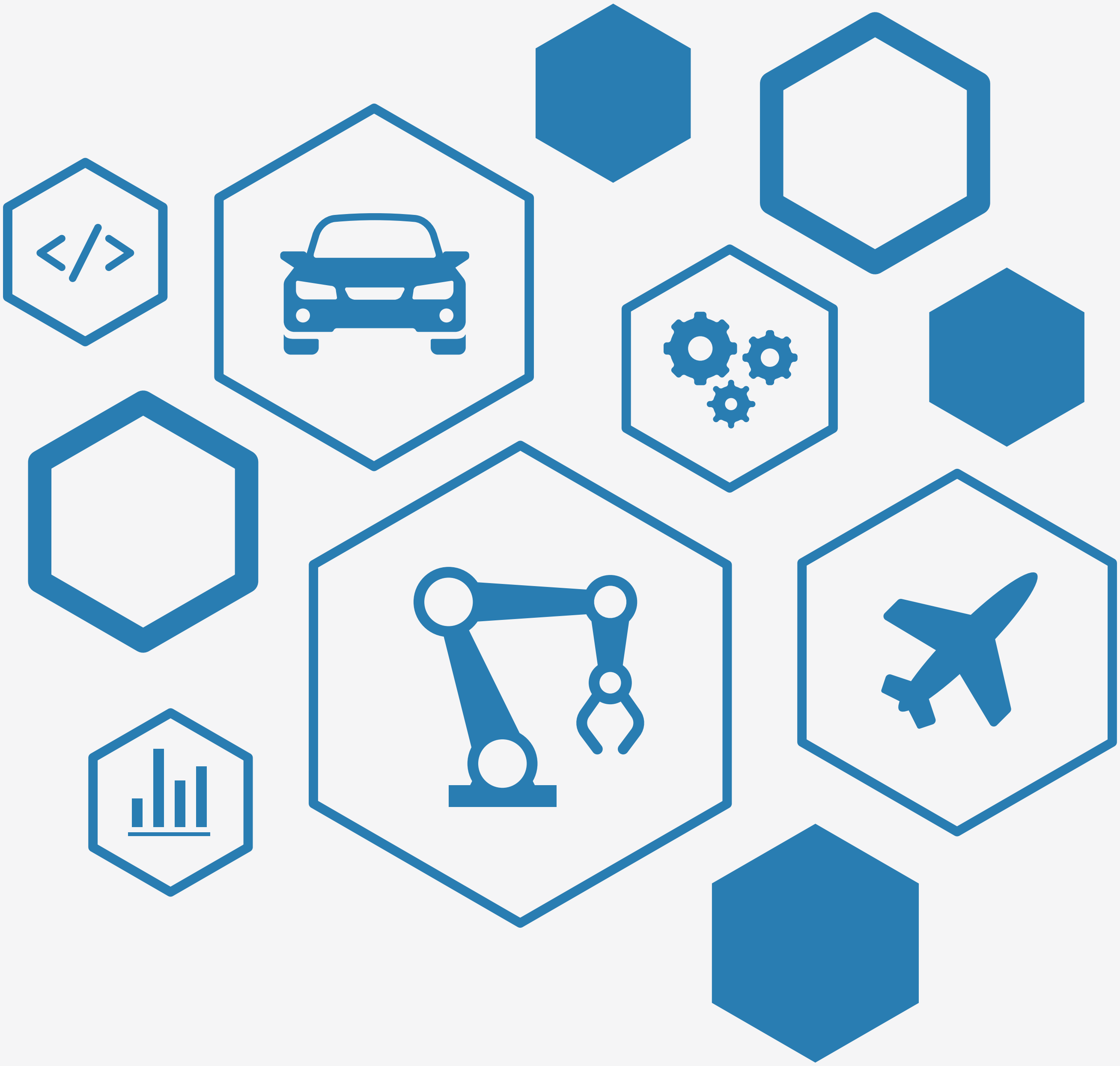
MathWorks®

Smart Industry System Design with MATLAB and Simulink

Answers to the Top 3 Engineering Questions



How Smart Industry Is Putting Data Front and Center

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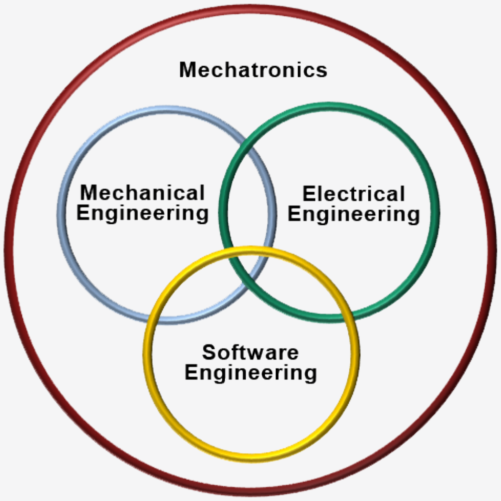
The industrial world is changing with the emergence of smart industry. Today's production machines and handling equipment have become highly integrated mechatronic systems with a significant portion of embedded software. This fact requires several domains – software engineering, IT, mechanical engineering, and electrical engineering – to work together and evolve the way they design, test, and verify machine software. Only then can they reach the expected level of functionality and quality.



Data Proliferation – Extracting Valuable Insight

A major driver of smart industry is the growing amount of data. Vision sensors, electric and hydraulic drives, even production machines and power plants all collect measured data during operation. This data contains information that can be transformed into business value using predictive models and algorithms. For example, machine learning techniques may be used to train a model to historical sensor data, so that the model can be used to predict future equipment failures and prevent production downtimes.

Deploying Analytics to Embedded Systems

As smart industry evolves, software components provide a significant part of the added value of machines and production plants. Embedded software running on PLCs, industrial PCs, or FPGAs use closed-loop control functionality that ensures product quality, and predictive maintenance algorithms for increased uptime without service intervention. Furthermore, embedded software is used for supervisory logic for state machines handling and automatic generation of optimized movement trajectories – even for safety-critical systems.

The Use of Model-Based Design

