



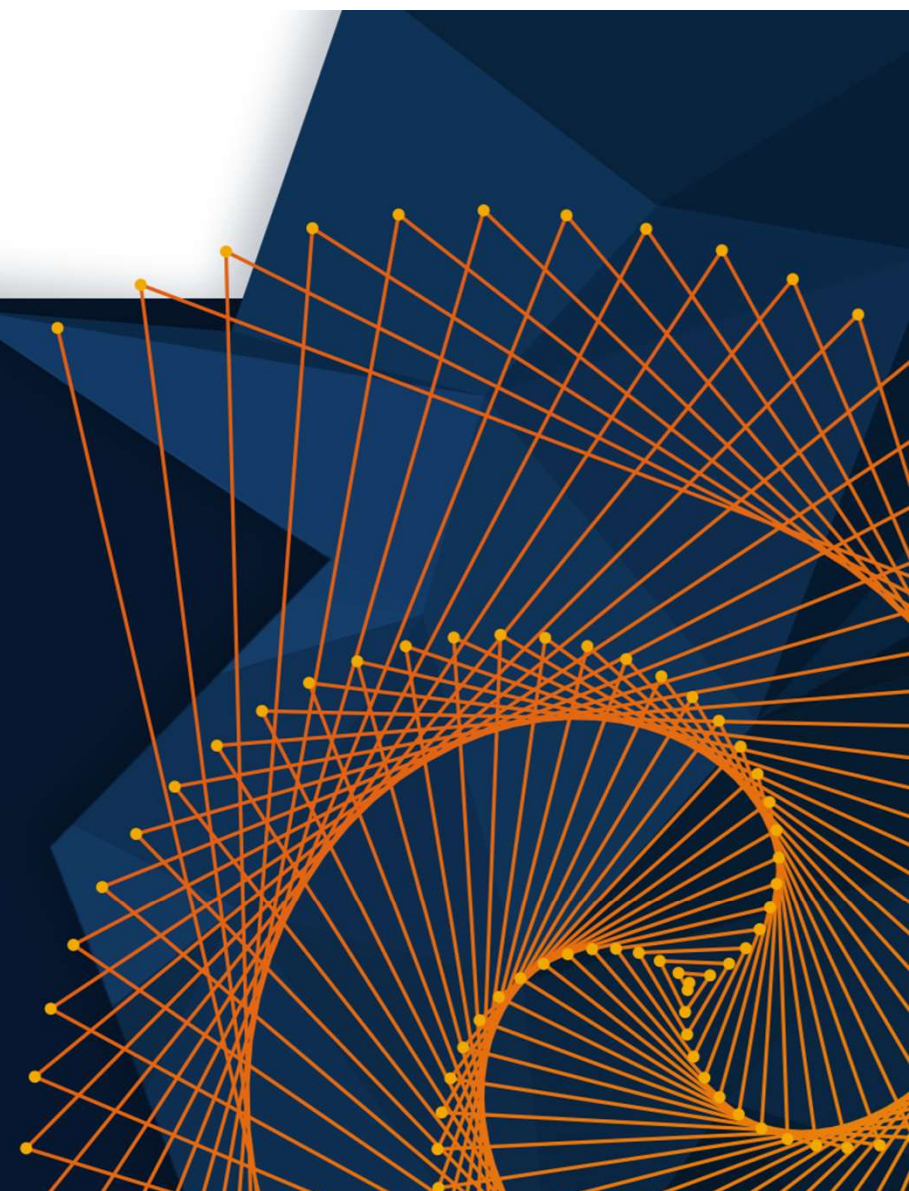
November 13–14, 2024 | Online

Model-Based Design Applied to Home Appliances

Ali Partovi



MATLAB EXPO

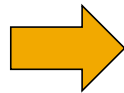


Our Transformation Journey Towards Model-Based Product Lines

