Virtual Hardware ECU – How to Significantly Increase Your Testing Throughput!

Elektrobit Tech Day

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Synopsys Inc.

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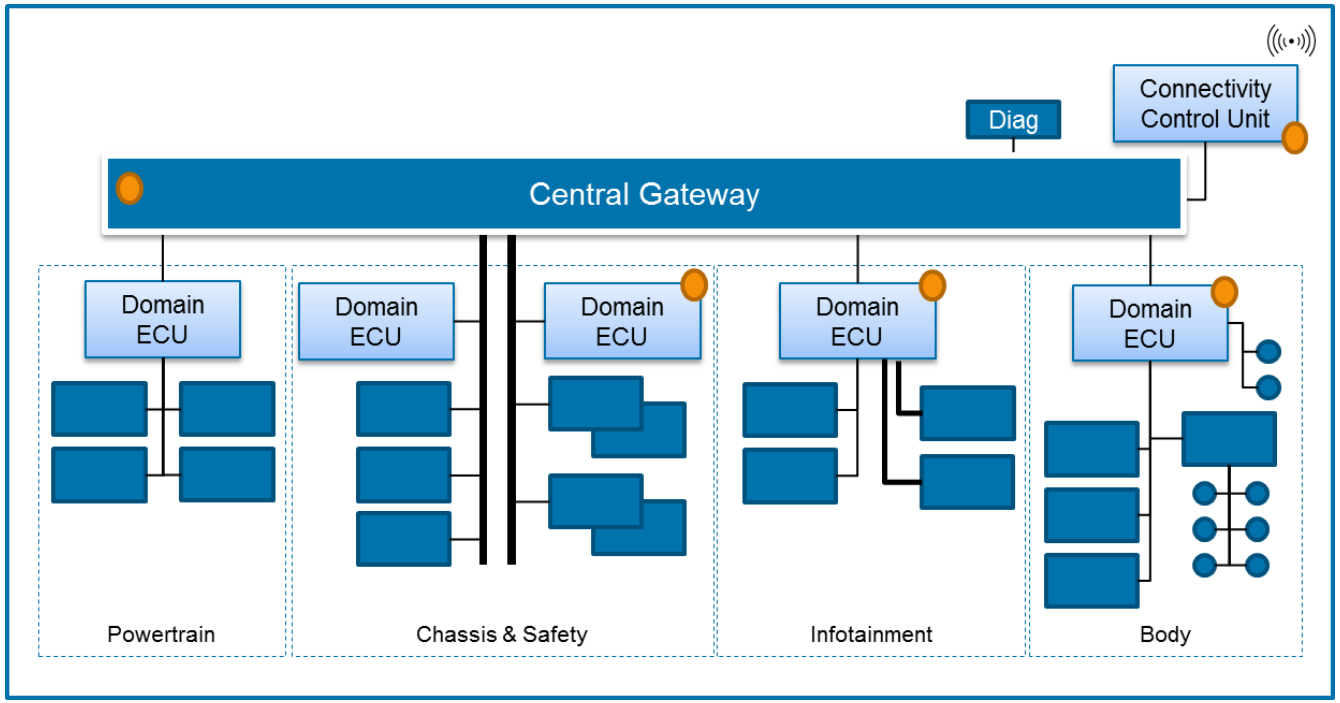
Agenda

- Automotive electronic evolution and the testing challenges
- What are Virtual Prototypes and Virtual Hardware ECU
- Increasing automotive systems testing throughput
- Requirements and experiences deploying Virtual Hardware ECUs

Automotive Evolution and Development Challenges

E/E Vehicle Architecture is Changing

Cars are Becoming Computers on Wheels



From modular/integration to DCU centralization and fusion to vehicle computer/cloud computing

Source: (R)Evolution of E/E Architectures SAE Paper 2015-01-0196 Robert Bosch

New Technologies & MCUs/SoCs

- In vehicle Networks: Ethernet & CAN-FD
- Domain ECU – High Computing power
- Basic System ECU – Embedded controllers
- Integration Platforms – SW Virtualization
- Central gateways – advanced routing
- Connected cars – Multi-points, QoS
- Multi-layer security
- Power Networks – 12V & 48V
- Safety mechanisms

MCU and SoC targeted at ADAS, EV/HEV, Powertrain, Chassis, ….

- Multicore
- Complex programmable subsystems
- Multiple connectivity interfaces (Ethernet AVD, CAN-FD)
- ISO 26262 safety mechanisms

Infineon AURIX 2nd Gen

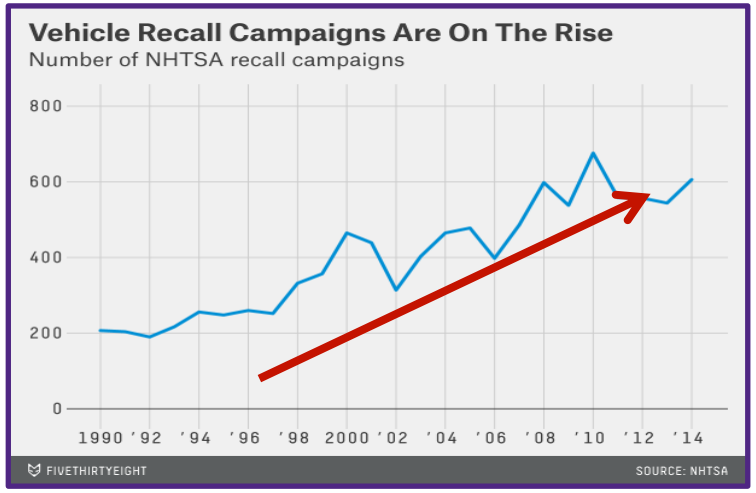
- 6 cores
- Gigabit Ethernet
- 12 CAN-FD
- 24 LIN
- HW Security Module

NXP S32V234

- Quad ARM Cortex-A53
- Dual Apex-2 Image Cognition Processor cores
- Image signal processing
- 3D GPU
- Hardware Security Encryption

Verification and Validation Effort is Dramatically Increasing

"There will be as many as 10 design revisions in the electrical and electronics area, where consumer expectations and **the rate of development are both rapidly increasing**"



"Every part of the vehicle has been impacted by electronics in the past 30 years, and today it accounts for more than 40% of a **vehicle's cost, up from 20%** just 10 years ago"

