

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

Elektrobit Tech Day

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Synopsys Inc.

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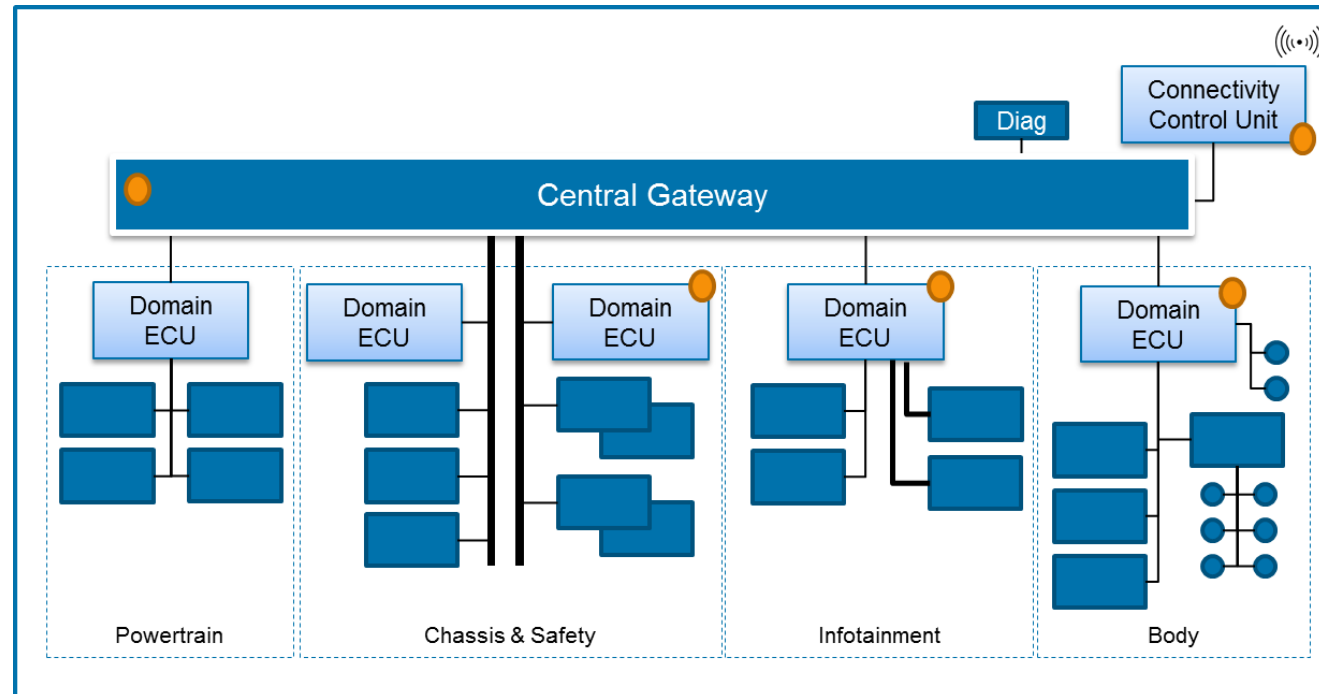
Agenda

- 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

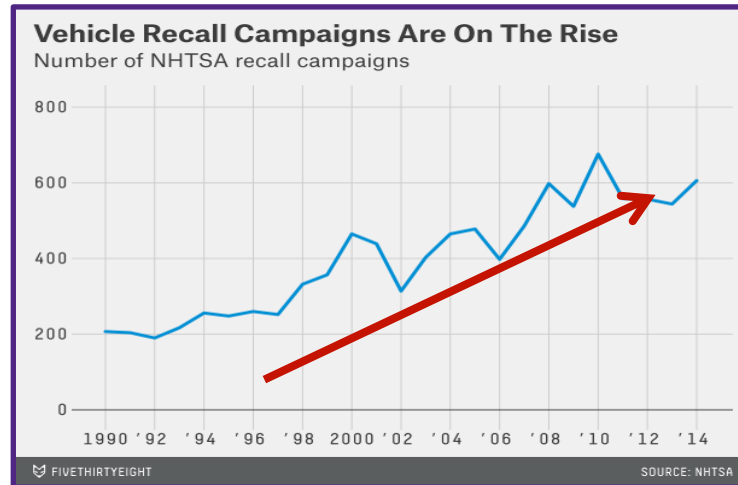
- 6 cores
- Gigabit Ethernet
- 12 CAN-FD
- 24 LIN
- HW Security Module

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**”