Yesterday



Mainly Mechanical
Component

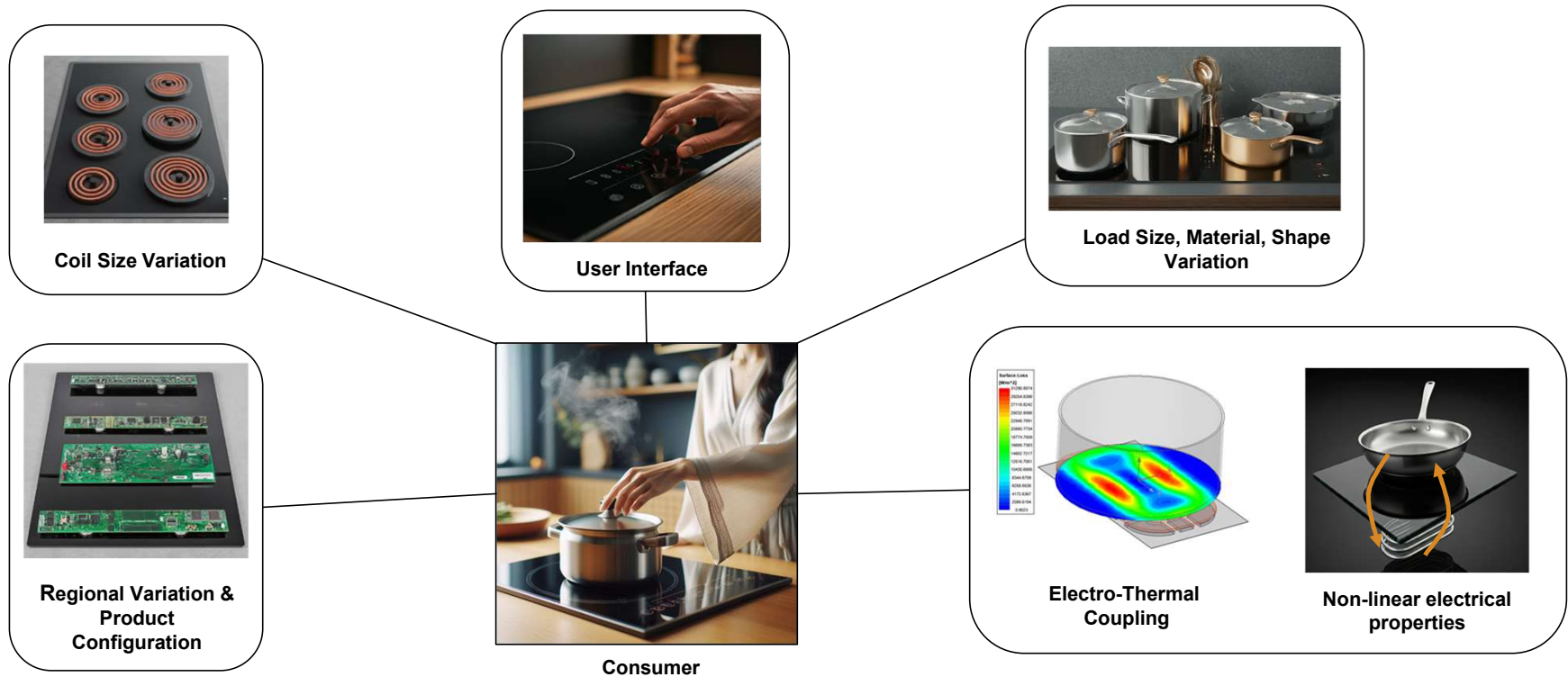


Today / Future



Requires a process to manage increasing complexity, enhance efficiency, and establish a predictable development workflow.

