

Ideas for Successful Model Integration with Standardized Software Architectures

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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 at a Glance

Key Figures (31DEC2014)

- 69,207 Employees Worldwide
- \$33 Billion Revenue

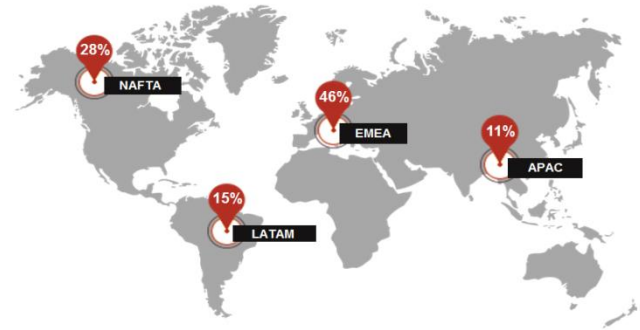
GLOBAL INDUSTRIAL FOOTPRINT (excl. JVs)



R&D Centers (Total: 49)



GROUP REVENUES BY GEOGRAPHY FY 2014*

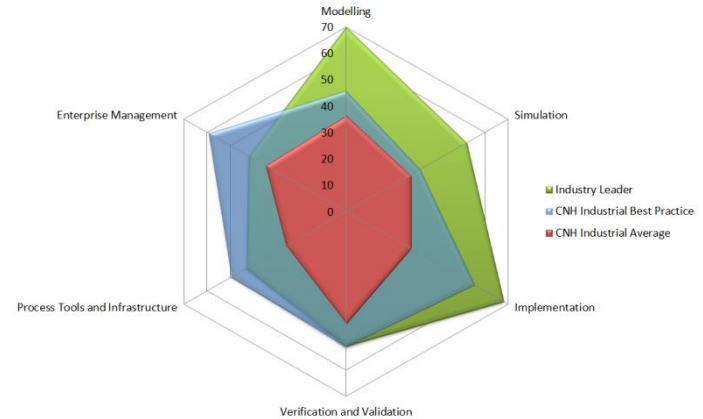


Integration – The Challenge

- As CNHi has embraced the challenge of changing development methodologies from traditional to Model Based new kinds of development problems have arised.
- Chief amoungst the challenges is the process of integrating the generated software into the software architecture.
- CNHi has analyzed the situation on many projects using both proprietary and standardized (e.g. AUTOSAR) software architectures.
- To achieve problem-free integration, it is first necessary to improve system design and software architecture processes.

Model Based Development at CNH Industrial:

- CNHi began developing software using MBD techniques as early as 2003.
- MBD currently used in many different types of vehicle systems: Engines, Transmissions, Aftertreatment, Body Controls, Hydraulics, Auto-Guidance.
- CNHi has many different teams implementing functions on many different vehicles in many locations globally. Standardization is an ongoing pursuit.
- In 2012 – 2013 CNHi was evaluated based on Mathworks MBD Maturity Framework. Since then CNHi has been working on standardizing our approach and improving our capabilities.



MBD Development at CNHi is improving.

This presentation covers one area we are improving – INTEGRATING control models into production controllers.

Integration Difficulties with MBD Projects

MBD + Proprietary Basic Software Package

Study was completed considering development of engine control software at CNH Industrial (“traditional” hand coding v. mixed MBD / handcode).

- Defects decreased as a percentage of development (41% vs. 32%)
- Integration errors increased on percentage basis (3.7% vs. 11.1%)

Change Source	Traditional Sw Development Process		Mixed Sw Development Process (July 2013)	
	SWCRs number	SWCRs %	SWCRs number	SWCRs %
Improvement Specification	238	59,4%	326,5	57,0%
New Functionality	Not Considered	0,0%	64,0	11,2%
Hand Code	95	23,7%	42,0	7,3%
Autocode	0	0,0%	40,0	7,0%
Framework (interfaces with Supplier Sw Modules)	15	3,7%	63,5	11,1%
Documentation	53	13,2%	37,0	6,5%
Total	401	100%	573	100%



- ← “Coding” Errors Decreased
- ← “Integration” Errors Increased
- ← Documentation Errors Decreased