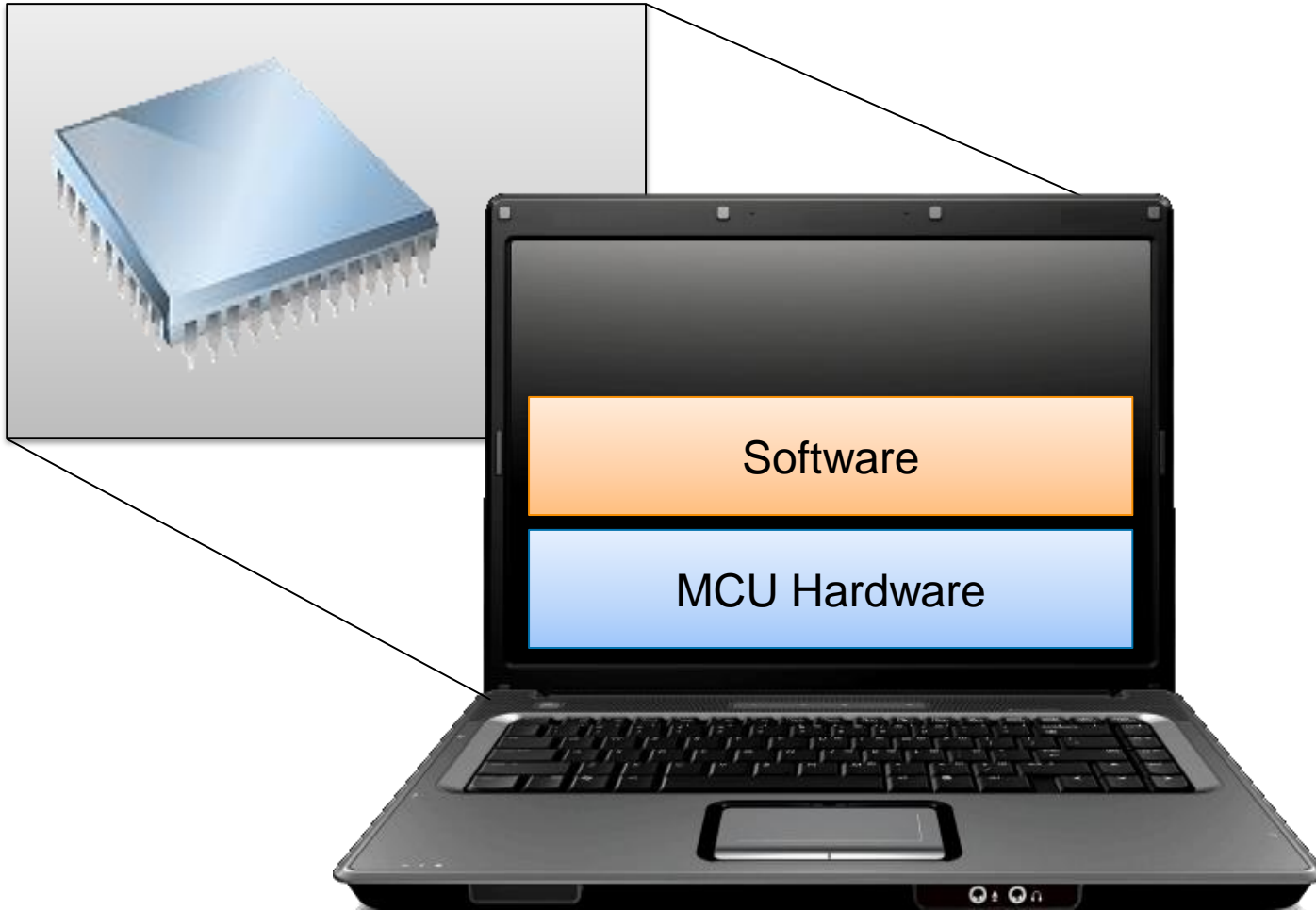
Development
Productivity

Quality/Security

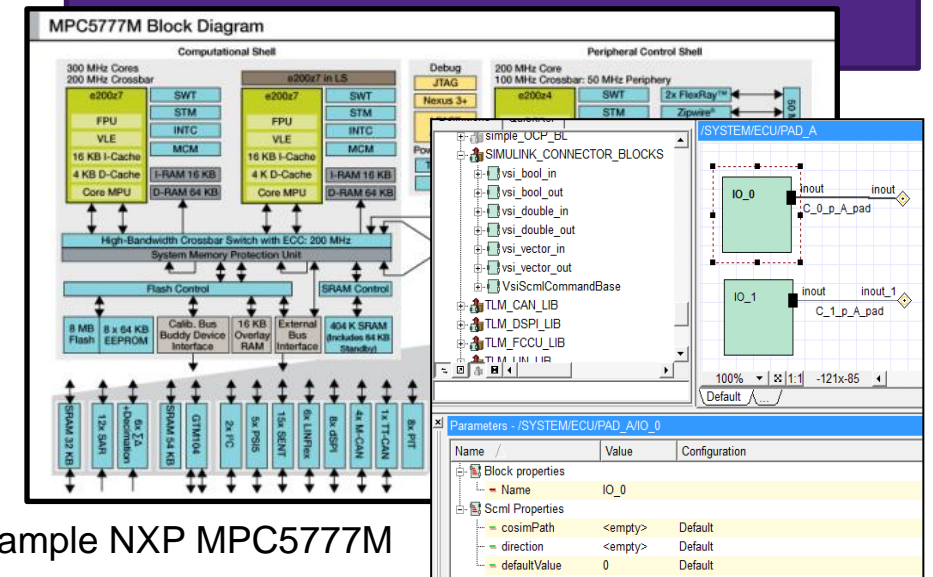
Costs

Introducing Virtual Prototypes

What is a Virtual Prototype?



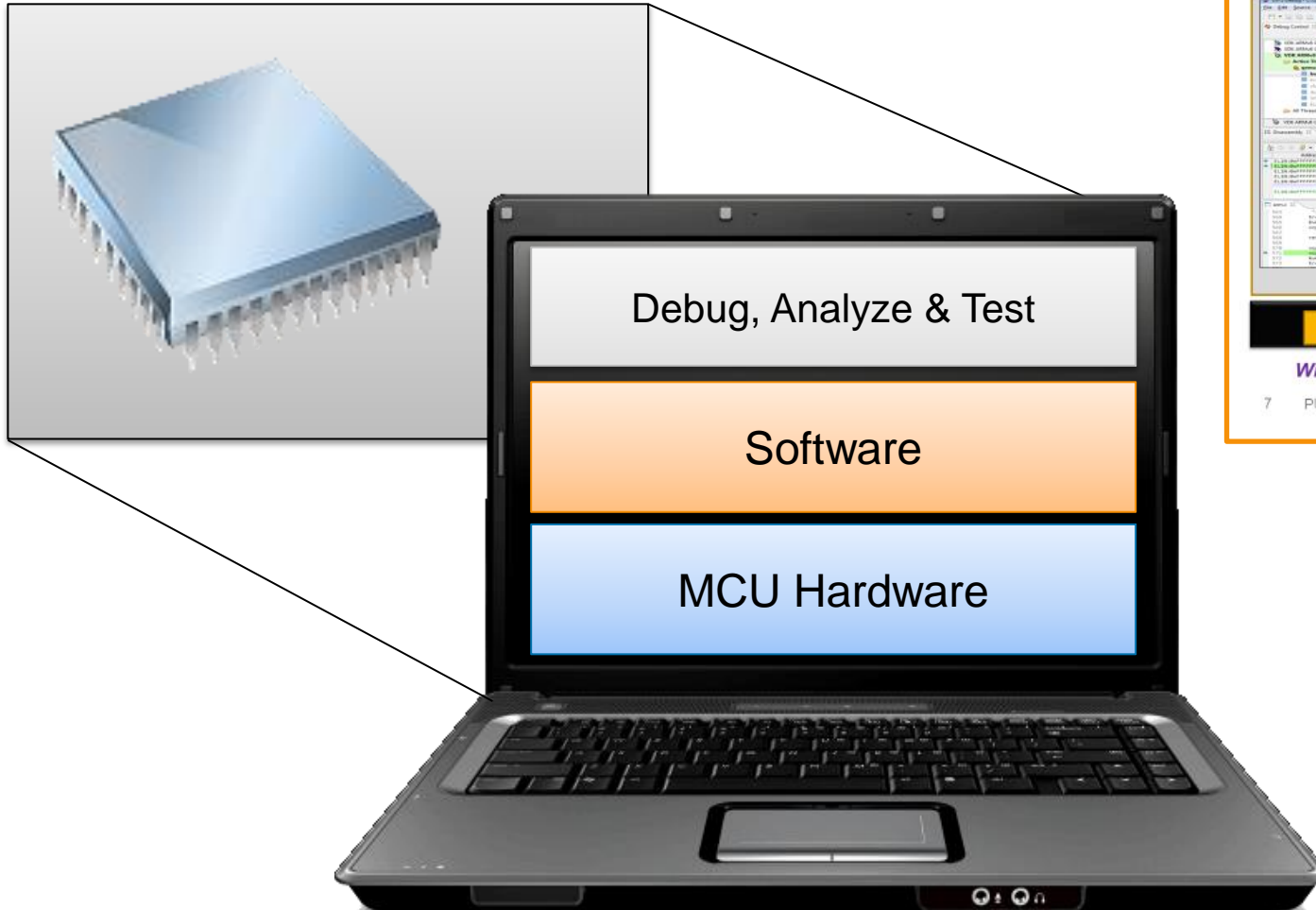
Fast model of a microcontroller (MCU) or system-on-chip (SoC) that can execute an unmodified binary executable



Example NXP MPC5777M

More than Hardware

Available Earlier, Easier to use for Debug!



