FULL VIRTUALIZATION OF RENAULT'S ENGINE MANAGEMENT SOFTWARE APPLICATION TO SYSTEM DEVELOPMENT

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Introduction

Renault has an established engine control SW development framework

- Field of application: Passenger Veh. & Light Duty Veh. with Diesel & Gasoline engines
- Framework is heavily based on Matlab / Simulink and the idea of MBD

Renault EMS architecture SW is composed out of

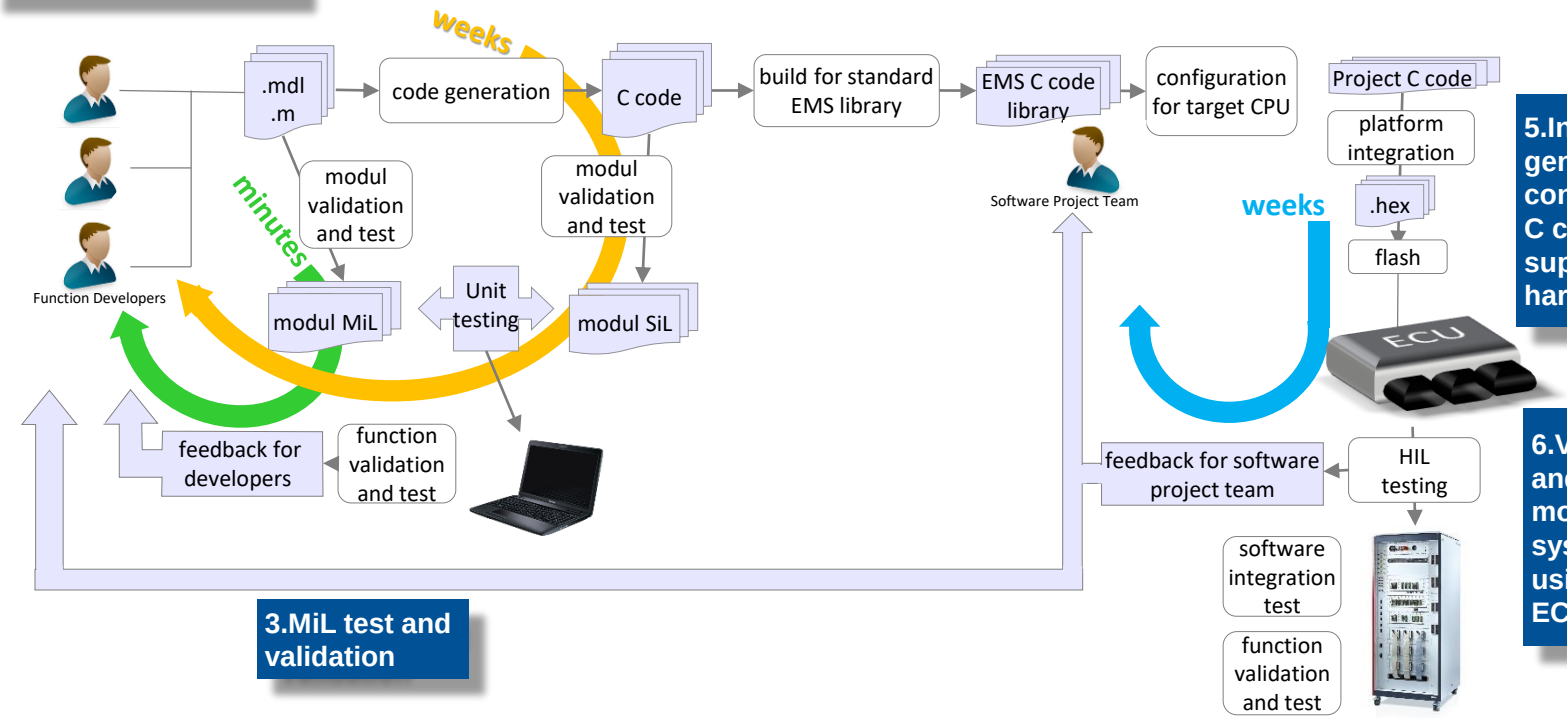
- 20 functions (ex. Air System, Combustion, …)
- A function consists of modules which are the smallest testable SW unit
- A module contains runnuables triggered by the Operating System (OS)

SW development framework at Renault

1.Specification of about 200 generic configurable modules per ECU using MATLAB / Simulink.

