FCA and CNH Industrial
Official Global Partners

MILANO 2015

Model based design at CNHi

The transition to full model based implementations

Carlo Cloet – Karel Viaene, CNHi Zedelgem

MathWorks Benelux user's conference

June 11th, 2015

Key Takeaways

- CNHi is adopting an end-to-end model-based development strategy
- Model based design is a key enabler for developing innovative functionalities

CNH Industrial

Our Products

Trucks

Buses

Firefighting Equipment

Civil Protection and Defence Vehicles

Skid Steer Loaders

Crawler Excavators

Engines and Transmissions

Tractors

Combines

CNH Industrial

Company Structure

CNH Industrial

Key Figures (31 Dec 2014)

1 company

12 brands

49 R&D Centers

64 plants

190 national markets

69,207 employees

6,100 individuals dedicated to innovation

7,518 active patents owned

$ 1,106 million invested in R&D

$ 6 million invested in training

$ 708 million net income

$ 32,555 million revenues

$ 8,857 million total available liquidity

Note: all figures provided herein are on a US GAAP $ basis unless otherwise indicated

Model based design at CNHi (Zedelgem)

+10 years of model-based design experience

Display Logic

Forage harvester automated filling

Sugar Cane Harvester Drivetrain

Grape Harvester Drivetrain

Combine header height control
Hydro-pneumatic suspension
Feedrate control

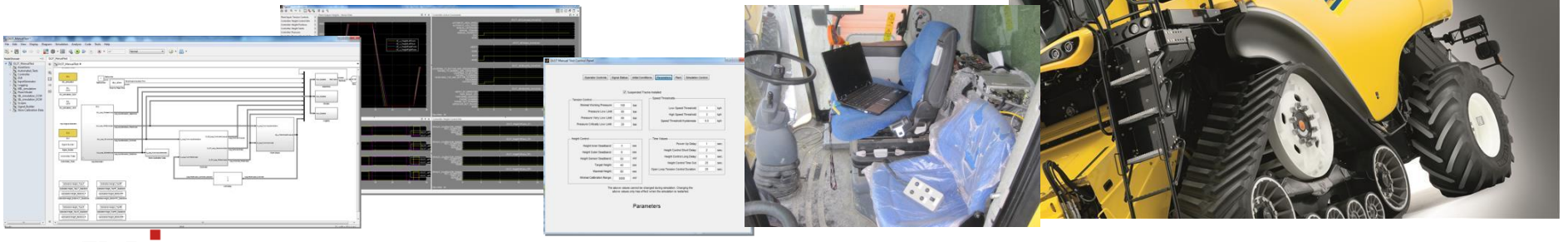
Baler HIL Testing

Baler application logic

Innovation Challenges and Achievements

Transitioning to a complete model-based implementation

- Objective: convert combine legacy C code to a full model-based implementation
  - Simplify transfer from innovation to product development
  - Avoid manual integration work
  - Consolidate legacy code base
  - Increase level of abstraction
  - Leverage MIL capability (test early, test often), rapid prototyping, etc



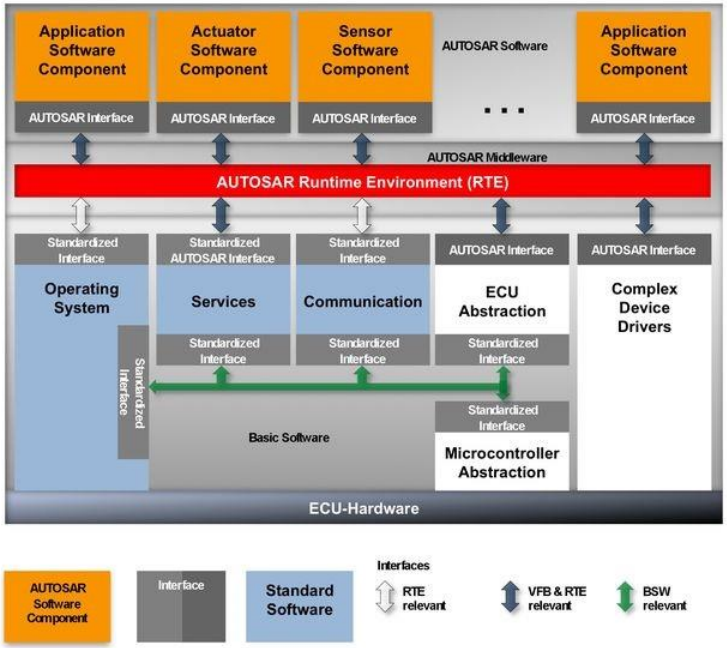
How did we get there and leverage MathWorks?