Software Developer's View in Virtual Prototype

No change of habits required

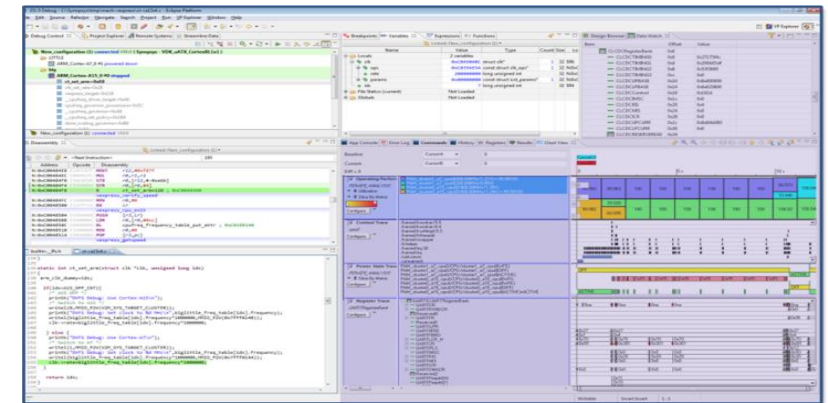
Standard Software Debugger

Virtual and Real IO

Debugger server
For multicore debug synchronization
Virtual Prototype
Virtual IO

With VDKs, all debugging becomes non-intrusive, deterministic=repeatable!

7 PUBLIC USE #NXPFTF



Start HW/SW Development Early

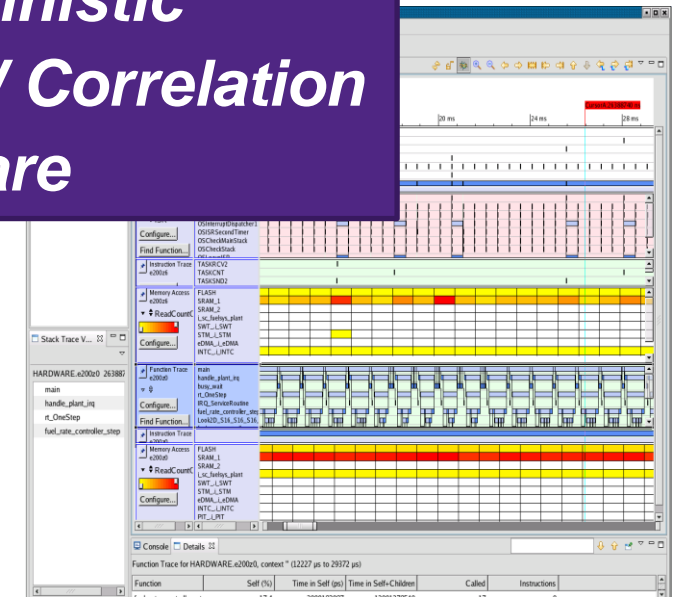
Before Silicon or Boards are Available

SW development 9-12 months earlier

Experience from Automotive Semi and Tier1/OEM SW Teams

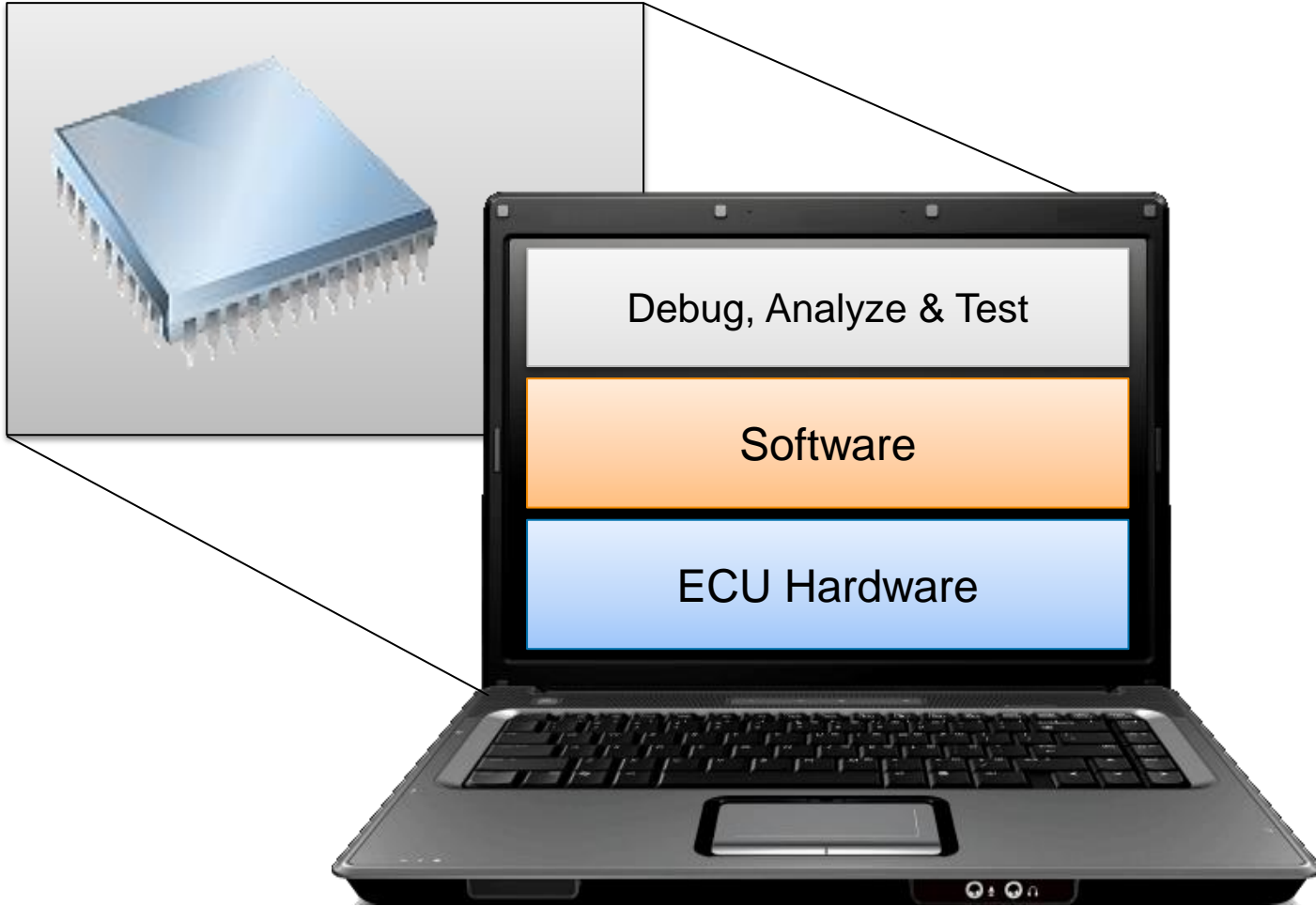
- Pre-silicon Dual OS (AUTOSAR & Linux) + Hypervisor bring up.
- Complex driver and communication
 - GTM, CAN, Ethernet communication, vision accelerators/sub-systems, ...
- Algorithm flow from Matlab/Simulink to embedded software