To become market leaders, equipment manufacturers need to develop skills and expertise in new software design approaches and technologies – to realize the efficiency, cost, and, therefore, competitive advantages that smart industry promises. Software design productivity and system reliability increase with Model-Based Design tools like MATLAB® and Simulink®. These tools facilitate modular software development of automation components, hardware-independent testing, and automatic code generation that can implement algorithms on embedded hardware platforms at the touch of a button.

The Race to Smart Industry Realization

Smart industry depends on the growing complexity of software and an ever-increasing amount of machine data. In the long term, the evolving trend will challenge engineers to become proficient in using new software design methods and data analytics tools in order to embrace this complexity.

Read full article in Embedded Computing Design

Top 3 Questions from Engineers

1. How can you use machine data to improve production performance or predict failure?

MATLAB allows you to **analyze machine and production data**, identify patterns, and **optimize machine parameters** and service intervals.

Workflows

Offline Data Analysis is used on recorded data stored in files, databases, or in the cloud.

Workflows:

- Import data into MATLAB
- Analyze data
- Use results to optimize machine throughput or service intervals

Online Data Analysis is used to continuously analyze machine behavior

Workflows:

- Read data via OPC UA and other standards
- Deploy real-time code (C/C++, IEC 61131-3) on PLC or embedded controller

Key Products

- *MATLAB*
- *OPC Toolbox™*
- *Data Acquisition Toolbox™*

User Story: *Newport Corporation Reduces Data Acquisition and Analysis Time by Hundreds of Hours*

Technical Article: *5 Types of Data and How to Analyze Them with MATLAB*

MATLAB helps you **analyze measured signals** (e.g., vibration data) by:

- Transferring into frequency domain
- Applying filters

Did You Know? Ready-made functions save time compared to manual programming (such as in Visual Studio).

