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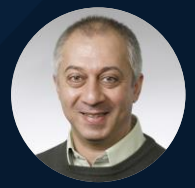
AUTOMOTIVE
CONFERENCE 2024
Europe

Future of Engineering Design in the Age of AI

Mehran Mestchian, MathWorks



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Summary

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AI-Driven Model-Based Design

Dynamic AI-Model Calibration for EdgeAI

Speed Bumps

Enhanced Loops, and Tools

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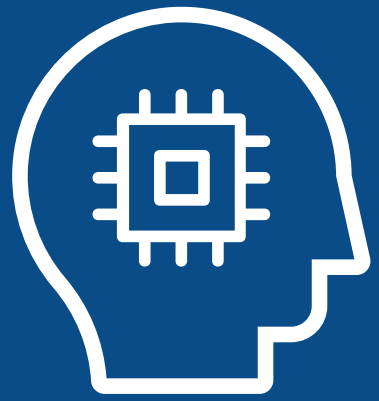
Megatrend
Slowly then …

ARTIFICIAL INTELLIGENCE

Any technique that enables machines to mimic human intelligence

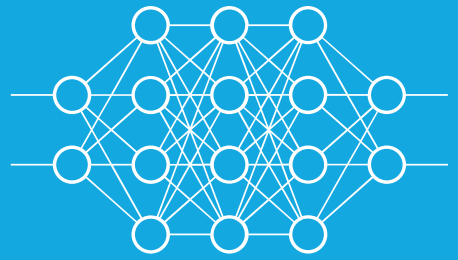


MACHINE LEARNING

Statistical methods that enable machines to "learn" tasks from data without explicitly programming

DEEP LEARNING

Neural networks with many layers that learn representations and tasks "directly" from data



1950s

1980s

2010s

1992

Neural Network Toolbox

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Megatrend
Slowly then Suddenly

1992

Toolboxes
- Neural Network Toolbox

2016 - 2019

Toolboxes
- Deep Learning Toolbox
- Text Analytics Toolbox
- Reinforcement Learning
- Predictive Maintenance Toolbox

Code Generation
- **GPU Coder**
- **MATLAB Coder**

Apps
- Image Labeler
- Deep Network Designer
- Video Labeler
- Signal Labeler

Interoperability
- TensorFlow-Keras Importer
- ONNX Support

2020 - 2021

Apps
- Experiment Manager
- Lidar Labeler
- Reinforcement Learning Designer

Compression
- Quantization

Code Generation
- **Deep Learning HDL Coder**

Model-Based Design
- Image Classification & Model Prediction
- Recurrent Neural Networks
- Object Detectors

Interoperability
- TensorFlow Model Importer

2022 - 2024

Accessibility
- Deep Learning Model Hub

Compression
- Taylor, Projection Pruning

Code Generation
- **TensorFlow Lite**

Interoperability
- TensorFlow Export
- PyTorch Import
- Co-execution examples

Verification
- Out of distribution detection
- Robustness

Domain Specific AI
- Medical Imaging
- Automated Visual Inspection

Over 500+ examples

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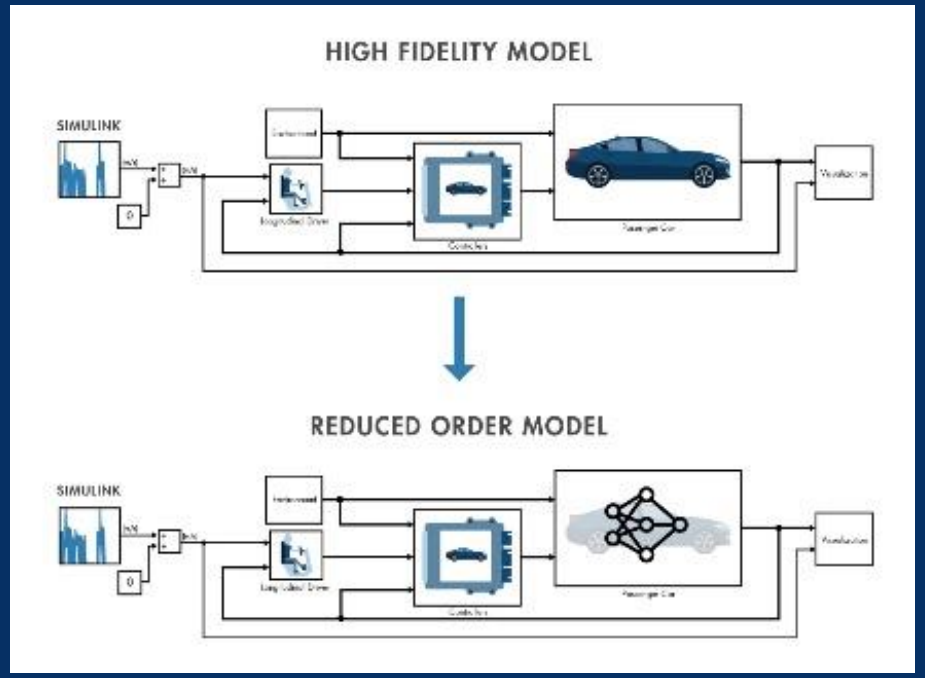
Megatrend
Slow then Suddenly

