



# Rapid Software Development for GTM Applications

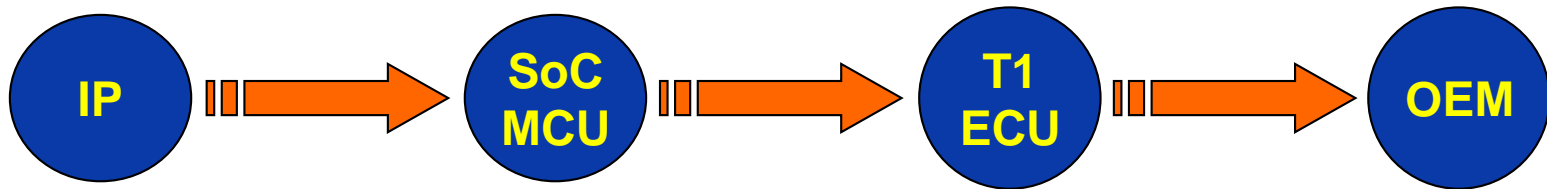
A software view on virtual prototyping



GTM TechDay, Livonia, MI, October 10, 2017



# Products and Services for the Automotive Value Chain



Embedded Software  
Services and Products

Virtual Prototyping  
Services and Products

VLAB Virtual Platform Creation and Simulation Technology and Tools

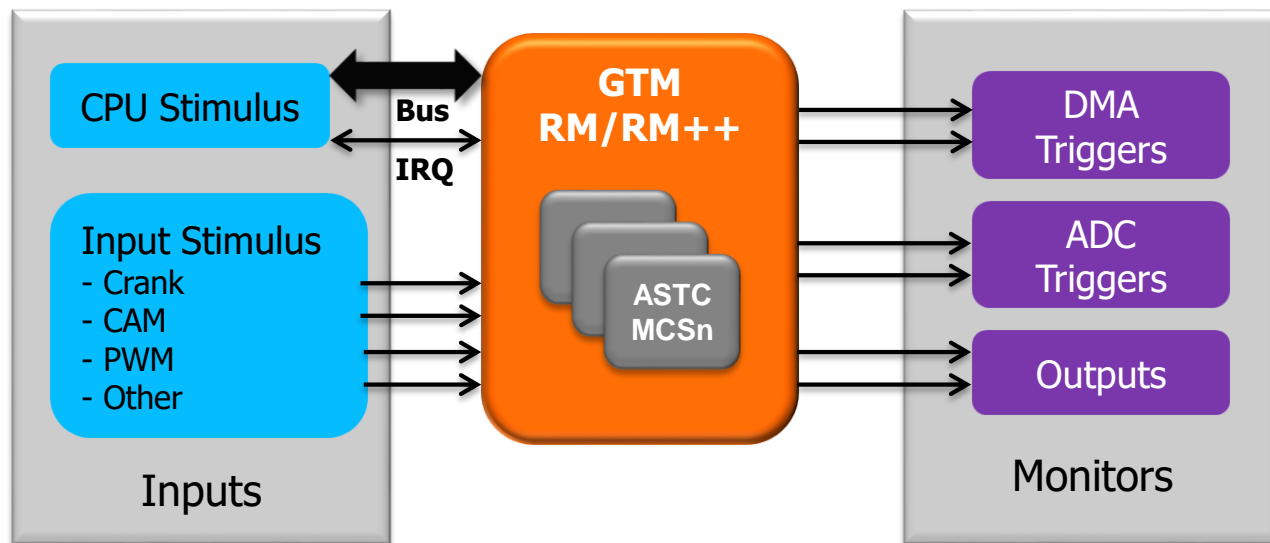
Virtualization Based Design – All-in-Software  
*Remove dependencies on hardware*  
*Virtual Platforms are created to serve the Design and Verification Process*



# Enhanced GTM Reference Model

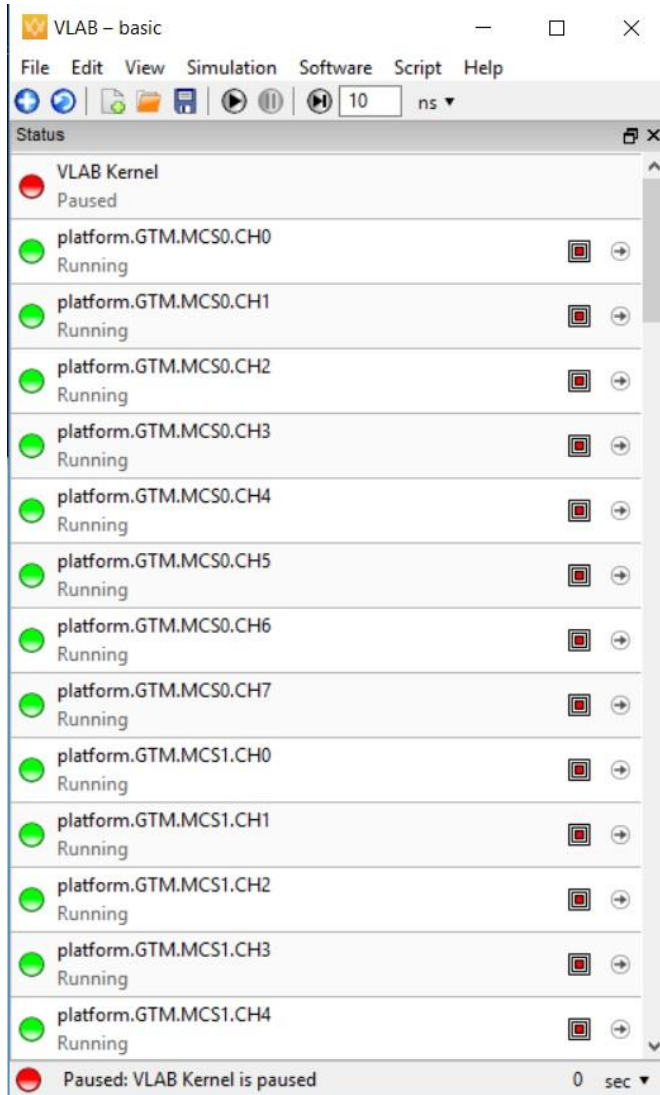


- When we were using the Bosch GTM Reference Model for our software development projects, we found ourselves limited in terms of visibility and debuggability of the MCS cores
- Hence – in partnership with Bosch – we created an enhanced GTM Reference Model with advanced instrumentation, tracing, watchpoint, breakpoint and software stepping support