2.Generation of C code (EMS application software) from all module specifications

4.Configuration of modules to fit to the specific needs of a software project,.



3.MiL test and validation

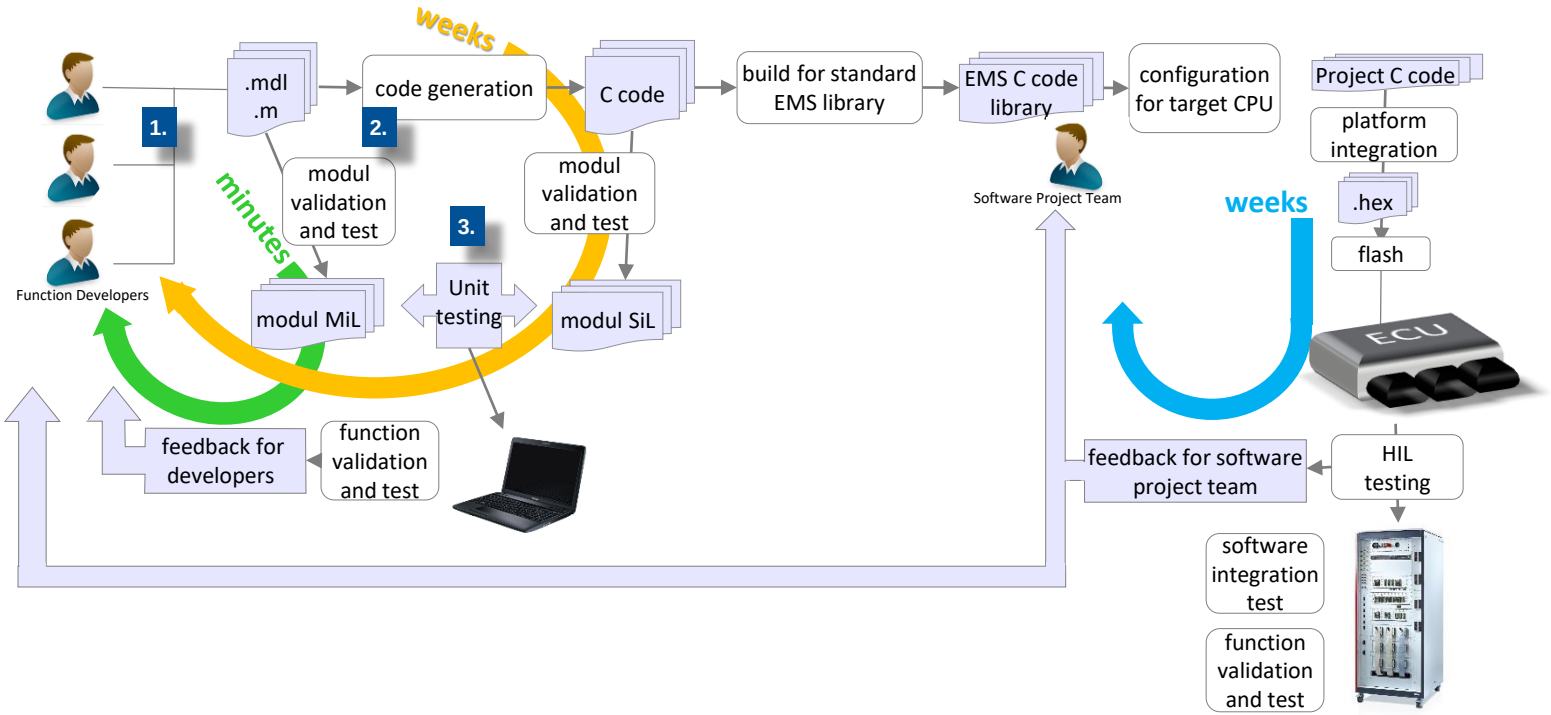
5.Integration of generated configured C code on supplied target hardware,