- 3 major challenges:
  - System integration
  - Team based development
  - Functional implementation and validation

How did we get there and leverage MathWorks?

Challenge 1: System Integration

- How to integrate 100's of models into a functioning vehicle?
- Key enablers: AUTOSAR architecture + Simulink built-in AUTOSAR support

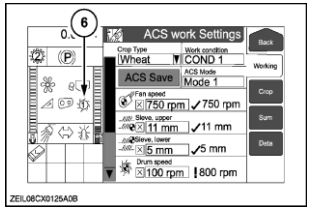


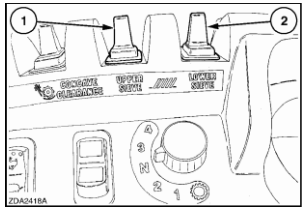
Source: http://www.autosar.org/about/technical-overview/

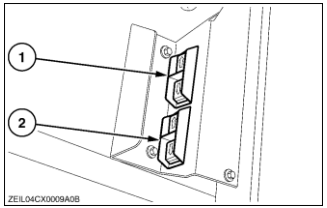
How did we get there and leverage MathWorks?

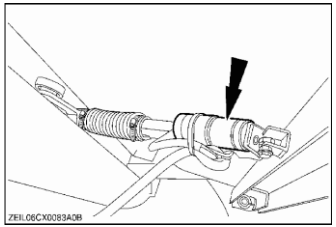
Challenge 1: System Integration

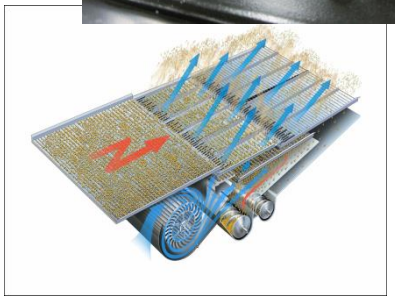
- Example subsystem: sieve control logic







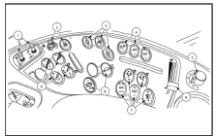


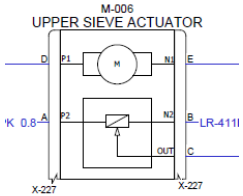


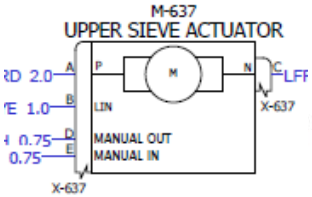
How did we get there and leverage MathWorks?