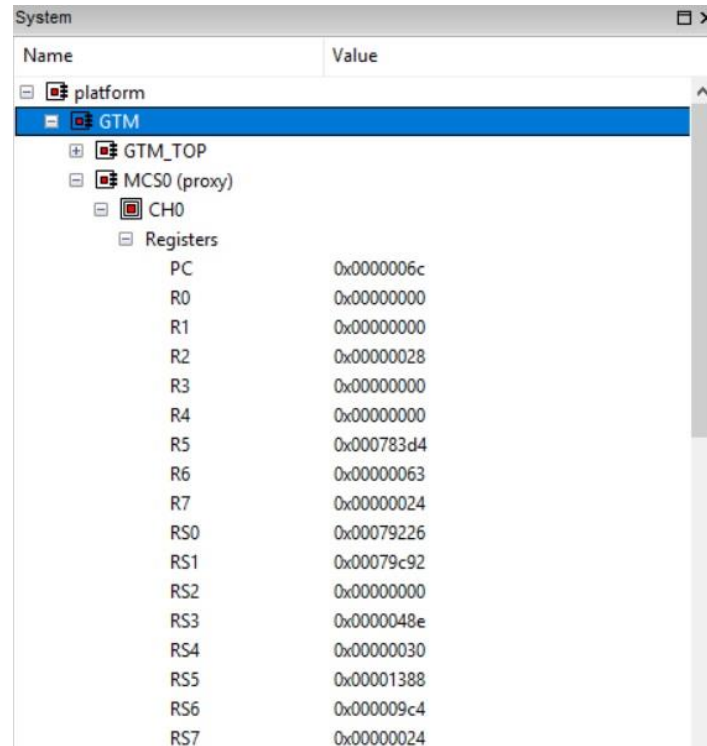




# Enhanced GTM Reference Model



- Provides visibility and debug access to each channel, each MCS
- Register tracing to VTF or VCD (including internal register modifications)