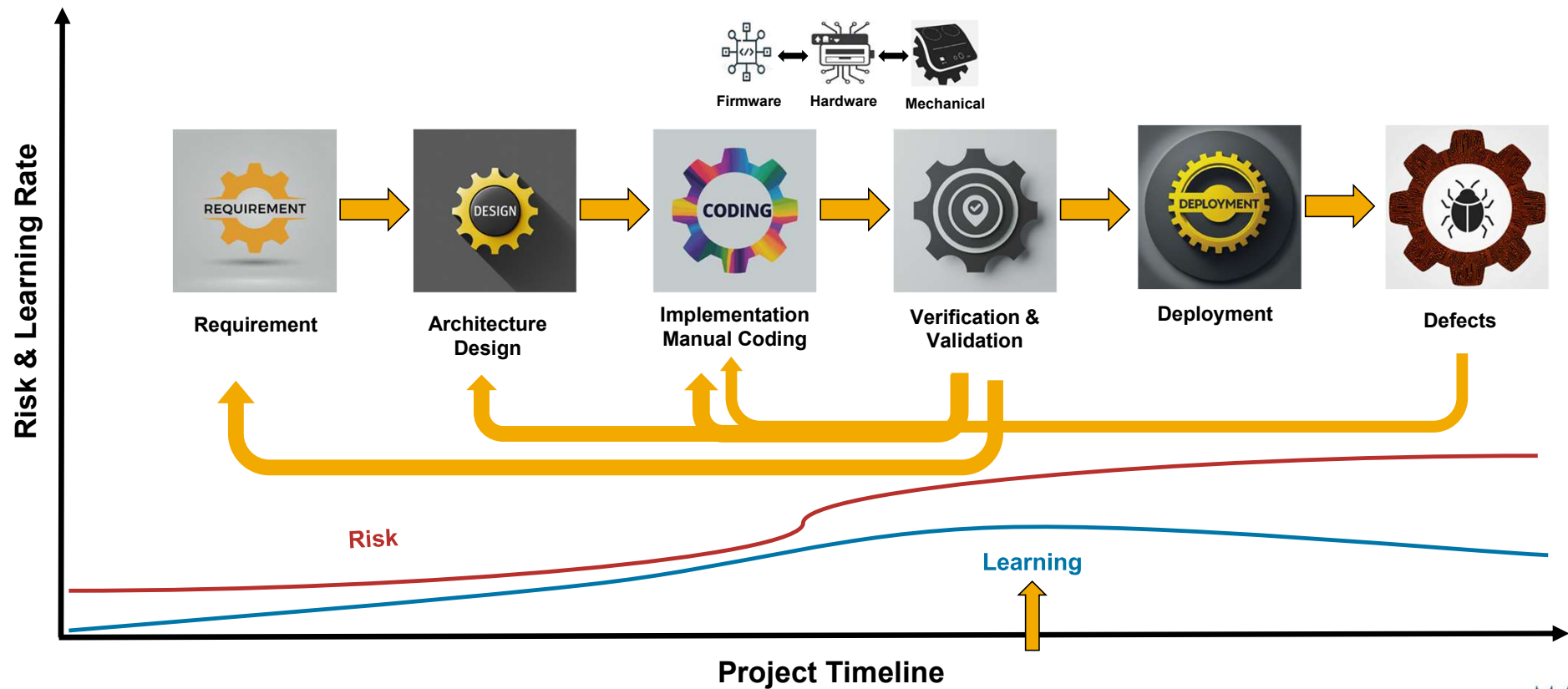
Induction Cooktop Complexity



Despite the complexities and variations, an efficient development process is essential to consistently meet requirements and ensure consumer satisfaction.

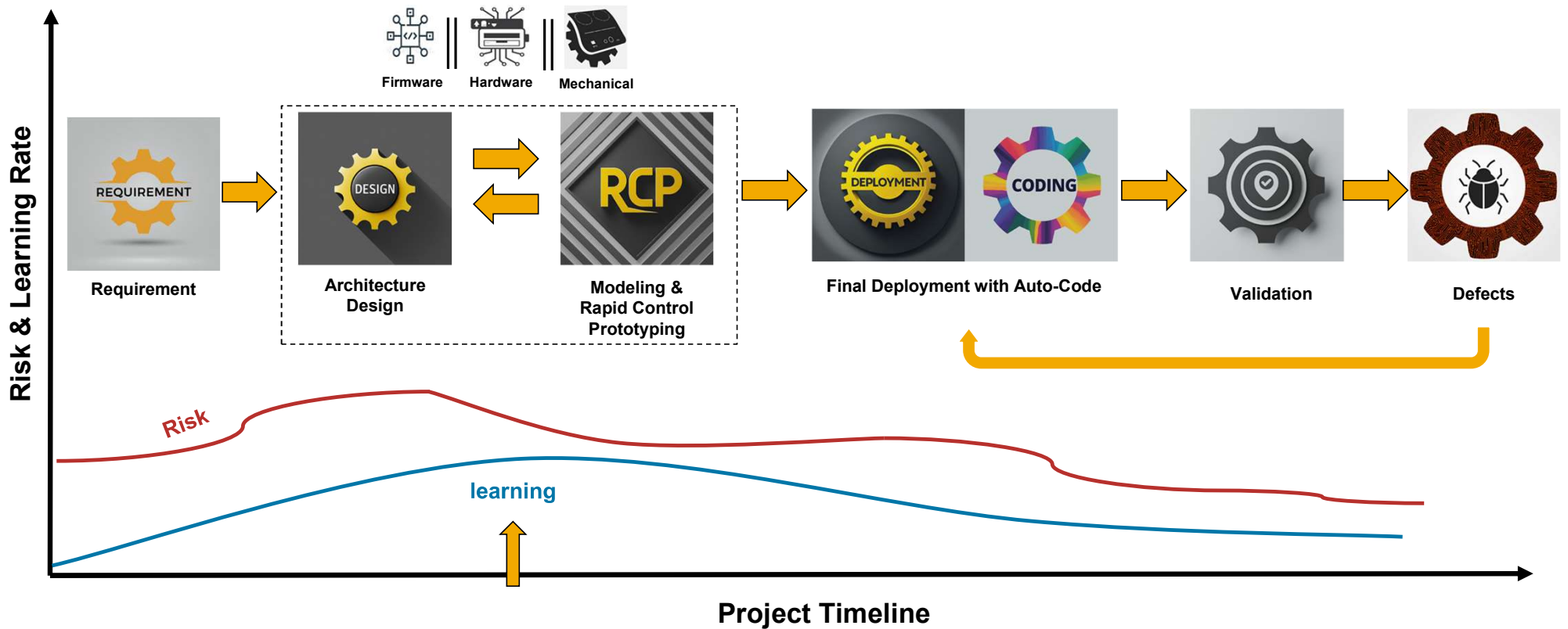
Our Transformation Journey: Yesterday

Delayed learning and testing hinder iterative development, making it difficult to manage complexity and driving up defect resolution cost.



Our Transformation Journey: Today

Rapid design iterations enable us to handle complexity effectively through early visibility, cross-disciplinary collaboration, and continuous verification and validation.