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

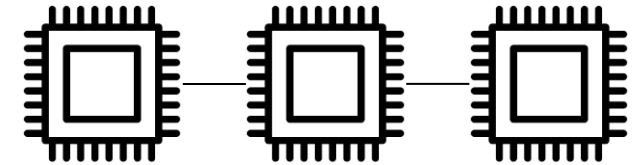


Moving to Virtual Hardware ECU

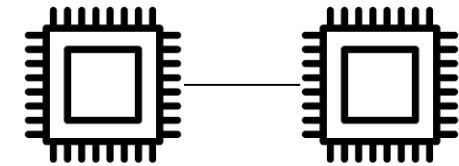
What is a Virtual Hardware ECU?



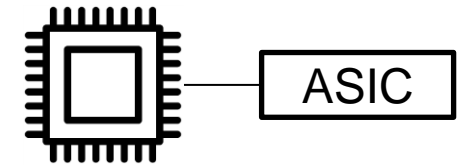
Fast model of the ECU Hardware with the benefits of virtual prototypes



Infotainment ECU



ADAS ECU



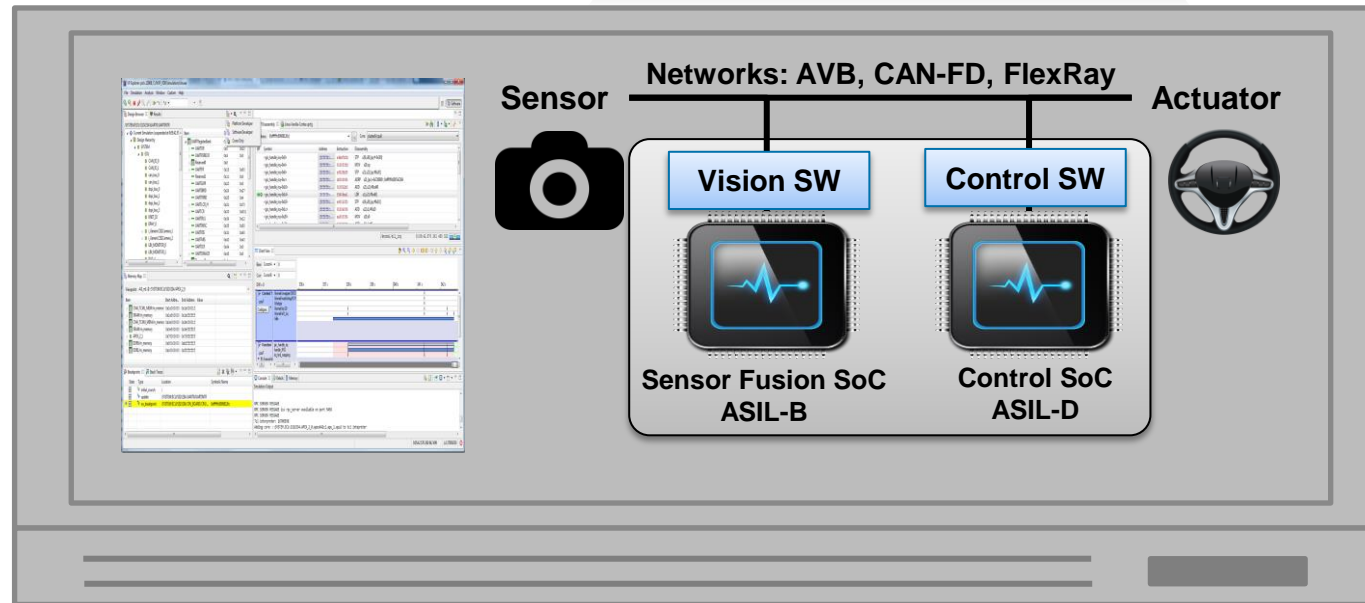
Powertrain ECU

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

Silicon
Availability

HW
Availability

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

Hardware-in-the-Loop

Development Gap



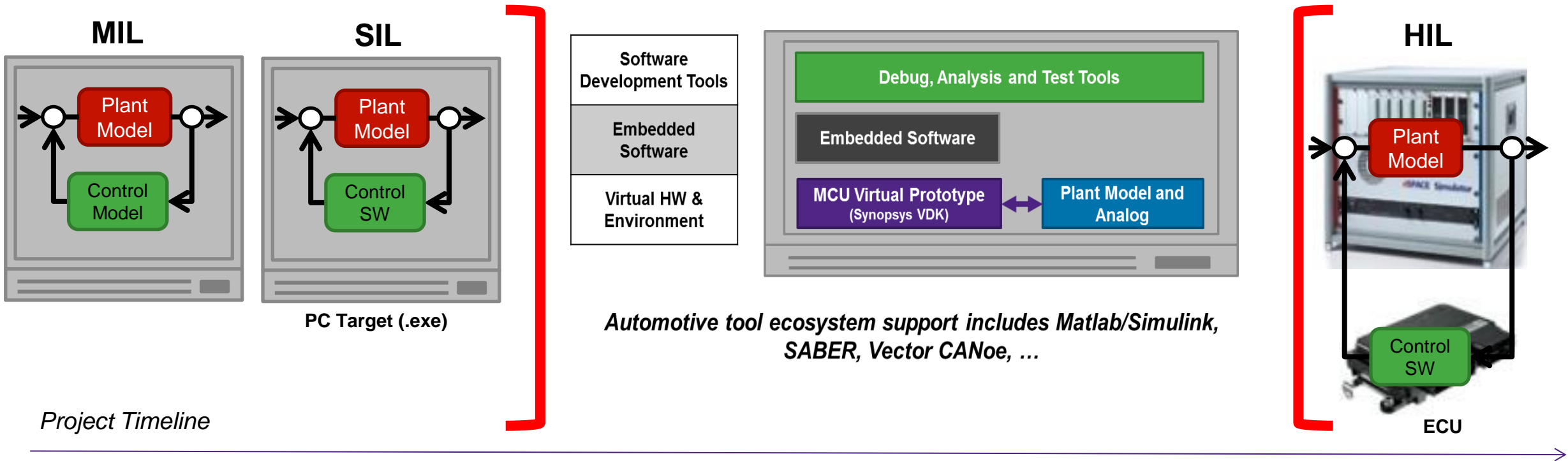
Project Timeline

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

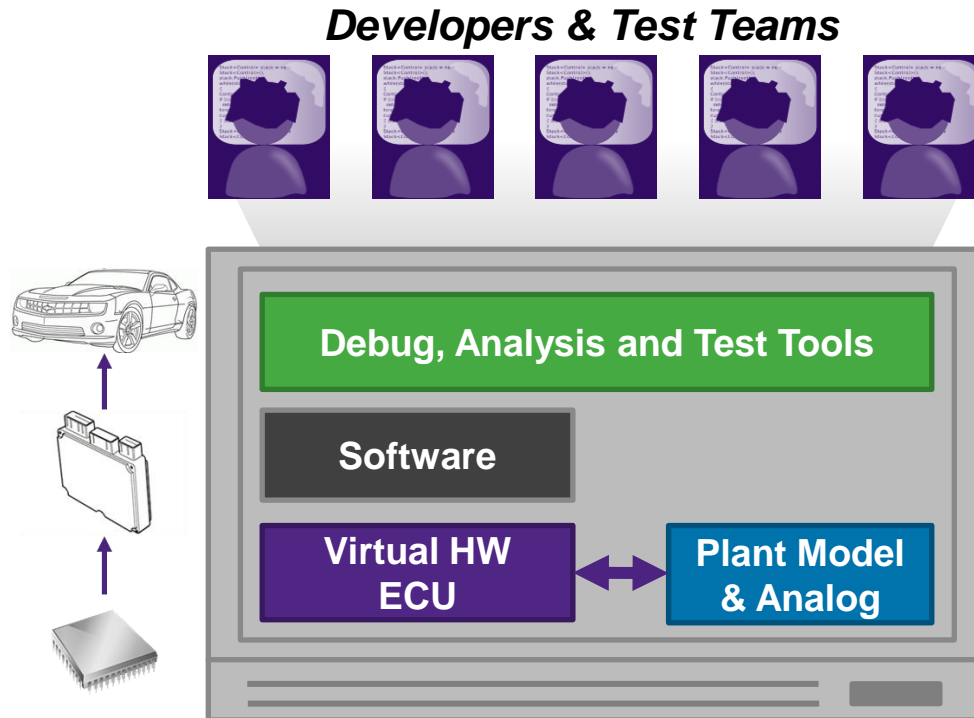


SW Development Early & Increased Testing Throughput

