SYMBIO

A FAURECIA MICHELIN HYDROGEN COMPANY

FROM MULTI-PHYSICAL SYSTEM SIMULATION TO INDUSTRIAL CODE GENERATION

10th October 2023 - MATLAB Expo France

@NEWCAP Event Center– Paris

Rémi FAYOLLE - Anthony MICHEL

MathWorks

About us

Rémi FAYOLLE – Software Engineering Manager

I started at *Dassault Systèmes* by developing desktop applications on CATIA V6 & 3D Experience platform. Aiming to go back to Grenoble, I joined *Symbio* as a Software Engineer 7 years ago. I focus on building a strong skilled team, with the right tools and developing the process to be able to answer our fuel cell development projects.

Anthony MICHEL – Applicative Software Manager

After several years within automotive safety SW development, I joined *Symbio* 3 years ago. My wish was to combine my knowledge of automotive software development to a cleaner mobility. I'm currently leading the industrialization of software development through Model Based Design.

SOMMAIRE

1.

Symbio company presentation

Hydrogen, a key lever

to meet today's most compelling challenges

Energy Sovereignty

Innovation Edge

Industrial Sovereignty

Employment Creation

A brand new ecosystem under construction

ECONOMY DECARBONATION

PRODUCTION

INFRASTRUCTURE
Transport & Distribution

H2

PUBLIC SUPPORT
Regulation & funding

ZERO-EMISSION APPLICATIONS

Over 30 years of experience,
Engaged builder of the hydrogen ecosystem

MICHELIN

SYMBIO

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FORVIA MICHELIN

SYMBIO HYDROGEN ACADEMY

Entry in USA

INNOPLATE
A Schaeffler Symbio Hydrogen Company

STELLANTIS

MICHELIN

FORVIA

2000 – 2010 – 2019 2020 – 2021 – 2022 – 2023 – 2024 to 2030…

100-500 Syst/Y

1 000-2 500 Syst/Y
Pilot plant in Vénissieux

15k-50k Syst/Y
Saint-Fons Gigafactory

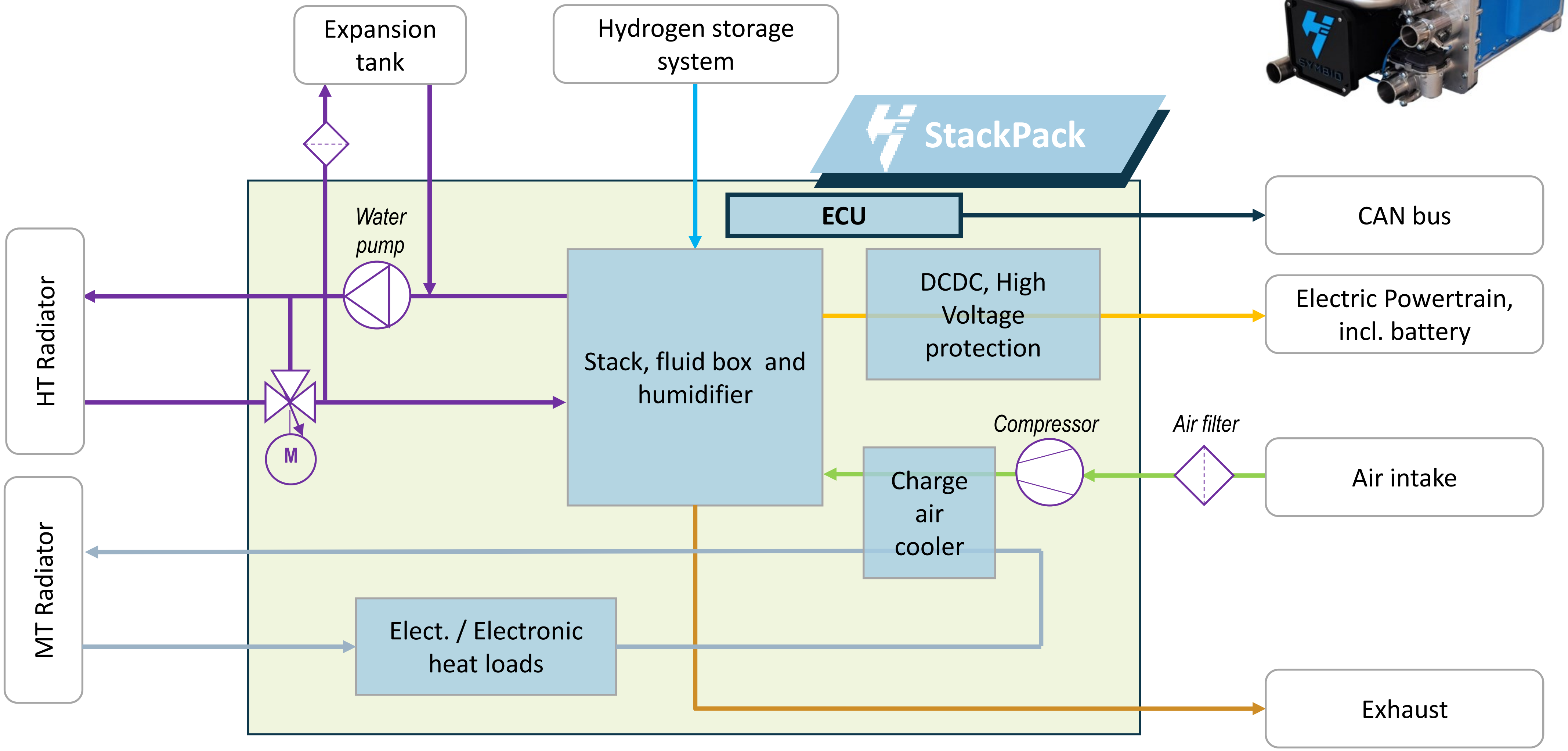
50k-200K Syst/Y
Global footprint

Trusted H2 Partner

2.

Development context & system presentation

H2 Fuel Cell system overview



Our H2Motive range meets all power and durability needs of the automotive market

COMPELLING BENEFITS

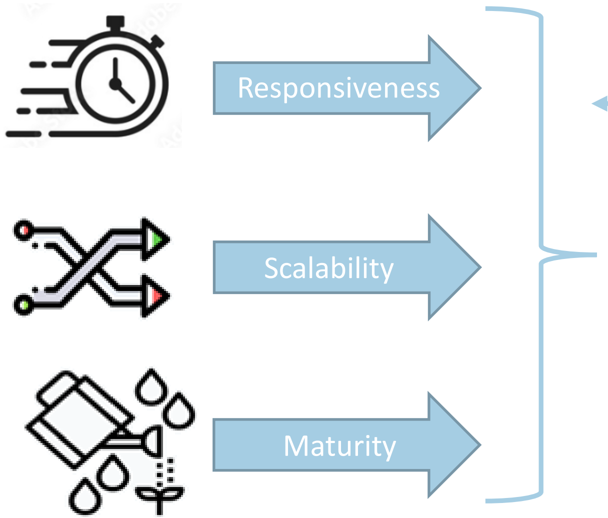
- **Zero-emission**
- **Fast refueling**: 3-5 min
- **Cruising range**: up to 1 000 km

H2 Fuel Cell System development expectations

- **Market hyper activities** request us to demonstrate the benefit of our systems thanks to prototypes & vehicles demonstrator in shortened development time

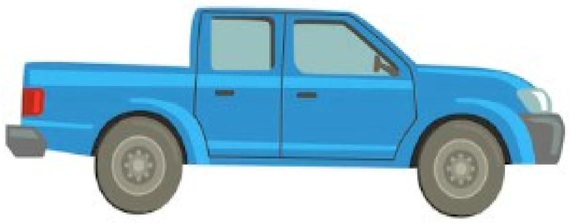
- **Product scalability** to develop range of H2 fuel cell systems that meets all power and durability expectations

- **Software function maturity & quality** to match hydrogen product specificities with automotive tier 1 standards