Architecture Design: Induction Cooktop

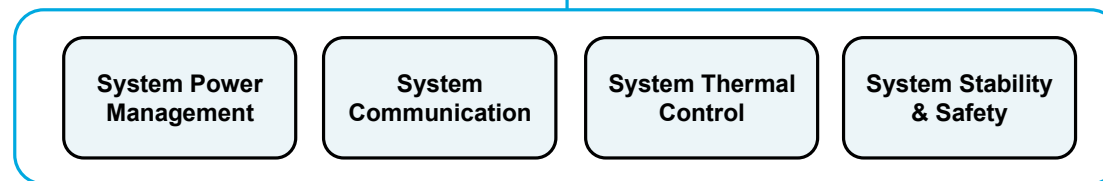
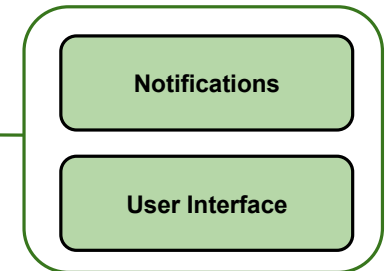
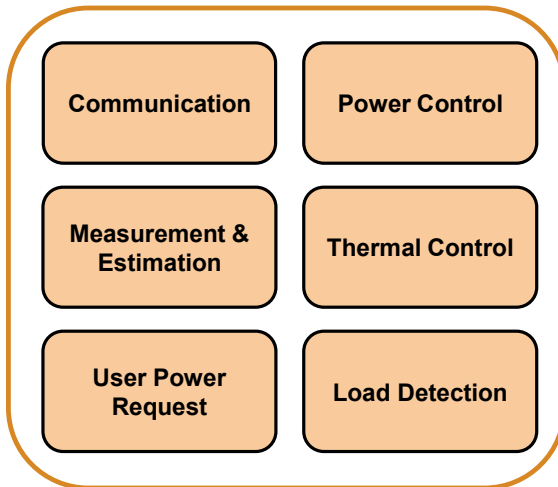
Focus on:

- Modular control and estimation architecture
- Reusable functions across coils' power control
- Parameterizable control and estimation algorithms
- Portability of algorithm to different hardware