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

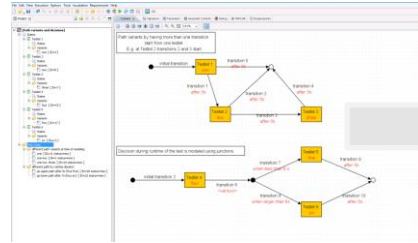
Establishing a vHIL Test Bench

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



Model-based Testing



Test Execution



ISO 26262

Test Case	Pass	Fail	Not Executed
TC_001	100%	0%	0%
TC_002	100%	0%	0%
TC_003	100%	0%	0%
TC_004	100%	0%	0%
TC_005	100%	0%	0%
TC_006	100%	0%	0%
TC_007	100%	0%	0%
TC_008	100%	0%	0%
TC_009	100%	0%	0%
TC_010	100%	0%	0%

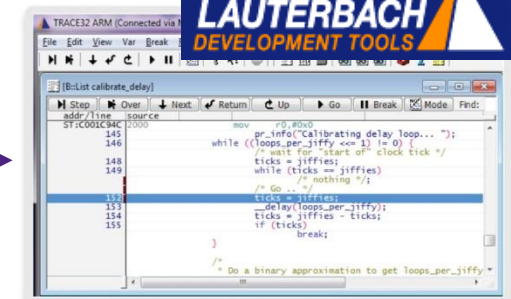
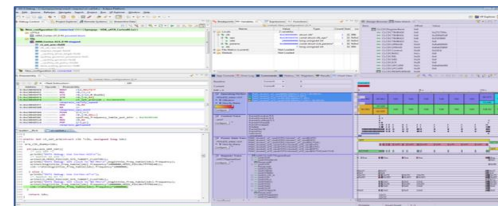
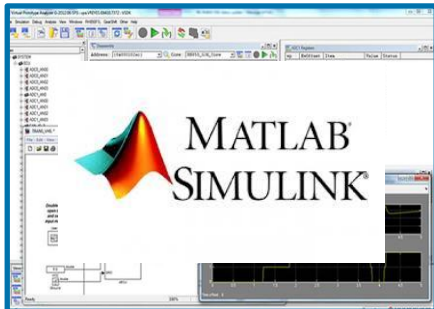
Testing
 ✓
 ✓
 ✗

Control Algorithm

Code Generation

Control Algorithm SW

AUTOSAR OS



Lauterbach Trace32
 Embedded Software Debugger

Engine model

Co-simulation

Synopsys VDK

Model-based Design

System under Test (SUT)