Source: Cortese, Demetrio. “New Model-Based Paradigm: Developing Embedded Software to the Functional Safety Standards, as ISO 26262, ISO 25119 and ISO 13849 through an efficient automation of Sw Development Life-Cycle. 2014 SAE International (2014-01-2394)

Process Goals for CNHi's Future SW architecture

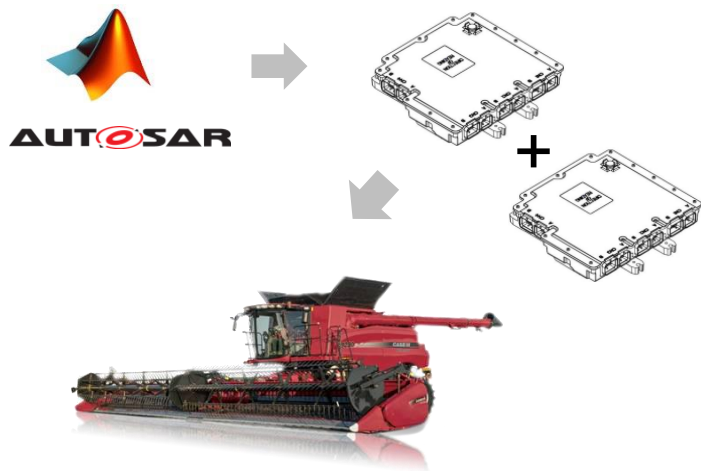
- **Model Development should be Simulink-Centric.** Modelers should focus on modeling, simulating and verifying functionality. Little or no time should be spent writing basic software modules or interfaces. Little knowledge of basic software architecture should be required of model developers.
- **SW Architecture & Interfaces should be documented only once.** This data should then be automatically applied to configure basic software and define interfaces for the models.

So far this has only partially been realized.

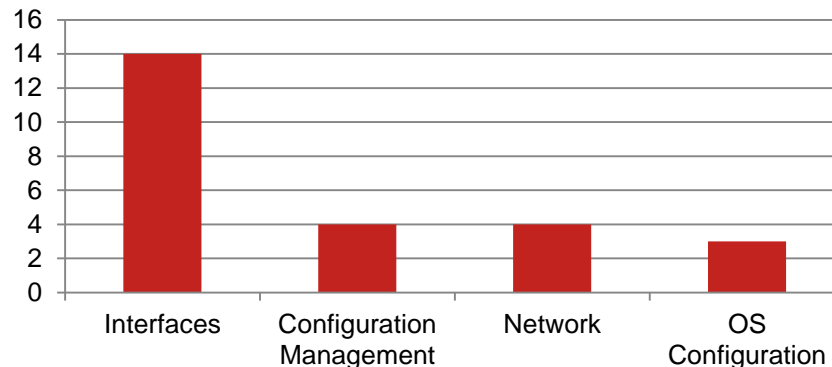
Integration Difficulties with MBD Projects

MBD + AUTOSAR

- Application consists of roughly 800 models split between 2 identical controllers.
- Simulink + Embedded Coder for code generation.
- 15 Model Developers, 3 Core Software Architecture Engineers
- 4 Development Locations (Illinois, Pennsylvania, Belgium, India)