6.Validation and test of all modules on system level using the real ECU

Assessment of SW development framework

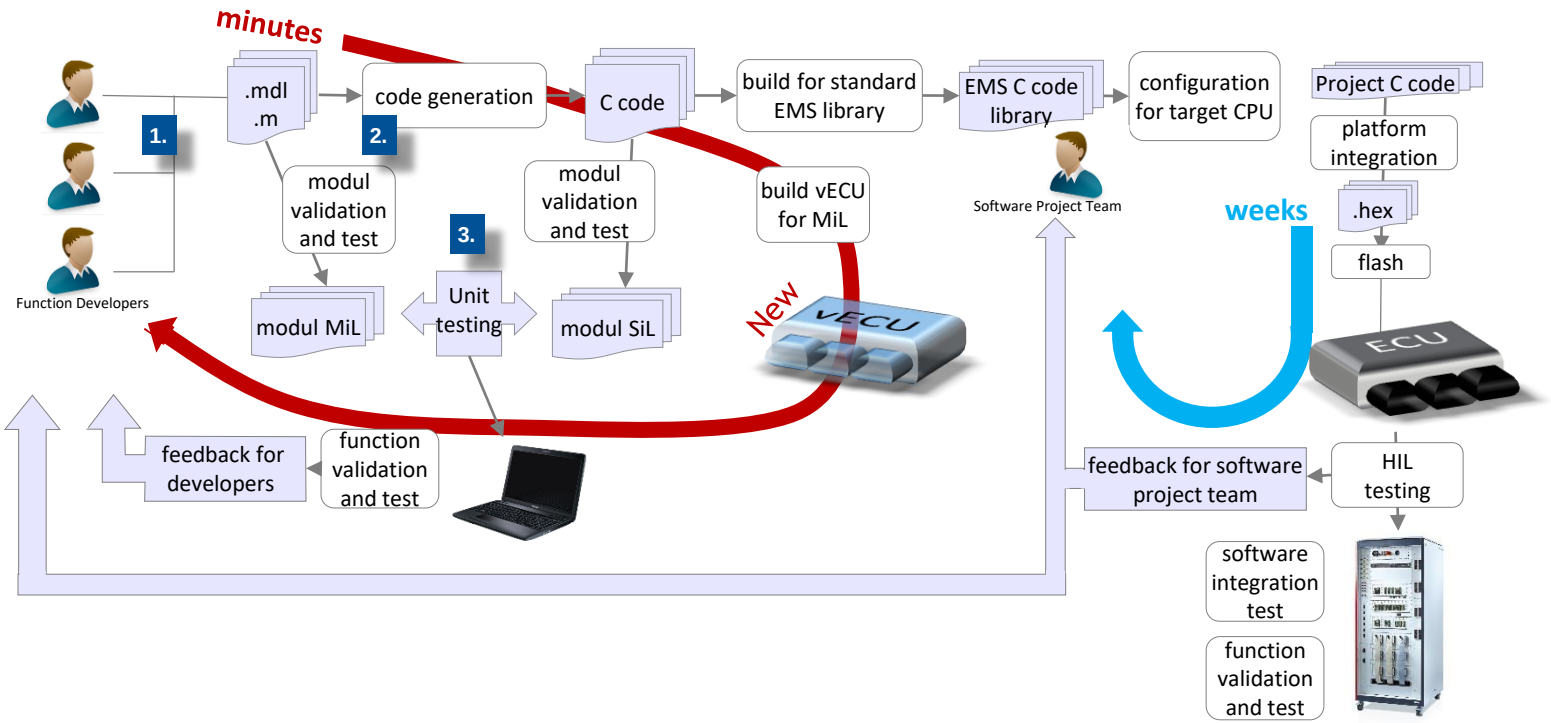
Critical assessment of the development framework

- There is considerable delay between delivery of a set of specs to SW project team and system-level tests based on an ECU that runs entire SW.