Challenge 1: System Integration

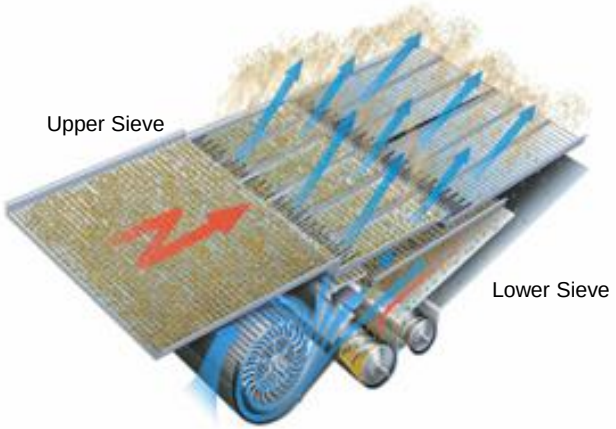
- Additional integration challenges







Same functionality,
different hardware

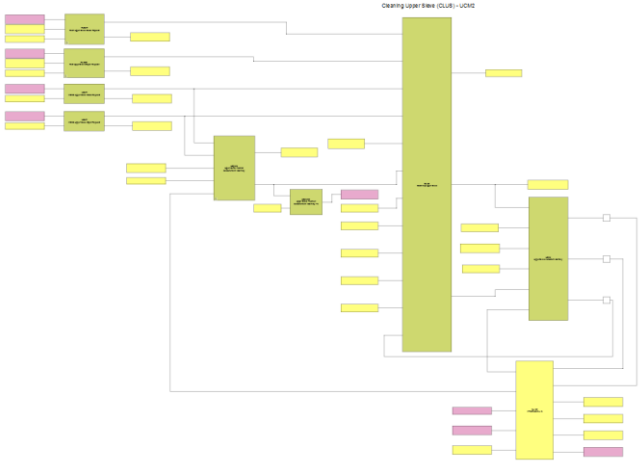


Same functionality,
multiple instances

How did we get there and leverage MathWorks?

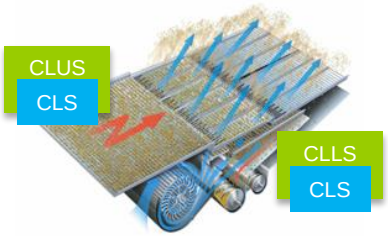
Challenge 1: System Integration

- Approach: component based architecture



Application SWCs
Sensor SWCs
Actuator SWCs

Application SWC re-use
by use of engineering unit interfaces



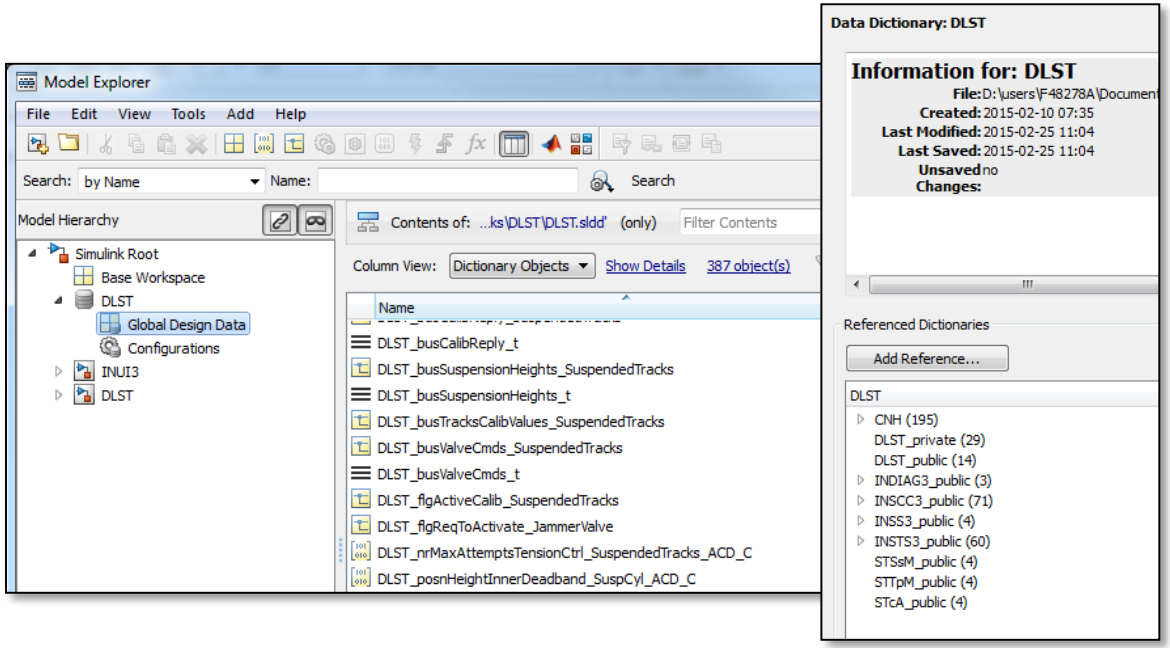
Multi-instance support
via Simulink library implementation

CLS

How did we get there and leverage MathWorks?