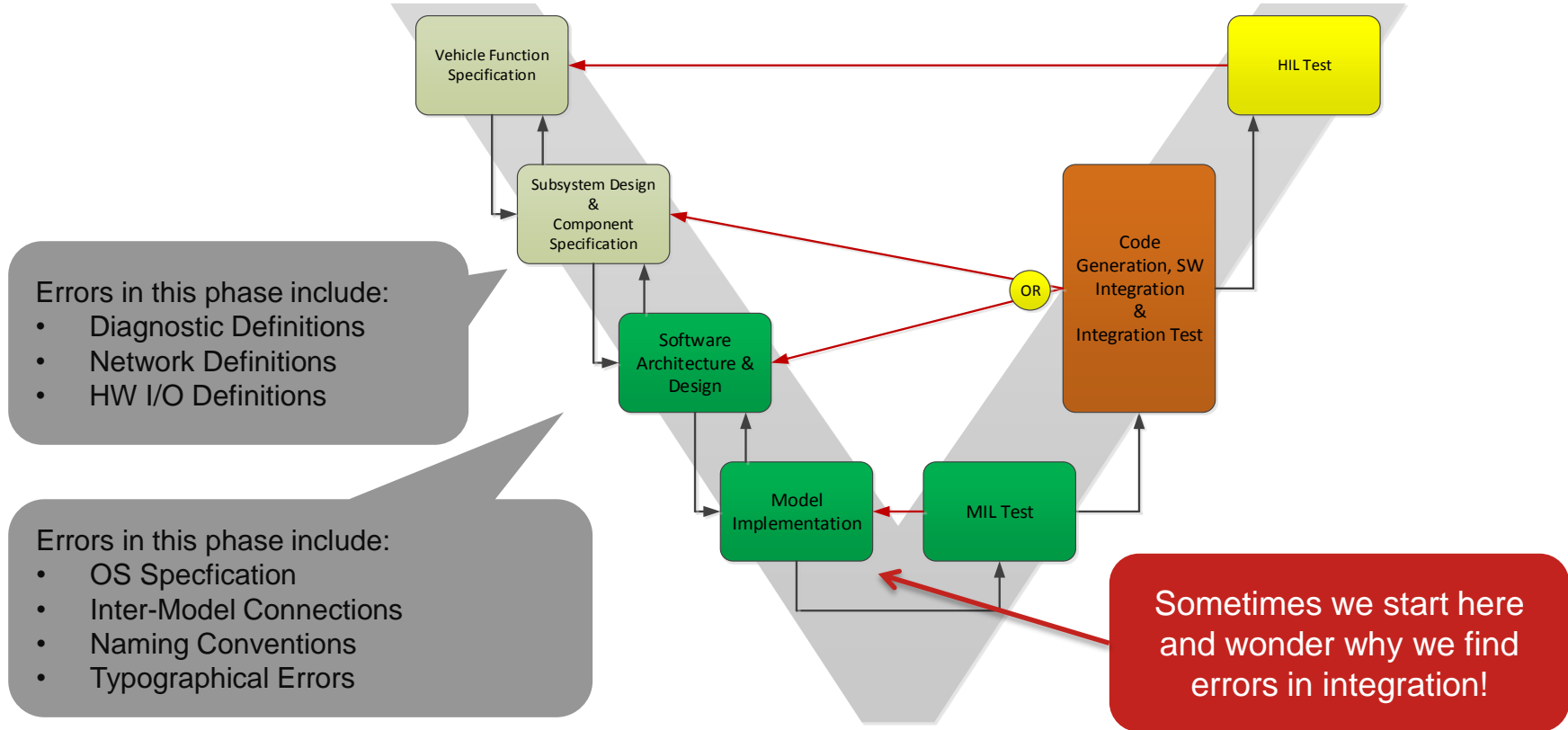
Pareto of Integration Defects, Release 35.0.1.0,
logged in 2015 (Reported 21APR2015)



Note: New Requirements + Functionality Defects + Integration Defects = 240 total change requests for this particular release.

Why do we have integration errors?

