Model-Based Design for Drilling Systems Development: Practical perspectives from other industries

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WW Industry Marketing Director

MathWorks®

Accelerating the pace of engineering and science

Agenda

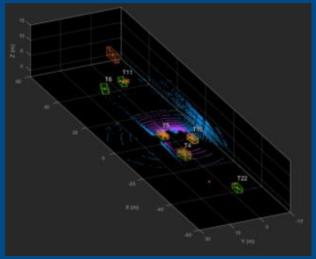
- MathWorks View on Industry Trends
- Industry Case Studies for Model-Based Design
- Summary of Practical Perspectives for Drilling Systems Development

MathWorks Customers / Key Industries

Aerospace & Defense

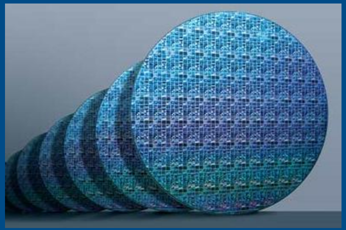



Automotive & Transportation

Communications, Electronics, Semiconductors






Finance




Industrials & Energy




Medical & BioPharm




Trends Across Key Industries

	Aerospace & Defense	Automotive & Transportation	Comm., Elec., Semi.	Finance	Industrials & Energy	Medical & BioPharma
Electrification	More Electric Aircraft	eMobility	Home Automation	N.A.	Process Automation, Renewables	Therapeutic Devices

Trends Across Key Industries

	Aerospace & Defense	Automotive & Transportation	Comm., Elec., Semi.	Finance	Industrials & Energy	Medical & BioPharma
Electrification	More Electric Aircraft	eMobility	Home Automation	N.A.	Process Automation, Renewables	Therapeutic Devices
Artificial Intelligence						
Connected / Wireless						
Autonomous						
Cloud						
Digital Transformation						
Standards & Regulations						

Trends Across Key Industries

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Electrification	More Electric Aircraft	eMobility	Home Automation	N.A.	Process Automation, Renewables	Therapeutic Devices
Artificial Intelligence	Engine Health Monitoring	ADAS	Semiconductor Manufacturing Yield Optimization	Fraud Detection	Predictive Maintenance	Drug Discovery
Connected / Wireless	C4ISR	V2X	IoT	Usage based insurance	Smart Grid	Surgical Robots Teleoperation
Autonomous	UAV's / Drones Military Ground Robots Space Exploration	Autonomous Driving	Survey & Inspection Delivery Drones	Algorithm driven financial services	Autonomous warehouses	Autonomous Cardiovascular-Respiratory Resuscitation
Cloud	JEDI	OTA Updates Diagnostics & Services	SaaS	Operational Risk Analytics	Demand and Asset Management	Wearables, Remote Health Diagnostics
Digital Transformation	Connected Systems of Systems	MaaS	Mass Customization	Blockchain	Industry 4.0	Digital Health
Standards & Regulations	DO 178 DO 254 ARP 4754	Electric Vehicles ISO 26262 SOTIF	5G	BASEL III / IV CECEL	IEC 61508 NERC MOD 26	IEC 62304

Trends Across Key Industries

Growing system complexity

- Algorithms
- Software (LOC)
- Computational Units (Processors, GPU's, etc.)
- Over-the-Air Updates
- …

Verification is the bottleneck

"To ensure safety in increasing degrees of autonomy, software quality and complexity are a key challenge for the automotive industry, requiring a rethink today's vehicle software and E/E architectures."

SDV Trends, Challenges, and Implications for OEMs - McKinsey presentation at Gasgoo – July 2020

	Aerospace & [illegible]	Automotive & [illegible]	Comm., Elec., Semi.	Finance	Industrials & [illegible]	Medical & [illegible]
Electrification	More Electric Aircraft	eMobility	Home Automation	N.A.	Process Automation, Renewables	Therapeutic Devices
Artificial Intelligence	Engine Health Monitoring	ADAS	Semiconductor Manufacturing Yield Optimization	Fraud Detection	Predictive Maintenance	Drug Discovery
Connected / Wireless	[illegible]	[illegible]	IoT	[illegible] insurance	Smart Grid	[illegible] Robots Teleoperation
Autonomous	UAV's / Drones Military Ground Robots Space Exploration	Autonomous Driving	Survey & Inspection Delivery Drones	[illegible] financial services	[illegible] warehouses	Autonomous Cardiovascular-Respiratory Resuscitation
Cloud	JEDI	OTA Updates Diagnostics & Services	SaaS	Operational Risk Analytics	Demand and Asset Management	[illegible]les, Remote Health Diagnostics
Digital Transformation	Connected Systems of Systems	MaaS	Mass Customization	Blockchain	Industry 4.0	Digital Health
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Model-Based Design