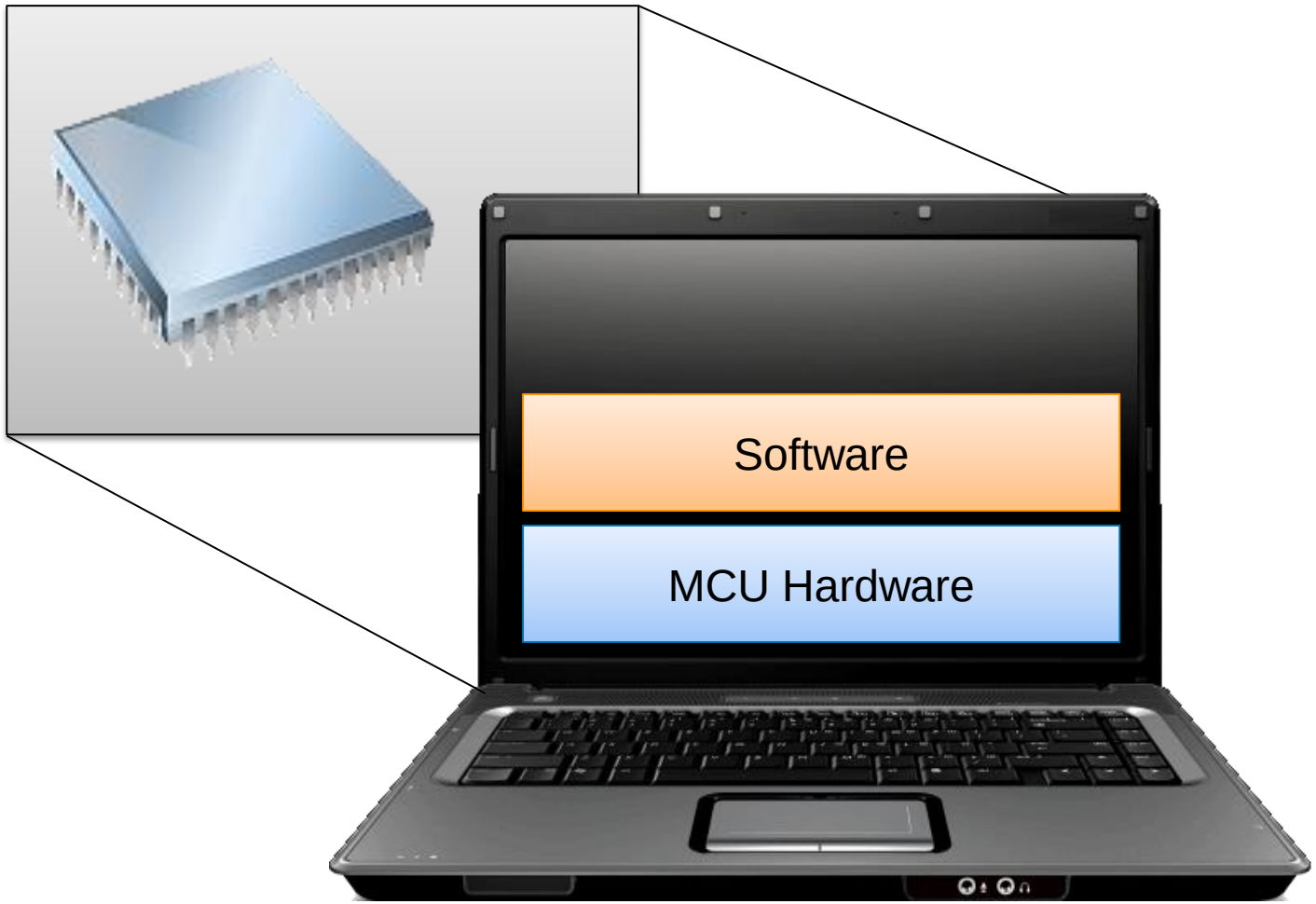
Development Productivity

Quality/Security

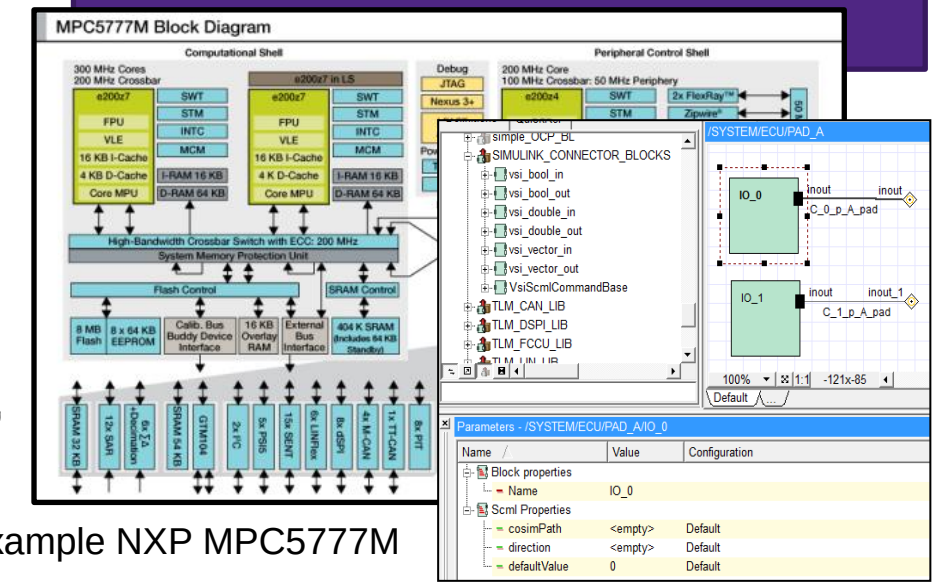
Costs

Introducing Virtual Prototypes

What is a Virtual Prototype?



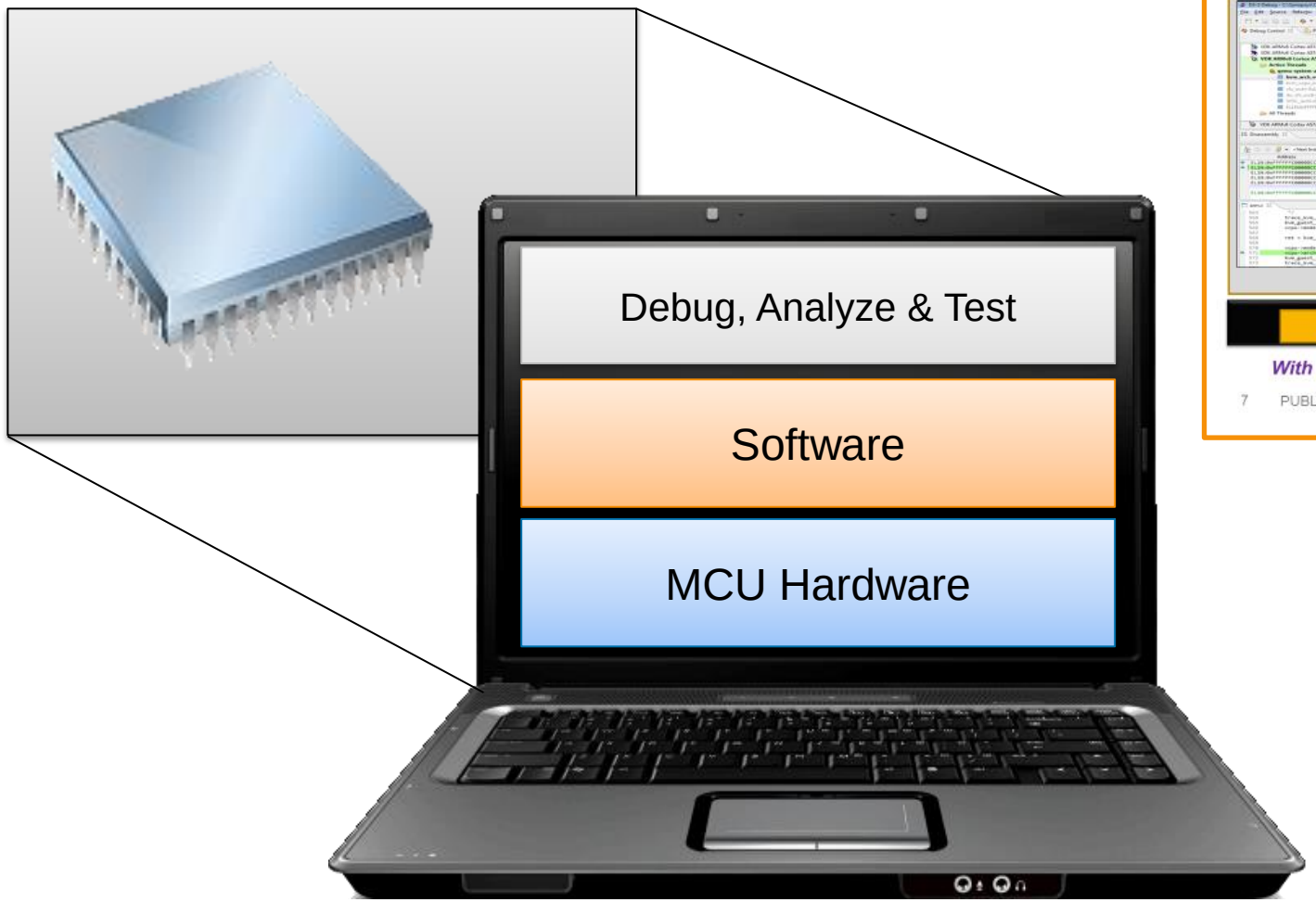
Fast model of a microcontroller (MCU) or system-on-chip (SoC) that can execute an unmodified binary executable