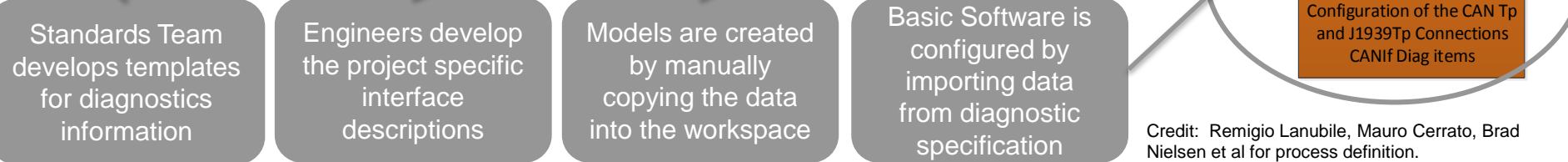
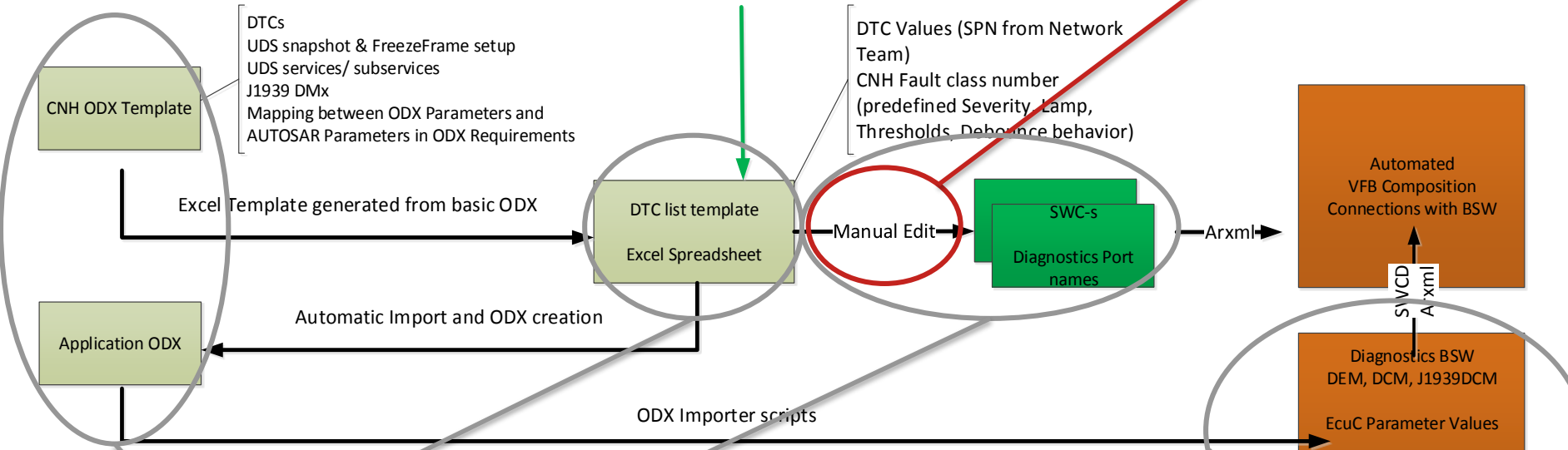
Study of Latest Combine Release



Example: Diagnostics Integration