Development time

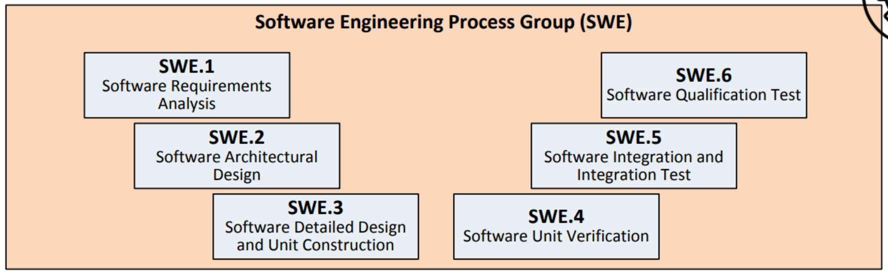
Fuel Cell System (FCS)



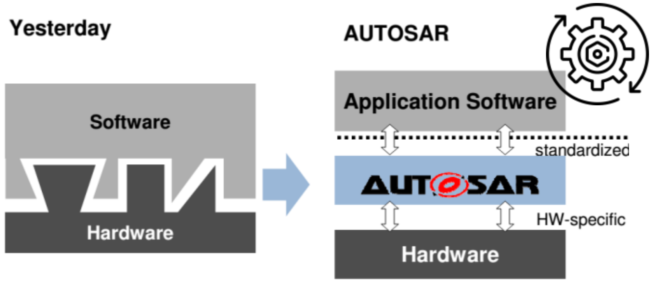
H2 Fuel Cell software development expectations

Automotive industries standards as guidelines and roadmap to confirm our Tier 1 position

AUTOMOTIVE SPICE®

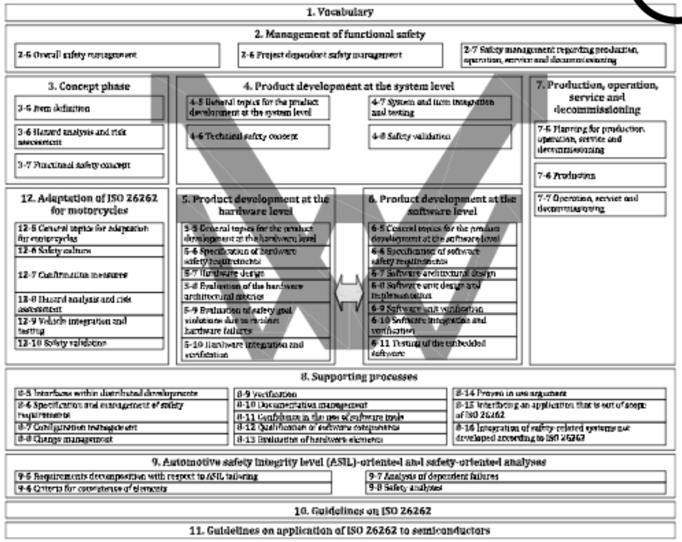


- ➢ As influence for quality processes



- ➢ As a target for modularity

ISO 26262



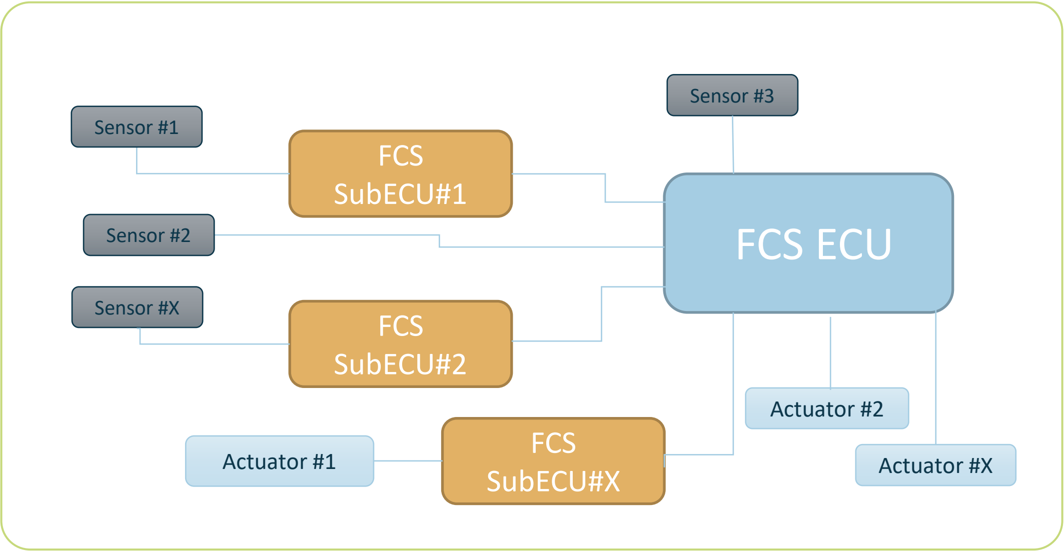
- ➢ As reference for safety processes

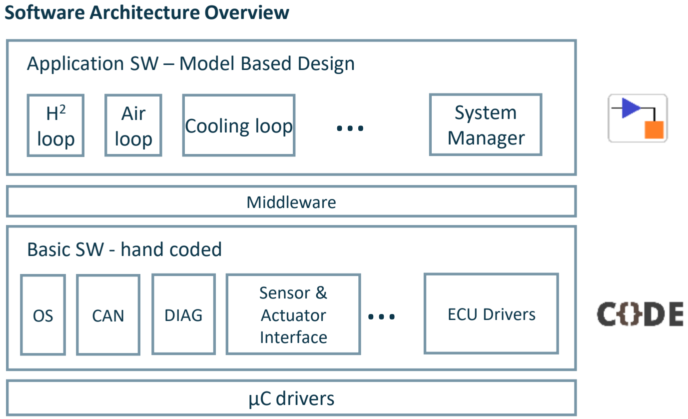
3.

Focus on function development with Model Based Design approach

A system with large components diversity

Multi component system overview:





Fuel Cell System (FCS) ECU is our automotive grade ECU which intend to support various interfaces & communication protocols in order to control:

- Hydrogen Circuit
- Air Circuit
- Power circuit
- Cooling circuit

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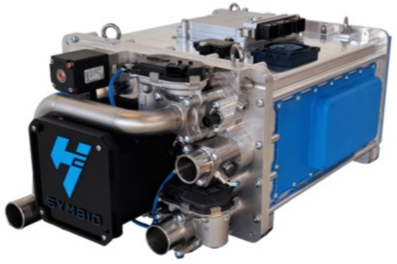
supporting Software development in automotive normative environment

Customer Request → Backlog → SW Architecture → SW Detailed Design → SW Application Testing → SW Integration → SW Calibration → HIL Testing → System Testing



