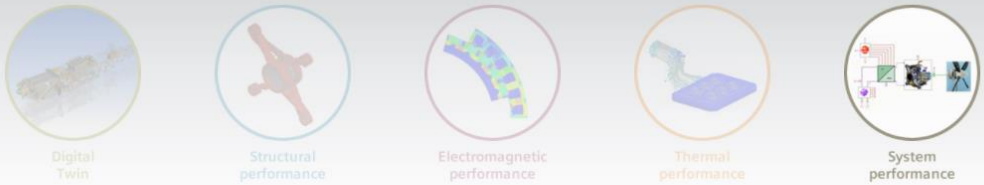


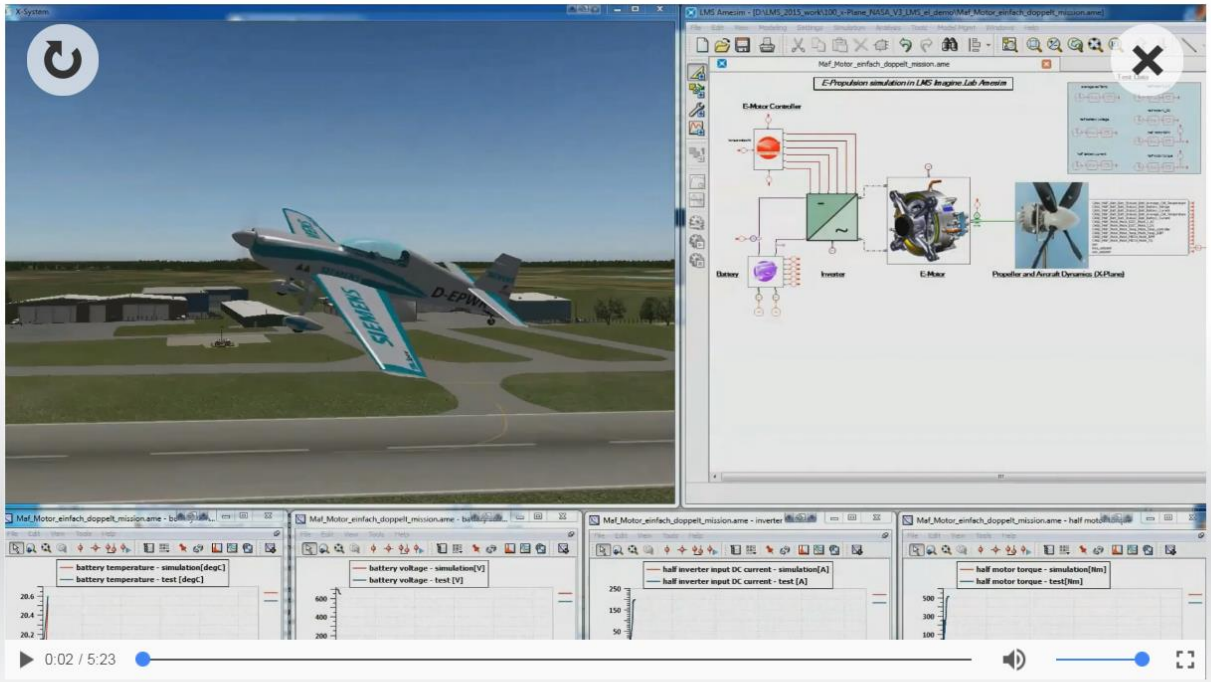
Optimization to reach the record flight:
... Simulation of the planned mission and continuous improvement

Via simulation to record flight

- simulation and mission optimization
- automatic data transfer
- data analysis with MindSphere

Virtual flight tests the optimal mission profile.

Analysis of actual data allows continuous system improvements.