Modeling

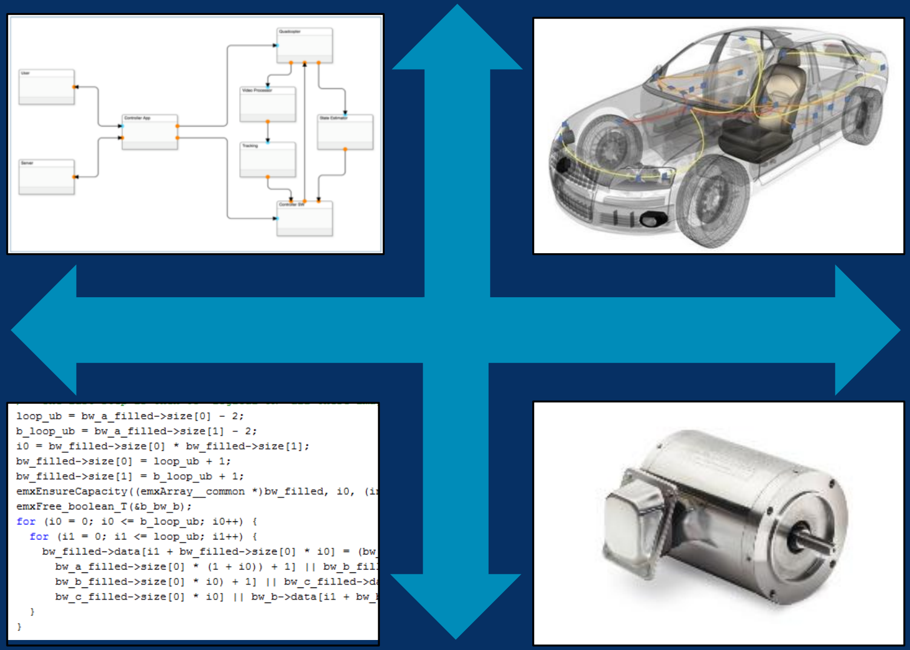
Simulation | Analysis

+

Automation

Coding | Verification

Systems



Software

Physics

Components

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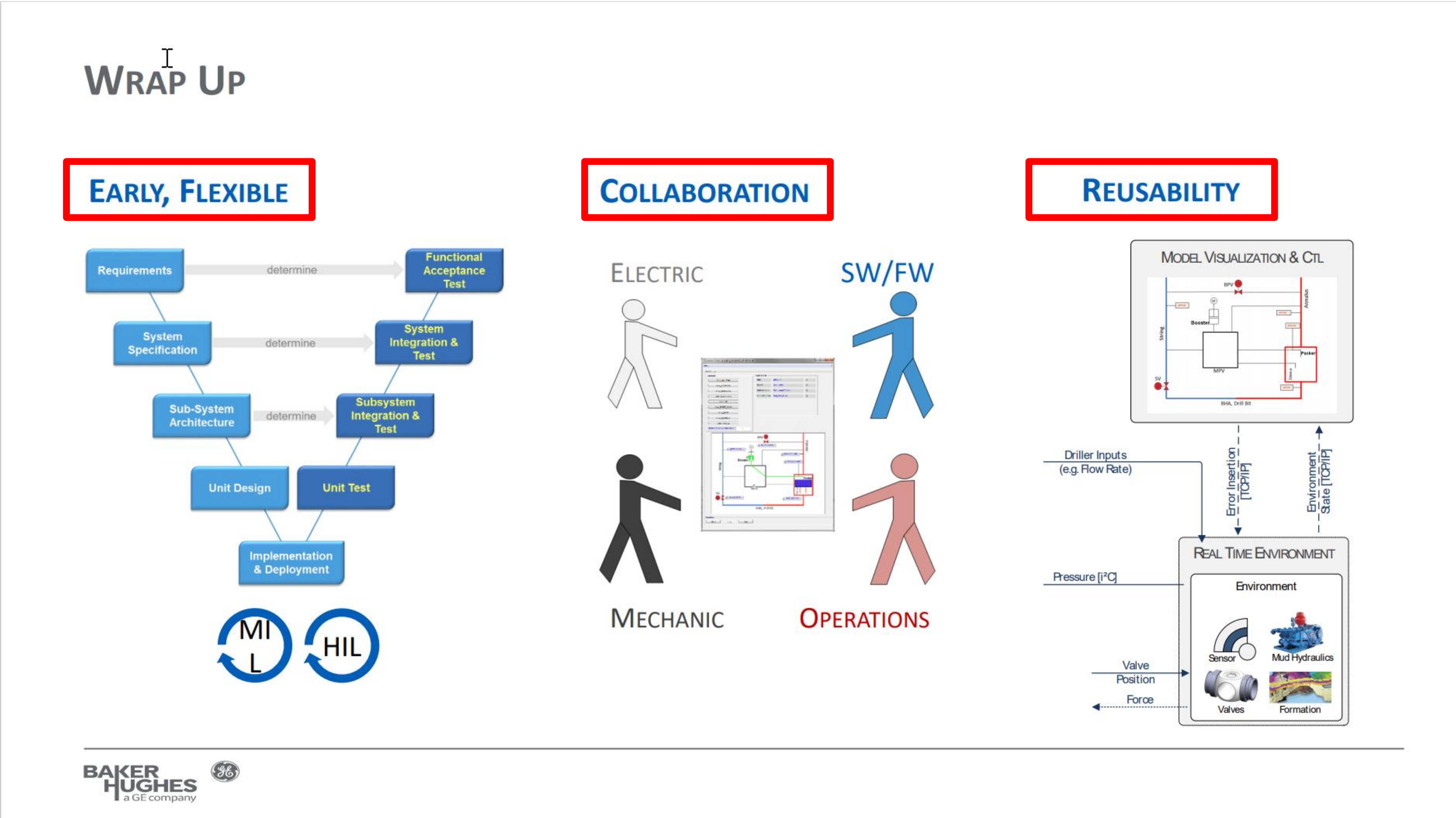
Model Based Design and Integration Testing of Oil & Gas Drilling Tools