Support of ISO 26262

Testing Earlier and Faster – Evaluating Corner Cases

Inject fault
anywhere

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

Control & Analyze
better

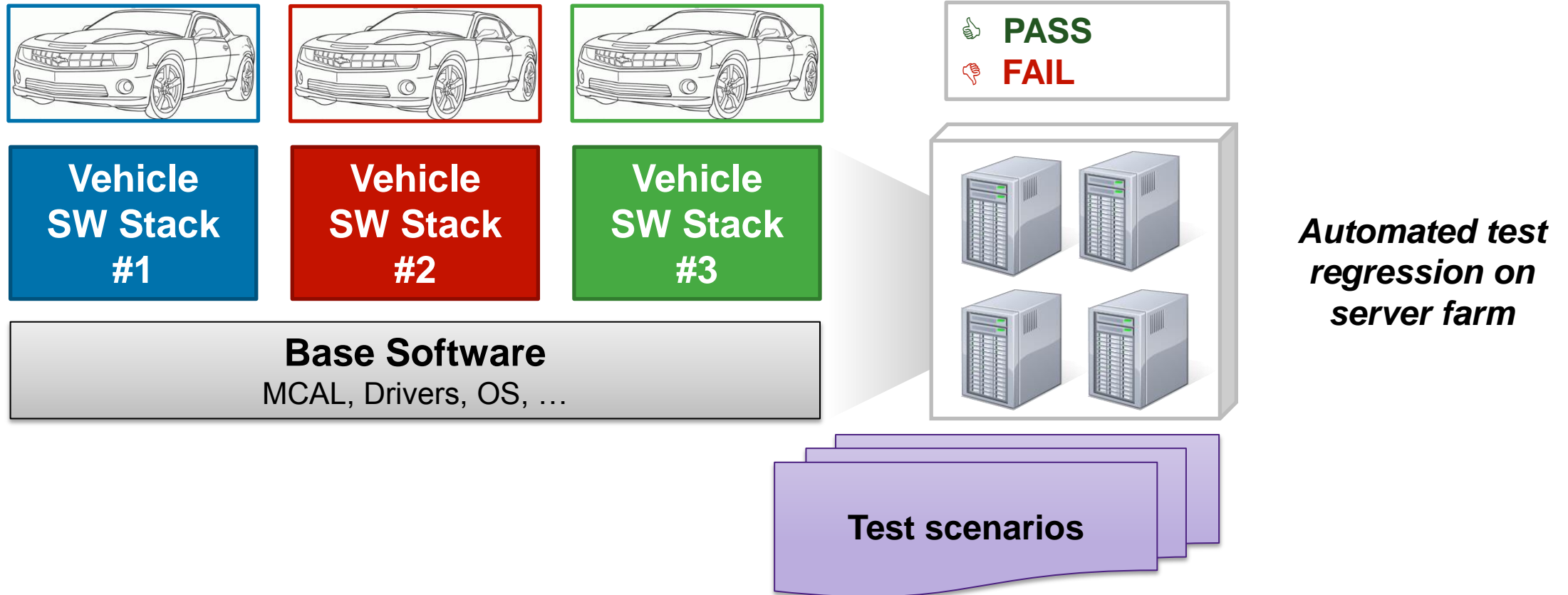
- Control triggered by SW, HW or time events
- Record and correlate all HW/SW events
- Non Intrusive

Repeat
deterministic

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

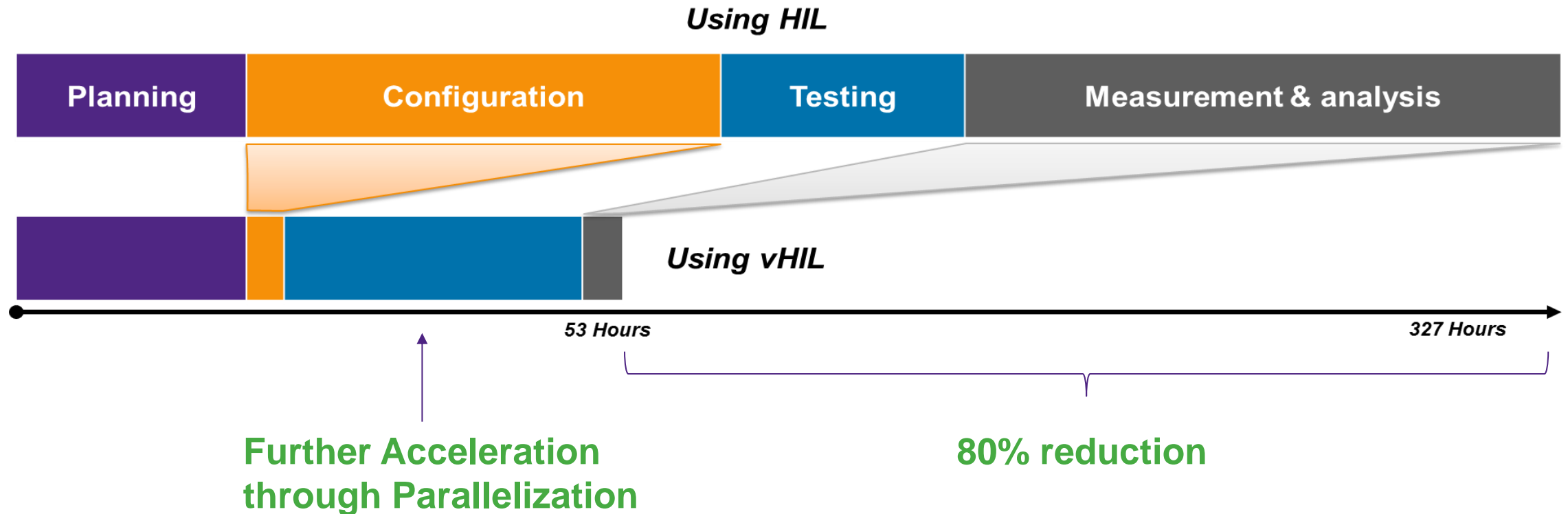
Accelerate Testing Productivity through Regression

Evaluate the Impact of Software Changes More Efficiently!