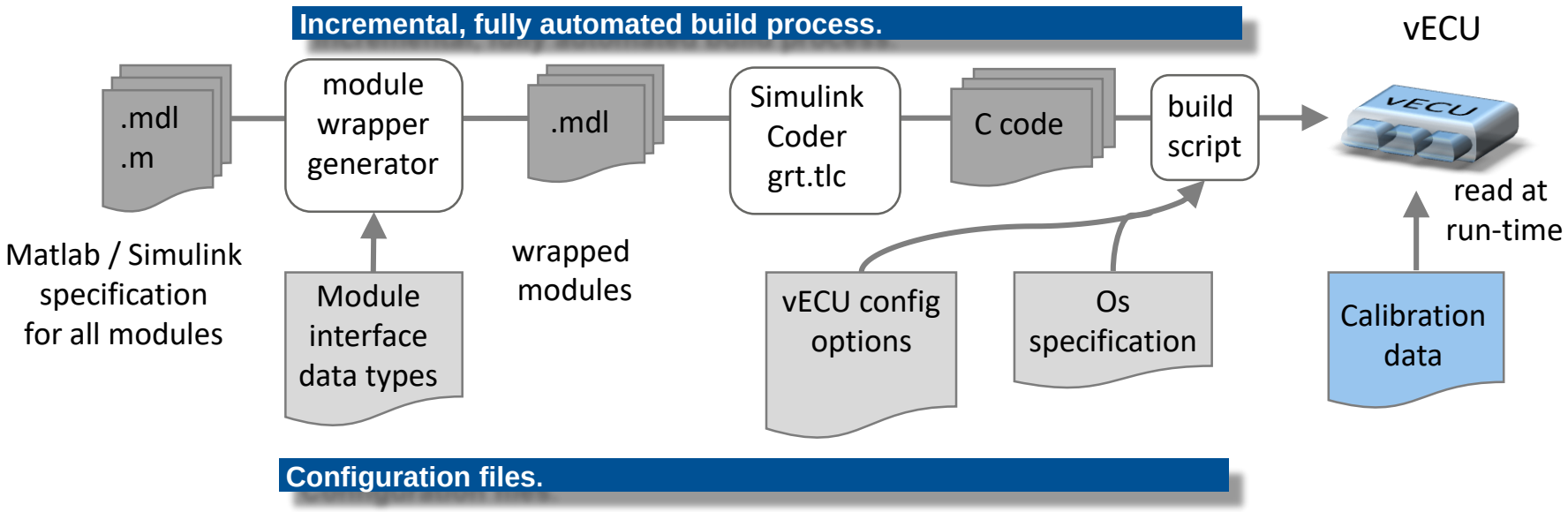
Place of vECU in SW development framework

- System-level test and validation should be performed interleaved with steps 1, 2 and 3 replacing the actual MiL, SiL validation process by a full ECU validation



vECU Build Process

Inputs
- Consistent set of modules
- Dictionary with data types of all variables
- Os specification.



Differences between real and virtual ECU

A vECU remains a model : not all tests that are relevant can be moved to the PC

- ***Zero-time execution*:** vECU behaves like a device with unlimited computing speed
- ***Missing basic software:*** basic software of the ECU platform is not part of the vECU
- ***Different production code*:** C code is close to but not fully equivalent to production code

► **Many of these differences can be avoided switching to a virtual processor type vECU**