Björn Beckmann, Baker Hughes a GE Company
https://www.mathworks.com/videos/model-based-design-and-integration-testing-oil-and-gas-drilling-tools-1532367928212.html

Digital Transformation in the Elevator Industry – Moving from Physical Testing to Simulation

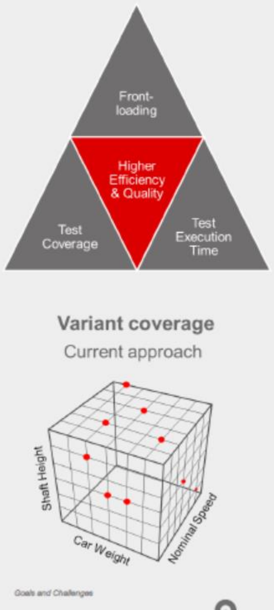
Goals and Challenges of Digital Transformation

Goals and Challenges

- Decrease the time and costs which are invested for physical testing (3200 hours in 2016 for software qualification tests in test towers)
- Elevator industry and certification is conservative

- Automated verification of different system configurations
- ~ 20'000 independent system variants with hundreds of different component configurations

- Drive a model and fact based development process
- Mindset of people and organizational structures



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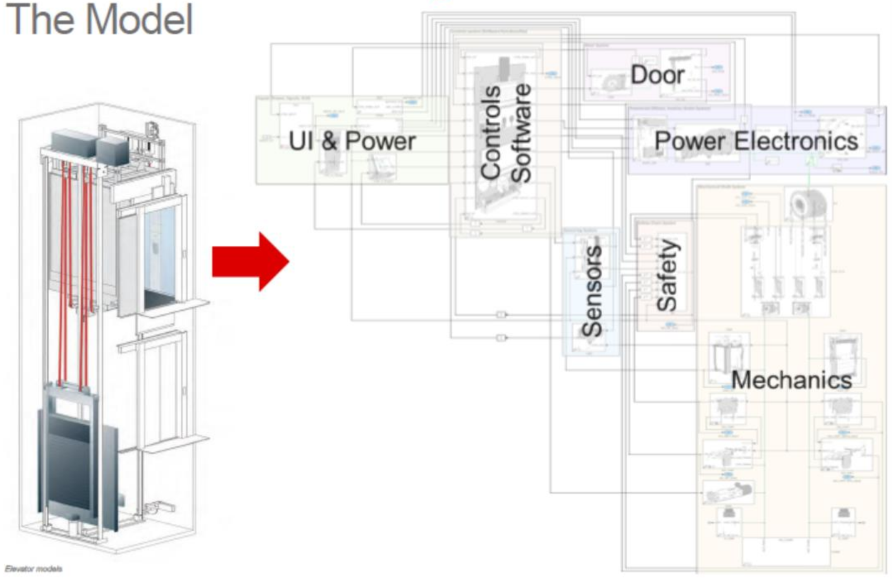
EDEn – The Elevator Dynamics Environment
The Model



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Model Facts

- One generic System Model
- ~11'000 blocks
- ~1'500 physical signals
- Covers 60 different system architectures
- 350 parameter to configure an elevator system
- ~70'000 lines of code