Challenge 2: Team based development

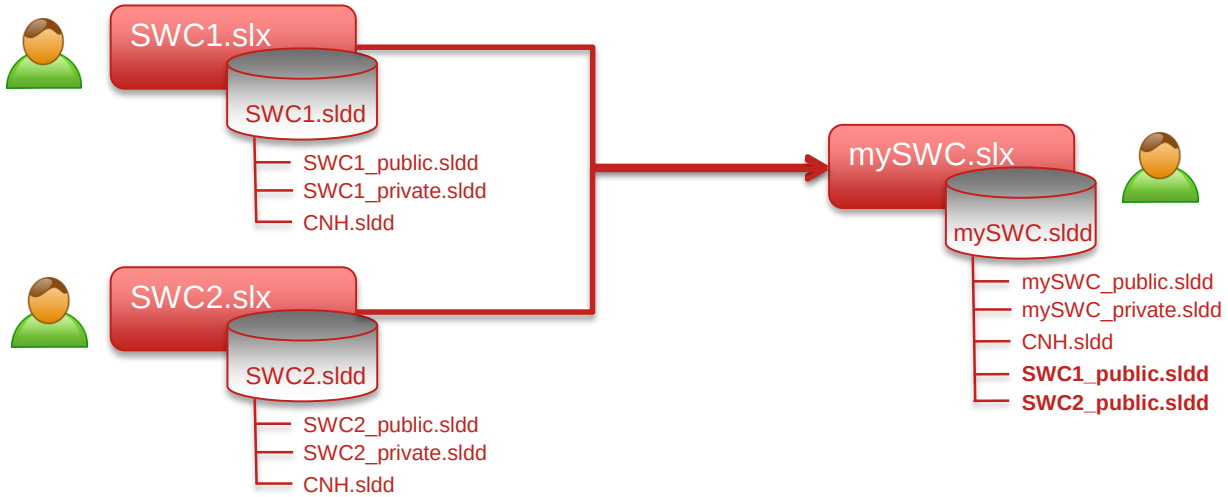
- How to enable concurrent model development by multiple people?
- Key enabler: Simulink data dictionary feature (introduced in R2014a)



How did we get there and leverage MathWorks?

Challenge 2: Team based development

- Using references to “public” data dictionaries to obtain input signal definitions
  - Public data dictionaries establish contracts among otherwise independent developers



How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation

- Intellifill on Forage harvester
  - Forage harvester operation
  - Automated trailer filling
    - ✓ 3D camera
    - ✓ https://www.youtube.com/watch?v=-zaQnygsMuQ
  - Why automation
  - Challenges


FR9000 IntelliFill™ System
NEW HOLLAND
AGRICULTURE

How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation

- Intellifill on Forage harvester
  - Forage harvester operation
  - Automated trailer filling
    - ✓ 3D camera
    - ✓ https://www.youtube.com/watch?v=-zaQnygsMuQ
  - Why automation
  - Challenges