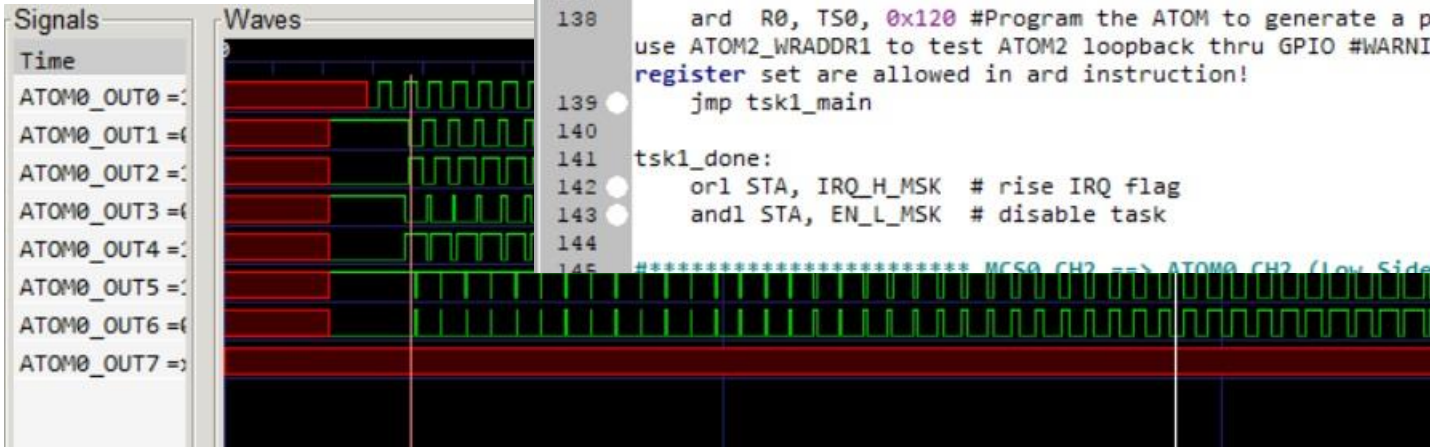


# Enhanced GTM Reference Model



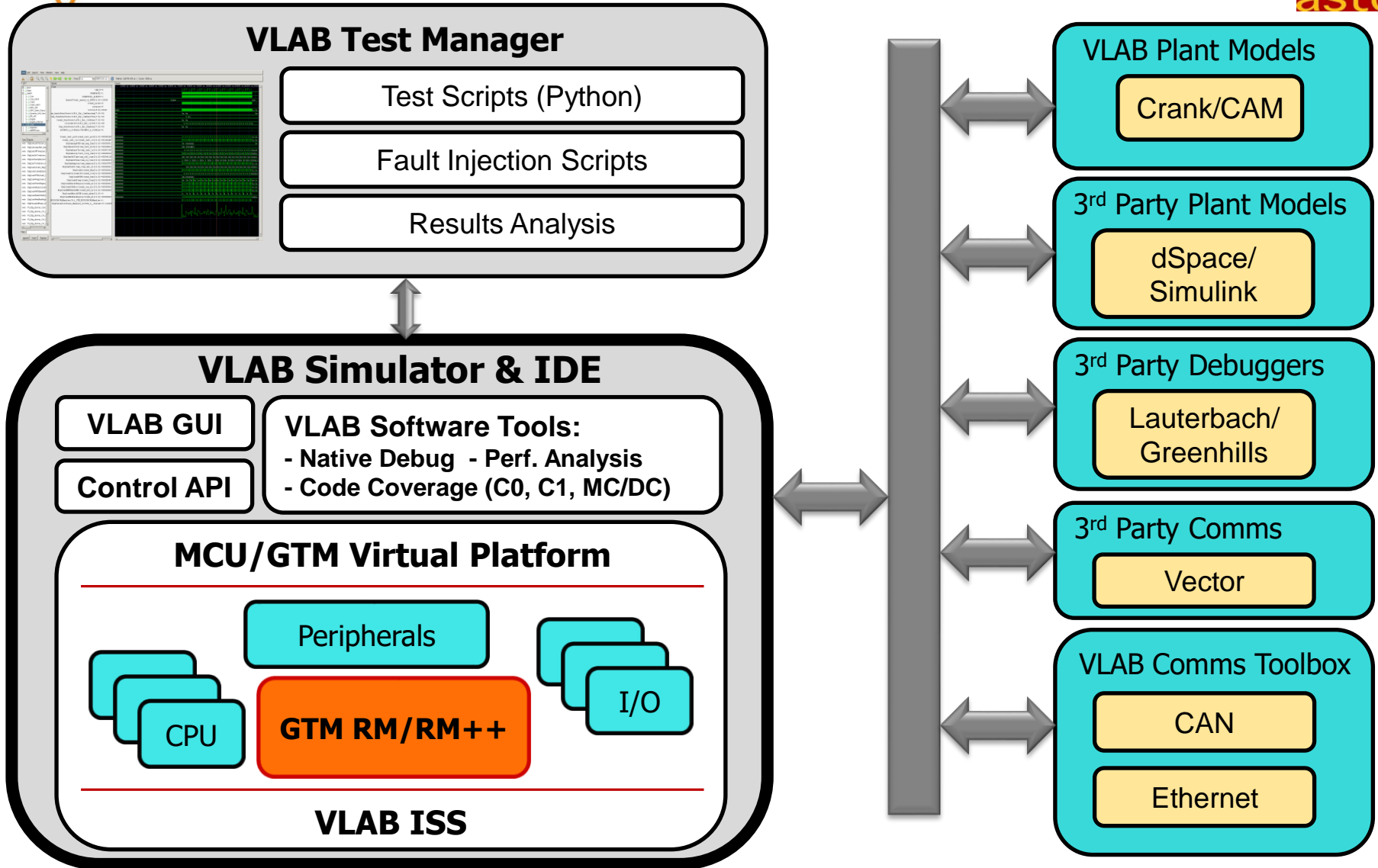
- Instructions **breakpoint** and **stepping** for each MCS core (at Source and Instruction level)
- Full software **source-level debug** for GTM/MCS code
- Tracing, breakpoints, watchpoints on GTM MCS code, registers, buses (ARU/AEI), channels and IO

```
Editor
Disassembly mcs0.mcs x
CH0
128
129 ● add R0, R6 #TS + start_point_A
130 ● mov R1, R0
131 ● add R1, R5 #TS + start_point_A+pwm_period
132
133 ● add R0, R3
134 ● sub R1, R3
135 ● #[TS + start_point_A+current_duty_phaseA/2, TS +
start_point_A+pwm_period+current_duty_phaseA/2]
136 ○ awr R0, R1, 0x1 #SR0 <==R0, SR1 <==R1
137
138 ● arw R0, TS0, 0x120 #Program the ATOM to generate a pulse between [R0,R1] !!!
use ATOM2_WRADDR1 to test ATOM2 loopback thru GPIO #WARNING: Only registers of ARU
register set are allowed in arw instruction!
139 ● jmp tsk1_main
140
141 tsk1_done:
142 ● orl STA, IRQ_H_MSK # rise IRQ flag
143 ● andl STA, EN_L_MSK # disable task
144
145 ***** MCS0_CH2 ==> ATOM0_CH2 (Low Side)
```





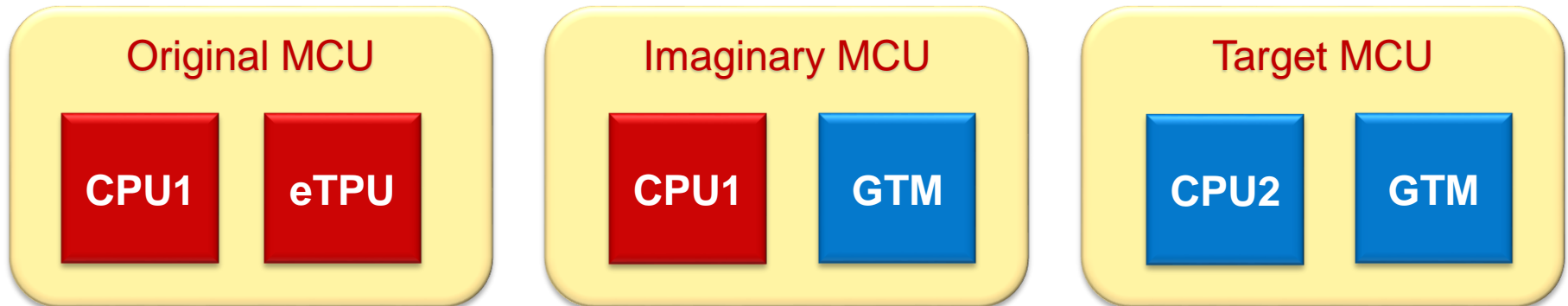
# VLAB Virtual Platforms





# Intermediate Architecture

- Virtual platforms don't necessarily have to represent a 'real' artefact, but can also provide an 'imaginary' stepping stone
- An example of such use is in a software migration project where an intermediate step serves to focus on the timer software first before adjusting the host CPU implementation

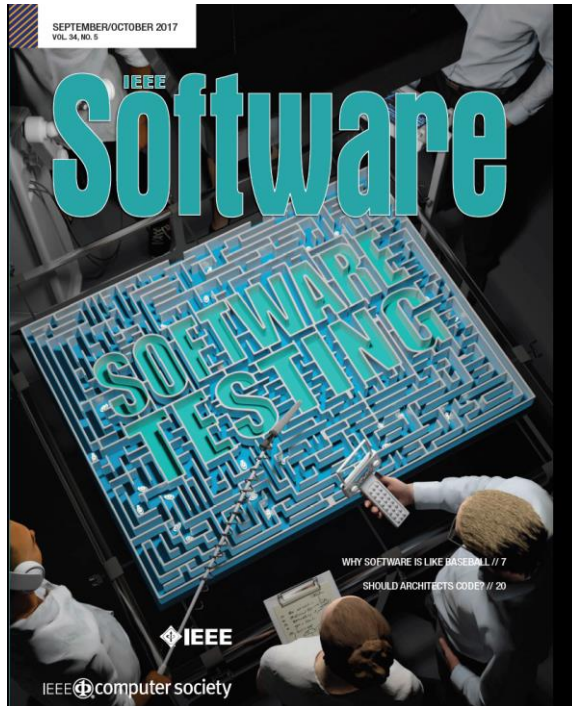






# From Virtual Prototyping to Continuous Integration

- Once your software engineers have and use a virtual prototype they are likely to embrace Continuous Integration
  - Use licenses overnight for regression
  - Set up dedicated Jenkins server