AI makes the impossible possible

AI enhances systems and processes



2015 2016 2017 2018 2019 2020 2021 2022 Generative AI

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AI in Engineering Design

Data-driven, Shaping of Preferred Solutions within Constraints

AI

Engineering

Design

DATA-DRIVEN MODELS **FIRST-PRINCIPLES MODELS**

AI
Lookup Tables

Kalman Filter
ARIMA

Simulink
Stateflow
Simscape

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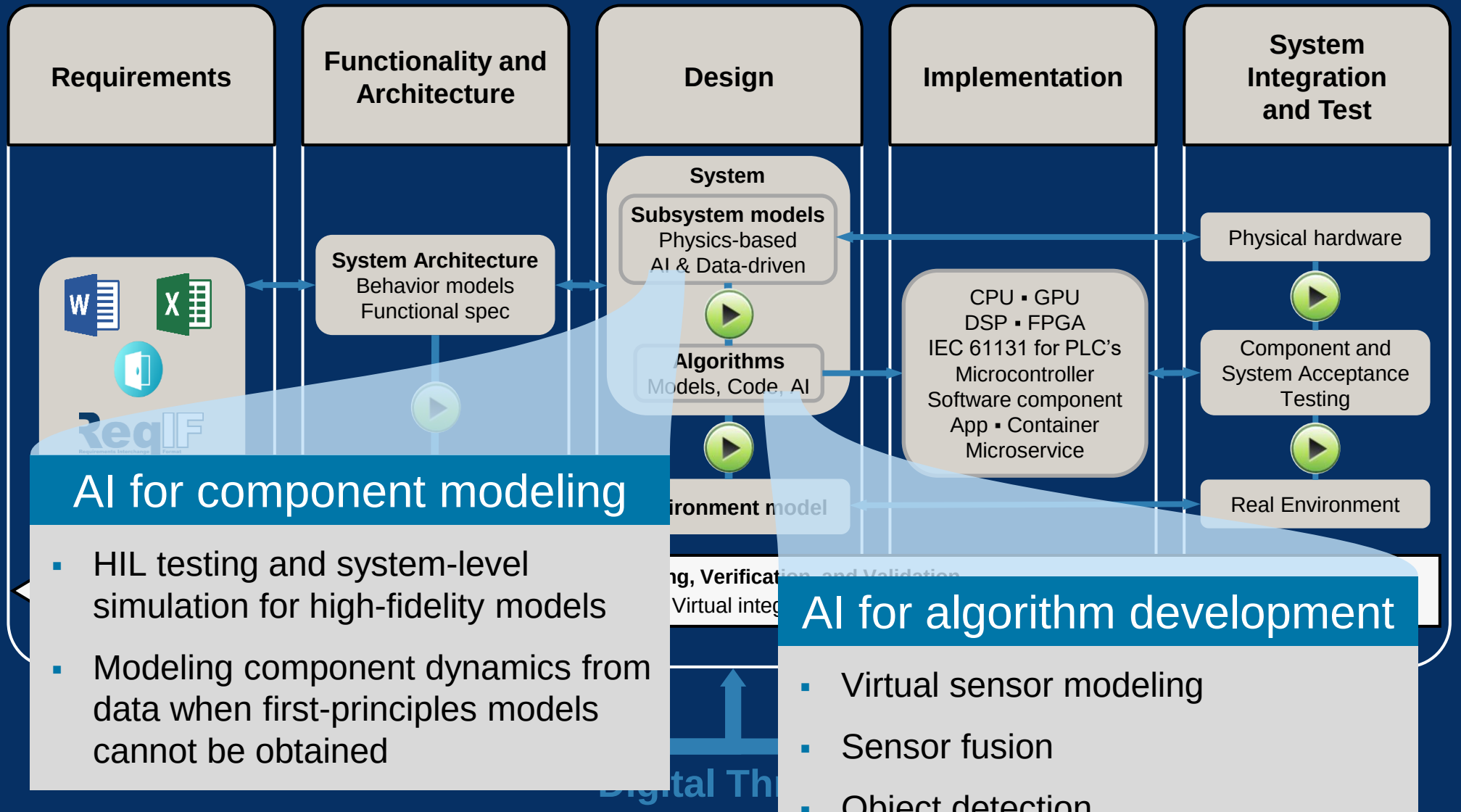
AI in MBD



AI for component modeling

- HIL testing and system-level simulation for high-fidelity models
- Modeling component dynamics from data when first-principles models cannot be obtained

AI for algorithm development

- Virtual sensor modeling
- Sensor fusion
- Object detection

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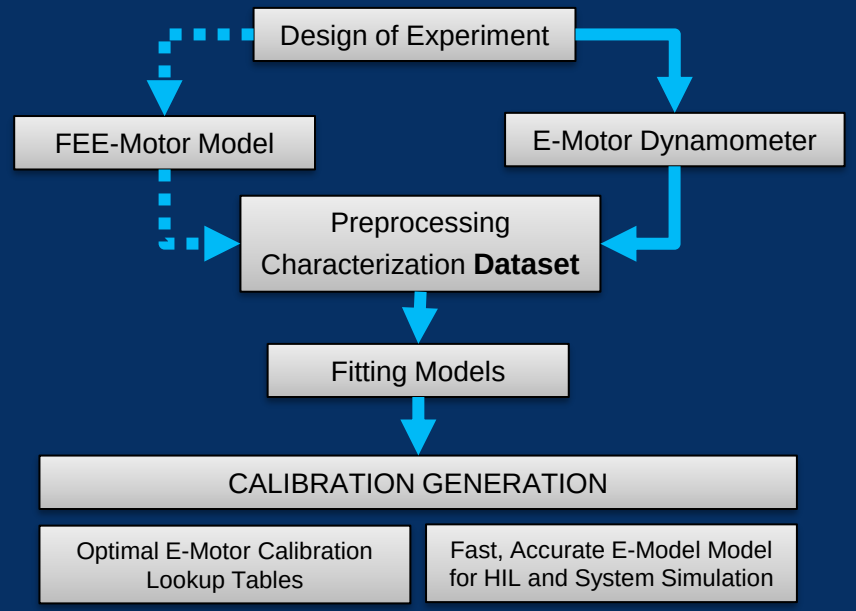
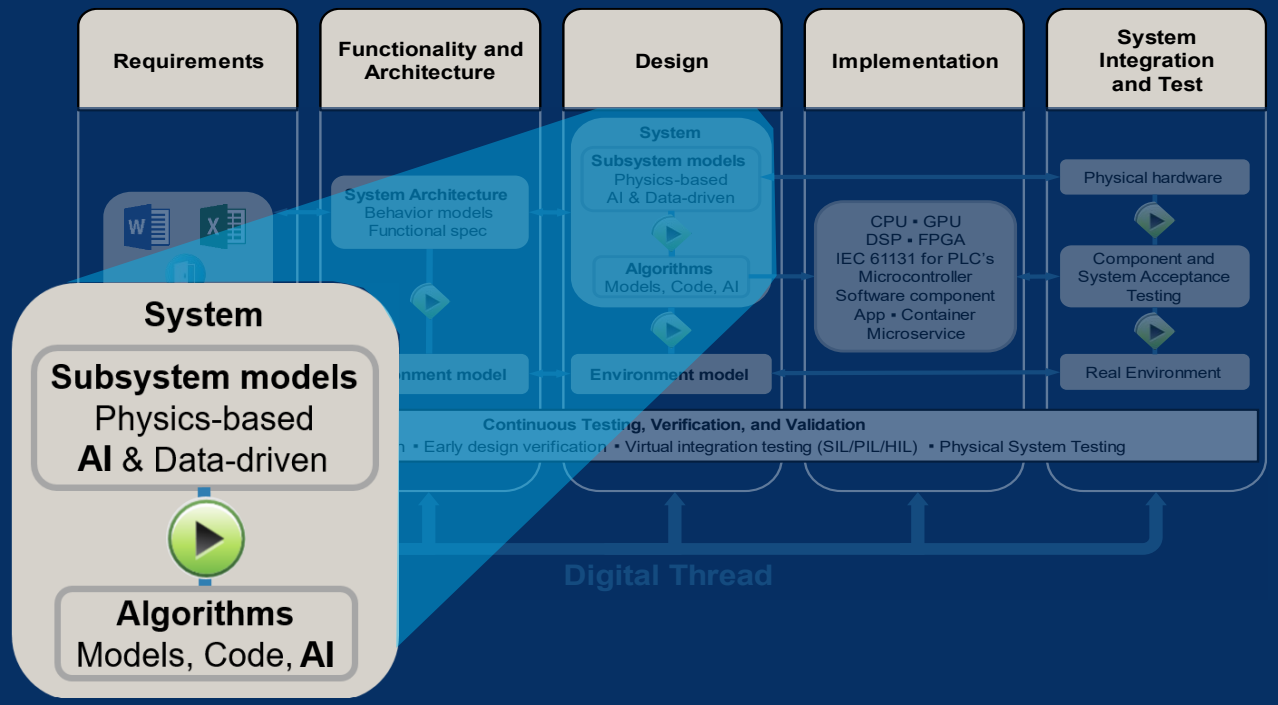
Model-Based Calibration Workflow



AI in MBD Workflows

MBC + DoE

Dynamic AI-Model Calibration



Data Preparation

- Data cleansing and preparation
- Human insight
- Simulation-generated data

AI Modeling

- Model design and tuning
- Hardware accelerated training
- Interoperability

Simulation & Test

- Integration with complex systems
- System simulation
- System verification and validation