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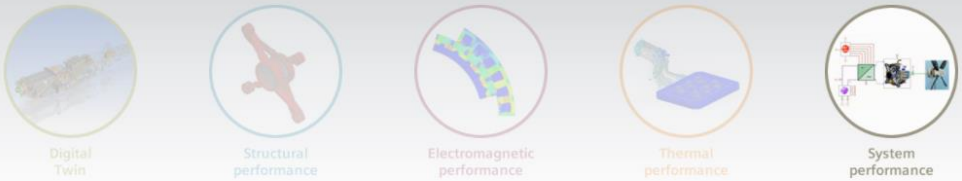
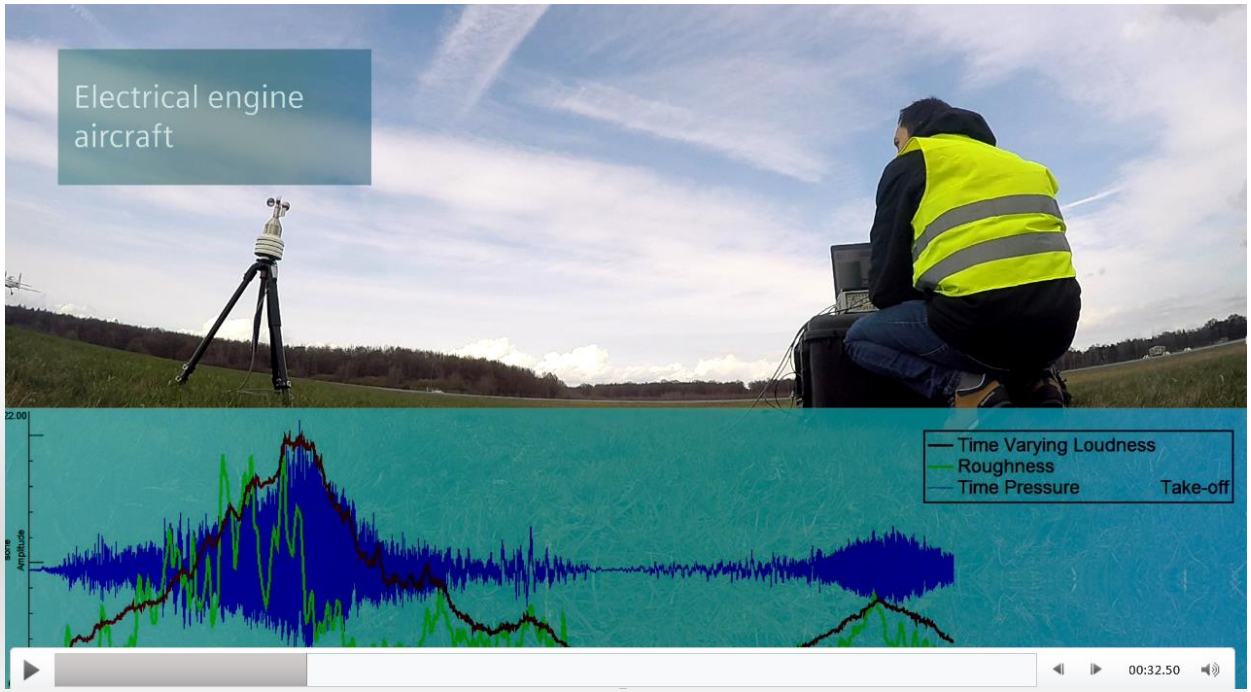


From concept to success

Noise comparison

- Simcenter noise and vibration engineering solutions enable comparison of acoustic levels for the standard Extra 330LT aircraft (internal combustion engine), and the Extra 330LE (SP260D propulsion system)
- the result: the SP260D produces 14.5dBA less noise in flight
- measurements and analysis were performed with the LMS SCADAS XS portable data acquisition and LMS Test



Key Systems Engineering Goals

- Provide a structured process for integrating and linking requirements, schedule, decision milestones, and verification
- Enable the project team to work to a single, integrated set of requirements and processes
- Enable integration of the system at the requirements and design stages (before sunk costs) rather than waiting until hardware and software is available
- Reduce unplanned and costly reengineering necessary to resolve omissions and integration difficulties

Q&A