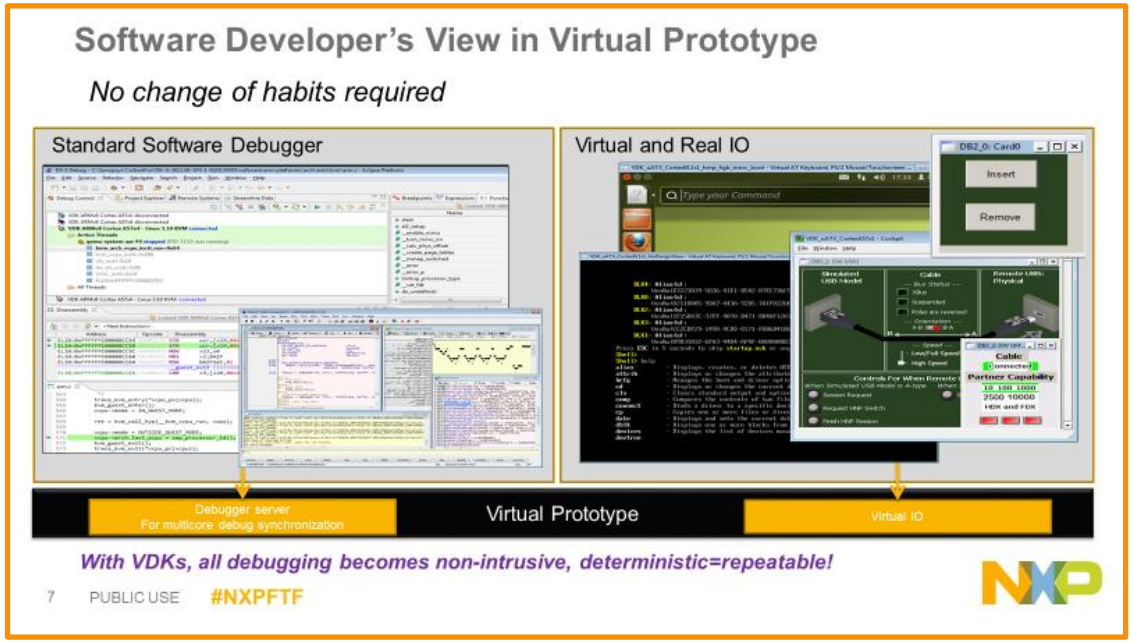


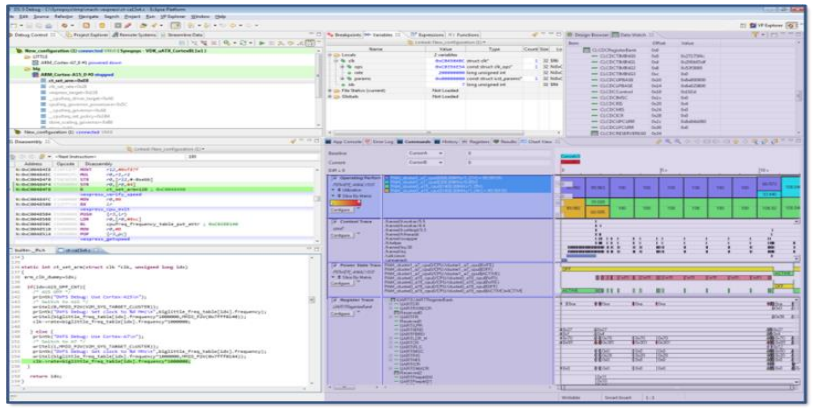
Example NXP MPC5777M

More than Hardware

Available Earlier, Easier to use for Debug!







Start HW/SW Development Early

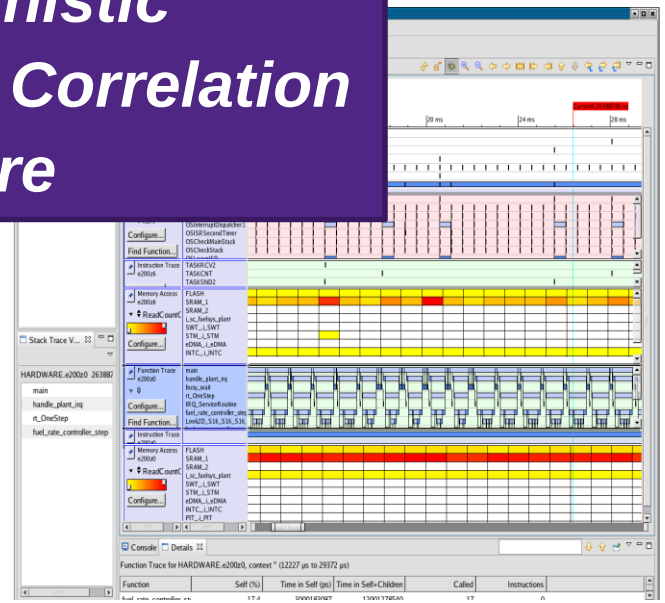
Before Silicon or Boards are Available

SW development 9-12 months earlier

Experience from Automotive Semi and Tier1/OEM SW Teams

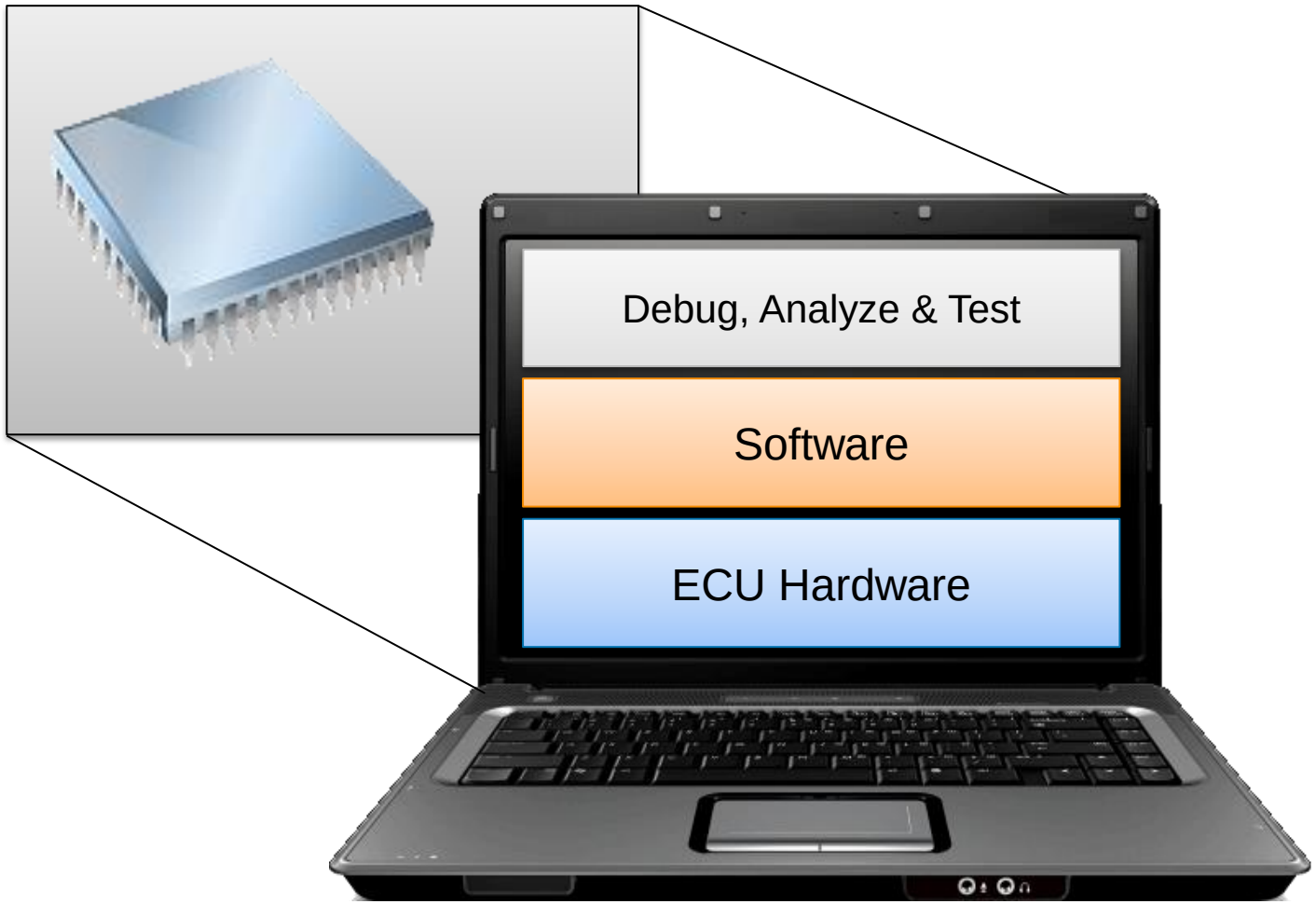
- Pre-silicon Dual OS (AUTOSAR & Linux) + Hypervisor bring up.
- Complex driver and communication
  - GTM, CAN, Ethernet communication, vision accelerators/sub-systems, …
- Algorithm flow from Matlab/Simulink to embedded software