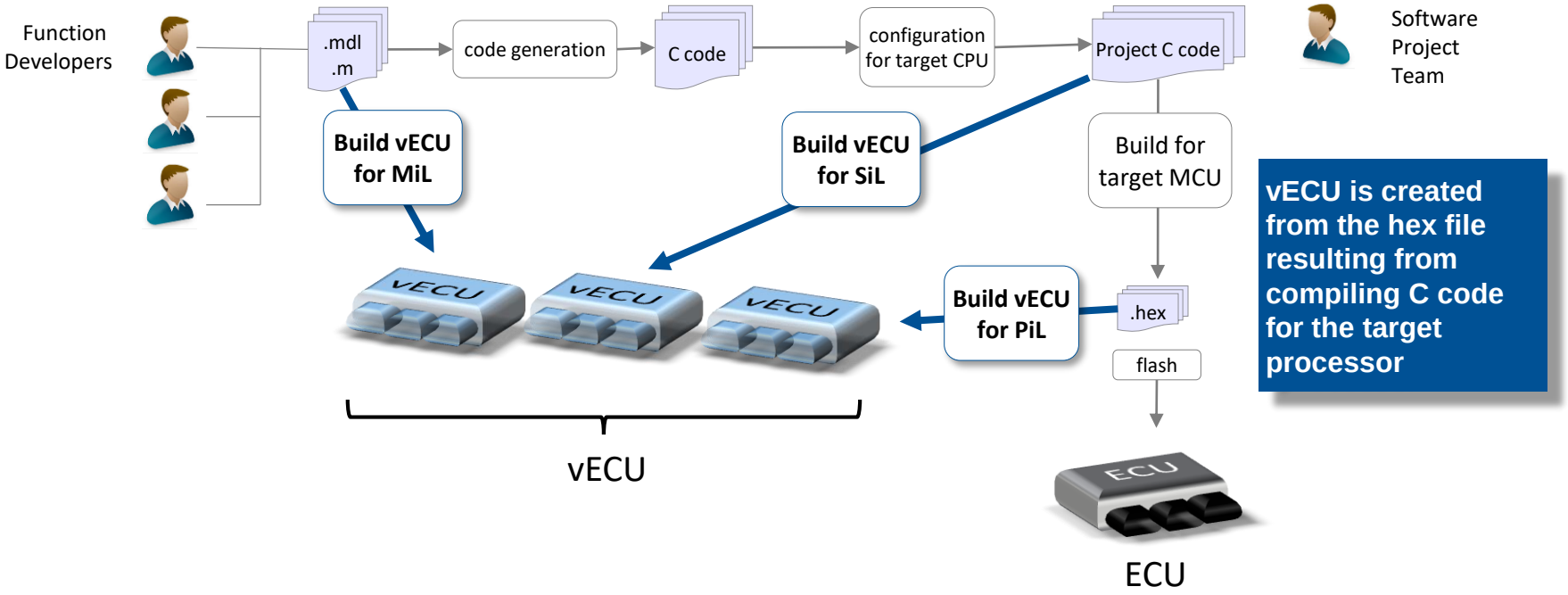
Runtime performance

- A virtual ECU for a typical Renault EMS loads & initializes in less than 5 sec. on a Windows PC
- Execution speed depends on the number of outputs to be recorded during simulation
  - Recording170 variables / ms, execution of the vECU is 4 times faster than real time.
  - Recoding 20.000 variables / ms, execution speed is 3 times slower than real time

3 options to create a vECU

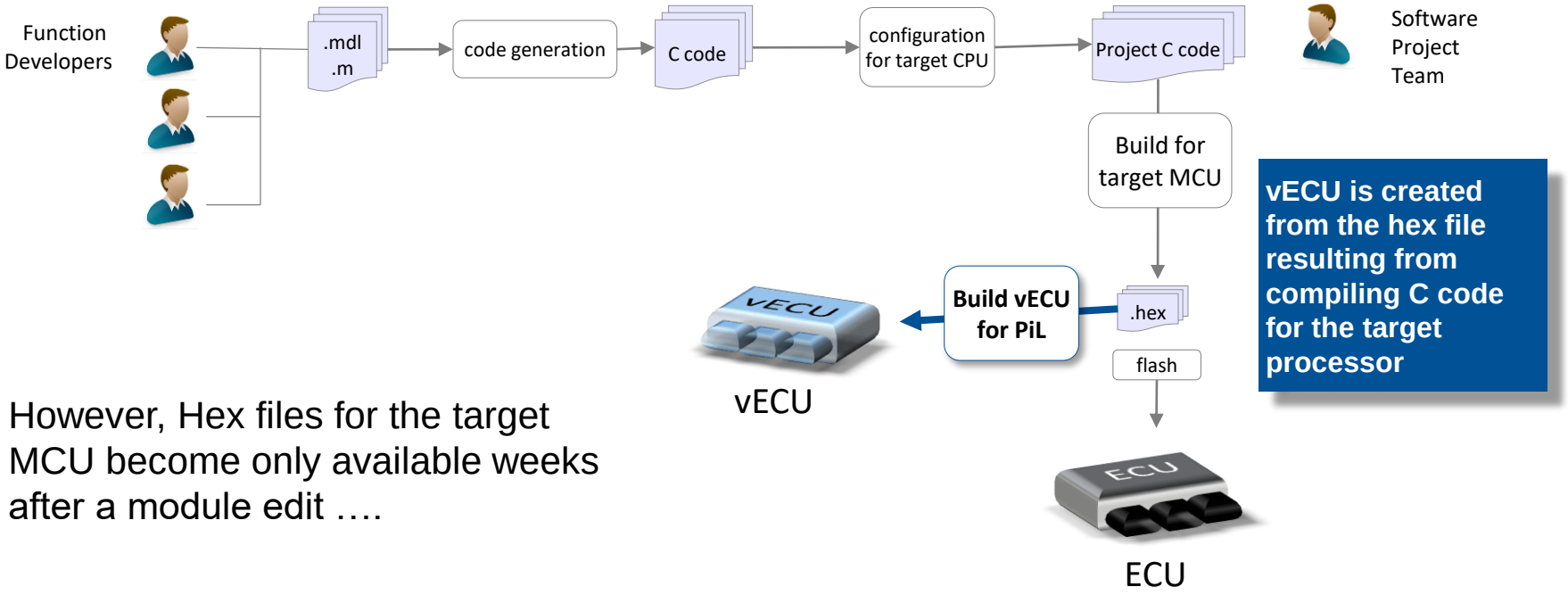
vECU is created from models that generate the C code