Current CNHi AUTOSAR Workflow

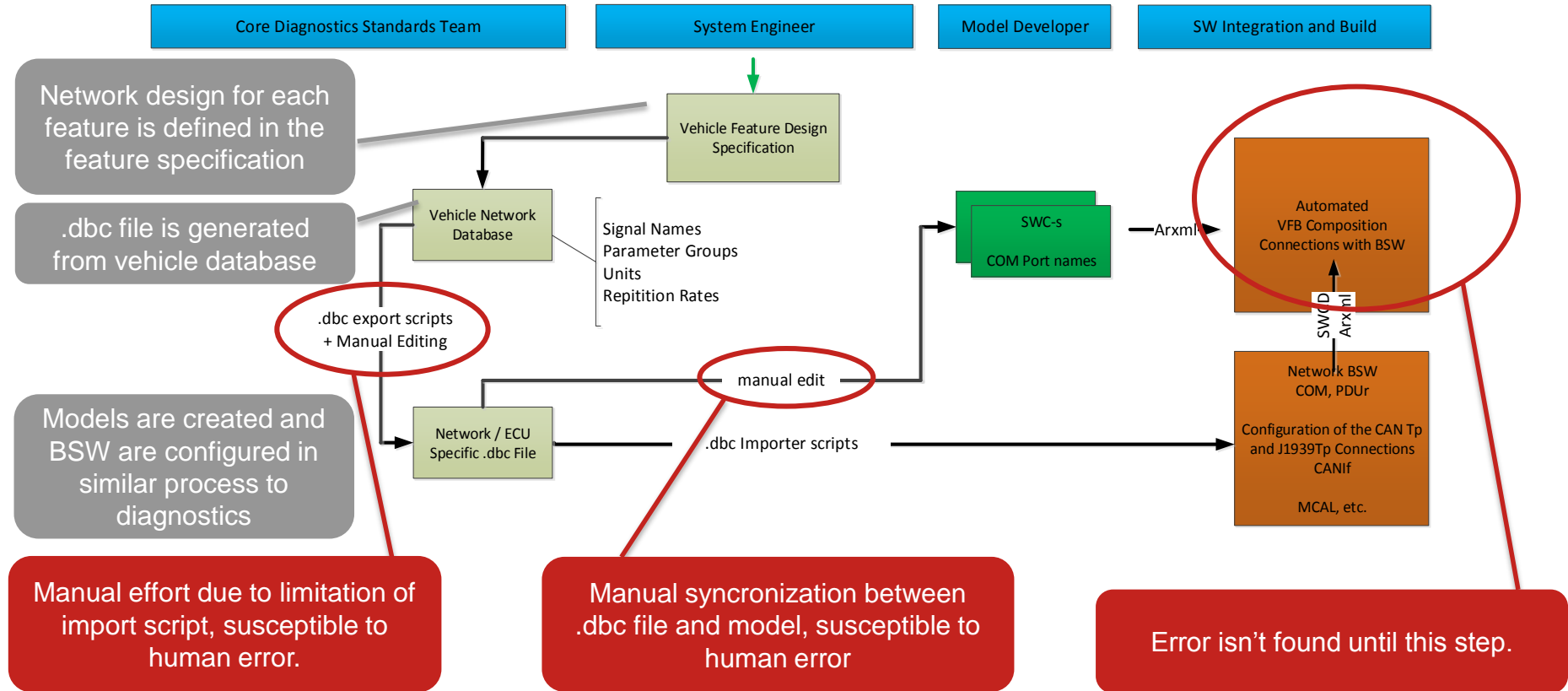
Currently a Manual Process – Human Error creeps in.