- ***Faster Debug***
- ***Non Intrusive***
- ***Deterministic***
- ***HW/SW Correlation***
- ***OS aware***

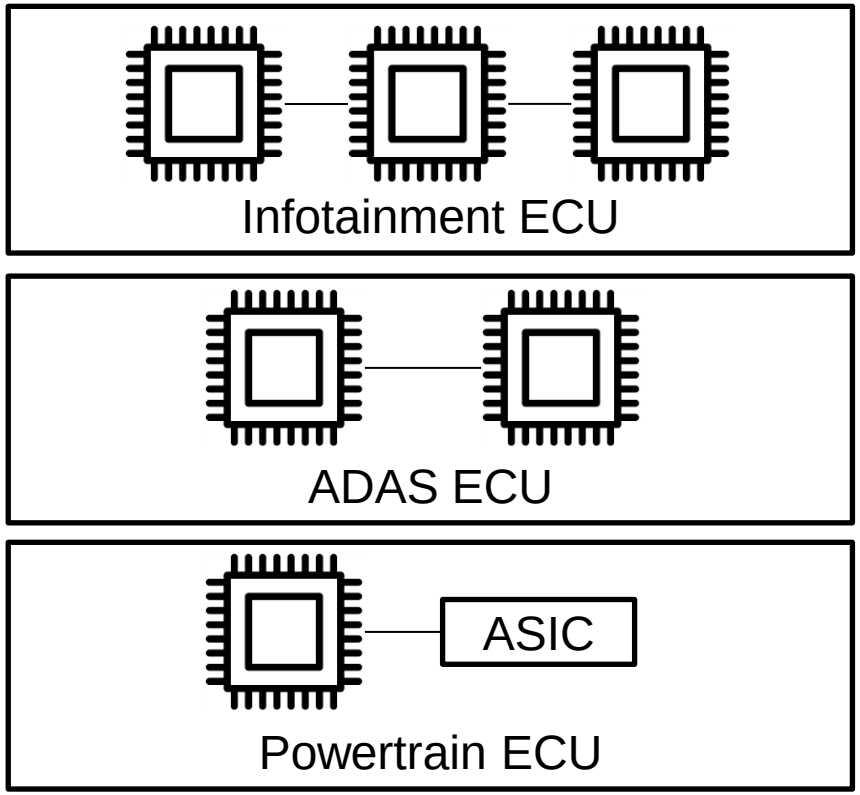


Moving to Virtual Hardware ECU

What is a Virtual Hardware ECU?



Fast model of the ECU Hardware with the benefits of virtual prototypes

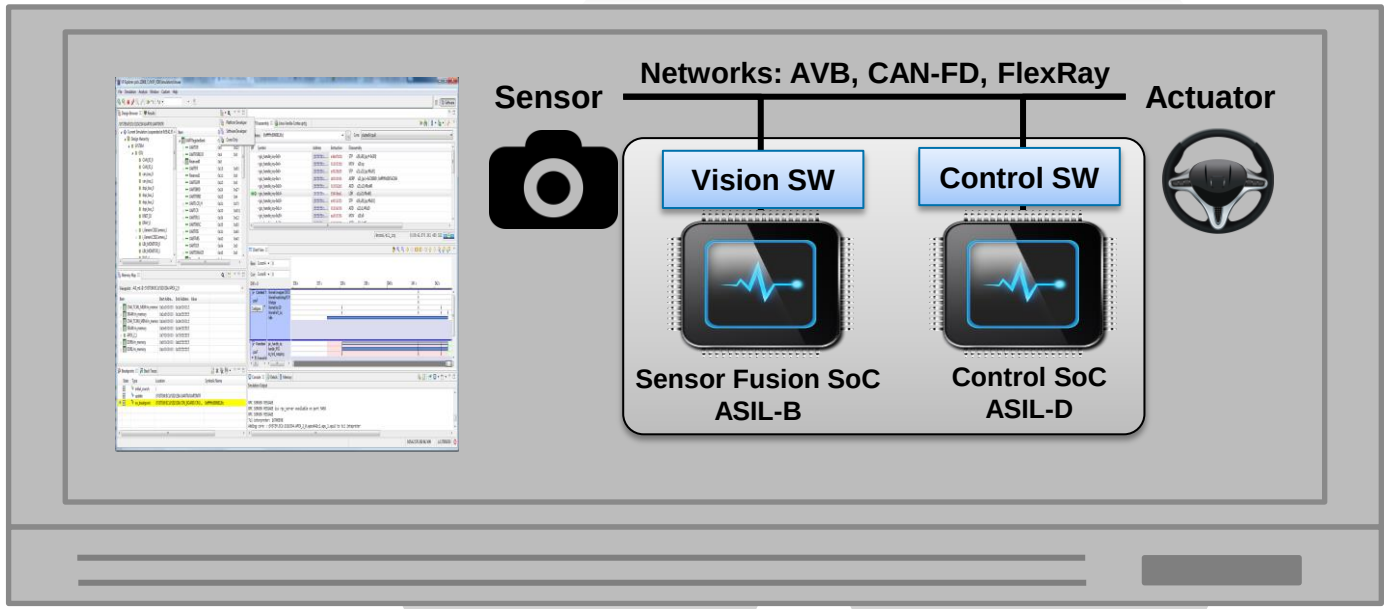


Example: ADAS Development

Virtual Prototype Available 9 Months Before ADAS ECU HW

ECU SW:

Communication Networks
ECU Board Support Package
Multicore software



SoC SW:

Linux
Hypervisor
Image processing

AUTOSAR
Complex drivers
Communication

Today's Leader's Start Early!

Why Virtual Prototypes?

- Early availability
- Better for debugging
- Easier to deploy

Virtual Prototype Use Cases

- Functional accurate software development
- Interactive day-in-day-out debugging
- Multicore SW, complex drivers, algorithm, AUTOSAR, hypervisor, communication protocols, … to applications

SW starts 18 months before silicon at semi

SW starts 12 months before silicon at lead Tier1/OEM

SW starts 9-12 before ECU HW at Tier1/OEM

Establishing a virtual Hardware-in-the-Loop test bench (vHIL)

Hardware-in-the-Loop

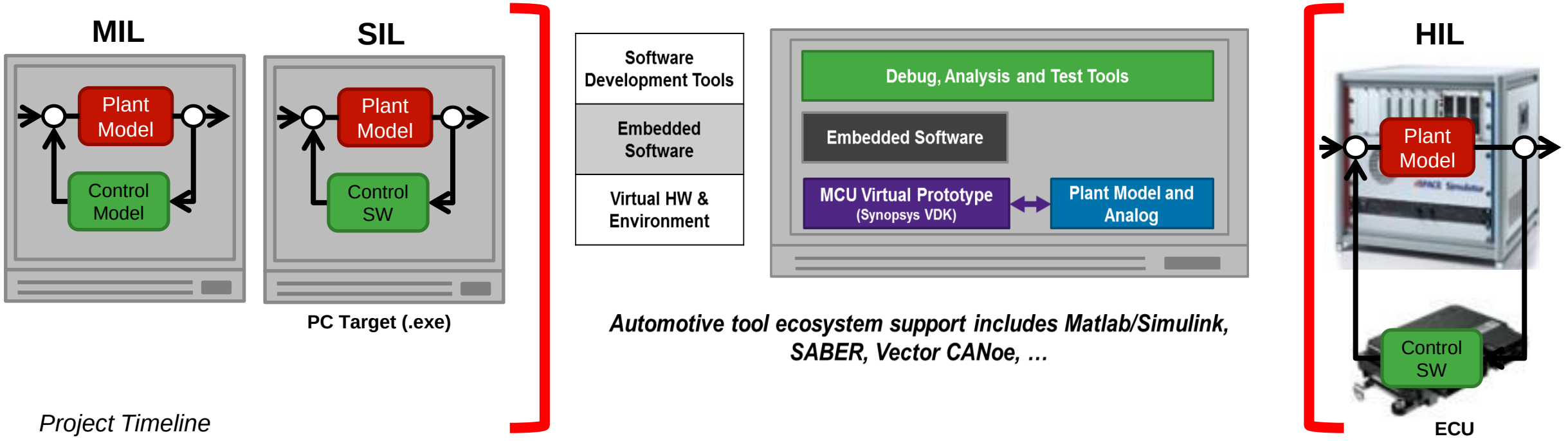
Development Gap

HIL Limitations:

- Access due to limited number of HIL systems (cost and access)
- Limited visibility and controllability
- Hard to deploy in regression
- Complex to set up, share, maintain and archive

Virtual Hardware-in-the-Loop

Start Before Test Benches are Available

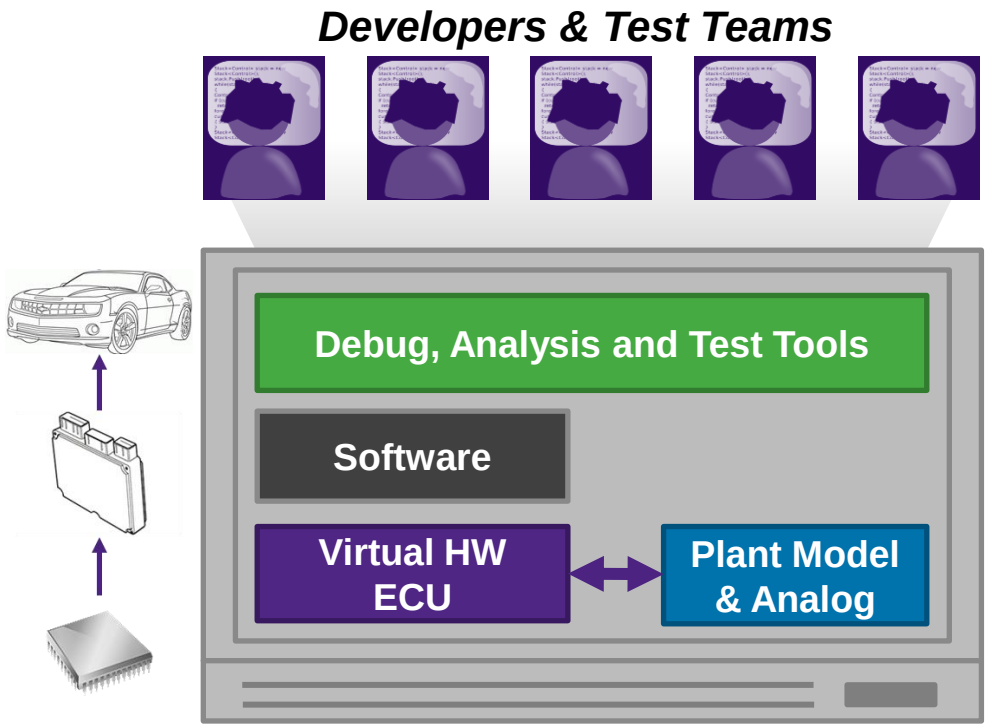


SW Development Early & Increased Testing Throughput

From Virtual SoCs to Virtual Hardware ECU(s) with Virtualizer and Automotive VDKs

Start early & accelerate development

- When SoC evaluation boards or ECU HW boards are not available
- 12-18 months earlier
- Easier and more efficient debug



Start earlier, test faster and better

- Frontload test development
- System SW testing
- Fault & coverage testing
- Regression

Early Software Development — HW Availability — **Increase Testing Throughput**

Establishing a vHIL Test Bench

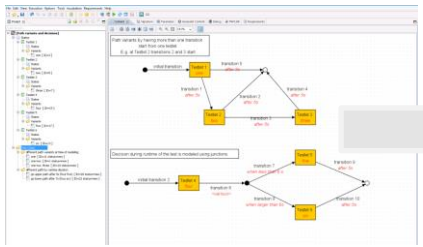
1. Virtual prototypes of MCU/SoC and modeling environment
2. Integration with software debuggers
3. Co-simulation interface with other simulators (example: Simulink, SABER, CANoe, …)
4. Tools to drive testing
5. Tools to analyze and report

Integrating with Automotive Flows

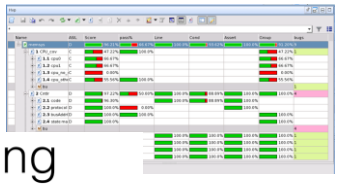
PIKETEC software engineering

tracetronic GUIDING YOUR VISION

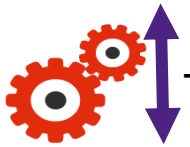
Model-based Testing



ISO 26262



Testing



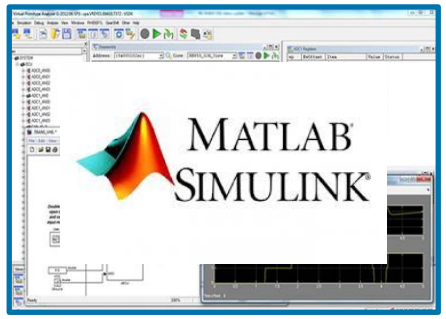
Test Execution

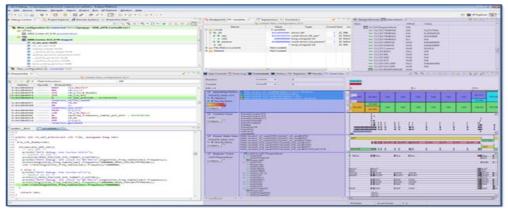
Control Algorithm

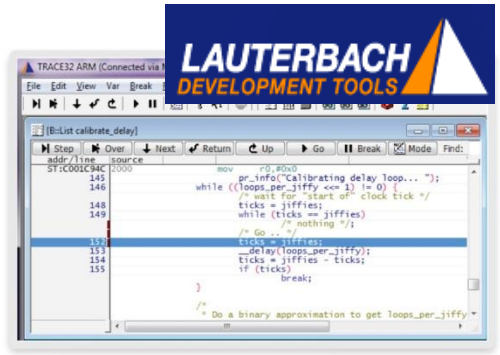
Code Generation

Control Algorithm SW

AUTOSAR OS







Engine model

Co-simulation

Synopsys VDK

Lauterbach Trace32
Embedded Software Debugger

Model-based Design

System under Test (SUT)