vECU is created from C code compiled for PC



Chip Simulaton

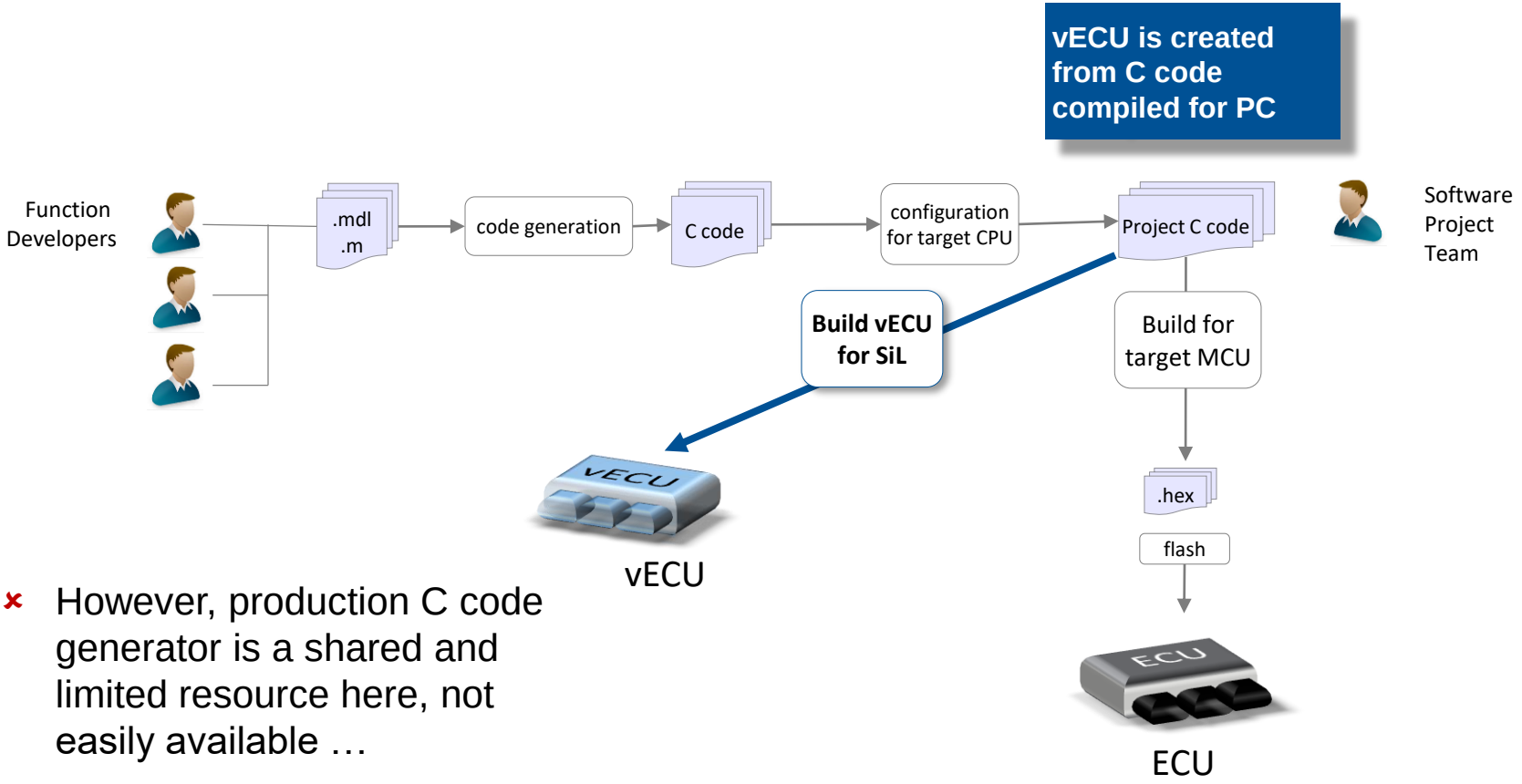
- Suppliers of ECU hardware and MCUs: to validate their ECU and chip designs (need of cycle accurate platform simulator)
- OEMs that need to integrate and calibrate supplied EMS software: to run EMS SW on PC when there is access to the hex files, but no access to the C code



- However, Hex files for the target MCU become only available weeks after a module edit ….