Deployment

- Embedded devices
- Enterprise systems
- Edge, cloud, desktop

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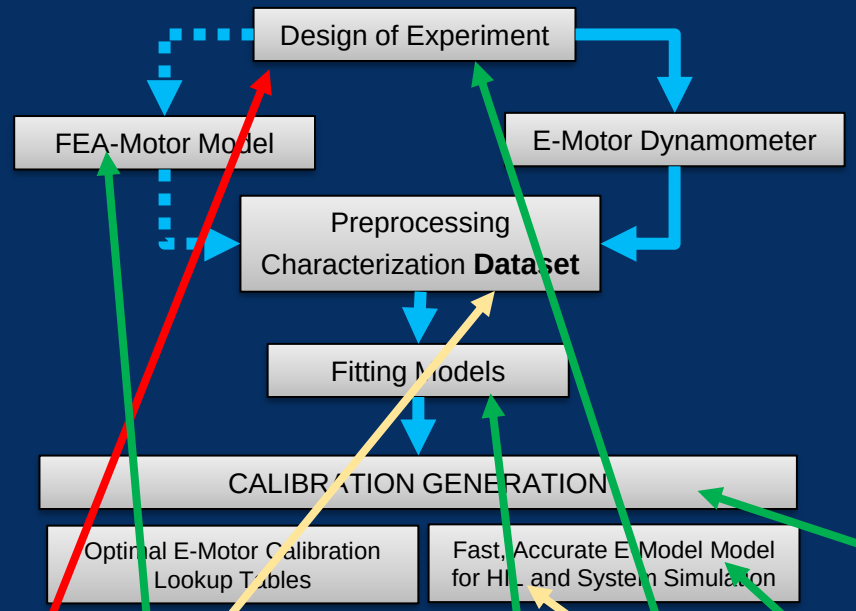
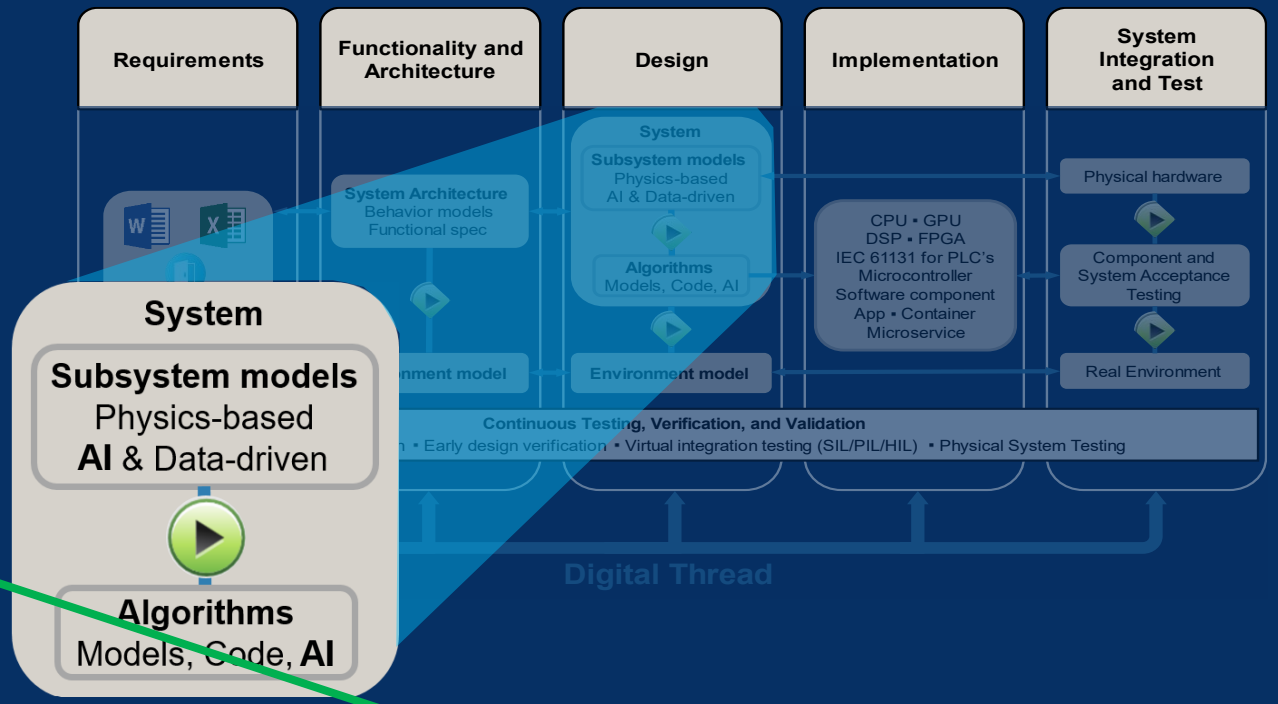
AI in MBD Workflows

MBC + DoE

Model-Based Calibration Workflow



Dynamic AI-Model Calibration



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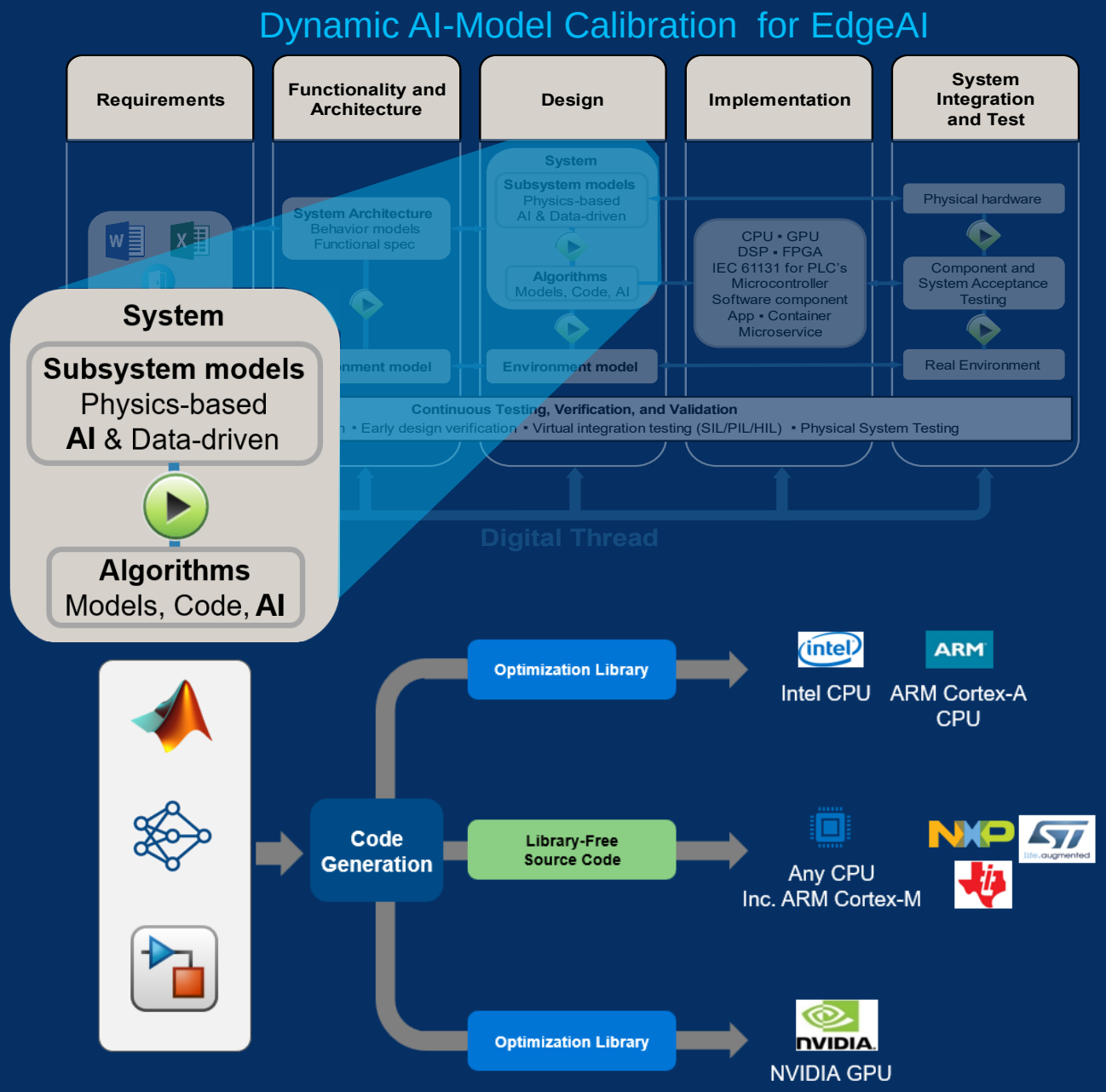
Future in the Age of AI	
Engineered Systems	Future-Proofing: Adaptive Soft design More Sensors, Fewer Knobs EdgeAI Integration
Software	Data-Centric Shift: Less Application Programming More AI-Model Dynamic Calibration Data Quality Increasing Central
Speed Bumps	Systematic V&V Certification Training Data Quality … etc.