Support of ISO 26262

Testing Earlier and Faster – Evaluating Corner Cases

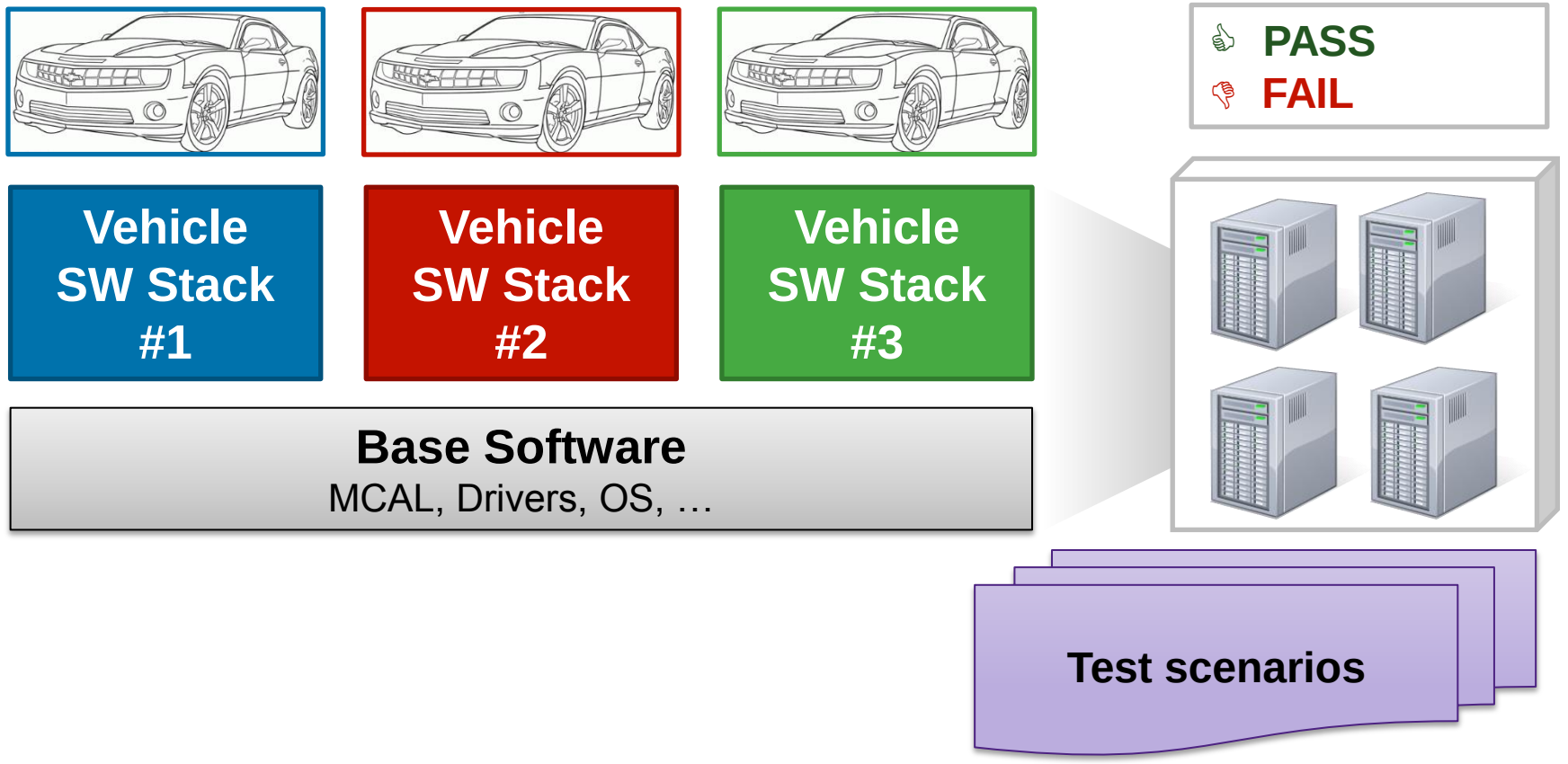
- Anywhere in hardware
- Anywhere in software
- Modify the state of the complete system
- Permanent fault

- Control triggered by SW, HW or time events
- Record and correlate all HW/SW events
- Non Intrusive

- Deterministic execution
- Overnight execution in regression
- Fast execution w/ complete SW stacks

Accelerate Testing Productivity through Regression

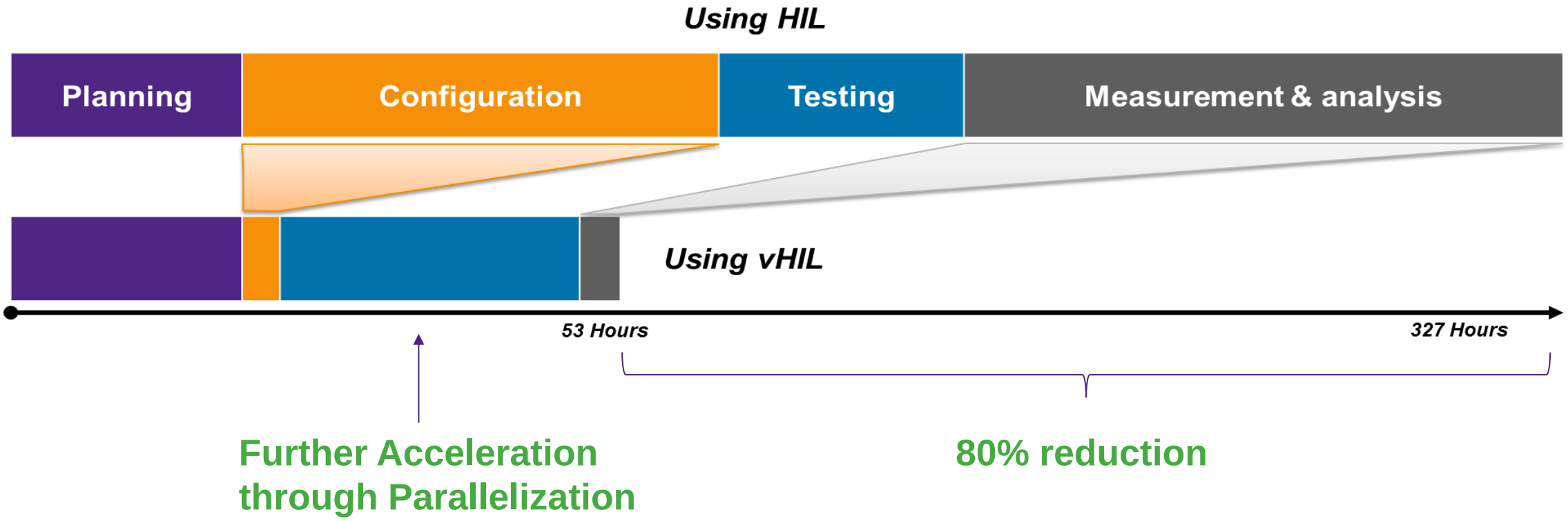
Evaluate the Impact of Software Changes More Efficiently!



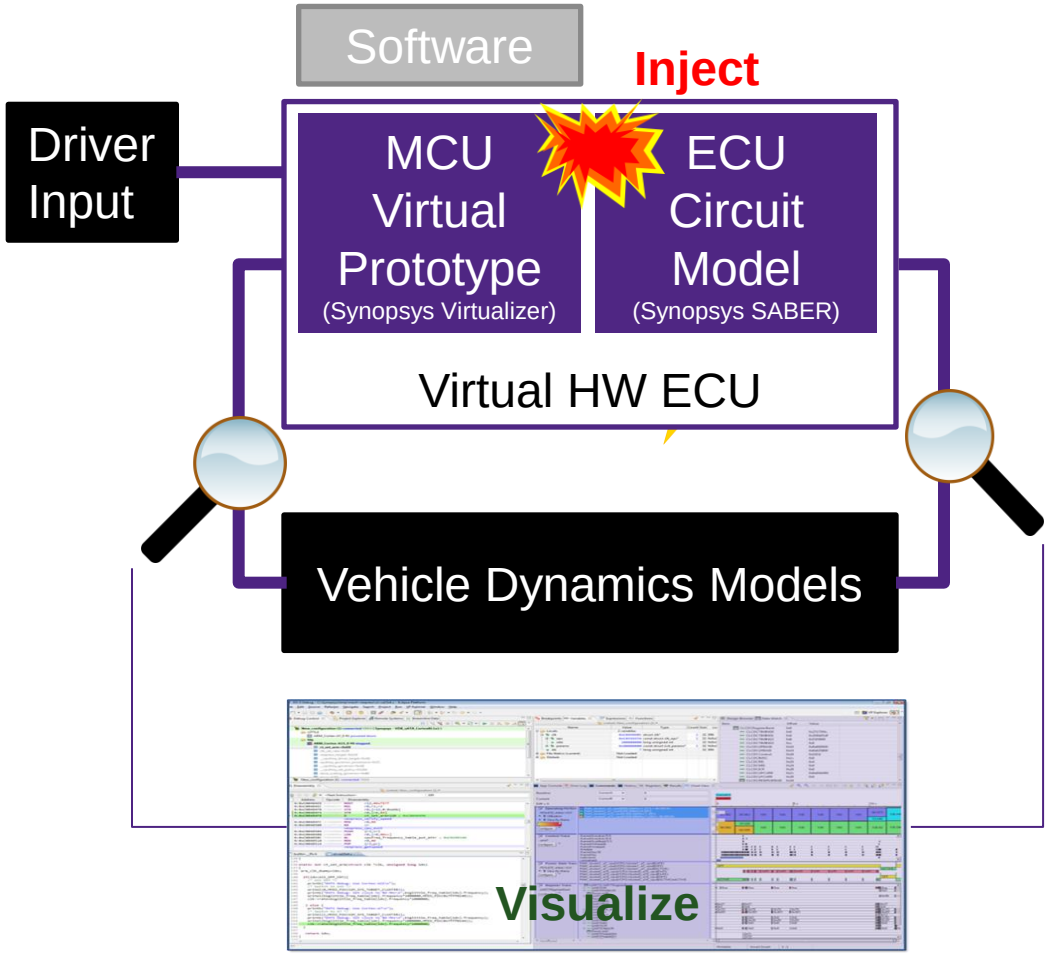
Automated test regression on server farm