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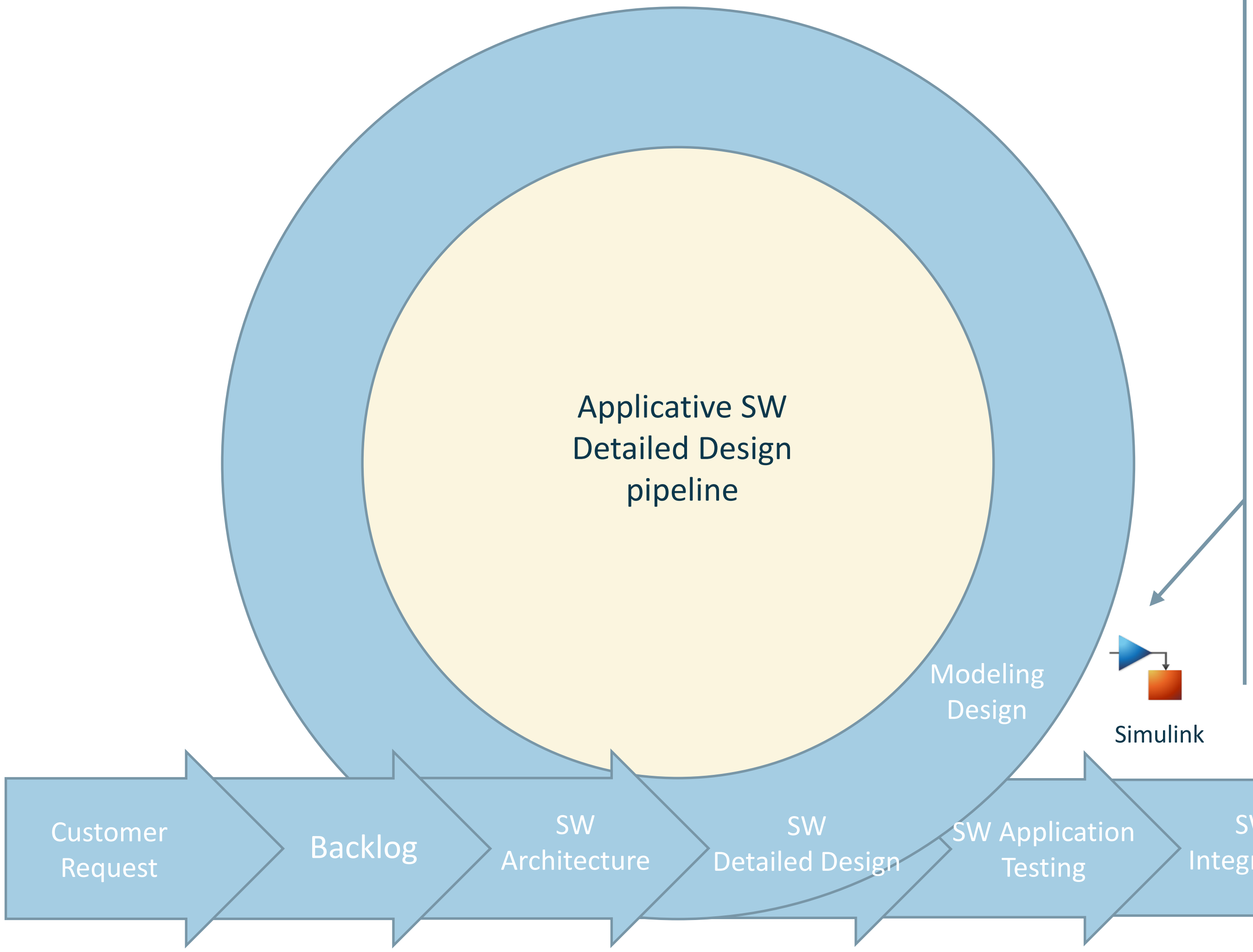
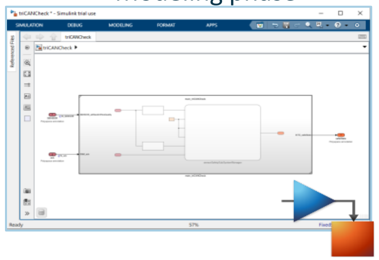


Purpose of functional design phase is to transform textual SW requirement into functional Simulink model

Textual requirements

Modeling phase



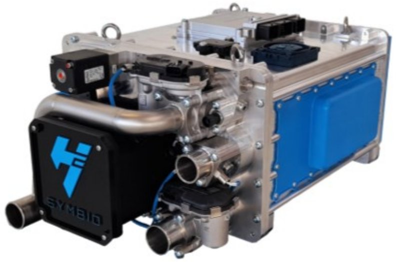
SW Unit

X Nb SW Units

Tips & highlights:

- Use template to uniformize development structure
- Use Simulink project to manage easily component initialization

Model design and its folder structure to welcome development workproducts



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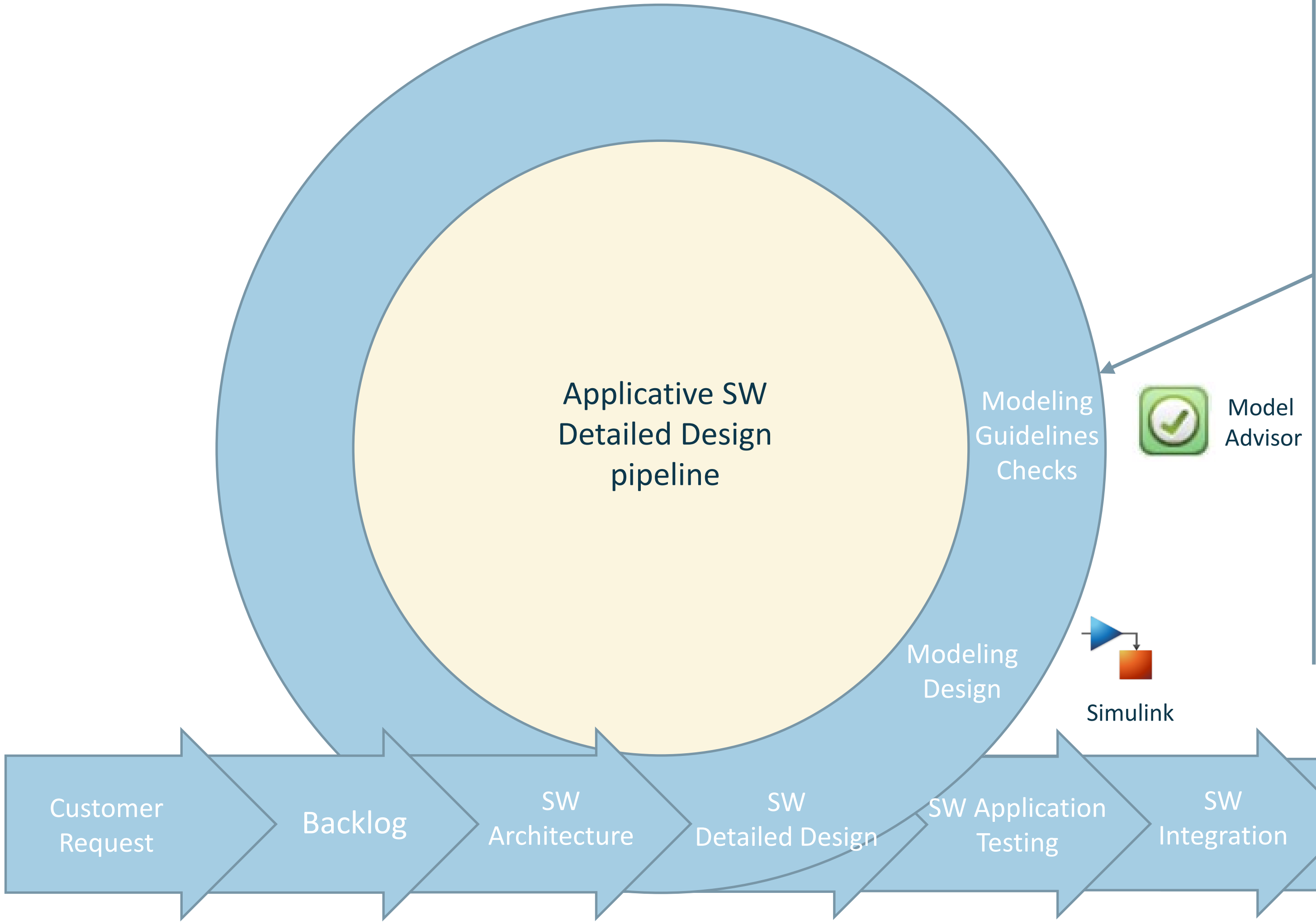
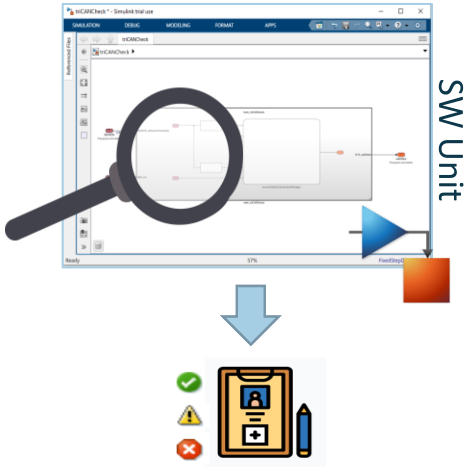


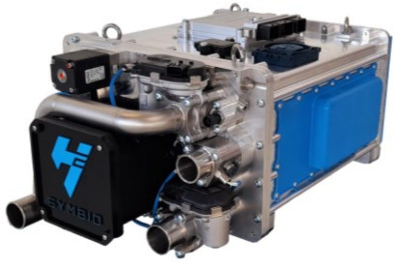
Purpose of modeling design checks phase is to perform static model analysis. It will prepare model to an easier & proper code generation



Tips & highlights:

- Modeling Standards for ISO26262, MAAB, …
- Custom Symbio checks to improve quality, best practice, readability, code customization