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Speed Bumps
Blackbox V&V

Traditional Software Development (Rule-Based)

Coverage

Traceability

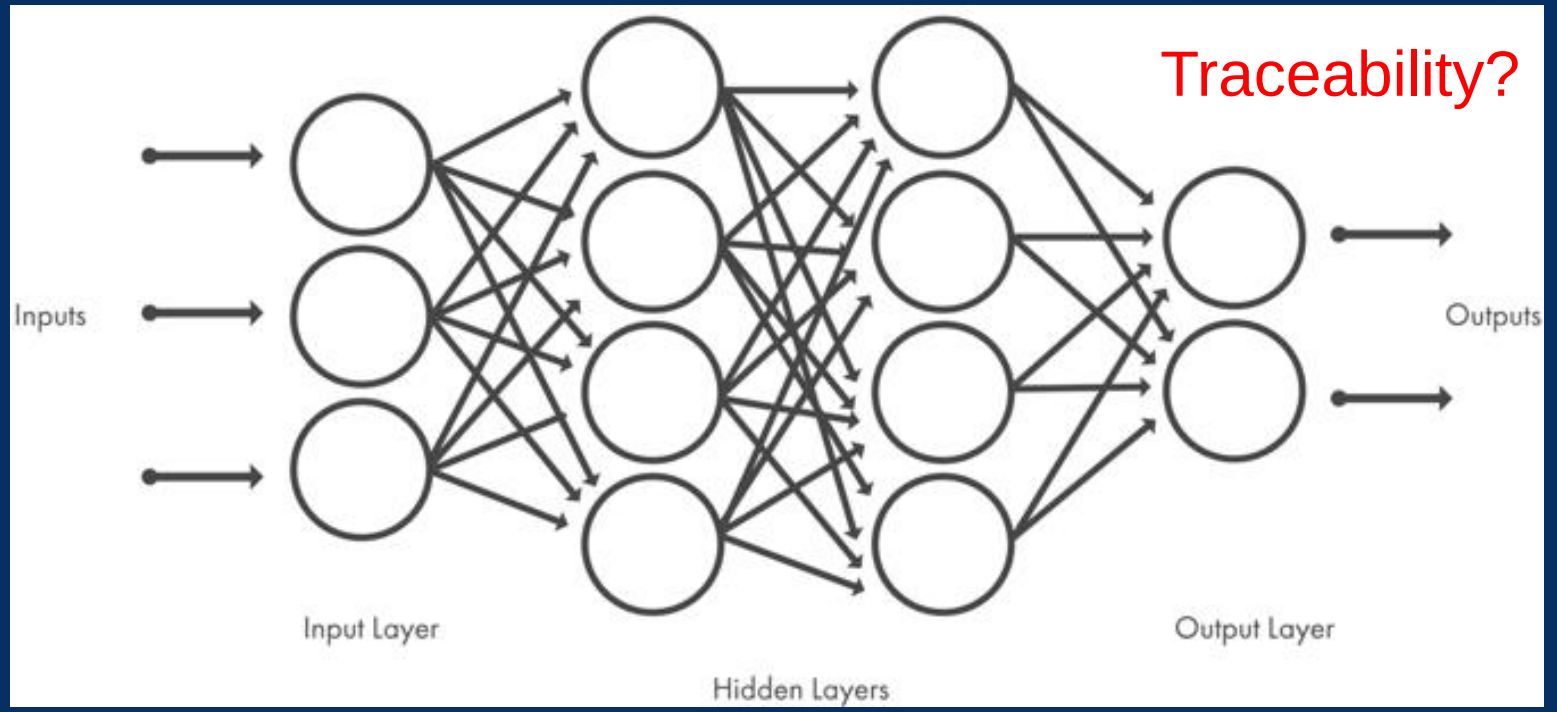
```
if (a > b) && (a > c)
    d = a;
end
d = d * 5;
```

Explainability

ML Development (Data-Driven)

Coverage?

Traceability?



Explainability?

(*) AIR6988 “Artificial intelligence in aeronautical systems. statement of concerns.” EUROCAE, Tech. Rep., 2021