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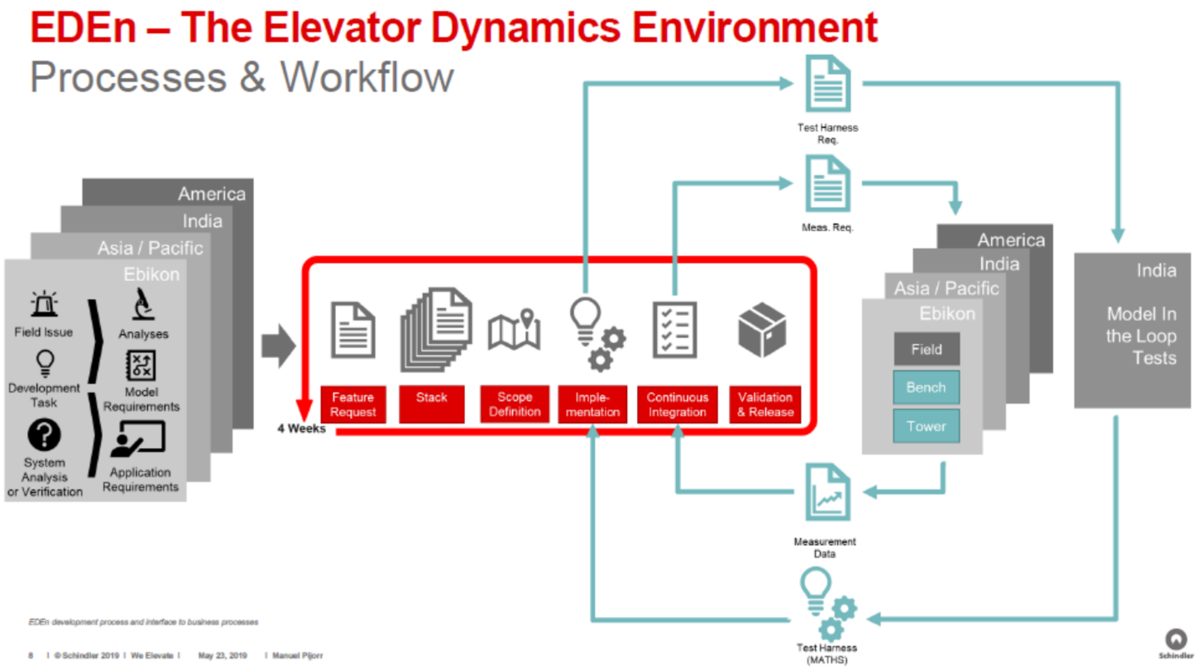
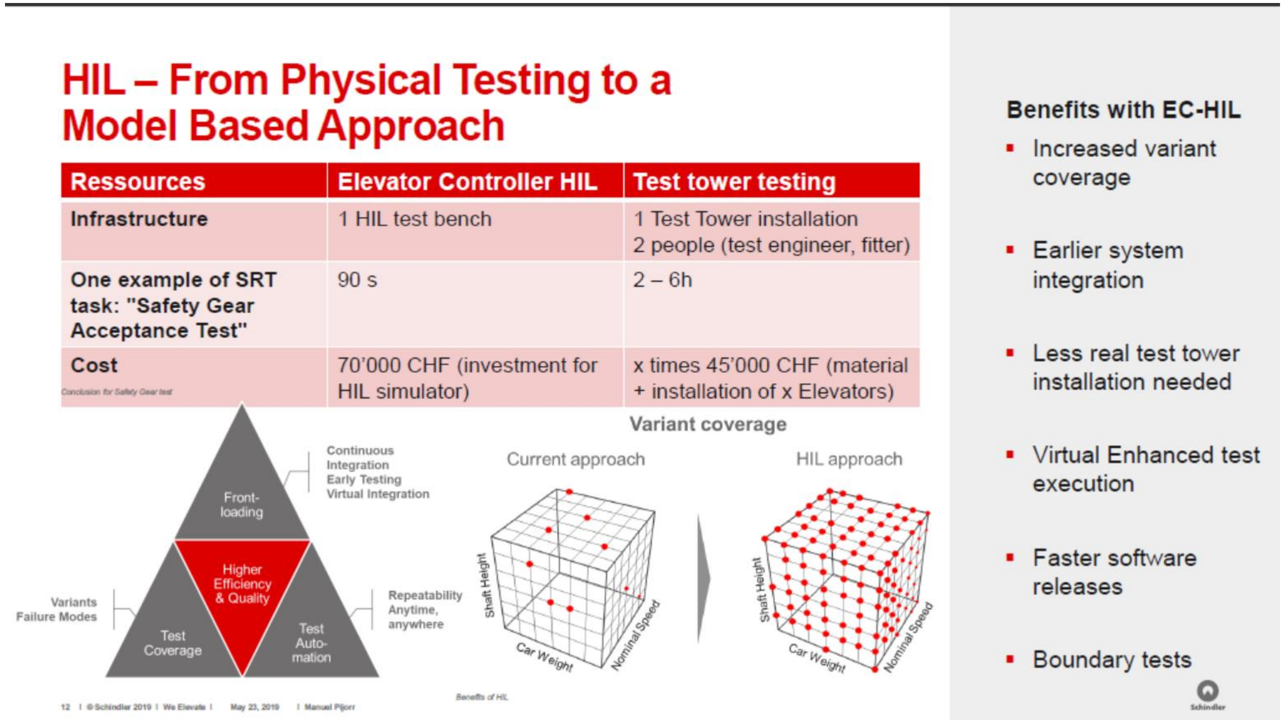
Digital Transformation in the Elevator Industry – Moving from Physical Testing to Simulation