Model review report associated to SW Unit



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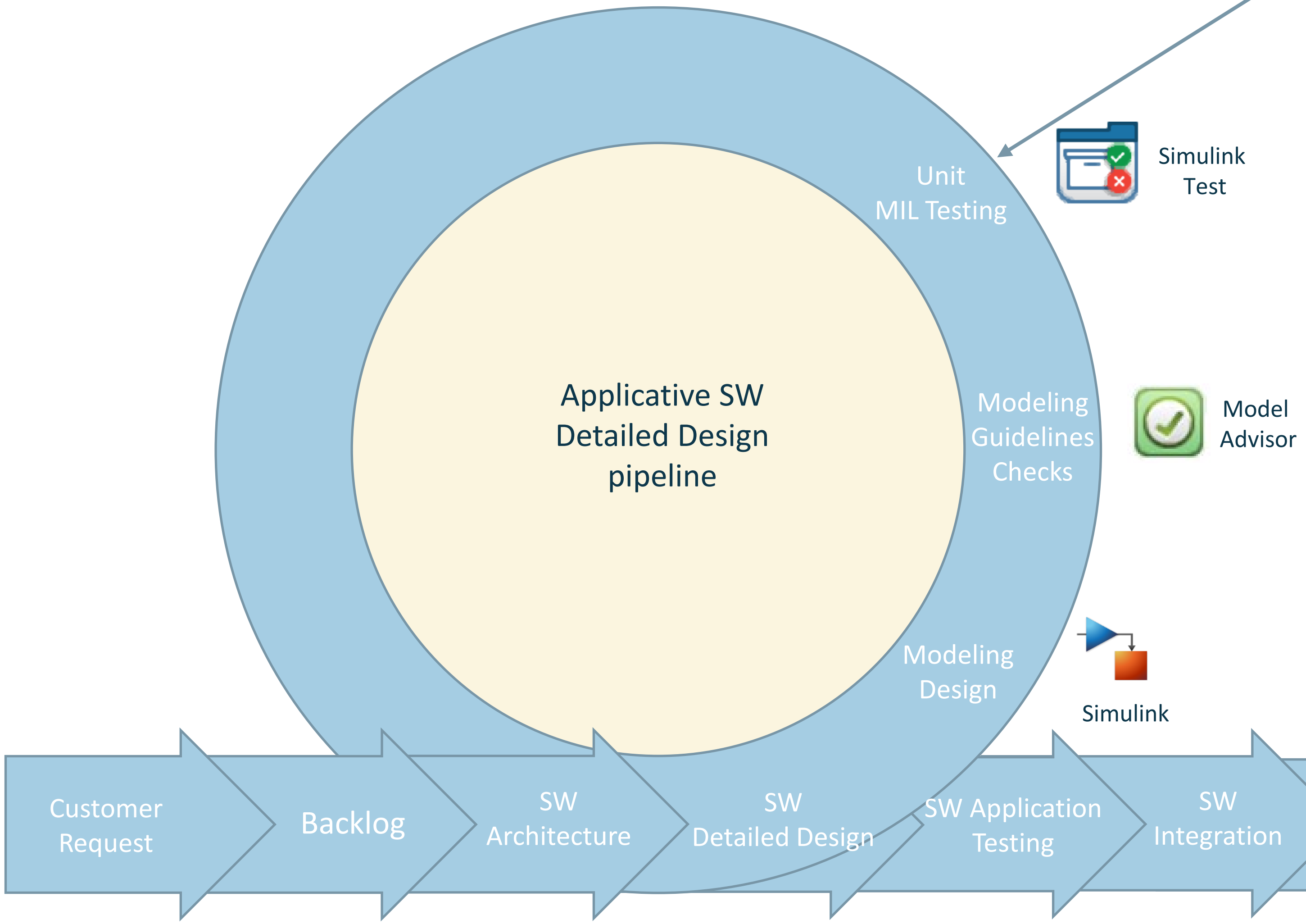
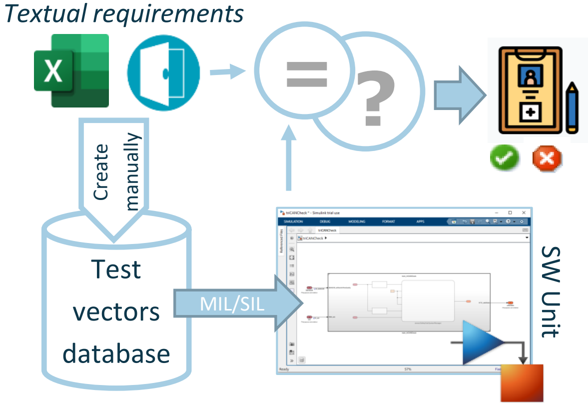


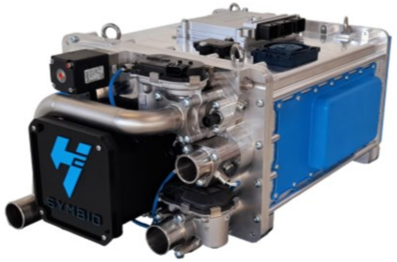
Purpose of unit testing phase is to verify that simulation results are compliant to SW requirements



Tips & highlights:

- Open loop test harnesses creation on SW units
- Simulink test manager to optimize test reuse

SW Unit with functional validation report



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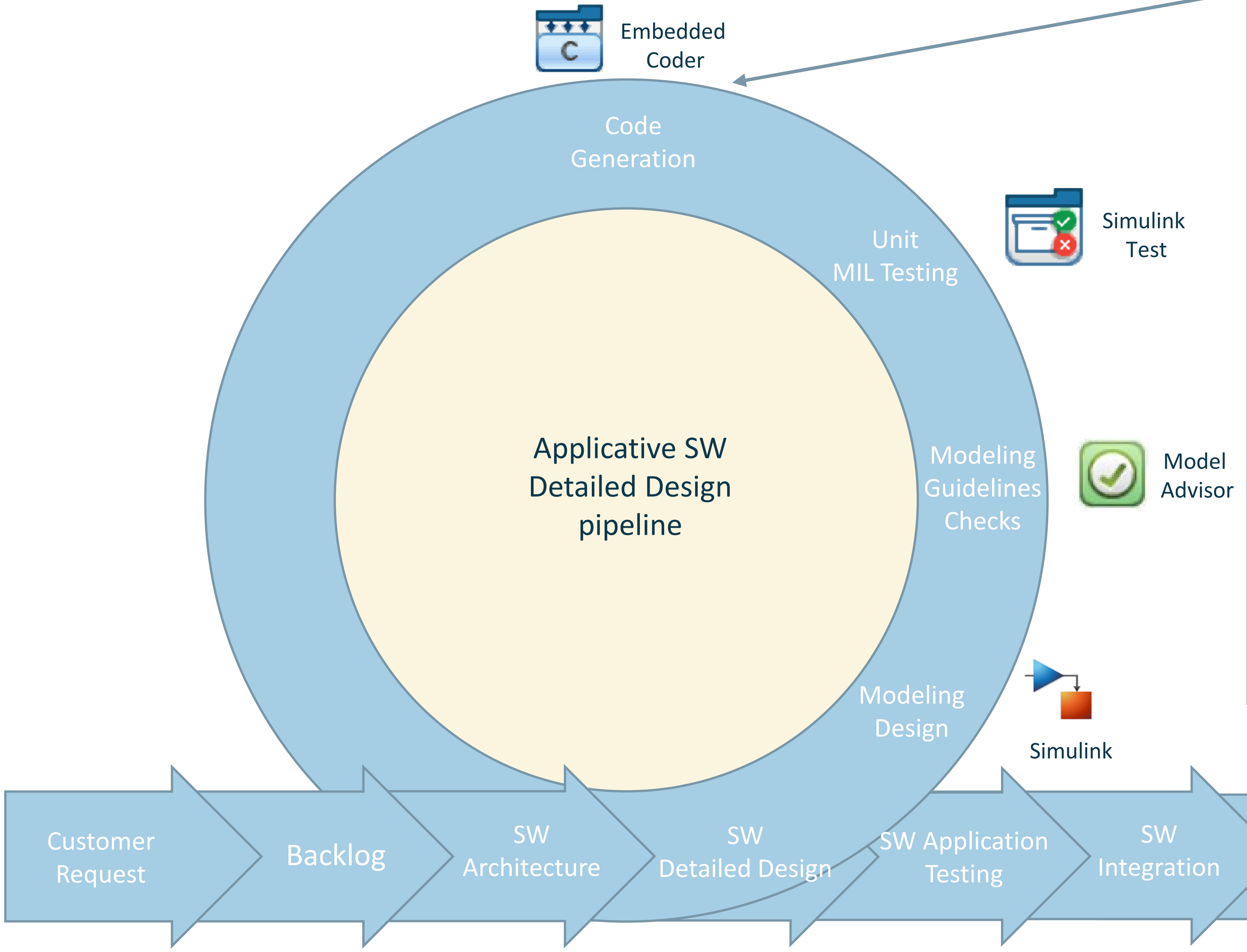
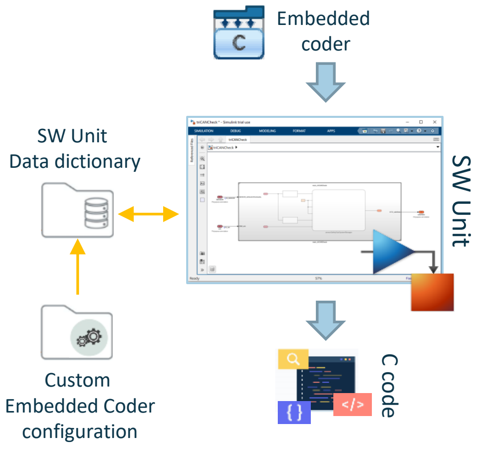