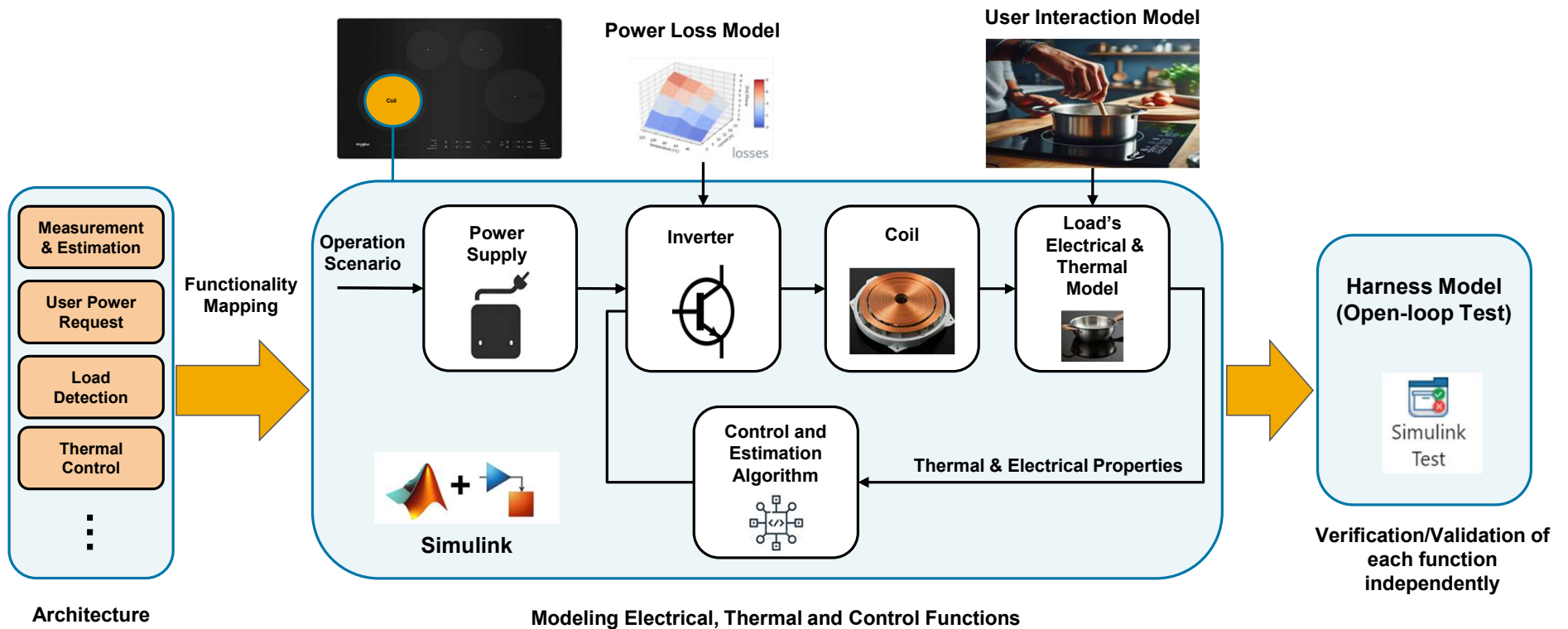


System-level Requirement

Simultaneous Coil Power Control

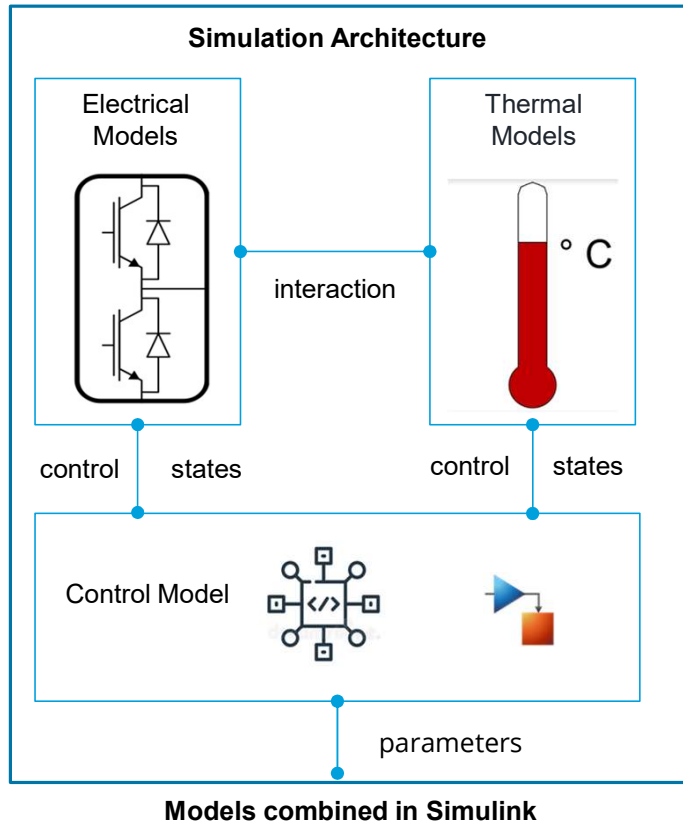


Function-level Modeling and Simulation: Induction Cooktop



Functional level modeling and open-loop testing provide a solid foundation for reliable subsystem integration, RCP, hardware-in-the-loop testing, auto code generation.

Physical Prototyping - Rapid Control Prototyping (RCP)



Communication
+
Analog/Digital IOs



speedgoat

Simulink Real-time Toolbox



Real-time
Data Logging

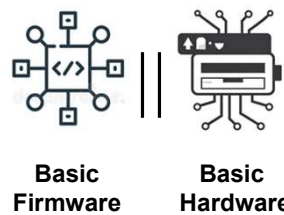


Project Acceleration by :

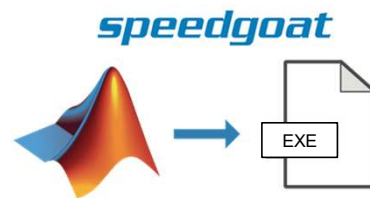
- Prototype performance evaluation
- Control running in real time
- Only basic SW layers needs to be ready
- Leverage old platforms for learning
- Direct acquisition of data

Rapid Control Prototyping - How it helped other teams?

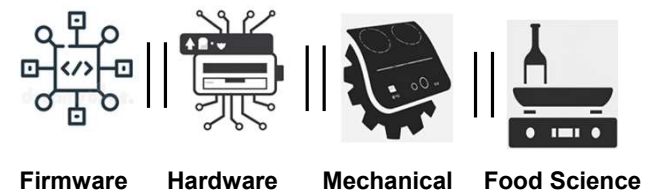
Standalone RCP applications facilitate parallel component development and testing across teams.



Basic Functionality Verification



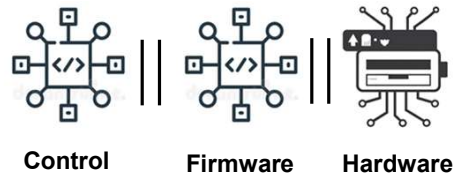
Royalty-Free MATLAB Standalone Application



Enabling other team to test their component/algorithm with RCP-based standalone application