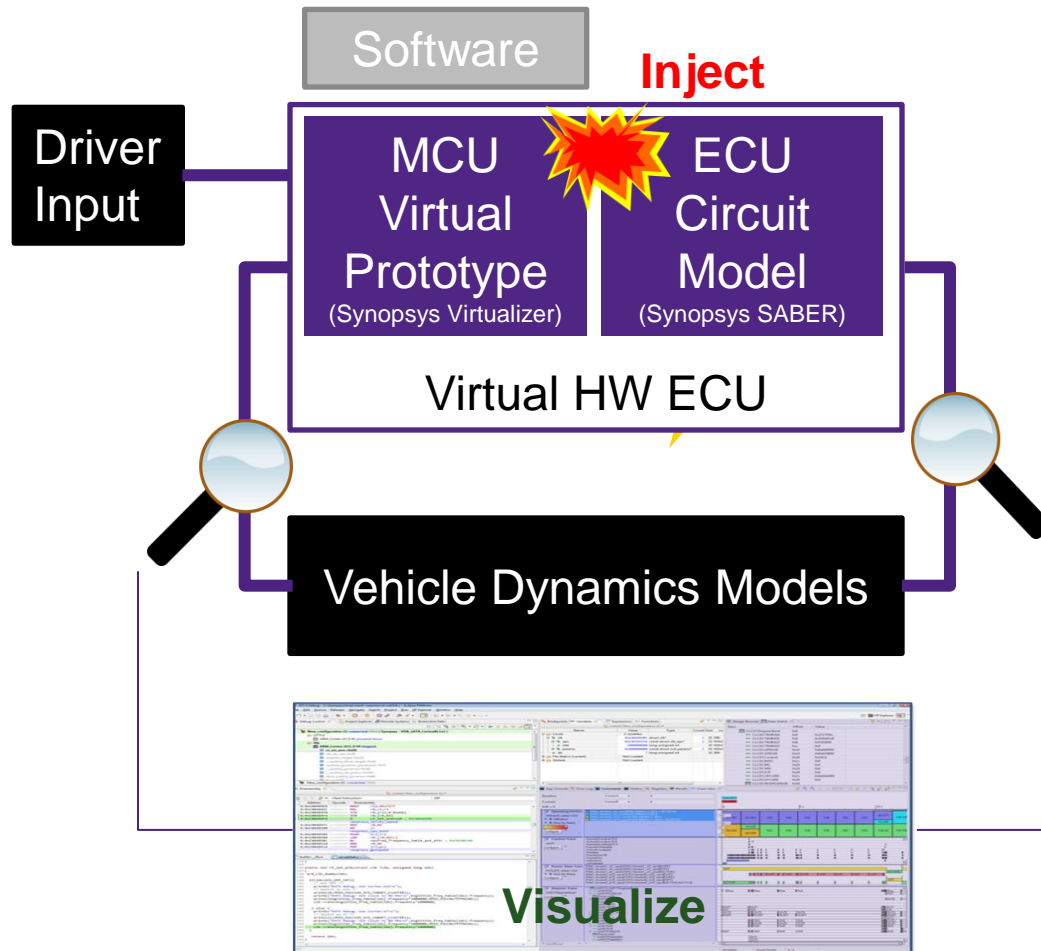


Significantly Increase Test Throughput

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



Application Example to vFMEA

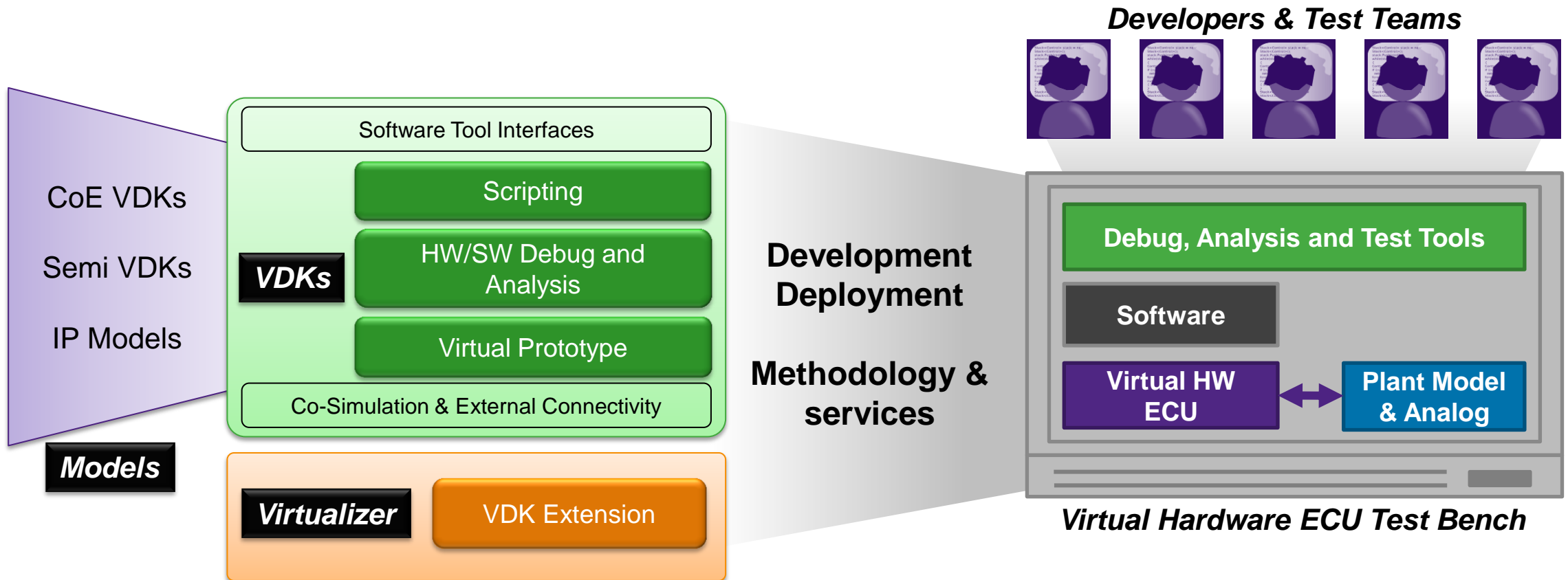


Actual Results

- 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

Automotive Centers of Excellence

Partnering with Tier 1 Automotive Semiconductors for Software Development

News Release
Synopsys Collaborates with Renesas to Advance Software Development Solutions for Automotive Applications
 Joint Engineering Team Overcomes Critical Problems to Speed Software-Defined and System Testing for Renesas' 800MHz Microcontroller-Based Design

MCUSTAR V200, Sept. 1, 2016 (pressroom.synopsys.com)

Highlights:

- Collaborative software development and system-level simulation "development-to-verify" workflow enables faster time-to-market, including the new 800MHz series
- Synopsys and Renesas combine system and hardware expertise to quickly implement high-performance safety-critical SoCs to accelerate for automotive
- High availability and fast time-to-market
- High availability and fast time-to-market

"The Virtual MCU Center of Excellence brings together the unique expertise of both companies to extend and optimize proven virtual prototyping technology for users of Renesas microcontrollers."



News Release
Synopsys Announces VDK for Freescale S32V200 MCU Family for Advanced Driver Assistance Systems Development
 Virtualization Development for Access Software Development, Integration and Test

MCUSTAR V200, Sept. 1, 2016 (pressroom.synopsys.com)

Highlights:

- Virtualization Development (VDK) enables early software development, integration and test for increased productivity, higher safety and virtual development cost
- New VDK provides the virtual prototype for the S32V200 MCU VDK software development tools and integration with automotive design tools enabling system-level testing using a virtual hardware-in-the-loop environment
- S32V200 virtual prototype development

"The VDK for Freescale S32V200, delivered through our Center of Excellence collaboration with Synopsys, helps our customers accelerate automotive system development and rapidly deliver high quality software to market."