Garden of EDEn - Apps deployed to web for use with an internet browser



Ressources	Elevator Controller HIL	Test tower testing
Infrastructure	1 HIL test bench	1 Test Tower installation 2 people (test engineer, fitter)
One example of SRT task: "Safety Gear Acceptance Test"	90 s	2 – 6h
Cost	70'000 CHF (investment for HIL simulator)	x times 45'000 CHF (material + installation of x Elevators)

Software Release Test in 1 night instead of 4 weeks with HIL and test automation

Vestas Develops Control Software for Wind Power Plants with Model-Based Design and Continuous Integration

Collaboration across countries

"We have dozens of ***engineers worldwide working in parallel on the same model*** *with lots of merges. Using Model-Based Design and CI together, we've shortened iterations and automated testing processes."*

Vestas turbines and power plant control.

Collaboration across customers and suppliers

"With Simulink and Embedded Coder, we can ***show our customers and grid operators*** *a simulation that incorporates the actual code that will run in our power plant controller. That's what grid operators want, and it gives Vestas an advantage over competitors who still use conventional approaches."*

"Grid operators want to see a simulation of how your plant will perform, and they want to know that the control code will match the simulation one-to-one. ***Today, not many companies can show this****. At Vestas we can because we use Model-Based Design with MATLAB and Simulink to model and simulate our power plant control systems and then use those same models to generate C++ code for system-level simulation and production."*

Link to user story

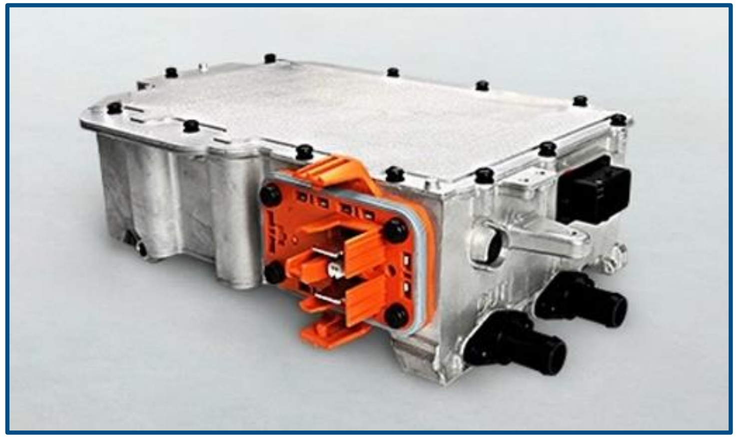
LG Electronics Develops ISO 26262–Compliant Power Inverter Control Software with Model-Based Design

Improved communication

*“Our initial objective in adopting Model-Based Design was to meet ISO 26262 recommendations. We soon discovered additional benefits to using MATLAB and Simulink, including **improved communication of technical design details between engineers in disparate fields**, which has led to a reduction in software defects.”*

Verification time reduced by 20%

“Without Model-Based Design I don’t think we would have achieved our ISO 26262 compliance objectives while completing the project on time.”



LG Electronics inverter for electrical and hybrid electric vehicles.

Automation & optimization

*“Because the code we generated with Embedded Coder was highly optimized, we were able to **meet our strict execution time requirement**. The generated code’s performance was comparable to that of C code written by hand.”*

Standards certification

*“Model-Based Design helped us **apply the design and verification methods required by ISO 26262**, including back-to-back verification and test coverage assessment. In particular, the automated test cases and reports in Simulink Test contributed significantly to reduced testing efforts.”*

[Link to user story]

Model-Based Design application to Certification Standards across Industries

ISO 26262

Kostal
Electronic Steering Column Lock

MIL-STD-188-165A

BAE Systems
Software-Defined Radio

DO-178

Bell Helicopter
Fly-by-wire flight controls

IEC-60880

MTU Germany
Nuclear Plant Emergency Generators

IEC 61508

GE Power
HDVC Power Systems

IEC 62304

Weinmann Medical Germany
Transport ventilator

Model-Driven Engineering, Modularity, and Re-Use

LEONARDO AIRBORNE & SPACE SYSTEMS

Development Environment

Infrastructure for Model-Based Design

Fundamental to developing complex multi-functional models is to have a development environment capable of supporting high integrity designs in collaboration.