Verification of Integrated System



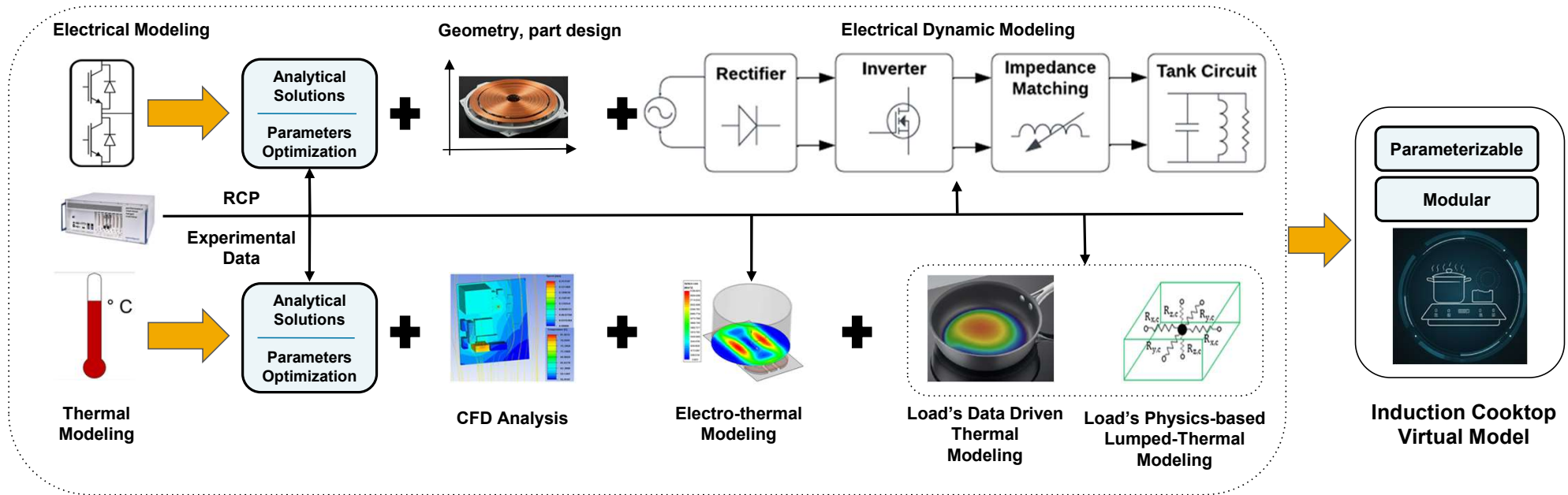
RCP logged data enables the virtualization of the system



Preliminary Parameter Tuning



Virtualization - How are we doing it?



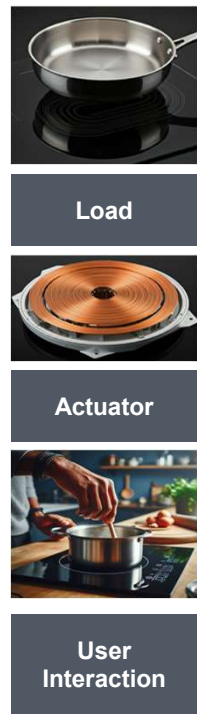
To understand

- How the power system behaves in different user cooking scenarios
- Thermal management of electronic components

Enables

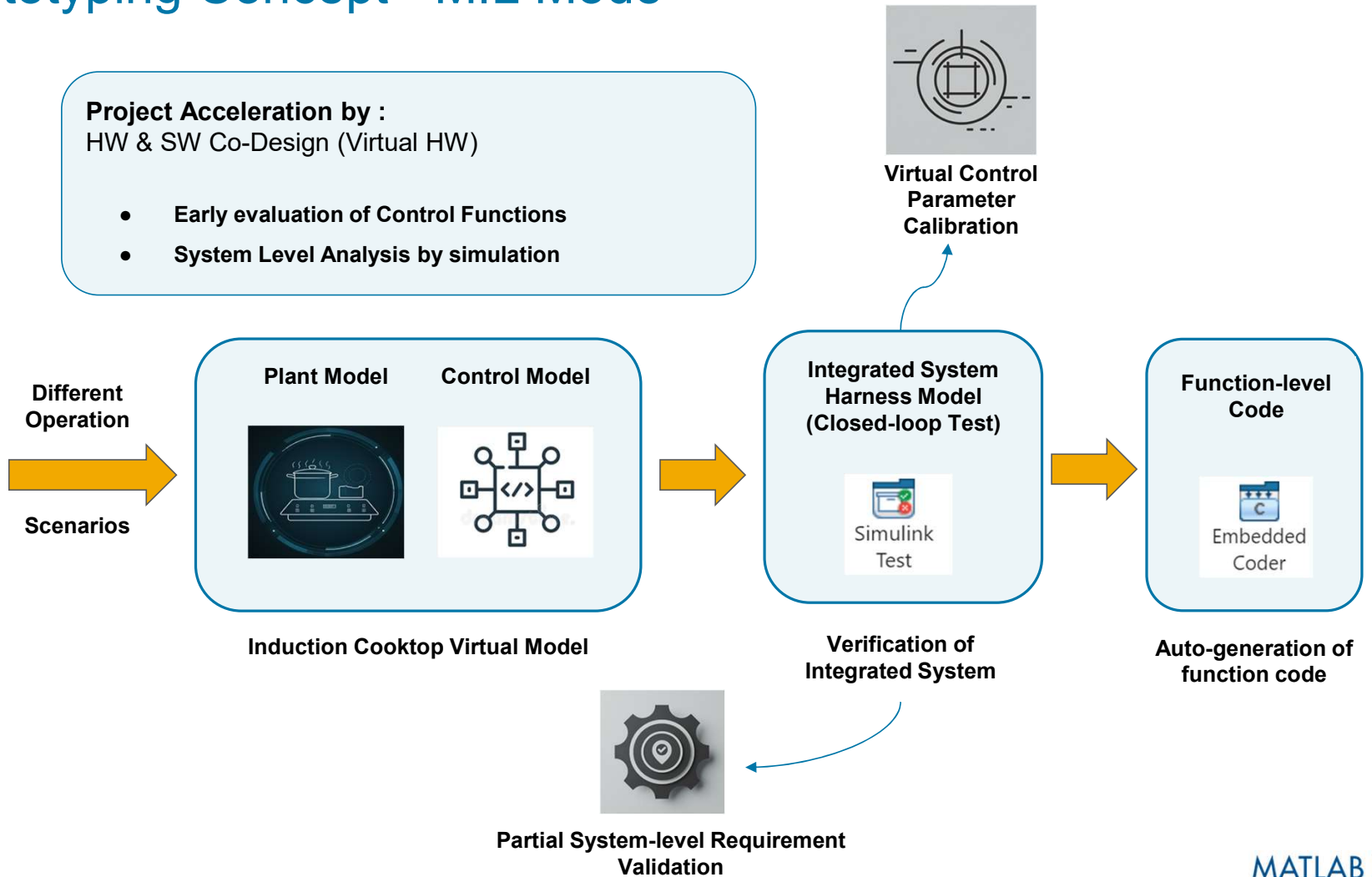
- Model-in-the-loop verification
- Virtual parameter calibration