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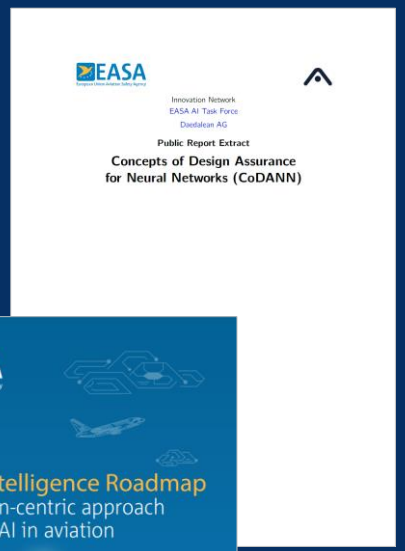
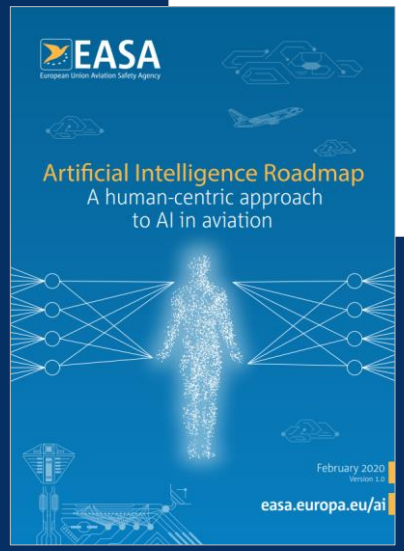
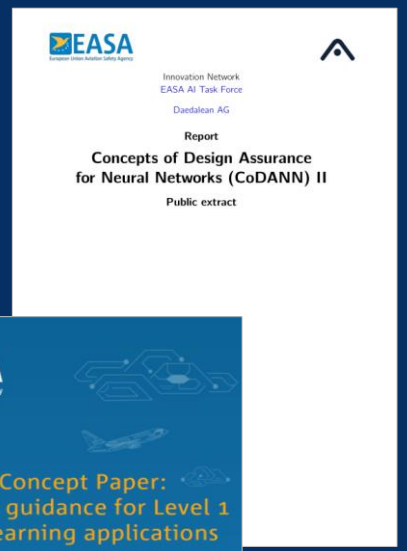
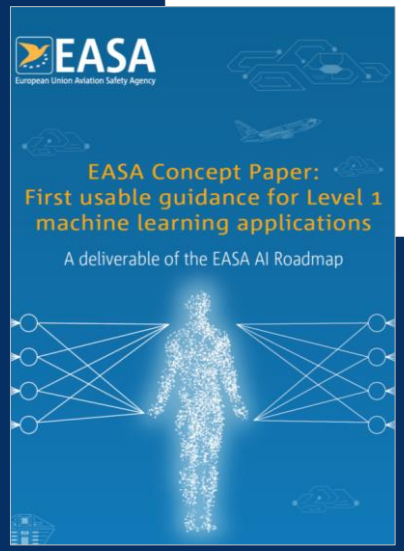
Industry and Regulators are making significant progress for Machine Learning Certification in Aerospace

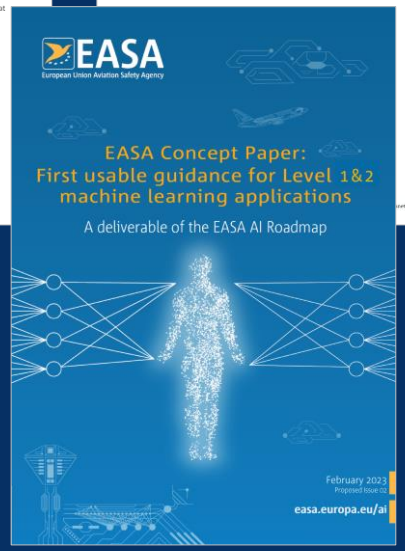
Speed Bumps
Regulations

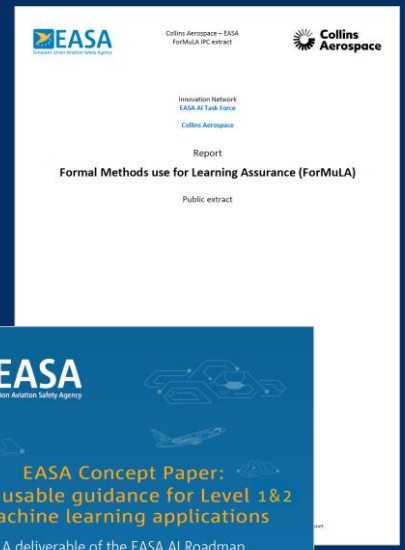












2020 2021 2022 2023

Sources: easa.europa.eu, eurocae.net, faa.gov

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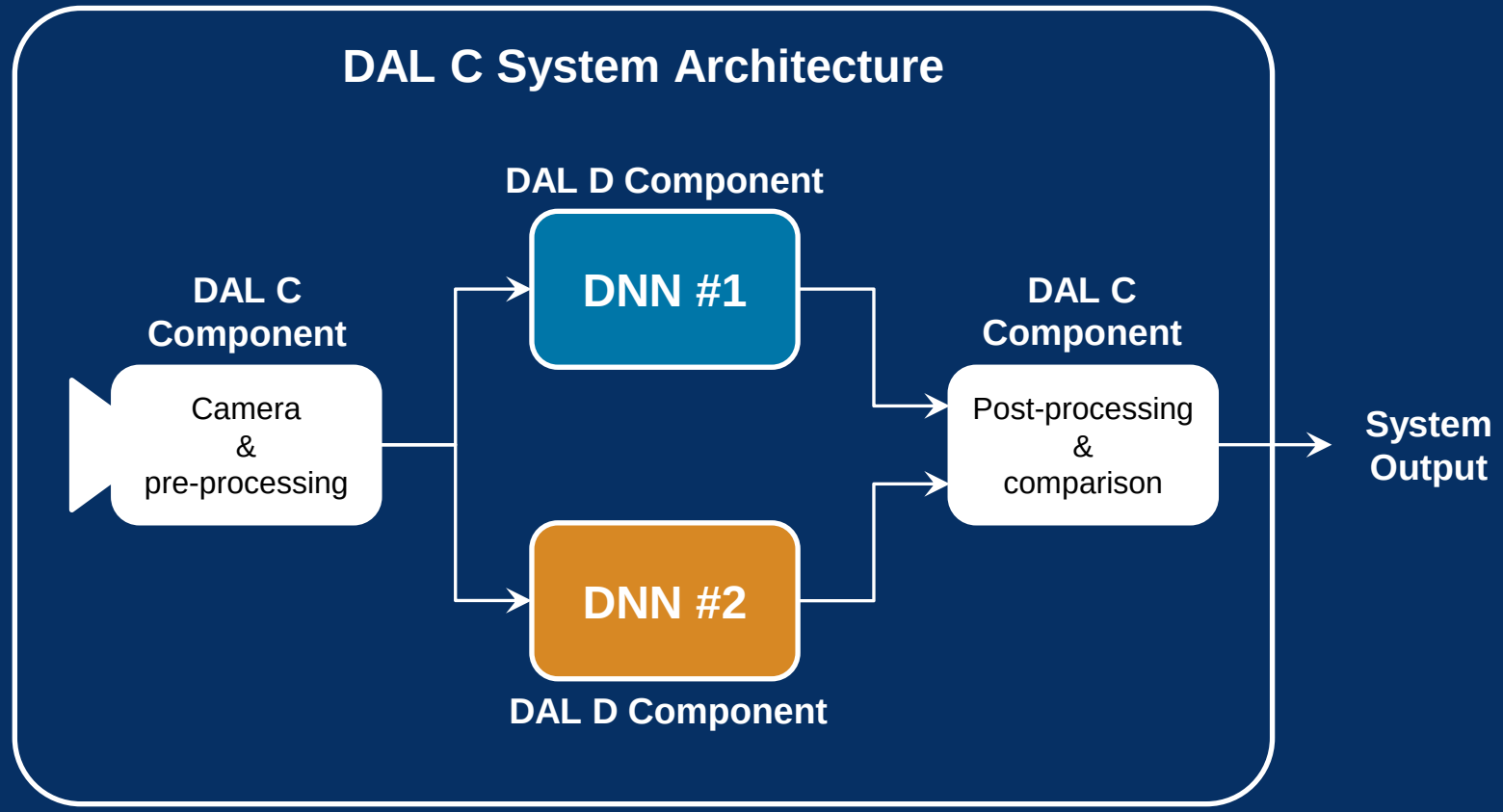
Design Assurance Level (DAL C)