How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation

Development

Simulation

Testing

Debugging

Integration

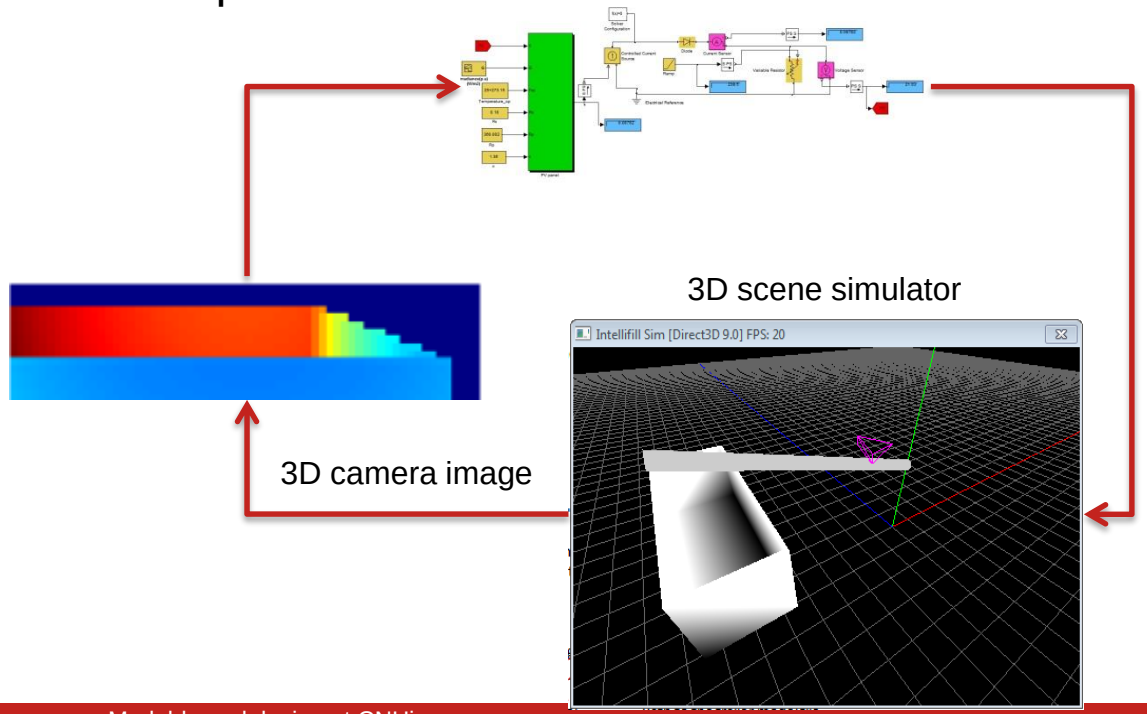
Code generation