Virtual Prototyping Concept - MIL Mode

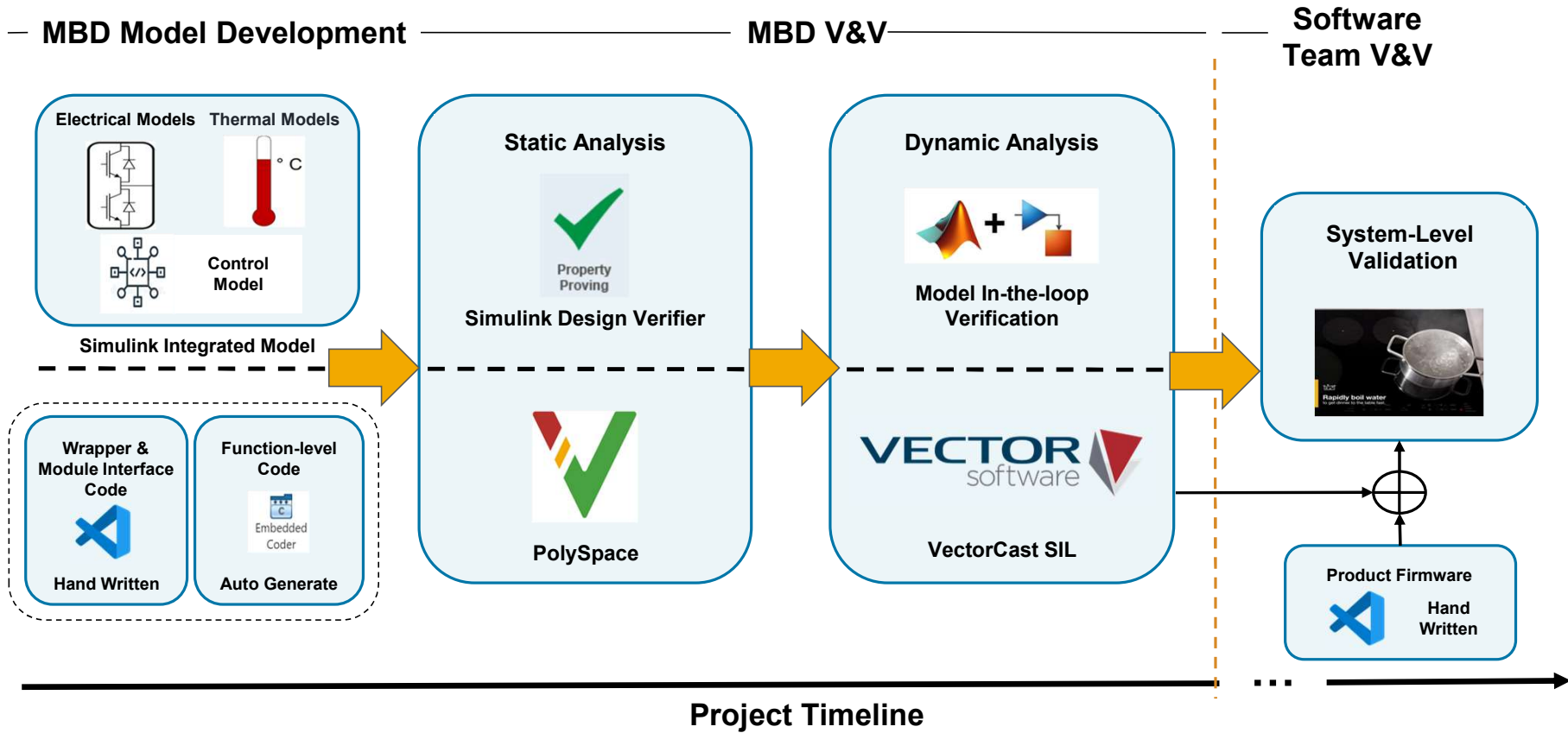


Project Acceleration by :
HW & SW Co-Design (Virtual HW)