Architectural Mitigation through dissimilar DAL D Components

Speed Bumps
Regulations



K. Dmitriev, J. Schumann, I. Bostanov, M. Abdelhamid, F.Holzapfel, "Runway Sign Classifier: A DAL C Certifiable Machine Learning System", *IEEE/AIAA 42th Digital Avionics Systems Conference (DASC)*, Barcelona, Spain, 2023

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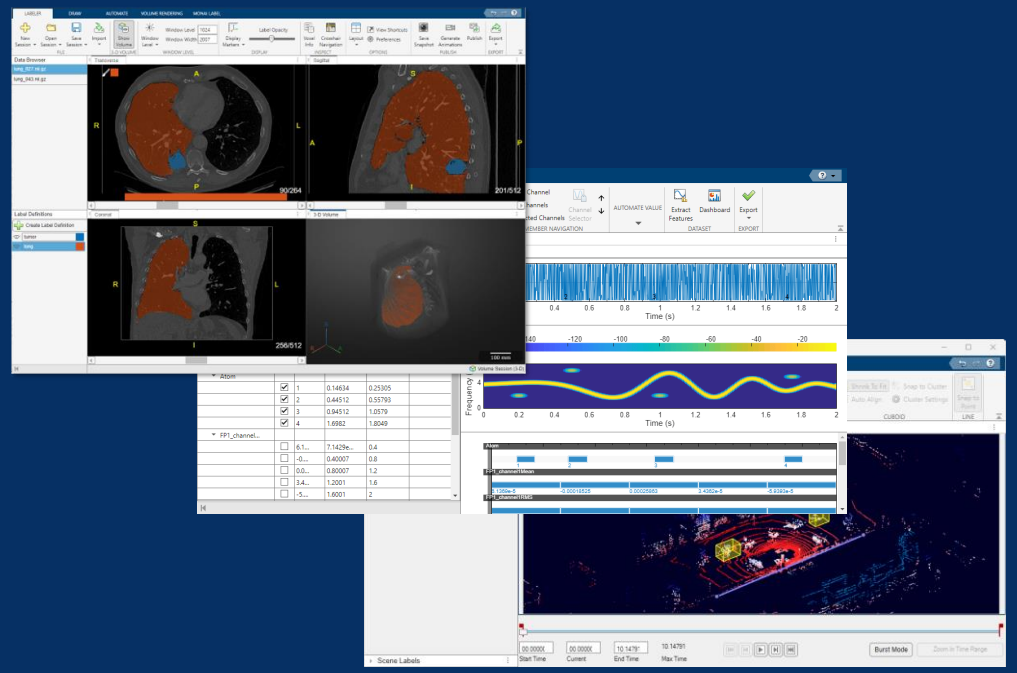
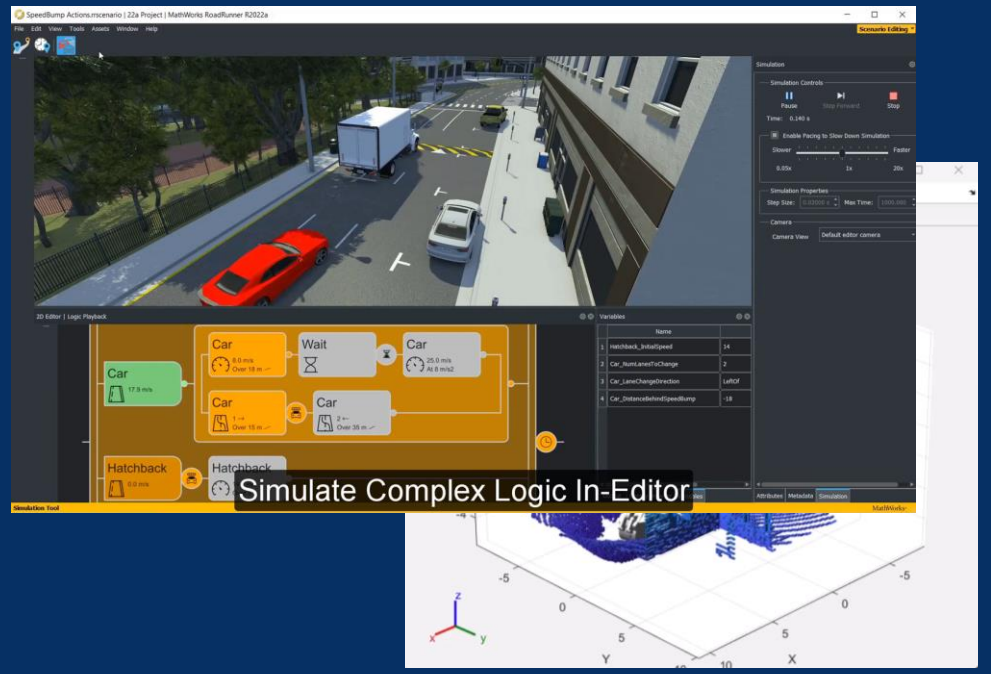
Domain-specific tools to support your data-processing needs for AI

Speed Bumps
Data Quality





Data Labelers with AI-guided Automation

Domain-specific Data Synthesis

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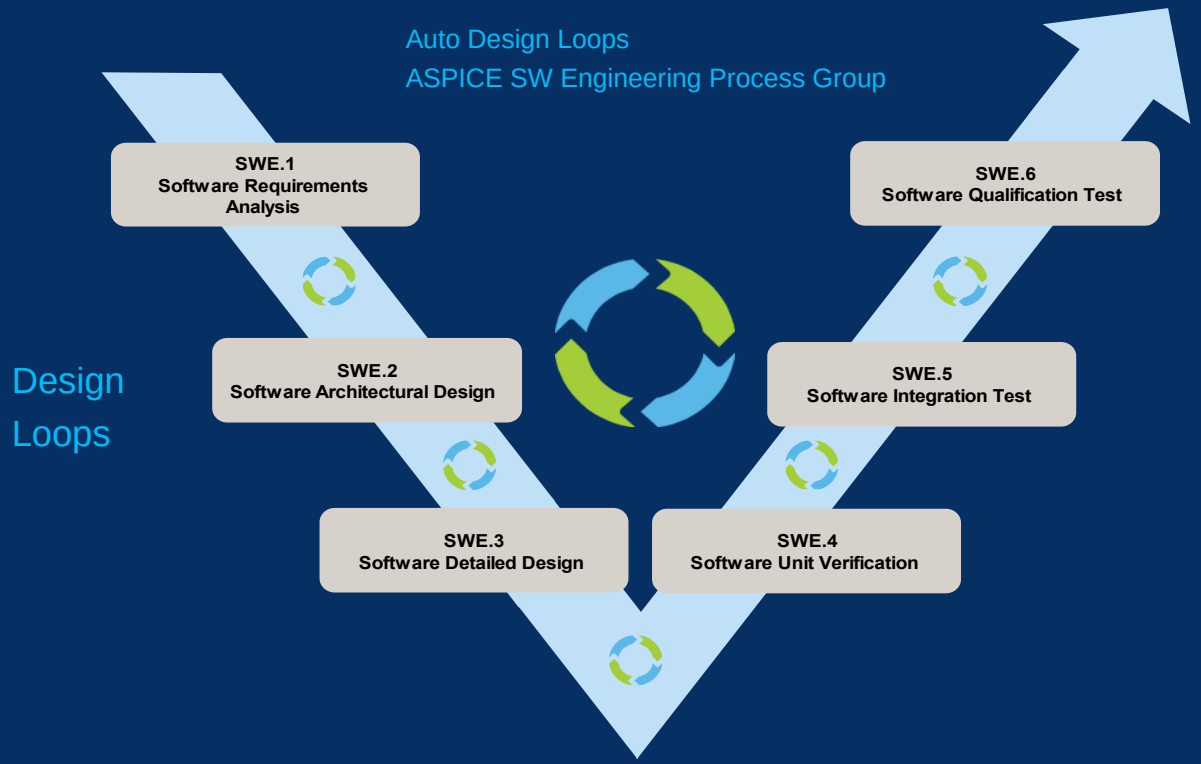