Significantly Increase Test Throughput

Test More and Faster – Higher Software Quality Earlier, at Every Development Milestone



Application Example to vFMEA

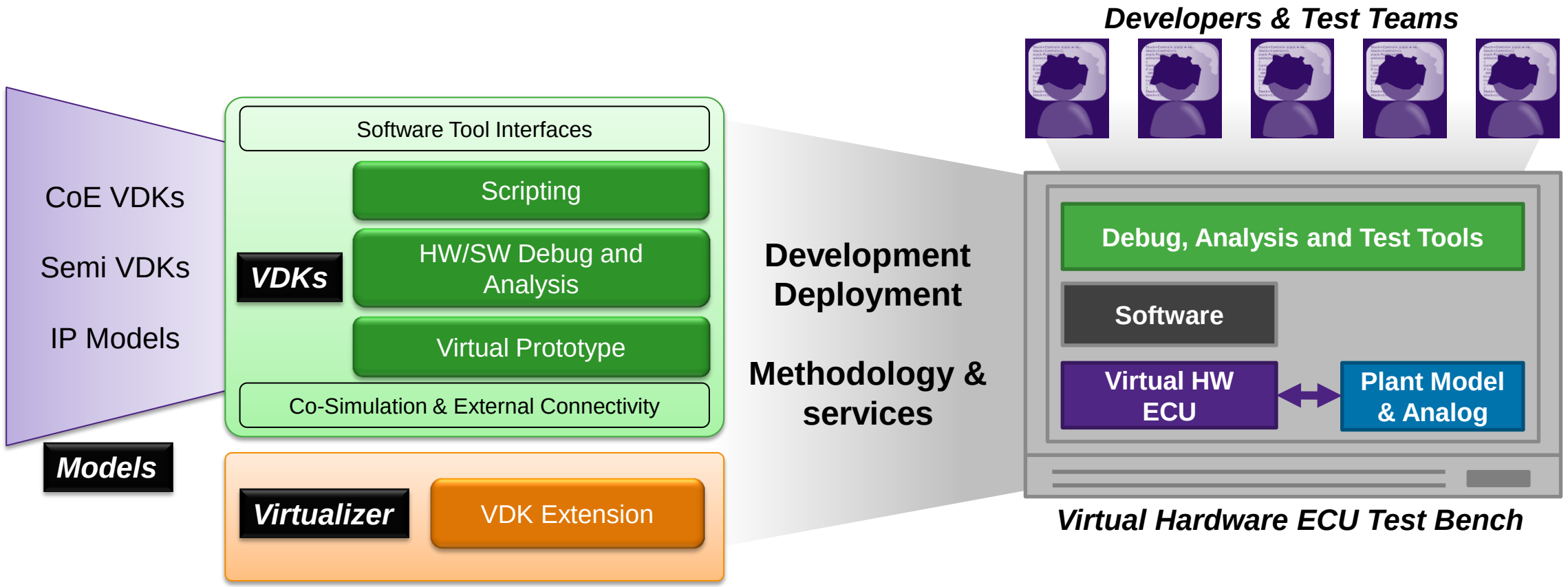


Actual Results

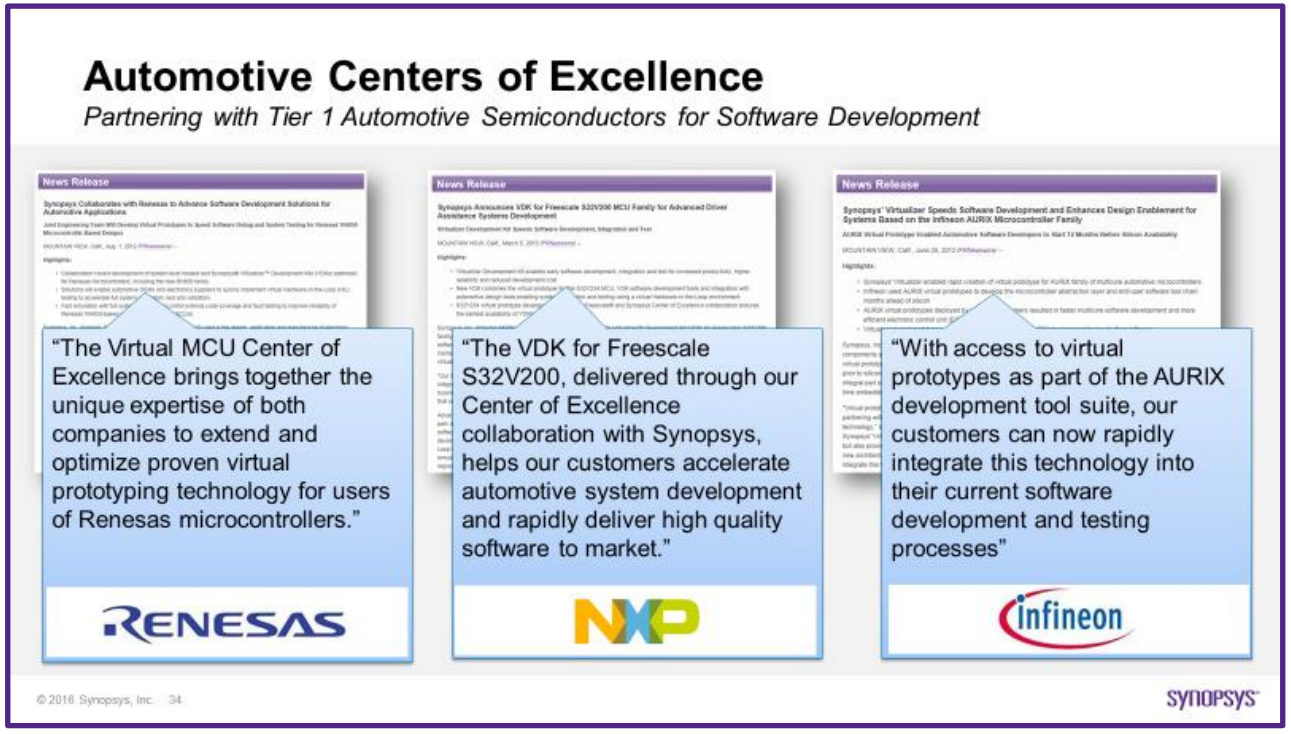
- Increased test coverage 200 to 900 tests
- Testing effort reduced from 3 man/months to 2 man weeks
- Reusable, safer and distributed access
- Faster analysis of result and change iteration