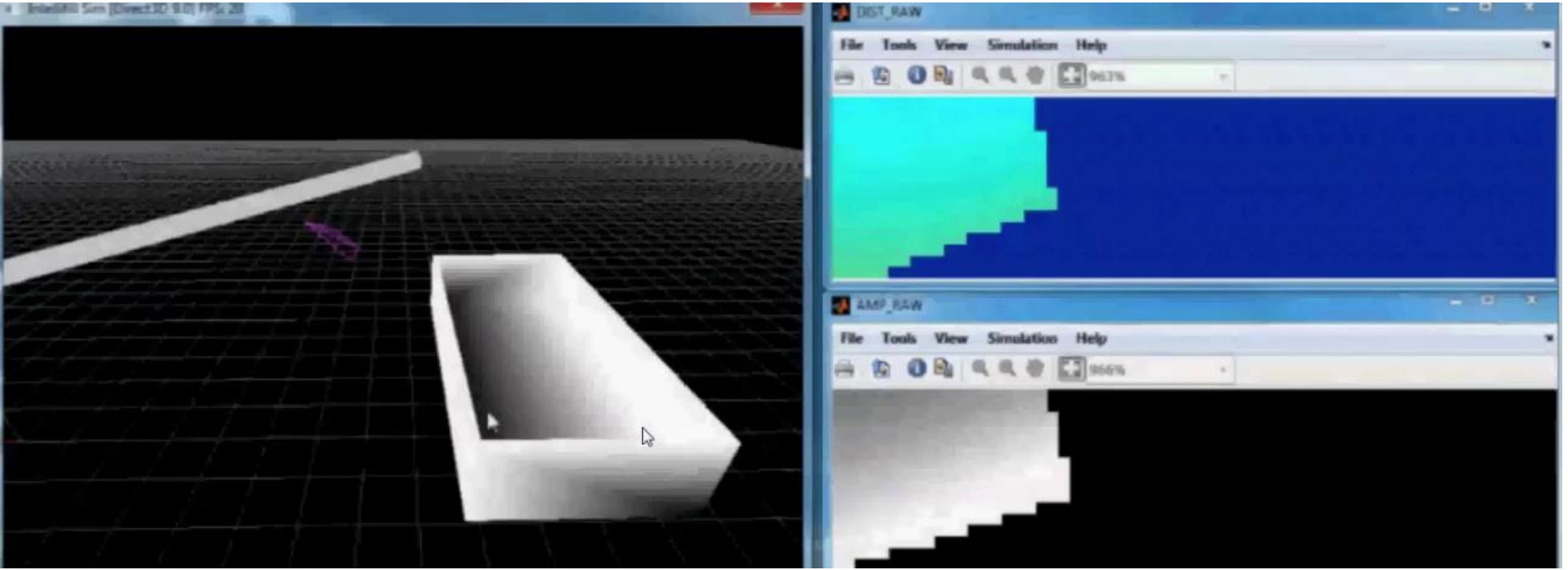
Validation

Verification

Validation

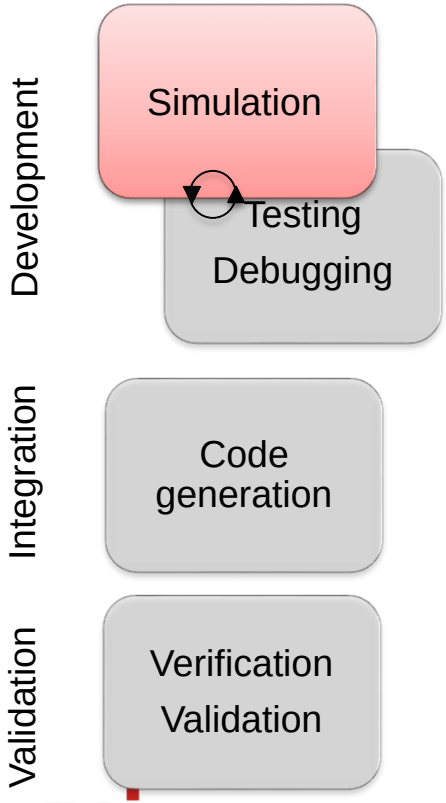
- Software architecture and algorithm development through closed loop MIL simulation