Common MATLAB & Simulink Workflows:

- Issue Management
- Source Control
- Test Automation

Jenkins Jira Software Bitbucket

General Us

LEONARDO AIRBORNE & SPACE SYSTEMS

Development Environment

Common Environment

Mandate the use of Simulink Projects for both MATLAB and Simulink designs

- Standardised environment setup
  - No more *'add all to path… then load this file… but not that one'*
- Use project Templates to distribute standardised projects
- Reflect model architecture using Referenced Projects
- Source Control integration

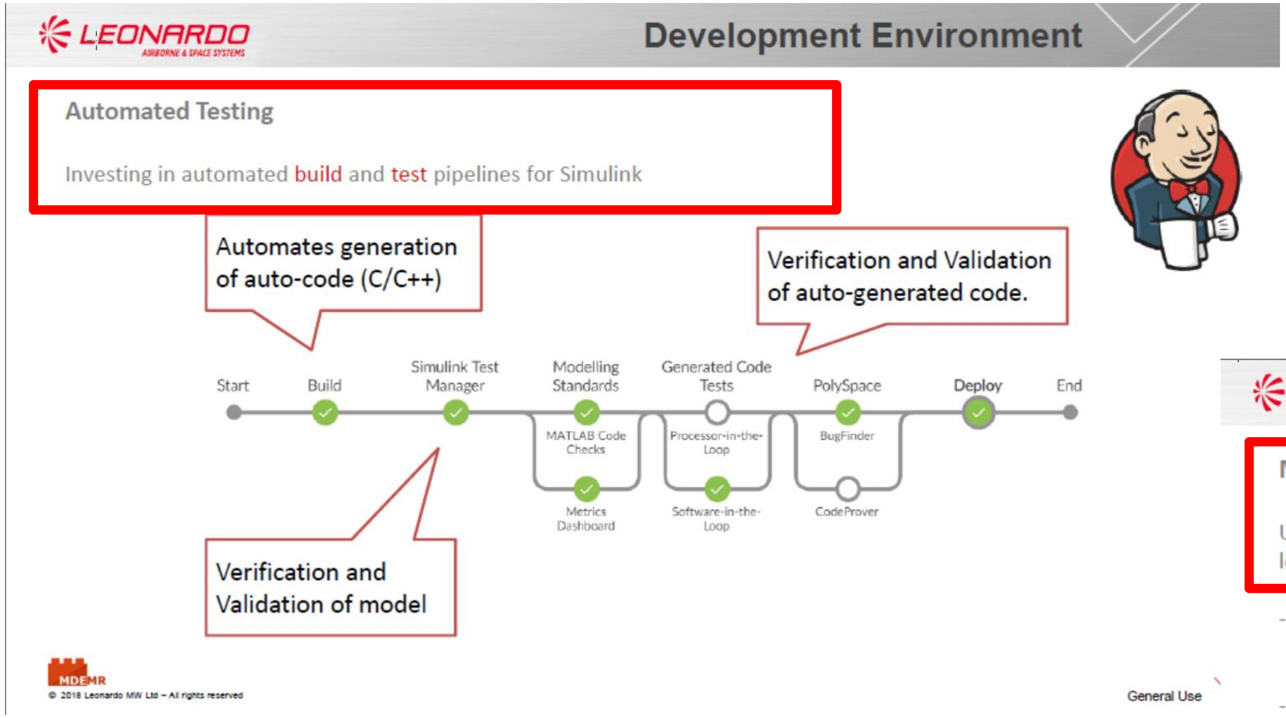
Simulink Projects

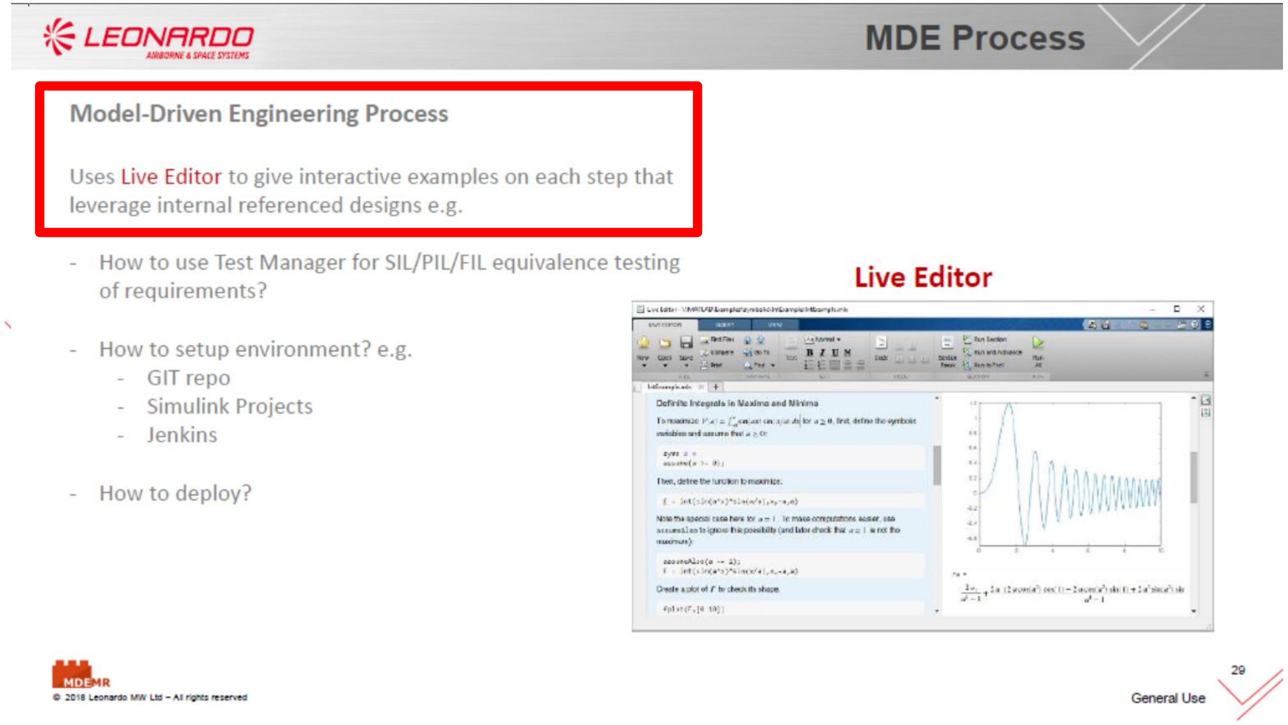
General Use 22

Andrew Carmichael & Rory Hughes, Leonardo

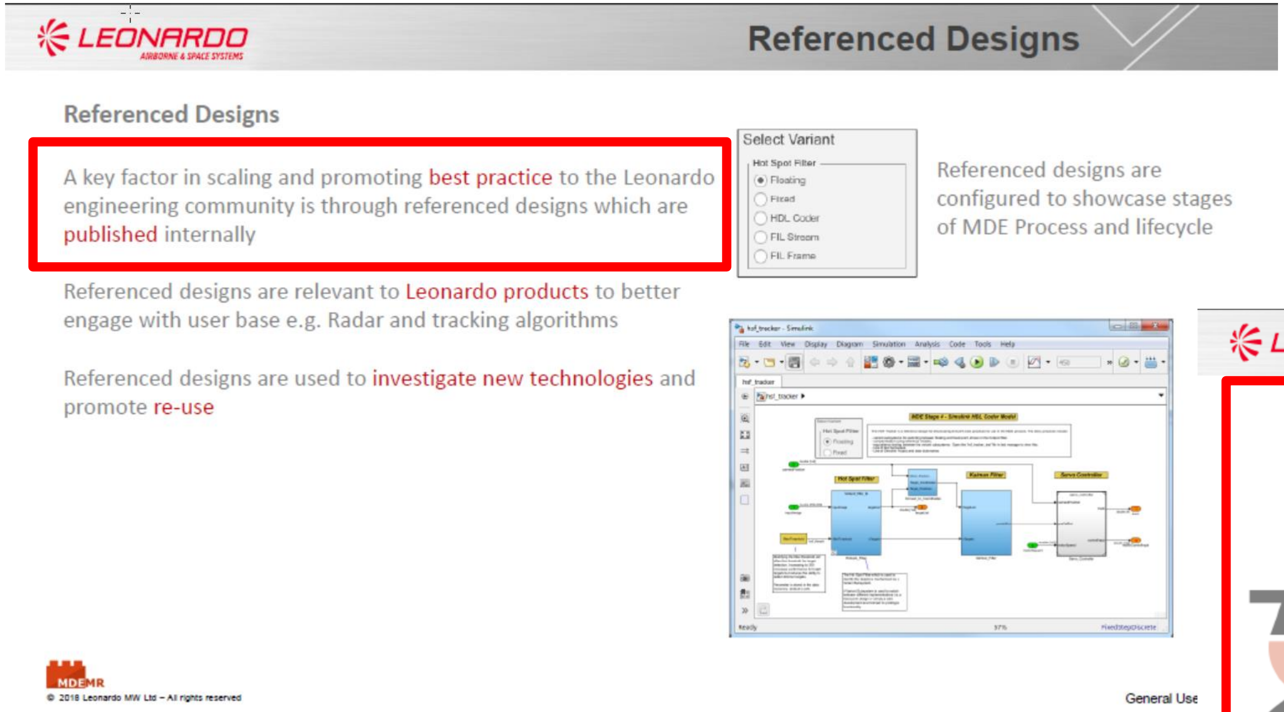
https://www.mathworks.com/videos/model-driven-engineering-modularity-and-re-use-1541022163033.html