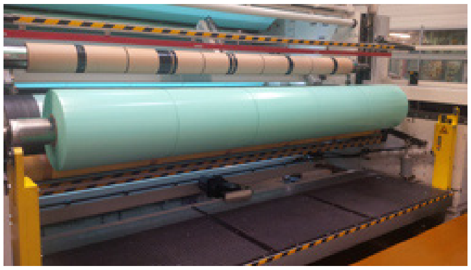
Key Products

- *MATLAB*
- *Signal Processing Toolbox™*

User Story: *BuildingIQ Develops Proactive Algorithms for HVAC Energy Optimization in Large-Scale Buildings*

Webinar: *Signal Processing and Machine Learning Techniques for Sensor Data Analytics*

Engineers working with large amounts of business and engineering data use **machine learning** to find patterns and build models to predict future outcomes based on historical data (such as for **predictive maintenance**).



Mondi Implements Statistics-Based Health Monitoring and Predictive Maintenance for Manufacturing Processes with Machine Learning

Key Products

- *MATLAB*
- *Statistics and Machine Learning Toolbox™*
- *Neural Network Toolbox™*

User Story: *Mondi Implements Statistics-Based Health Monitoring and Predictive Maintenance for Manufacturing Processes with Machine Learning*

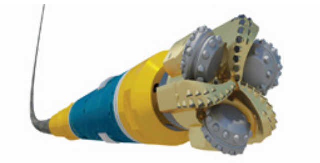
Webinar: *Machine Learning Made Easy*

Technical Article: *Data-Driven Insights with MATLAB Analytics: An Energy Load Forecasting Case Study*

Overview: *Predictive Maintenance*

2. How can you develop optimized closed-loop controllers for increasingly complex systems?

Virtual commissioning based on Model-Based Design helps optimize controls structures and parameters during simulation. During **simulation** it is faster, safer and less expensive to design and test your controller and optimize parameters.

Workflows	
MATLAB and Simulink products for **control system design** support: • Plant modeling • Parameter optimization • Automated testing and reporting • Automatic code generation (C/C++, IEC 61131-3, HDL) **Did You Know?** Automatic code generation generates highly efficient code for your controller and helps avoid coding errors.	**Key Products** • *Simulink* • *Stateflow®* • *Simulink Control Design™* • *Control System Toolbox™* • *Model Predictive Control Toolbox™* User Story: *Metso Develops Controller for Energy-Saving Digital Hydraulic System for Papermaking Equipment Using Model-Based Design* Overview: *Control Design Software*
Control system design starts with a **plant model** for system simulation. MATLAB and Simulink products support a variety of plant modeling approaches: • **Physical modeling** using blocks that represent mechanical, electrical, magnetic, hydraulic, pneumatic, and thermal components • **System identification** based on measured data **Did You Know?** You can design your system without the need to wait for hardware.	**Key Products** • *Simscape™ products for physical modeling* • *System Identification Toolbox™* User Story: *manroland Develops High-Precision Commercial Printing Press Controller* Overview: *Creating Accurate Plant Models* Technical Article: *Modeling Complex Mechanical Structures with SimMechanics*
Perform **early verification and testing** on your system model through: • Desktop simulation • Real-time testing • Automated test scenarios • Formal verification **Did You Know?** Find design errors before building hardware and creating production software.  Baker Hughes Improves Precision of Oil and Gas Drilling Equipment	**Key Products** • *Simulink Design Verifier™* • *Simulink Verification and Validation™* • *Simulink Test™* • *Polyspace Bug Finder™ and Polyspace Code Prover™* • *Simulink Real-Time™* User Story: *Baker Hughes Improves Precision of Oil and Gas Drilling Equipment* Overview: *Verification, Validation, and Test*

3. How can you implement controls algorithms and state machines on a PLC or industrial PC?

Automatic code generation allows you to deploy algorithms that have been tested in simulation on common PLC or industrial PC platforms – using either **IEC 61131-3** (structured text or ladder diagram) or **C/C++**.

Workflows

Automatic code generation converts tested models and algorithms into highly efficient embedded real-time code (C/C++ and IEC 61131-3).