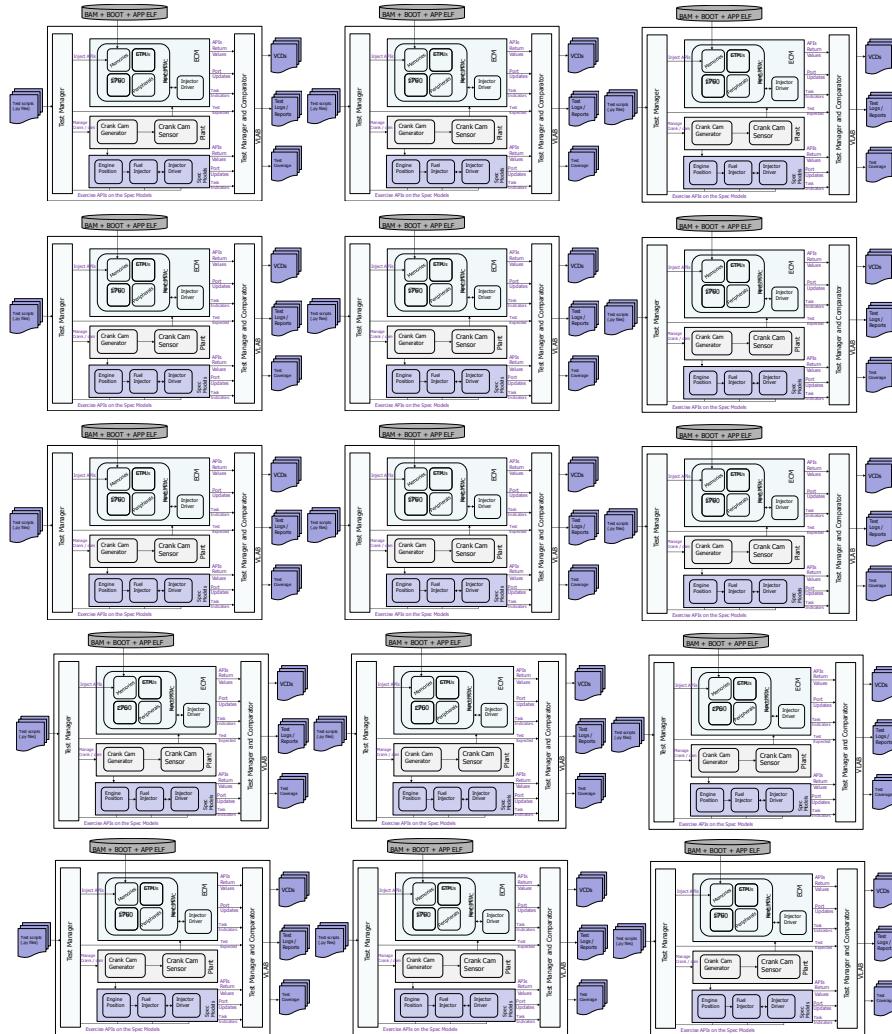


- *This requires the development of infrastructure to support continuous integration (CI) and the continuous delivery of automotive systems.*
- *To integrate as often and early as possible, practitioners should invest in virtualized integration platforms.*
- *This makes CI possible during the development process and minimizes dependency on other parts of the system.*





# Parallel Automated Test Regressions



- 24 – 256 CPU Farm,
- Running many simulations in parallel
- Large test suites executed in parallel at a fraction of time
- VP test suite execution is faster than on HW





# From Continuous Integration to All-in-Software



- Once Continuous Integration is there, engineers may embrace the concept of development without hardware
  - Bring more in software, earlier and later in the process
  - Specification models to develop tests early
  - Hardware models to circumvent shortage and dependencies
  - Connections to hardware later to capture behavior and compare
- We call this *Virtualization Based Development* or *All-in-Software*

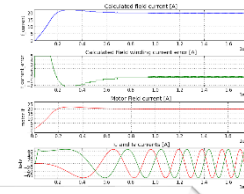
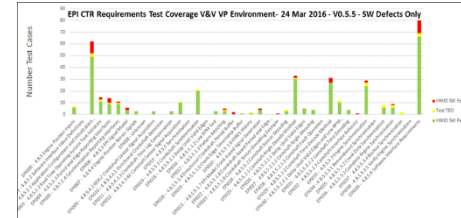
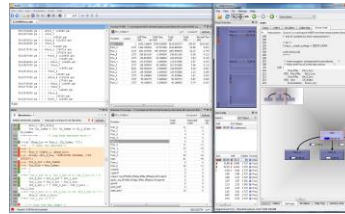
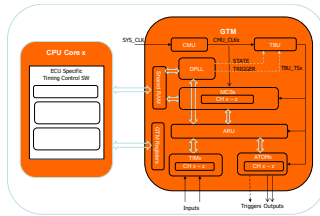
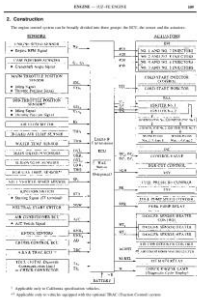
Concurrent SW, HW, and TW (Testware) Development, Validation, and Optimization  
Continuous Build, Integration and Test with Rapid Iterations and Progress

***Embedded Made Agile***





# Virtualization-Based Development All-in-Software



Definition / Specification

Architecture / Design

Implementation (Code/Test)

Validation

Optimization

Executable Specs

CVR Tests  
CTR Tests

Arch / Design Platform

Design Verification Tests  
Performance Metrics

Software, RTL

SW Tests (Unit, Feature, ...)  
RTL Tests

SW, HW, System

SW/HW/System Val Tests  
Functional Safety Tests

ECU Control System

System KPI Tests  
ECU Calibration Tests

Key Use Cases:

- ✓ Req Spec Analysis
- ✓ Rapid Spec Prototyping
- ✓ Early Test Development

Key Use Cases:

- ✓ Arch/Design Analysis
- ✓ Rapid Design Prototyping
- ✓ Early Test Development
- ✓ HW Spec Validation