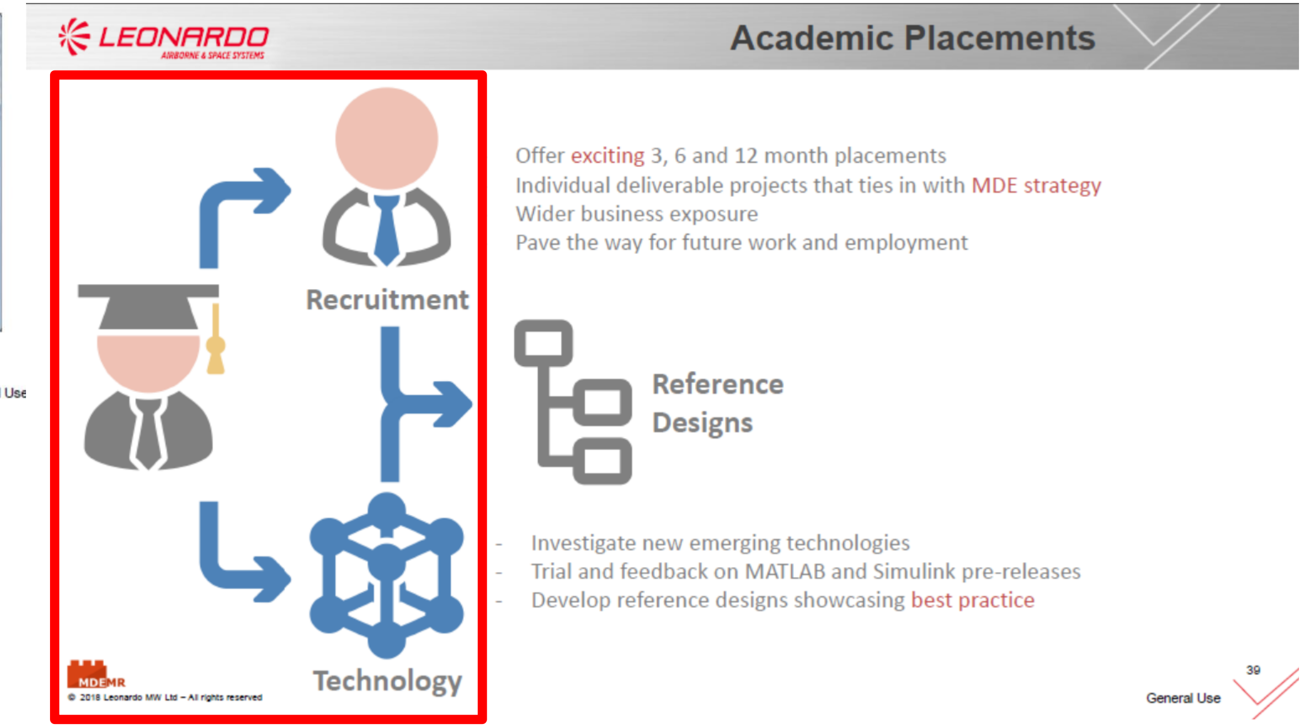
Model-Driven Engineering, Modularity, and Re-Use





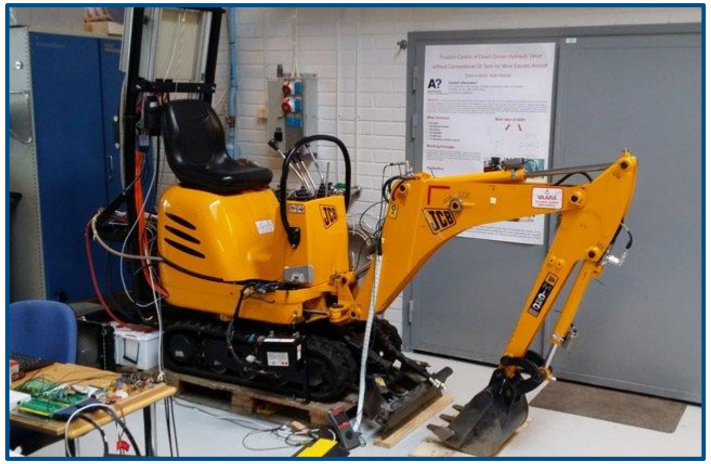
Model-Driven Engineering, Modularity, and Re-Use





Aalto University Works with Industry Partners to Develop Energy-Efficient Designs for Construction Equipment

"With MATLAB, Simulink, and Simscape we were able to create and validate designs spanning multiple domains—mechanical, electrical, and hydraulic—that are now being used by our commercial partners to improve energy efficiency on their machines."



The one-tonne micro excavator modeled by Aalto University and Tampere University researchers in the EL-Zon and EZE projects.

"We have close relationships with off-road machinery manufacturers in Finland, with whom we share our results, and in some cases, Simulink models. The companies use the models to run detailed simulations and continue their own development projects."

*"The students who work with us gain a number of valuable skills, including **how to work on a team** and how to model and simulate real systems with MATLAB and Simulink. These are the same tools used by many of the companies we work with, making it **easy for our students to be hired directly from our project once they graduate**."*

Link to user story

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Model-Based Design Enables

- Collaboration across
  - Engineers from different disciplines
  - Teams based in different countries
  - The supply chain: customers-OEM-suppliers
- Process and systems development workflow
  - Reference designs using models for reuse and scalability across organization
  - Apps deployed via web allow reuse without requiring expertise in MATLAB/Simulink
  - Code generation for heterogenous computing platforms
  - Continuous integration and test in an agile development environment
  - Compliance with industry standards
- Engineering workforce development through industry and academia collaboration