The most comprehensive Virtual Hardware ECU Solution

Synopsys Solution from Modeling to Test Bench Deployment



Synopsys & the Automotive Ecosystem



SYNOPSYS

SABER

ARM

COSIDE

tracetronic

LAUTERBACH DEVELOPMENT TOOLS

Green Hills SOFTWARE

pls Development Tools

CHIAS TEK

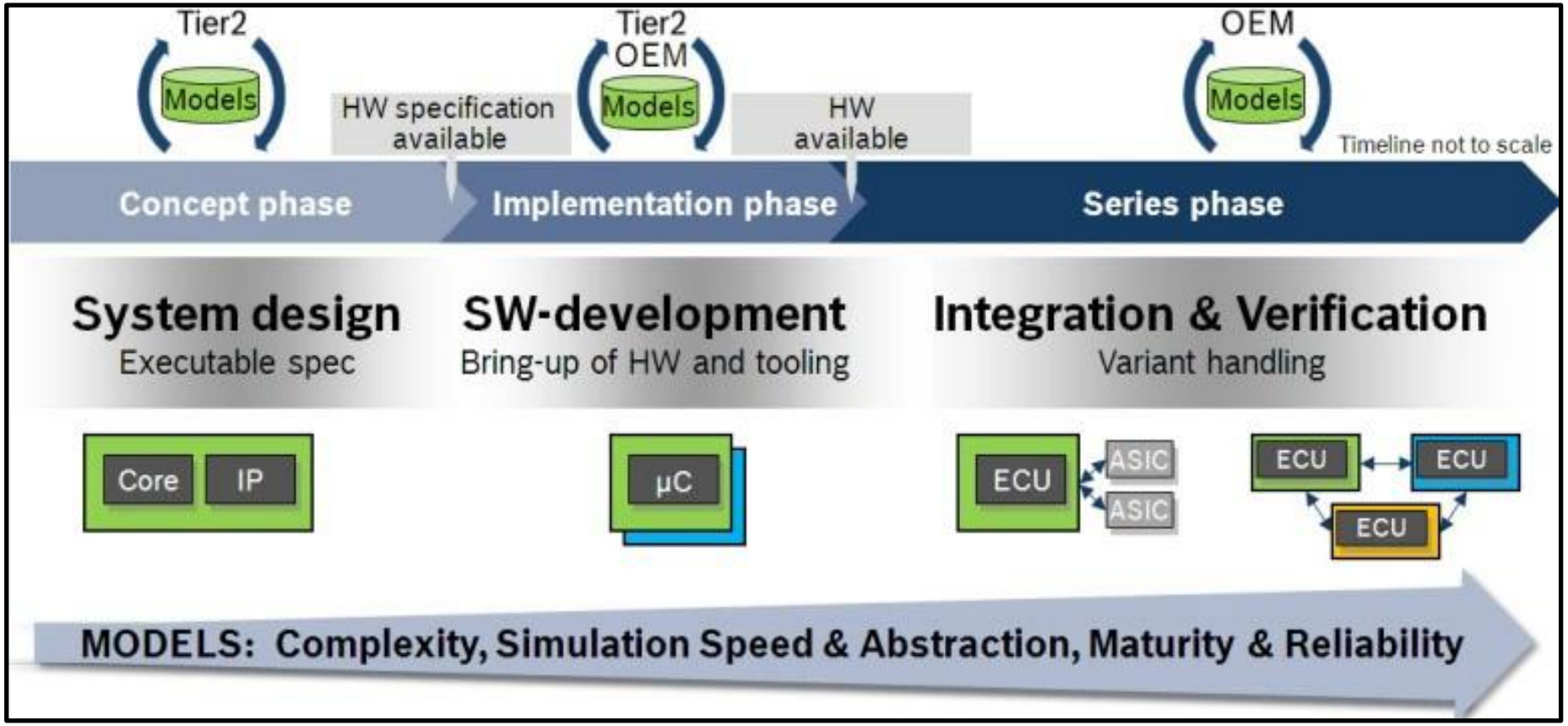
vector

MathWorks

PIKETEC software engineering

Software & System Development, Integration & Test

Virtual Platforms: Breaking New Grounds - IEEE



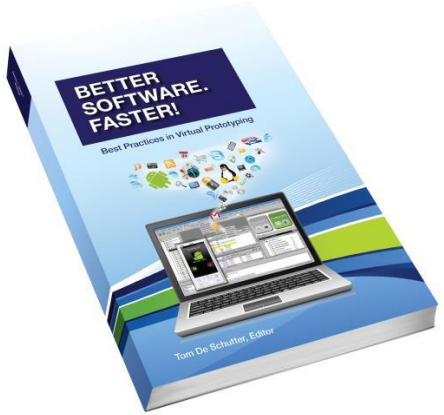
Source: IEEE 978-3-9810801-8-6/DATE12/©2012 EDAA http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=06176558 – **Robert Bosch Gmbh**

Proven at Automotive Tier 1 and OEM

Case Studies - Free Book http://www.synopsys.com/VPBook

BOSCH

The success rate for the introduction of virtual prototyping over the last couple of years is quite high. About **70% percent** of my internal customers are **repeat customers** after their first serious pilot engagement.
Virtual prototypes are of great help to support software developers to **find issues** in their software when it comes to reacting to faulty hardware."



HITACHI
Inspire the Next

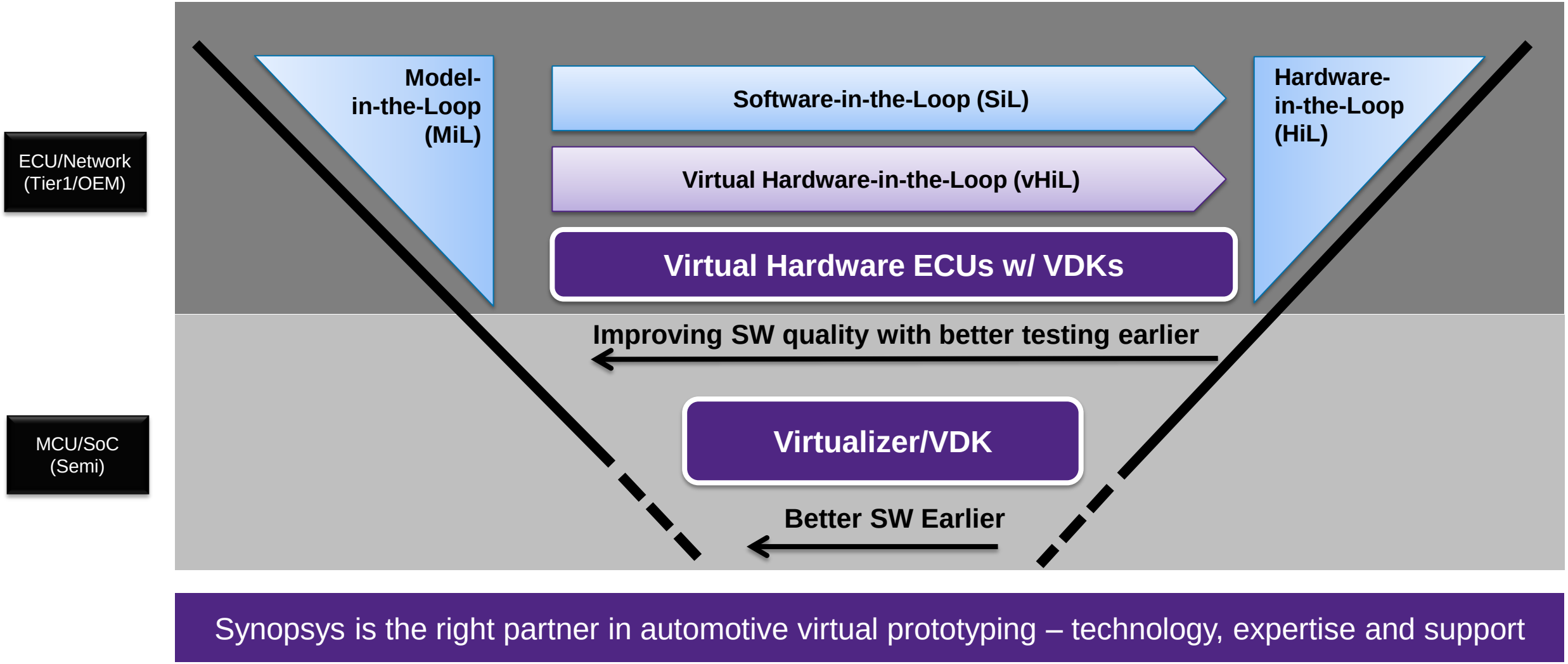
Over time we found that the use of virtual prototypes is not only applicable for the design and implementation of software, but for the **entire system-level testing and validation** of the product dependability."

GM

We observed **100% functional accuracy** in the results, that is, the same test that would pass/fail on the board would also pass/fail on the virtual board."
In addition, in terms of simulation **fidelity of execution timing**, we gathered very promising results, in the range of 2% to 11% error. This means that the same test that would run functionally equivalent on the board and on the virtual board, would take say 1 second to run on the target and between 1.02 and 1.11 seconds on the virtual prototype."

Virtual Hardware ECU Accelerate System Testing

Proven and Deployed Today



Synopsys is the right partner in automotive virtual prototyping – technology, expertise and support


SYNOPSYS®
Silicon to Software™