- Early evaluation of Control Functions
- System Level Analysis by simulation



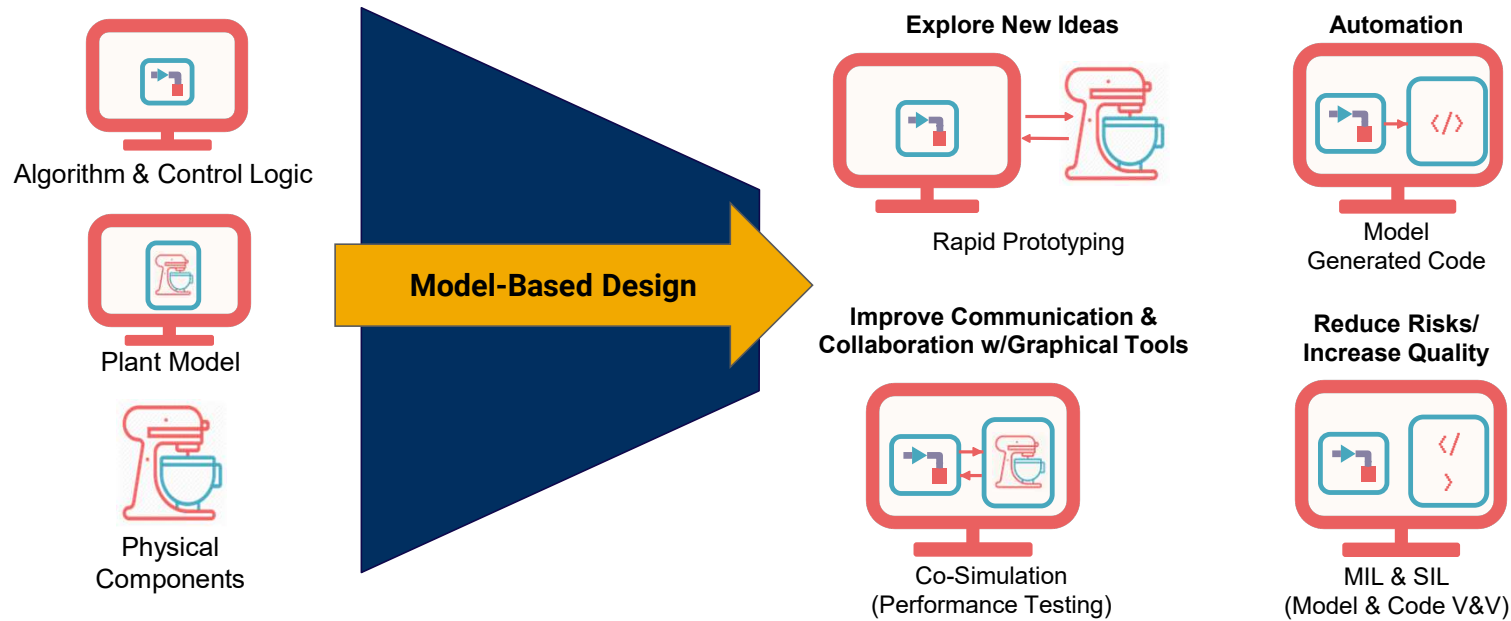
Verification and Validation



Utilizing model development in Simulink and auto-gen allows for early MBD V&V in the development process, leading to more efficient and robust outcomes.

Transition to Model-based Design Process

The Control Models are designed to generate **predictions** while being **robust, readable, configurable, testable, reusable, properly documented, and ready for integration** with firmware.



How MBD Has Helped Induction Cooktop Development

Model-based design manages system complexity more efficiently, enabling the incorporation of complex features into the product and enhancing the consumer experience.



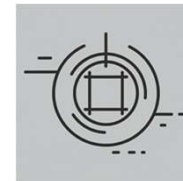
SW & Controls & HW Concurrent Design



Quick Learning Cycles



V&V Automation



Virtual Calibration




Knowledge retention (MBSE)

THANK YOU!

JOIN THE CONVERSATION

 @WhirlpoolCorp

 [LinkedIn.com/company/Whirlpool-Corporation](https://www.linkedin.com/company/Whirlpool-Corporation)

 [WhirlpoolCorp.com](https://www.WhirlpoolCorp.com)