Did You Know? This workflow is much faster than hand coding – enabling developers of industrial controls to increase productivity 200-300%. It's also less error prone.

Key Products

- *Simulink PLC Coder™*
- *MATLAB Coder™*
- *Simulink Coder™*
- *Embedded Coder™*

User Story: *ENGEL Speeds Development of Injection Molding Machine Controllers*

Webinar: *Model-Based Design for Automation Systems*

IEC 61508 is the primary safety standard for industrial controls. **TÜV SÜD** has certified the following products:

- Embedded Coder
- Polyspace code verifiers
- Simulink PLC Coder

Did You Know? TÜV SÜD certifications are based on application-specific verification and validation workflows that are provided in the IEC Certification Kit.

Key Products

- *IEC Certification Kit™*
- *Polyspace Bug Finder™ and Polyspace Code Prover™*
- *Embedded Coder*
- *Simulink PLC Coder*

Technical Article: *Improving Software Quality with Static Code Analysis*

Link: *Supported Standards and Products*

Automatic code generation is available for most common **PLC and industrial PC platforms**. MathWorks works with hardware partners to ensure compatibility with their integrated development environments (IDEs).

PLC partners:

- 3S CODESYS
- B&R Automation Studio™
- Bachmann M-Target
- Beckhoff® TwinCAT™
- Mitsubishi CW Workbench
- Omron Sysmac Studio
- Phoenix Contact® PC WORX™
- Rexroth IndraWorks
- Rockwell Automation® RSLogix™ and Studio 5000
- Siemens STEP 7, WinAC and TIA Portal

Supported PLC Platforms

- *Support for Third-Party IDEs in Simulink PLC Coder*
- *Hardware Support for PLC Code Generation (C/C++ and IEC 61131-3)*

User Story: *AVL Develops Dynamic Controller for Engine Conditioning System Using Embedded Code Generation for PLCs*

AVL Develops Dynamic Controller for Engine Conditioning System Using Embedded Code Generation for PLCs

Voice of the User

"With Model-Based Design, we see development time reduction, cost savings, and improved time-to-market. ***Automatic code generation*** *saves a great deal of time. In addition, we can simply change the model to update our design, and we know it will be implemented as required. Our* ***design iterations****, from making changes to hardware testing, are* ***completed in five minutes****."*

– Arend-Jan Beltman, Centre for Concepts in Mechatronics

*"On previous projects, we have written structured text by hand for the feedforward control, but it would be too complicated to implement feedback control of the Bionic Handling Assistant on a PLC using this manual approach—****we simply would not have done it****. Simulink PLC Coder enabled us to* ***generate the structured text automatically in minutes****."*

– Dr. Rüdiger Neumann, Festo

"As a manufacturing company ***we don't have data scientists with machine learning expertise****, but MathWorks provided the tools and technical know-how that enabled us to develop a production preventative maintenance system in a matter of months."*

– Dr. Michael Kohlert, Mondi

"As a process engineer I had no experience with ***neural networks or machine learning****. I worked through the MATLAB examples to find the best machine learning functions for generating virtual metrology.* ***I couldn't have done this in C or Python****—it would've taken too long to find, validate, and integrate the right packages."*

– Emil Schmitt-Weaver, ASML

"Our shopfloor management system AMS ZPoint-CI collects a ***huge amount of machine, process, and product data*** *24 hours a day. By analyzing this data immediately in MATLAB and AMS Analysis-CI we have achieved a* ***tenfold increase in precision, a 30% reduction in total cycle time****, and a significant increase in production output."*

– Alexander Meisinger, Stiwa

Additional Resources

With MATLAB and Simulink, engineers don't need to be programming experts to build and implement high-quality software. They can focus on their technical engineering expertise for designing the functionality of technical systems. MATLAB and Simulink are easy to:

- Learn – with free tutorials and professional training
- Apply – with thousands of code examples and applications from MATLAB engineers and the user community
- Master – by getting answers to your toughest questions from the user community, in the comprehensive documentation, or via technical support