Purpose of code generation phase is to transform functional SW Unit model into C- source code.



Tips & highlights:

- Highly customized code generated (class parameter, TLC files)
- Centralized embedded coder configuration

SW Unit code available and standardized between SW developers' laptops

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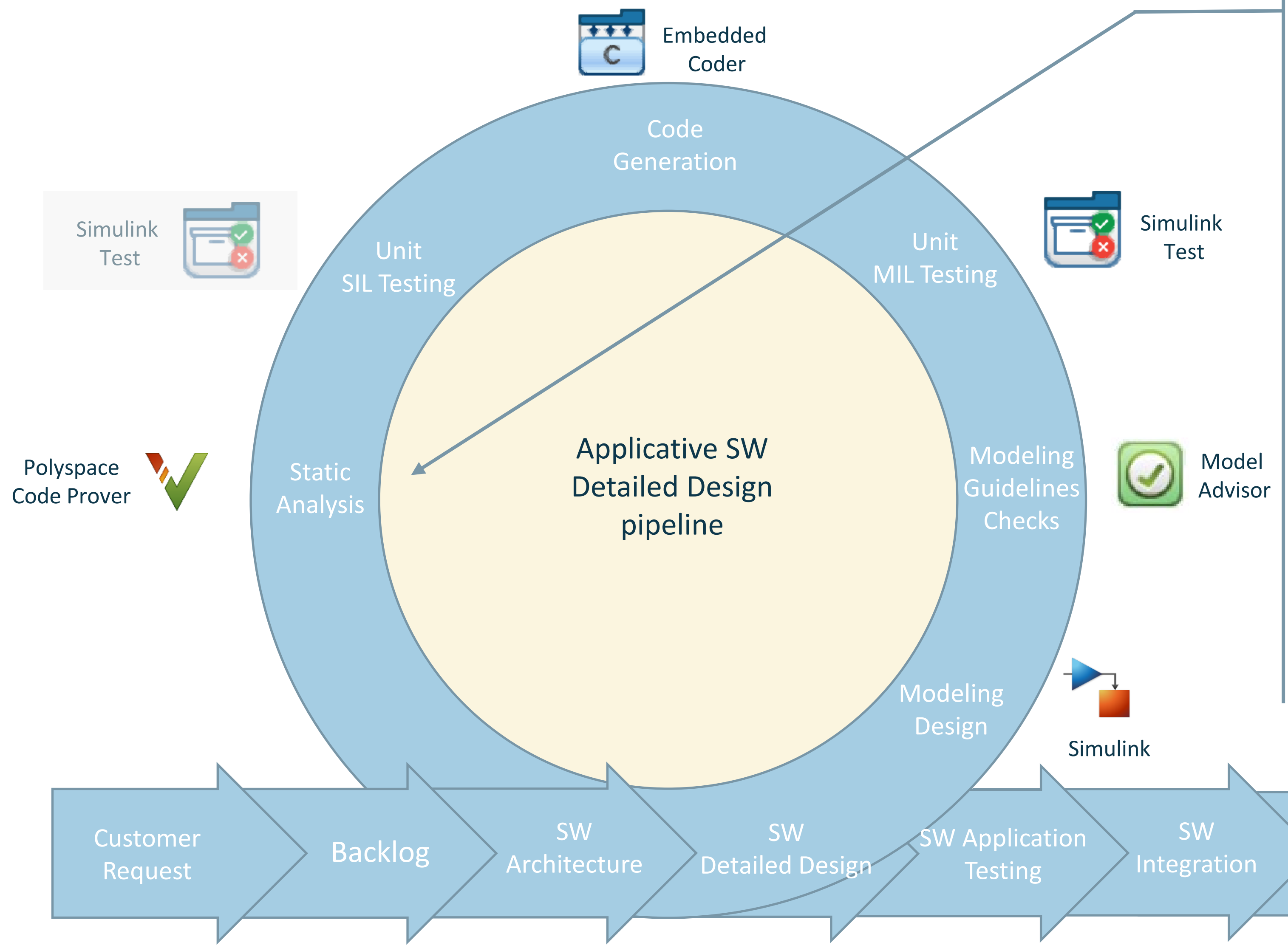
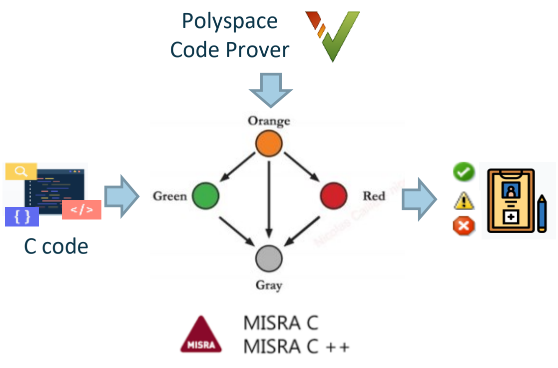


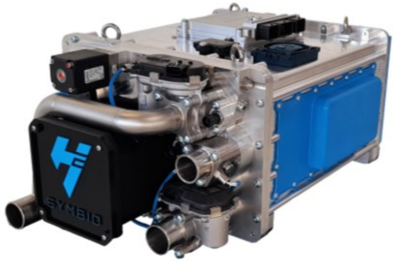
Purpose of static analysis is to proves the absence of run-time errors in generated C source code



Tips & highlights:

- Manage SW unit complexity to make easier orange checks review
- Prepare your auto code generator to match MISRA C-2012 expectations