SiL type vECU

- Compared to chip simulation, vECU for SiL runs typically faster and provides better support for C level debugging, if compiled with debug option

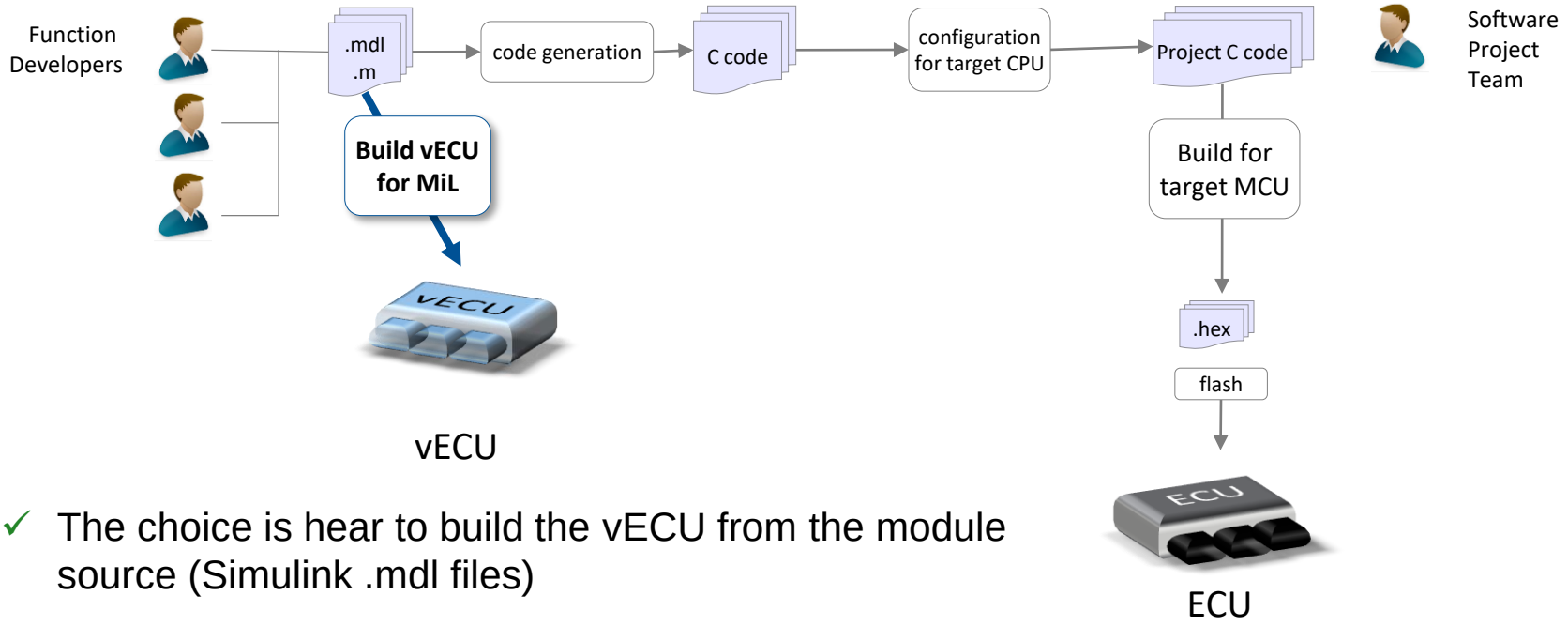


- However, production C code generator is a shared and limited resource here, not easily available …

MiL type vECU

- In the automotive world today dominates MBD on PC with MATLAB/Simulink
- But this does not mean that developers are typically able to simulate their ECU on PC

vECU is created from models that generate the C code



✓ The choice is hear to build the vECU from the module source (Simulink .mdl files)

vECU Applications

- **Definition of system requirements**
  Completion of environmental model by EMS
- **Module development in system context**
  Bypassing / replacing implementation of module in vECU
- **Pre calibration of the EMS ; frontload calibration related activities**
- **Virtual integration of modules before production C code is generated**

- **Move selected tests from HiL to MiL**
- **Vehicle-level simulation**
  Completion of Digital Electronic Integration PlatForm
  Validate networked ECUs in vehicle context