Credit: Remigio Lanubile, Mauro Cerrato, Brad Nielsen et al for process definition.

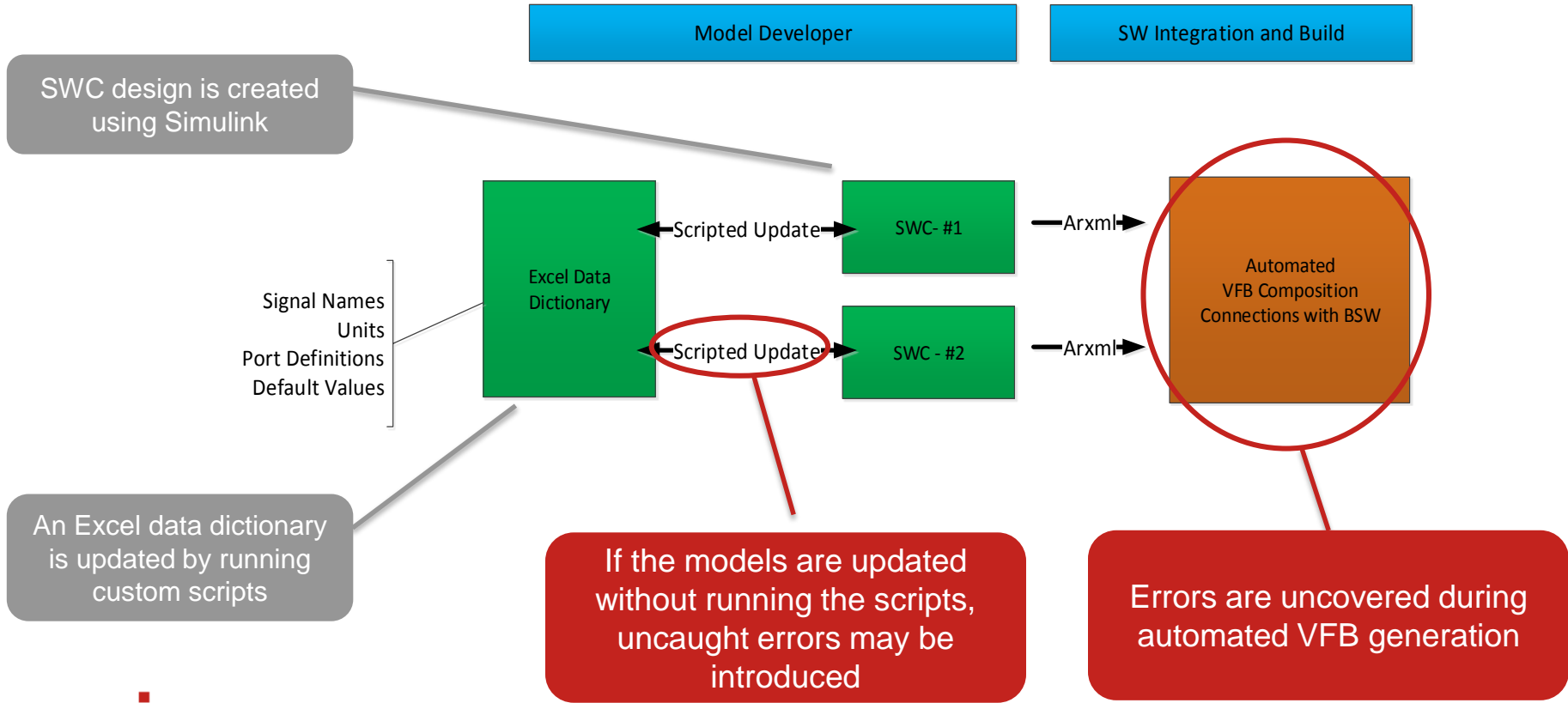
Example: Network Integration

Current CNHi AUTOSAR Workflow



Example: Network Integration

Current CNHi AUTOSAR Workflow



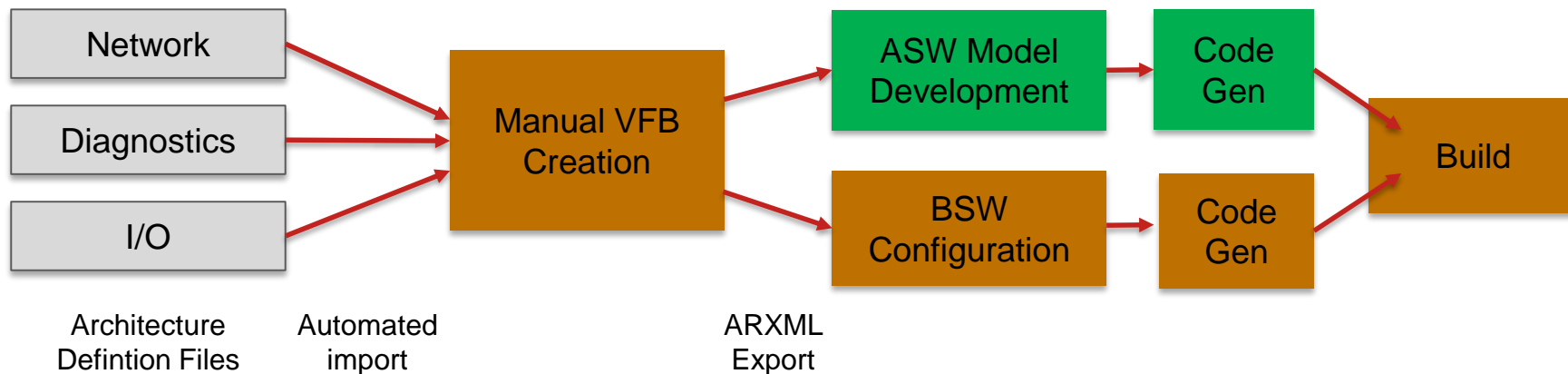
What is necessary to improve?

- Up front specification. Do not expect model development to be perfect if the model requirements are incomplete.
- Upfront definition of subsystem and software architecture, automatic population of architecture specification into model environment
- Ability to check design activities against the specification, through an automated mechanism, to eliminate errors before the integration phase begins. Part of “unit testing” activities.

Where will CNHi focus it's attention?

- **Data Dictionary** - improvements to ensure that all models inputs are synchronized
- **Automatic scripts** to import the interfaces from the architecture definition files (e.g. ODX, .dbc, Excel) into the model, ensuring the model developer cannot make an interface mistake.
- **Automatic scripts** to check the models against the architecture definition files and data dictionaries prior to the integration activity.

OR, Re-Engineer the process . . .



Reverse the procedure. Perform the integration (e.g. develop the VFB) and export the ARXML into Simulink. Architecture definition to software integration is then a serial process, rather than multiple activities happening in parallel.

Requires rigorous software architecture definition up-front.

Questions?