<u>Static analysis report</u> for MISRA compliancy and runtime error check



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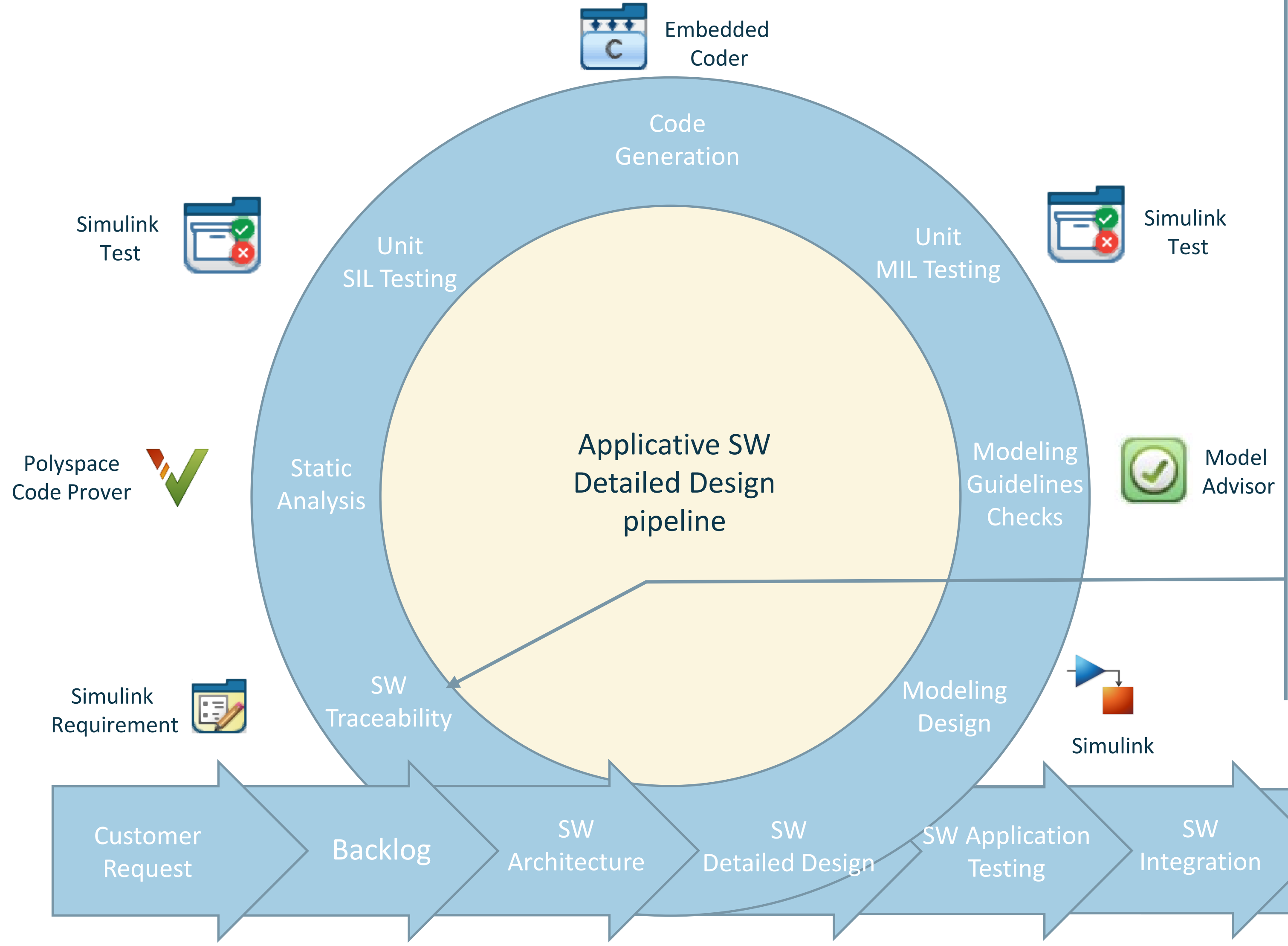
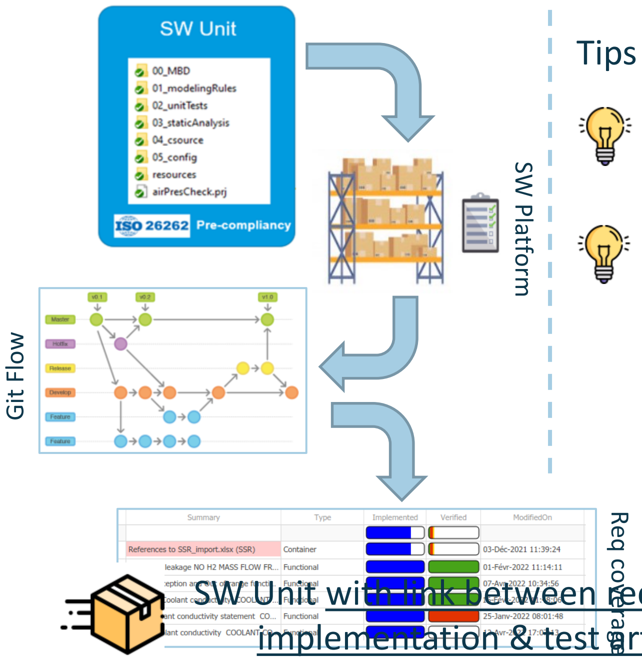
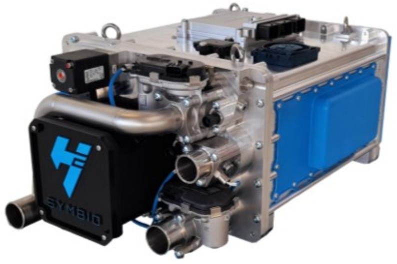


Purpose of SW traceability is to ensure consistency between software requirements, models, generated code and associated test results .



Tips & highlights:

- **Refine requirements** and allocate it to SW units
- Import requirements into Mathworks environment with Simulink requirement



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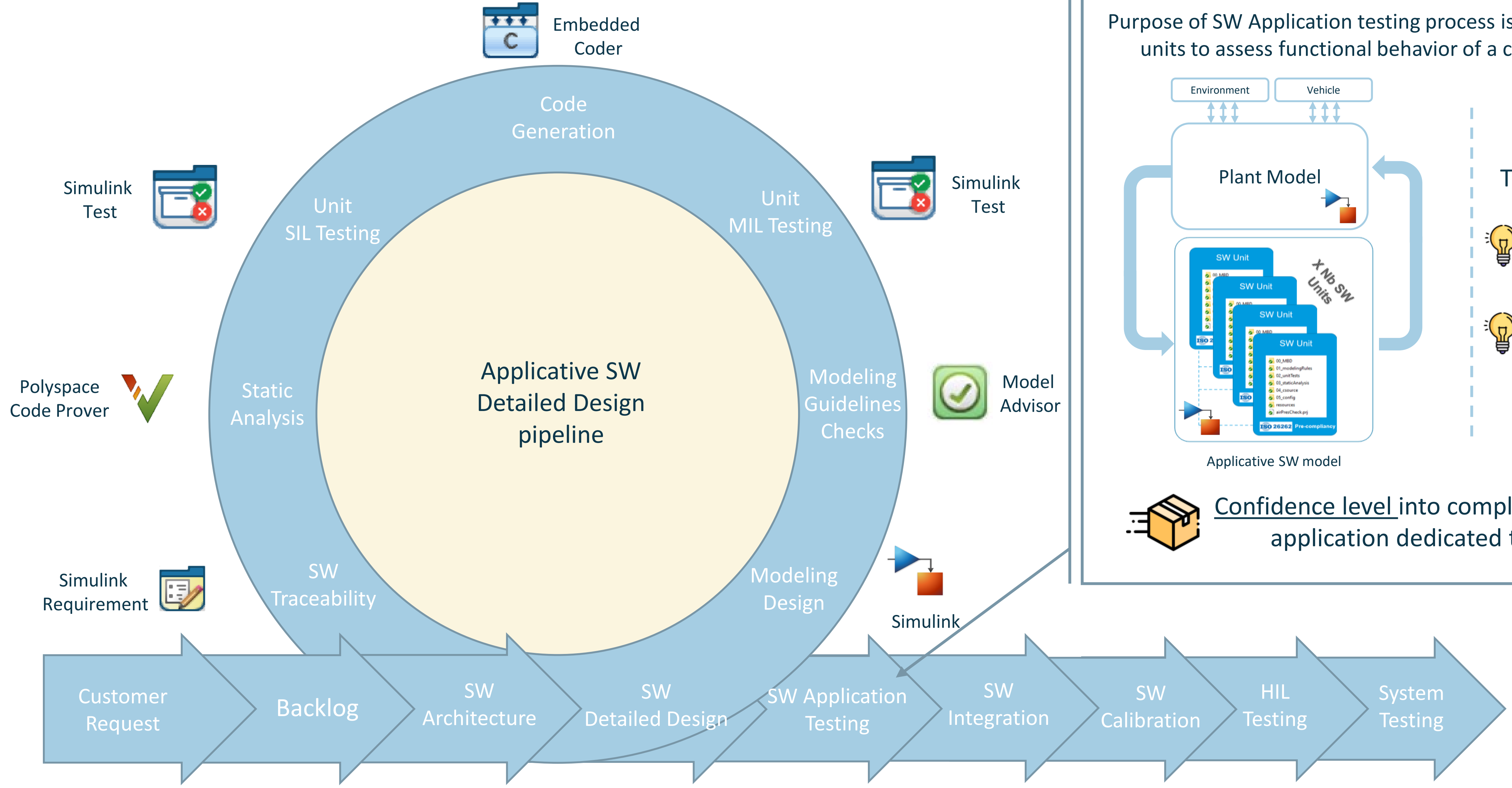


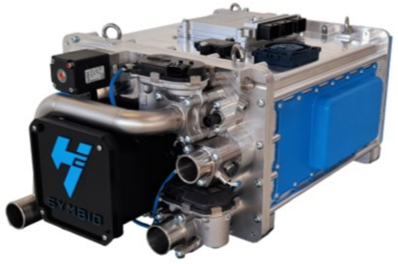
Purpose of SW Application testing process is to bring & link together SW units to assess functional behavior of a complete SW application.