Key Use Cases:

- ✓ SW Development
- ✓ SW/HW Integration
- ✓ SW Test
- ✓ HW HDL Test (SWIL)

Key Use Cases:

- ✓ SW/HW Validation
- ✓ System (OL/CL) Validation
- ✓ HILS Validation
- ✓ Functional Safety Analysis

Key Use Cases:

- ✓ BSP/BSW Optimization
- ✓ ECU SW Optimization
- ✓ ECU SW Calibration

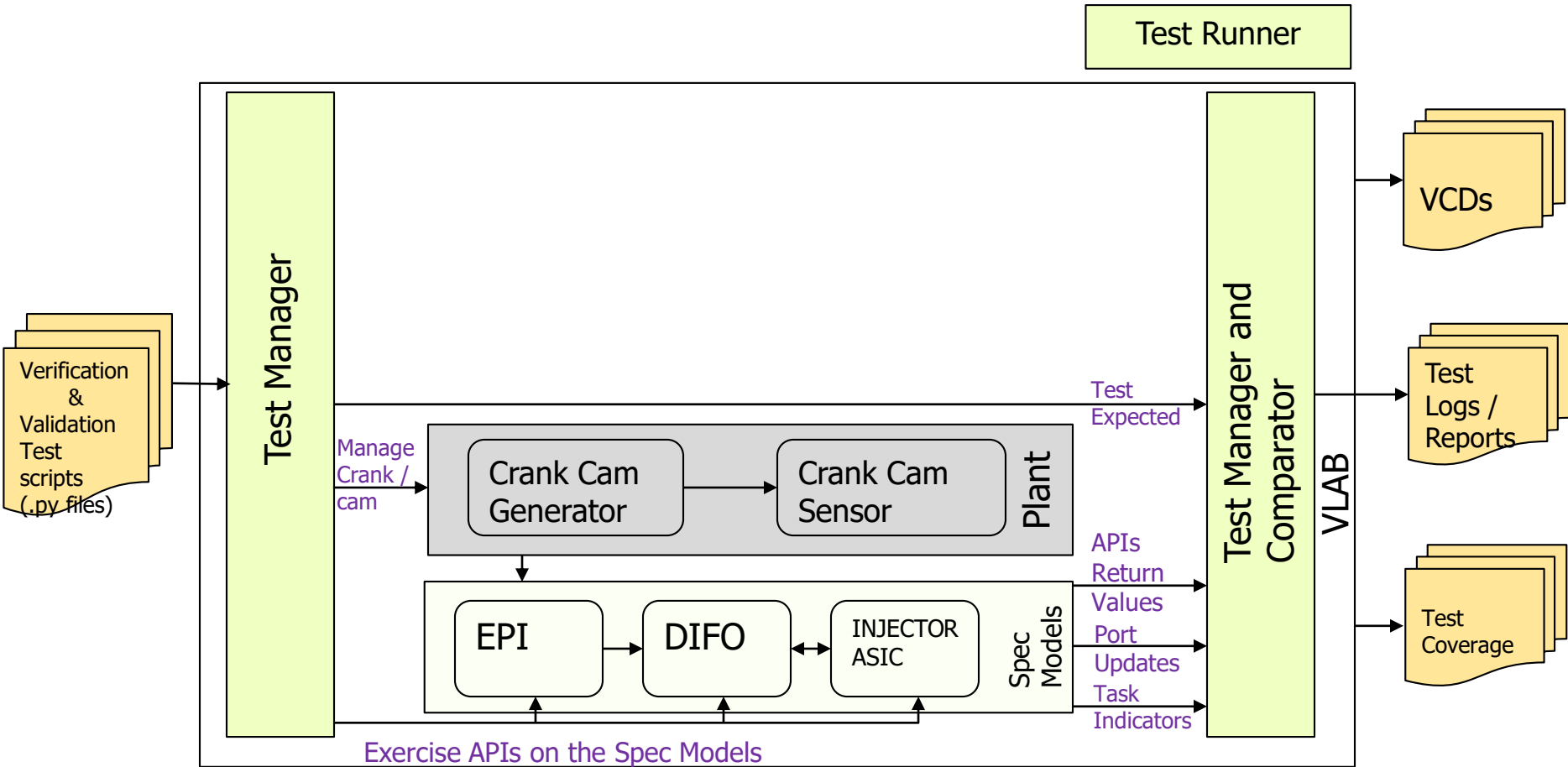
Concurrent SW, HW, and TW (Testware) Development, Validation, and Optimization  
Continuous Build, Integration and Test with Rapid Iterations and Progress