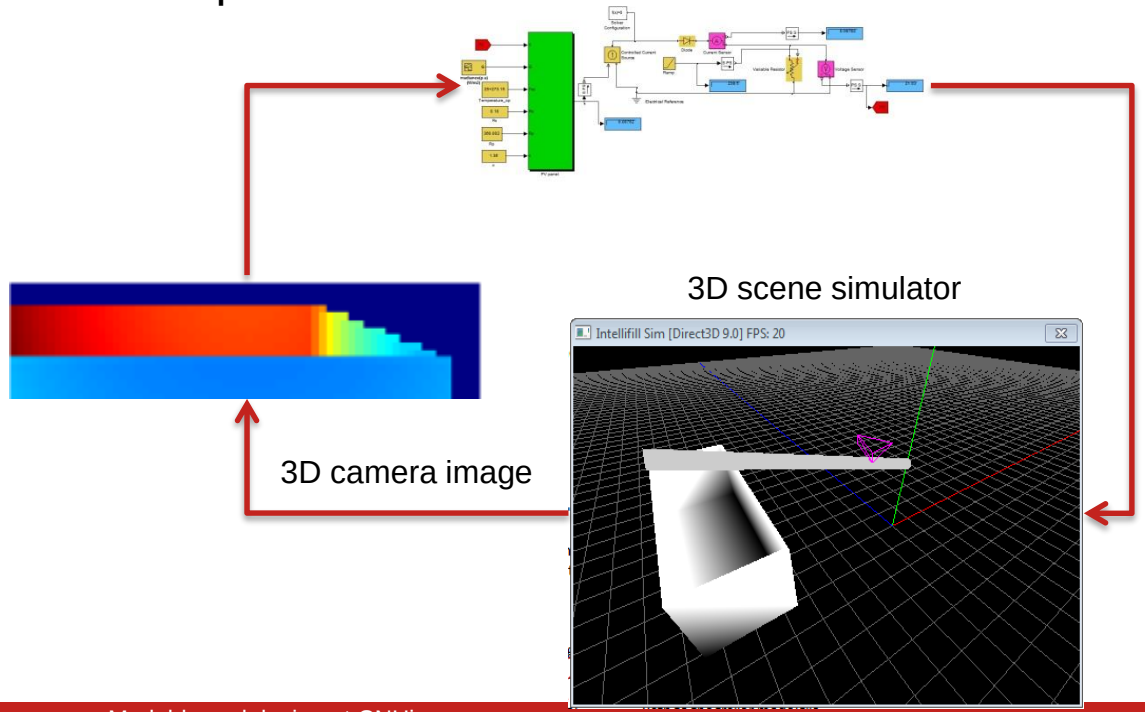

DIST_RAW
File
Tools
View
Simulation
Help
AMP_RAW
File
Tools
View
Simulation
Help

How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation

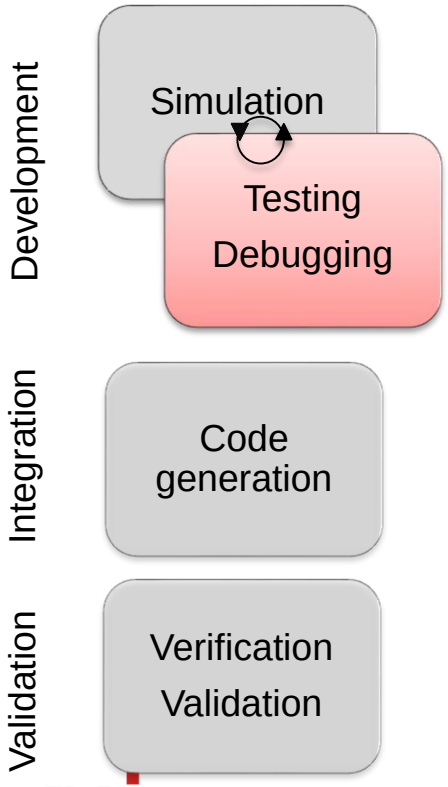


- Software architecture and algorithm development through closed loop MIL simulation



How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation



- On vehicle testing, debugging and fine-tuning in simulink environment

Embedded platform: MPC5121e

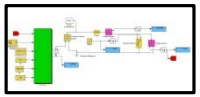
- User input
- Visualisation

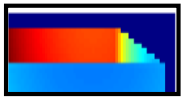
ICT

CAN

Image processing
& controls

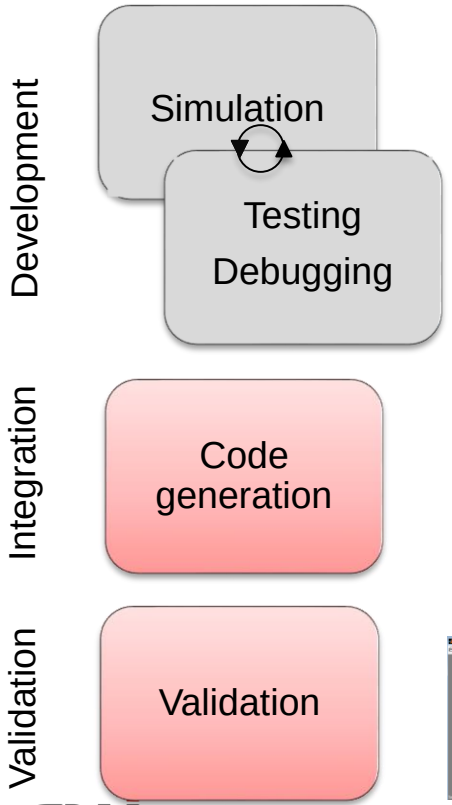
VNT





How did we get there and leverage MathWorks?

Challenge 3: Functional implementation and validation



- Integration in Vehicle display controller with embedded coder

Embedded platform: MPC5121e

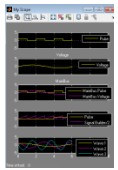
- User input
- Visualisation
- Image processing & controls

Embedded coder

CAN

VNT

Monitoring



Key Takeaways

- CNHi is adopting an end-to-end model-based development strategy
  - Enabler 1: Simulink built-in AUTOSAR support
  - Enabler 2: Simulink datadictionary feature

- Model based design is a key enabler for developing innovative functionalities
  - Enabler 1: MIL simulation: Closed loop simulation with 3D scene simulator
  - Enabler 2: Rapid Prototyping: Instrument control toolbox & Vehicle network toolbox
  - Enabler 3: Code generation: Embedded coder allows fast integration