News Release
Synopsys' Virtualizer Speeds Software Development and Enhances Design Enablement for Systems Based on the Infineon AURIX Microcontroller Family
 AURIX Virtual Prototypes Enable Automotive Software Developers to Meet 12-Month Release Window Availability

MCUSTAR V200, Sept. 1, 2016 (pressroom.synopsys.com)

Highlights:

- Synopsys' Virtualizer enabled rapid creation of virtual prototypes for AURIX family of multi-core automotive microcontrollers
- Infineon and AURIX virtual prototypes to improve the microcontroller abstraction layer and auto-user software tool chain
- AURIX virtual prototypes improved

"With access to virtual prototypes as part of the AURIX development tool suite, our customers can now rapidly integrate this technology into their current software development and testing processes"



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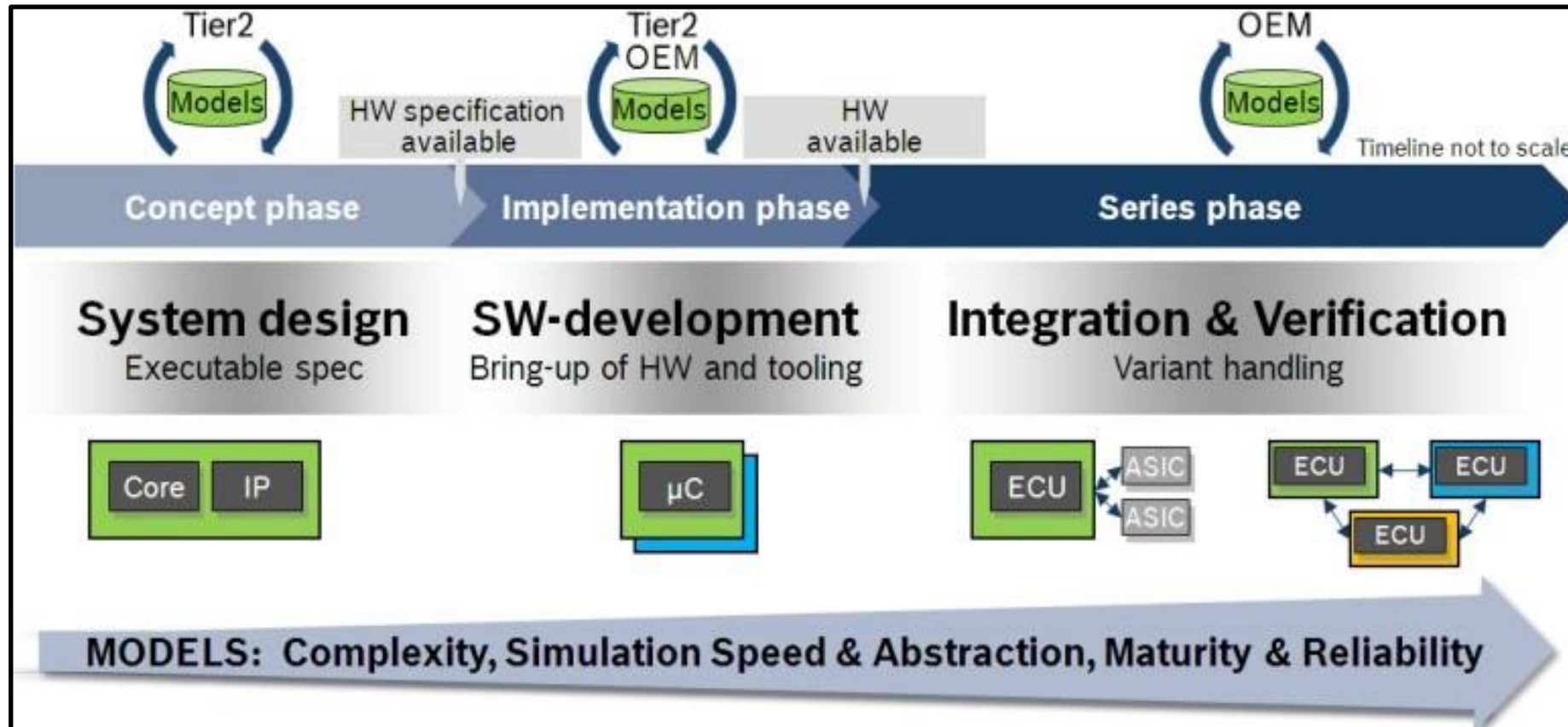
vector

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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>



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.”



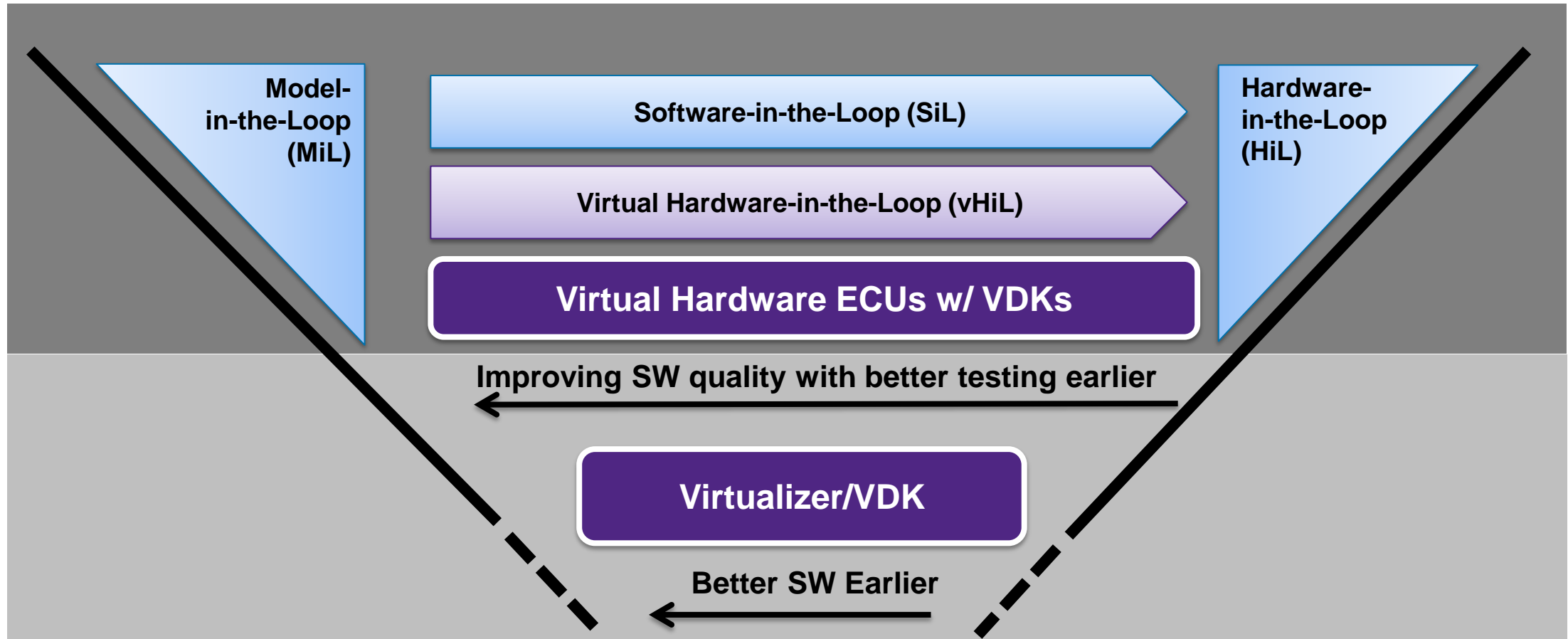
Over time we found that the use of virtual prototypes is not only applicable for the design and implementation of software, but for the **entire system-level testing and validation** of the product dependability.”



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[™]