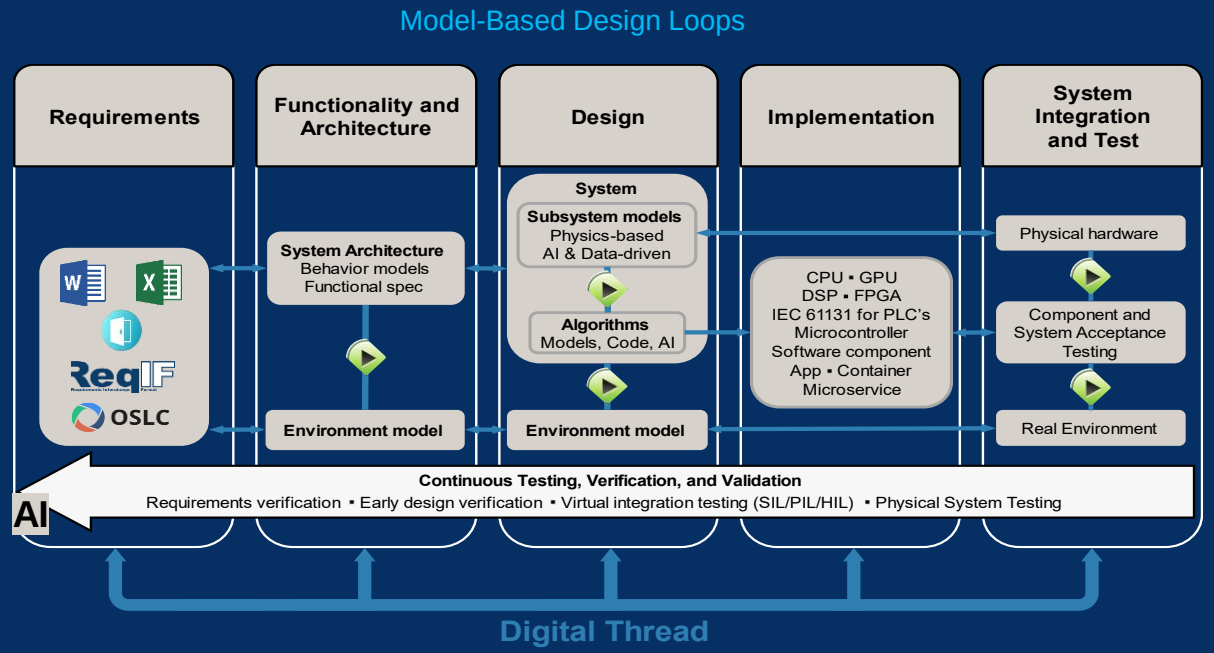

AI

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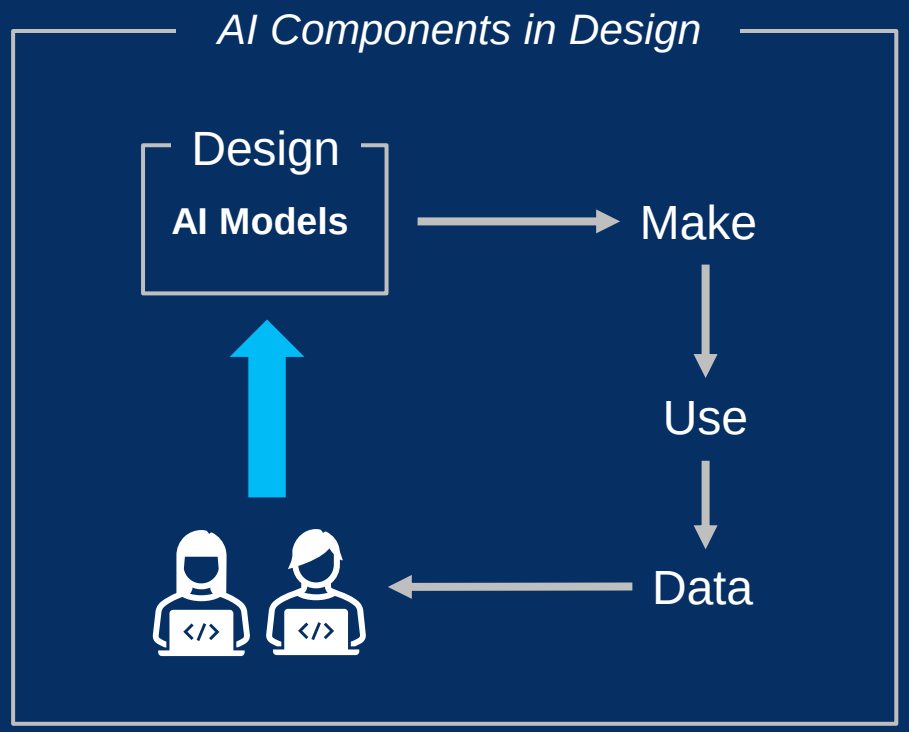
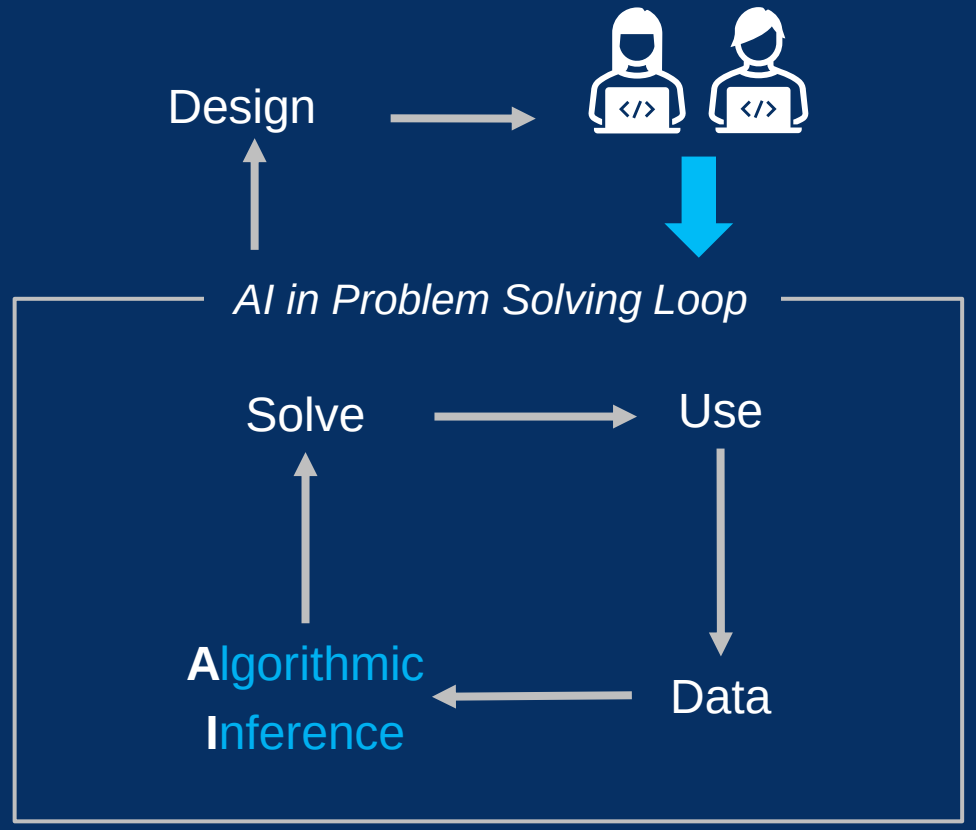
AI in Engineering Design