Applicative SW model

Tips & highlights:

- **Generate automatically** SW integration model based on configurations files
- Try to maintain up to date connection between Applicative & Plant model

Confidence level into complete/partial SW application dedicated to project



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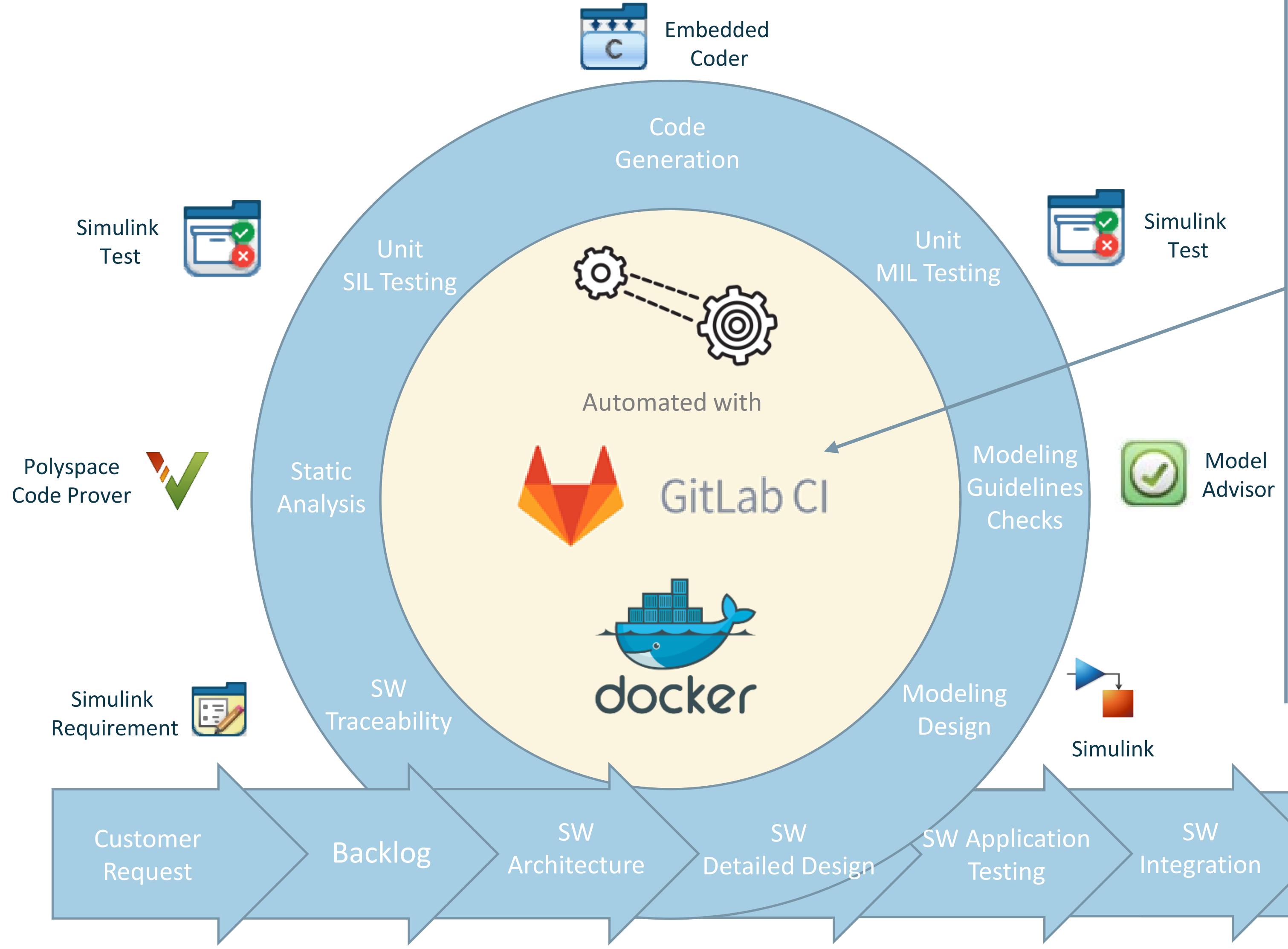
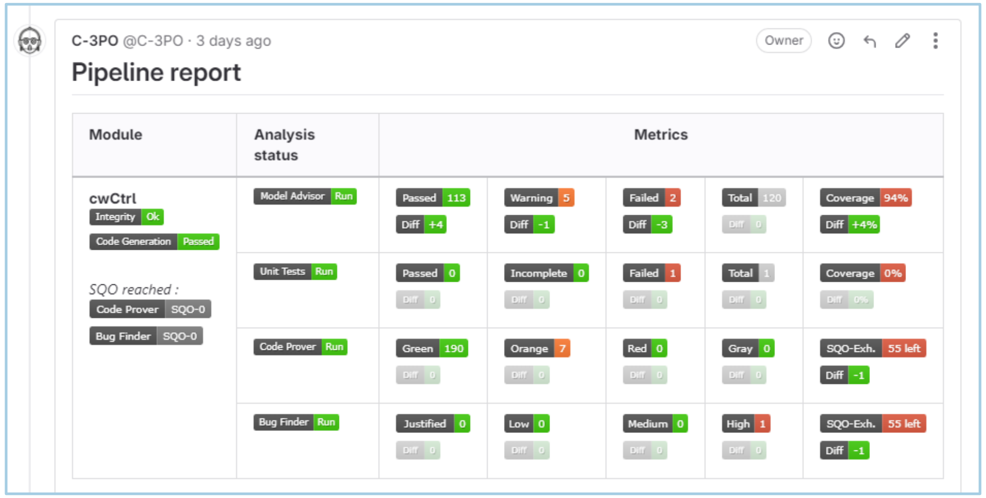


CI system focus model's designers on function development instead of workproducts creation.



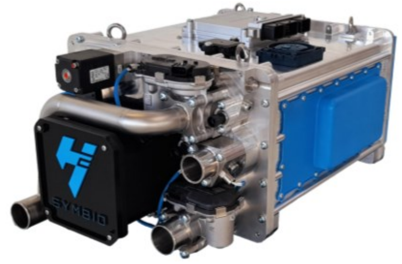
C-3PO @C-3PO · 3 days ago

Pipeline report

Module	Analysis status	Metrics				
cwCtrl Integrity Ok Code Generation Passed *SQO reached :* Code Prover SQO-0 Bug Finder SQO-0	Model Advisor Run	Passed 113 Diff +4	Warning 5 Diff -1	Failed 2 Diff -3	Total 120 Diff 0	Coverage 94% Diff +4%
	Unit Tests Run	Passed 0 Diff 0	Incomplete 0 Diff 0	Failed 1 Diff 0	Total 1 Diff 0	Coverage 0% Diff 0%
	Code Prover Run	Green 190 Diff 0	Orange 7 Diff 0	Red 0 Diff 0	Gray 0 Diff 0	SQO-Exh. 55 left Diff -1
	Bug Finder Run	Justified 0 Diff 0	Low 0 Diff 0	Medium 0 Diff 0	High 1 Diff 0	SQO-Exh. 55 left Diff -1