*Embedded Made Agile*



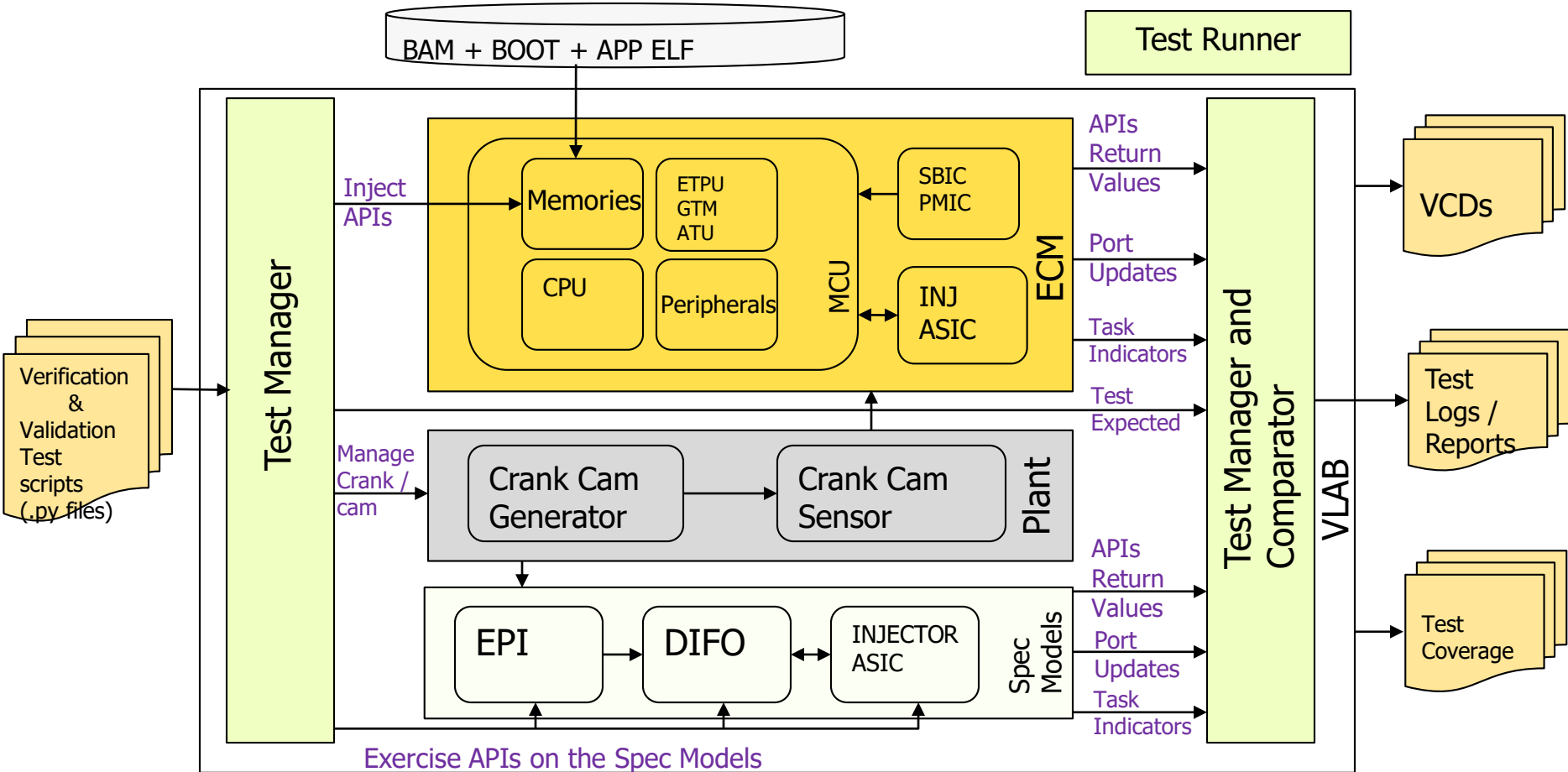


# VBD/AIS: Engine Management ECU





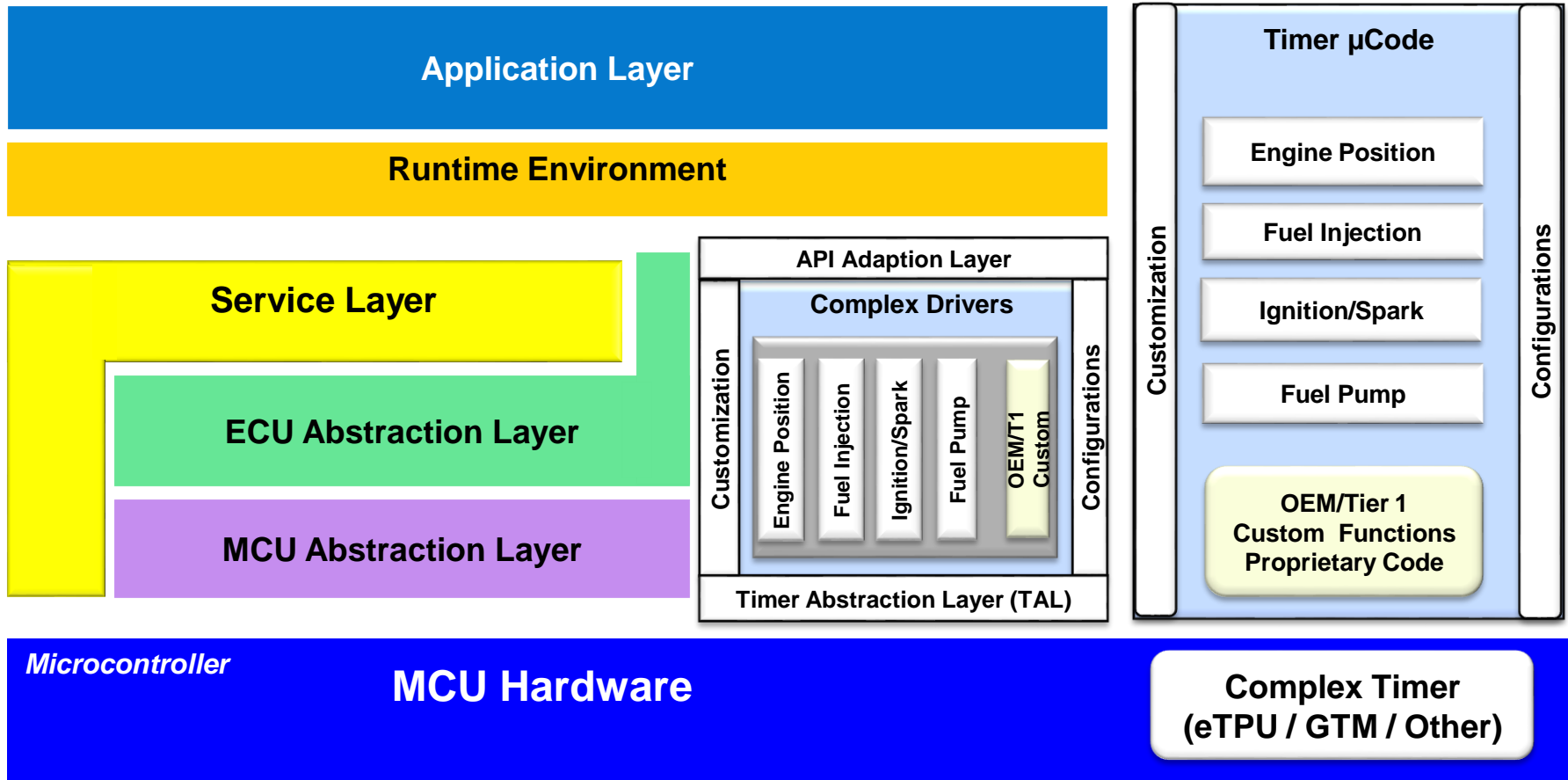
# VBD/AIS: Engine Management ECU





# ASTC GTM Software Libraries

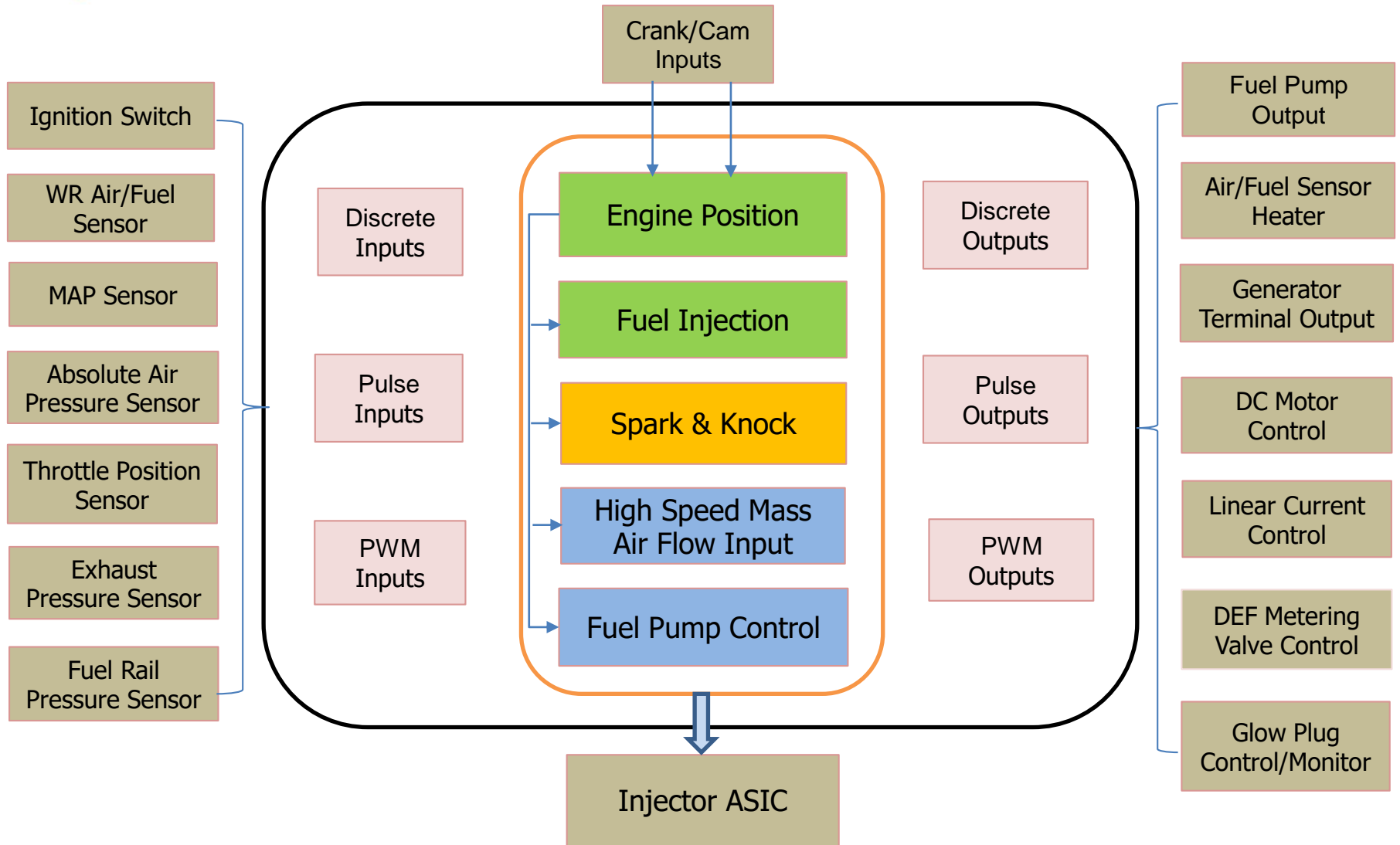
## Powertrain Driver Software







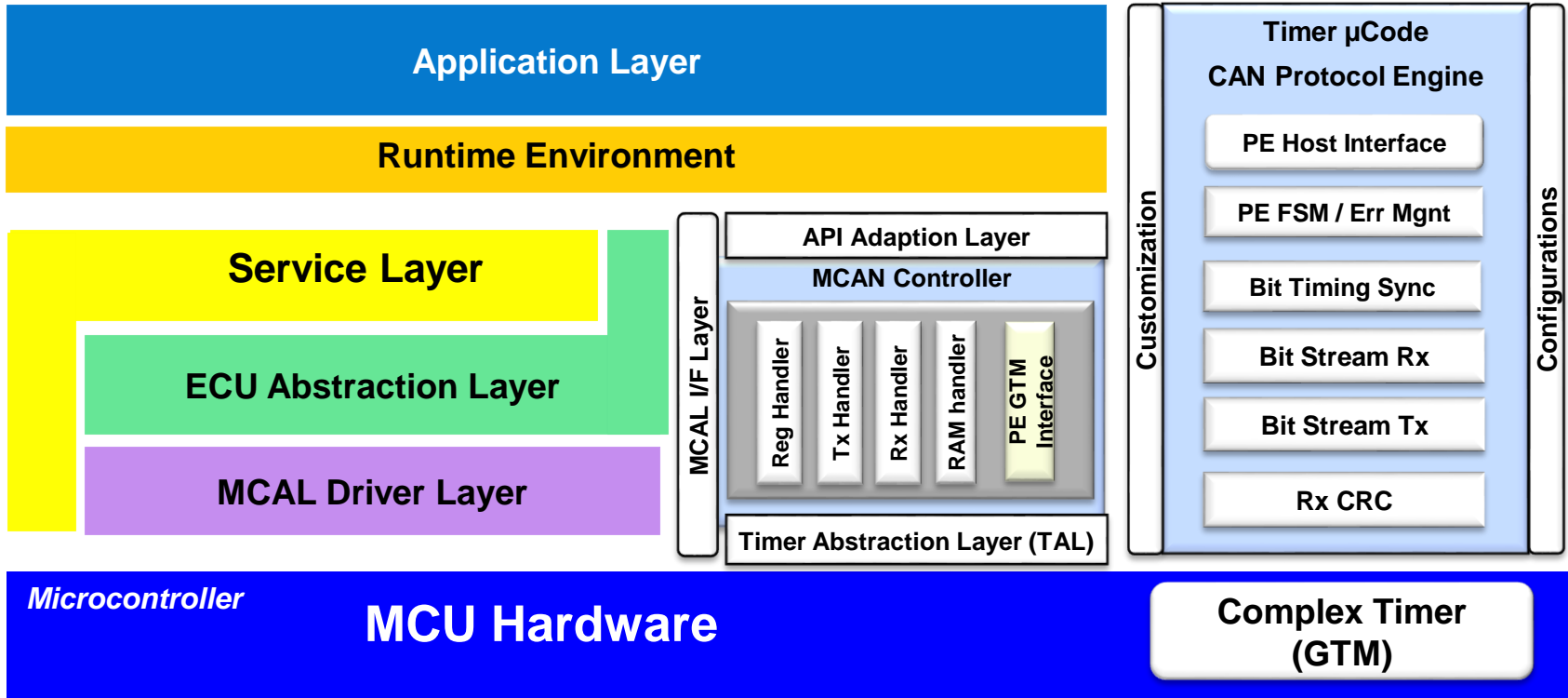
# Timer CDD SDK for Engine Control





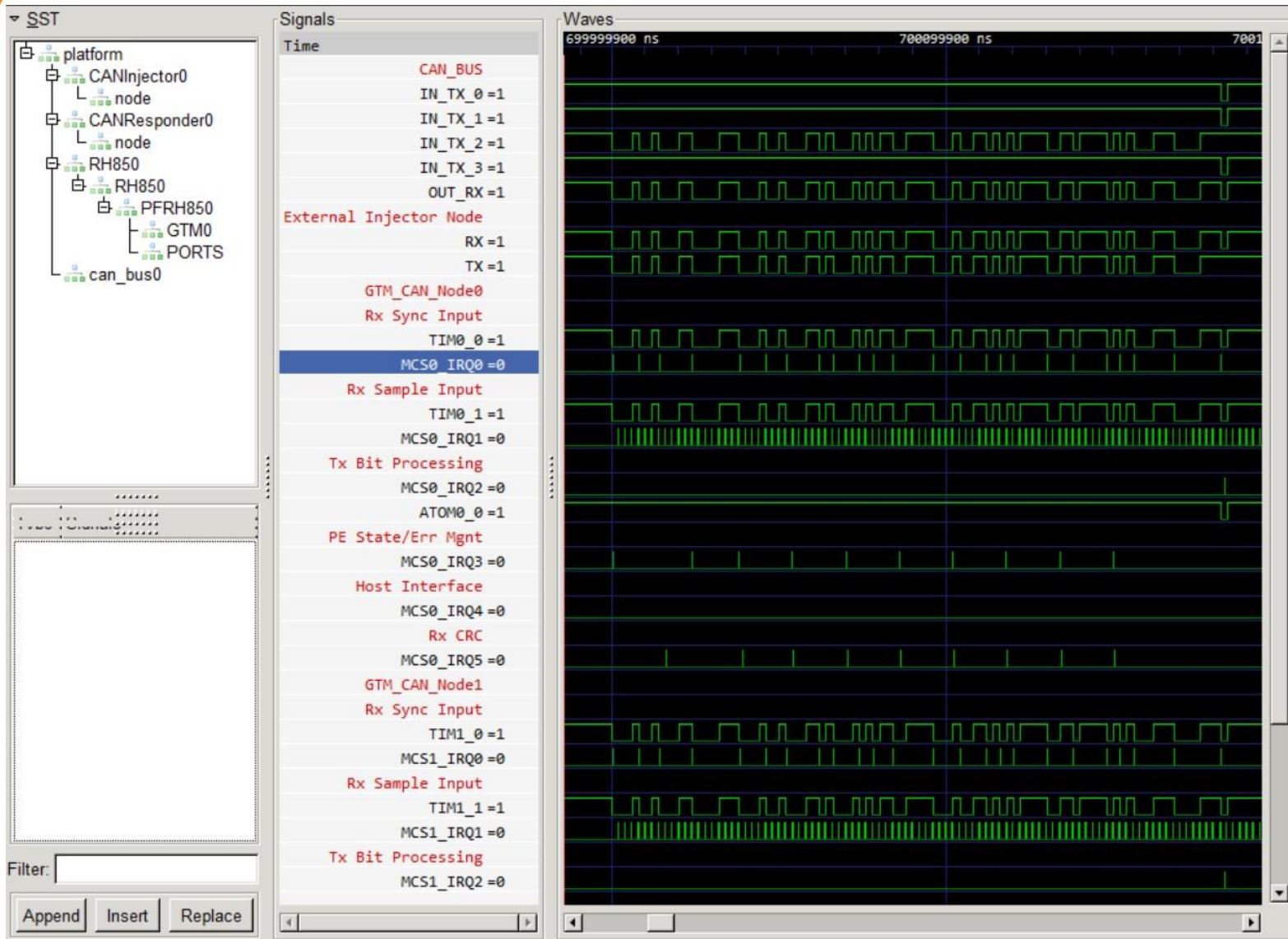
# ASTC GTM Software Libraries

## Serial Interfaces through GTM, e.g. CAN





# Sending and receiving CAN-FD via GTM





# GTM Products and Services



## GTM Software Libraries

Both GTM microcode and CPU code libraries

Powertrain functions

Communication protocols (including CAN, CAN-FD)

## Virtual Platforms

GTM Model Toolbox with enhanced GTM model

MCU Virtual Platforms with integrated enhanced GTM (Aurix, RH850)

ECU Virtual Platforms, including closed loop and HILS

## Automotive Software Services

Migration support from eTPU to GTM

Complex low level timing control software

Engine control, motor control and others

## Virtual Platform Services

Regression environments

Executable specification modelling

Test development and execution



[www.vlabworks.com](http://www.vlabworks.com)

Advancing the Technology of Electronic System Design

[www.astc-design.com](http://www.astc-design.com)

Advancing the Design of Electronic Systems

North America

**Chris Ward**

[chris.ward@astc-design.com](mailto:chris.ward@astc-design.com)

Europe

**Ad Peeters**

[ad.peeters@astc-design.com](mailto:ad.peeters@astc-design.com)