Data-driven, shaping of preferred solutions within constraints

Design Loops





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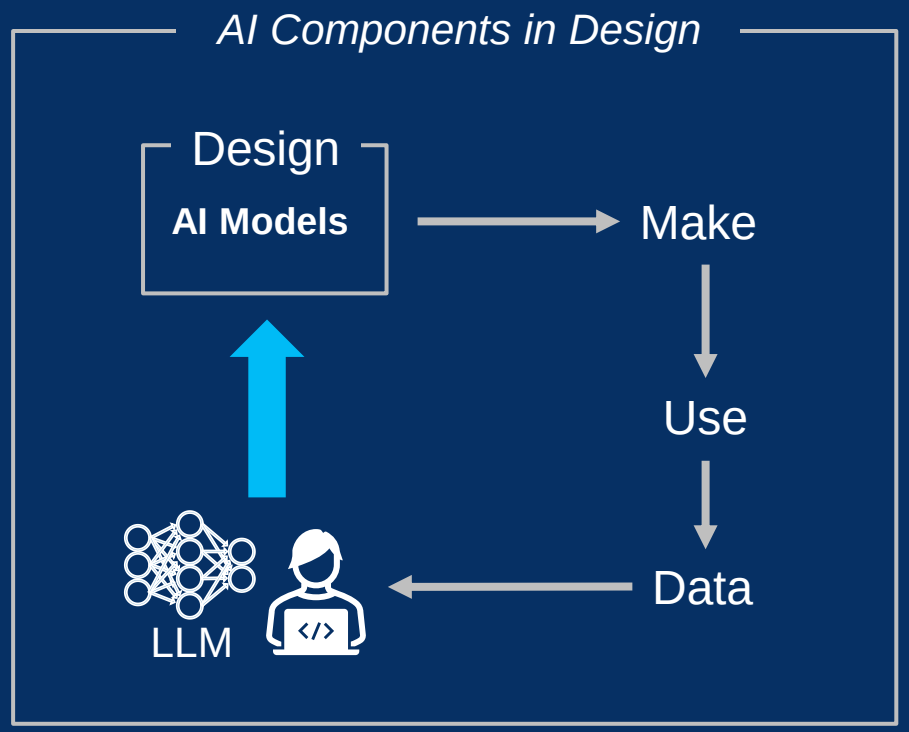

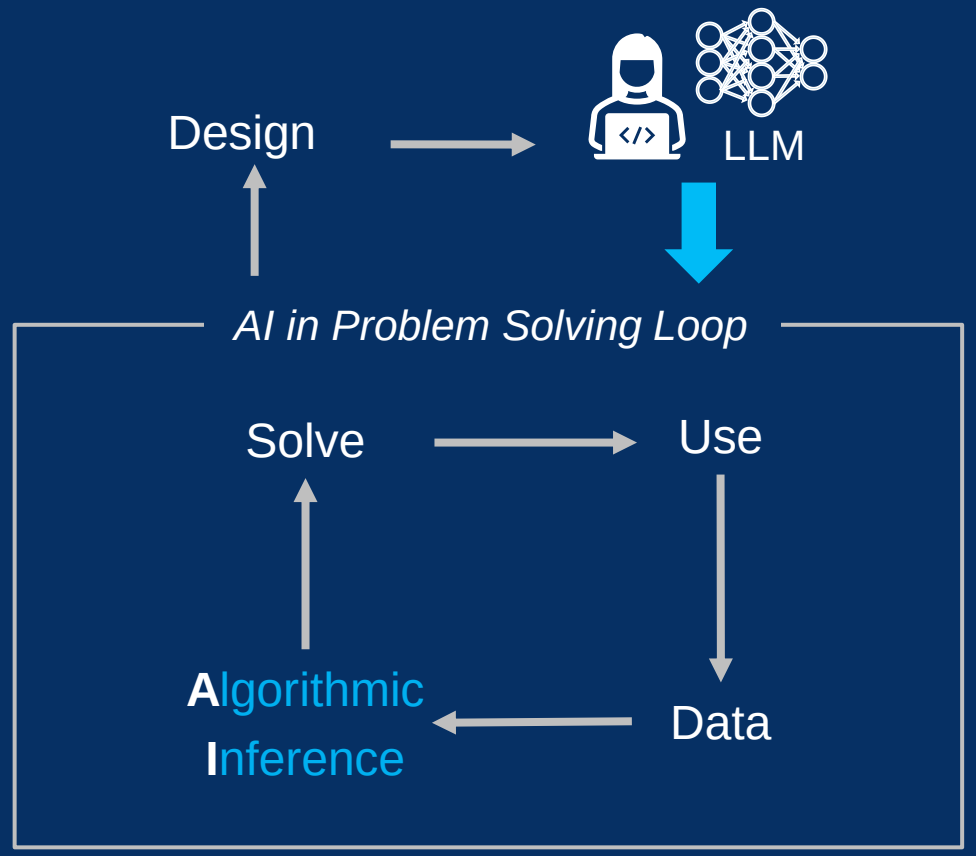

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How Generative AI will Impact Engineering Workflows

Augment Existing Workflows

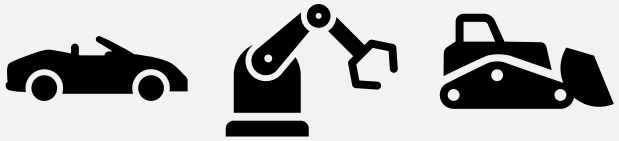
- Learn while doing
- Create code, analyses, models, etc. using NLP
- Check, verify, validate

Empower MATLAB and Simulink Users to Build

- Access popular models for text, images, video, etc.
- Build custom transformer models
- Easy from options from platforms like Hugging Face

Generative AI in Engineered Systems

- Apply LLM innovations to time-series sensor data
- Real-time and near-real-time systems
- Safety-critical



Now, Near-term → Future

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Summary

AI & MathWorks	**Story Continues**
AI-Driven Model-Based-Design	**Integrated Box Model-Based Design**
Dynamic AI-Model Calibration for EdgeAI	**You can do it!**
Speed Bumps	**Yes, … working on it**
Enhanced Loops, and Tools	**Significant plans in works**

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