Move selected tests from HiL to MiL

Same plant model
- Engine
- Vehicle
- Gearbox
- Driver Model

Same tests

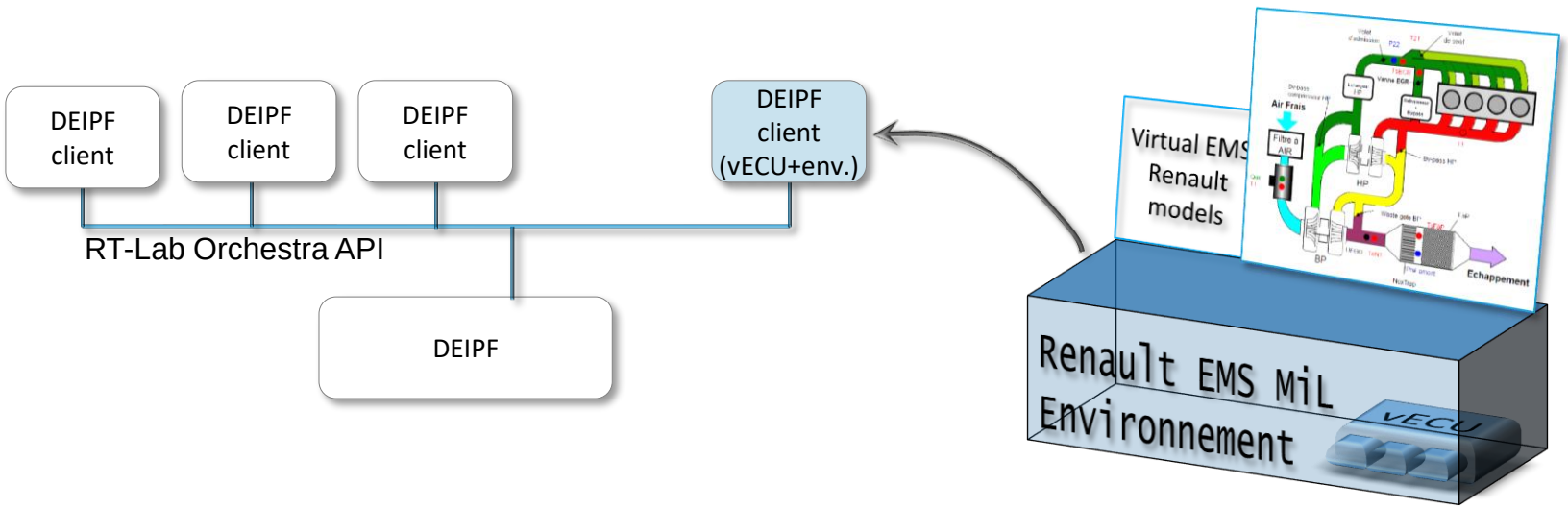
What can be moved?
- Applicative SoftWare validation tests

What has to stay on HIL?
- Task scheduling tests of function that combine ASW and BSW runnables
- Task distribution between cores

Advantages

- ✓ Frontloading of automatic tests of applicative functions
- ✓ 1st Software tests can be done 6 weeks early
  - Faster feedback to function designers
  - More time to correct errors
- ✓ Cost of a vECU is significantly lower compared to cost of a HIL

Vehicle-level simulation : Digital Electronic Integration PlatForm



- ✓ Check of flow coherency between all vehicles ECUs right after model design
- ✓ Intersystem Functional Validation including all vehicle ECUs
- ✓ Issues detection before physical Vehicle Integration Platform tests
  - Increased time on error corrections
  - Lower Cost

vECU Applications

- Definition of system requirements ; completion of environmental model by EMS
- Module dev. in system context ; bypassing / replacing implementation of module in vECU
- Pre calibration of the EMS ; frontload calibration related activities
- Virtual integration of modules before production C code is generated

- Move selected tests from HiL to MiL
- Vehicle-level simulation ; completion of a Digital Electronic Integration PlatForm (D-EIPF) to validate networked ECUs in vehicle context

IV. Conclusions

- In 2016, Renault created the 1st fully functional virtual EMS
- Process has been repeated for about 6 releases (updates and different platforms) of the EMS software since then

- Renault started to use virtual ECUs to frontload test and calibration related activities
- First results of these activities have been encouraging so far

- Existing MiL-based virtual ECUs will be complemented by SiL-based virtual ECUs

Thank you

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