CI report generated with CI system

With automated & regular feedback along V-cycle activities



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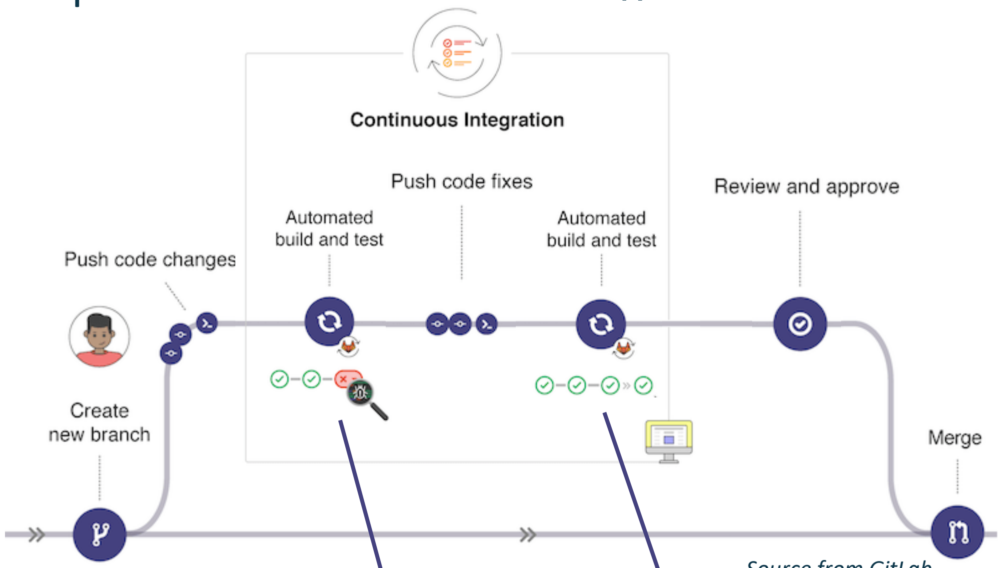
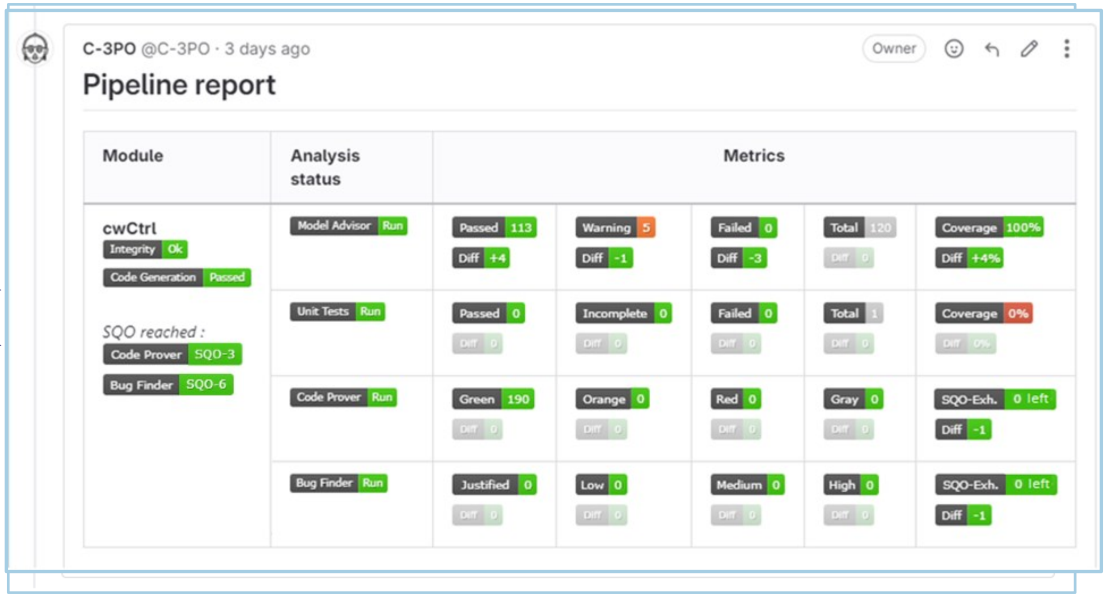
Focus CI system & automation process (1/2)

A partner associated to SW engineers



Source from GitLab

- What could be automatized?
  - **Merge request creation** with SW design metrics included
  - **Model Advisor, Embedded Coder, Simulink test, Polyspace Code Prover**, …
  - All elements seen before (test reports, Modeling guideline review, static analysis report, …) except functional design creation and part of SW traceability



Tips & highlights :

- **Use GitLab CI** to trigger jobs **on impacted components only** when files are pushed on server
- Use **MathWorks docker image**
- Produce **reports** and **upload artifacts**

Focus CI system & automation process (2/2)

A generated quality overview dashboard, providing **global metrics** on the SW platform.

SW Components quality status

Component	Model Advisor	Unit tests	Code gen.	SQO	
				Reached	Objective
airBackPresCheck	Coverage 100%	Coverage 0%	Code Generation Passed	Code Prover SQO-0 Bug Finder SQO-0	SQO-Exh. 14 left SQO-Exh. 23 left
airBackPresGuard	Coverage 100%	Unit Tests Not Run	Code Generation Passed	Code Prover SQO-3 Bug Finder SQO-6	SQO-Exh. 10 left SQO-Exh. 7 left
airBackPresValvCtrl	Coverage 93%	Coverage 100%	Code Generation Passed	Code Prover SQO-0 Bug Finder SQO-0	SQO-Exh. 52 left SQO-Exh. 59 left
airDilutionCheck	Coverage 97%	Coverage 100%	Code Generation Passed	Code Prover SQO-0 Bug Finder SQO-0	SQO-Exh. 69 left SQO-Exh. 78 left

Nightly dashboard overview

- **Daily update** on all metrics
- Automatized **on main branches** for each repo
- Available for all **SW components** and **integrated projects**

Tips & highlights :

- Use GitLab CI to trigger **nightly jobs**
- Use **MathWorks docker image**
- Produce **reports** and **upload artifacts**

4.

Conclusion

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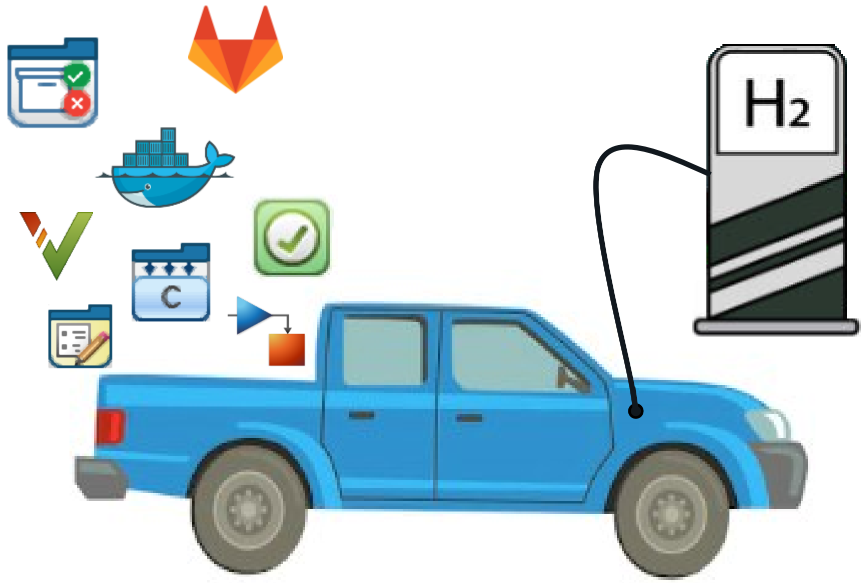
Faster time to market to match with H2 challenges & company roadmap

- Model-Based Design is particularly adapted to design complex systems such as fuel cell system, it allow to:
    - **Reduce need to access real systems** thanks to simulation approach
    - Embedded code is generated automatically from model, which **reduces effort** and **eliminates hand-coding errors**
    - **Stimulate innovation** thanks to possibility to try new ideas

- Model Based Design associated to Continuous Integration system will help to:
    - **Implement incremental workflow**, by testing design, refining, and retesting throughout the development process.
    - **Test and validate continuously** rather than at the end of the process so that many errors are found and corrected before system
    - **Improve system maturity & code quality** by focusing SW developer on function algorithms



And help company to execute a well-defined industrial roadmap

Investing in large state-of-the-art industrial facilities to ensure cost-competitiveness and service OEM's growing volume needs

2018-2020

100-500 systems/year

2021-2023

1 000-2 500 systems/year

Fully automated line

2024-2026

15k-50k systems/year

Scalable manufacturing - Process reaching lower cycle time

Design to manufacturing, optimized with industrial process

2027-2030

50k-200K systems/year

Global production footprint

A leading hydrogen systems ***innovation partner*** *for fuel cell solutions accompanying our customers …*

…to accelerate ***zero-emission transportation world-wide***

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BUILDING
A POSITIVE
FUTURE