GTM simulation and validation in PAVE360

23rd September 2022

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Company Update

Shift left …to ensure software maturity using digital models

PAVE360 OPEN Digital Twin Platform

Strategy… building trust through open collaboration

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Siemens Digital Industries Software

Siemens AG

Digital Industries   Smart Infrastructure   Mobility   Siemens Advanta   Portfolio Companies   Siemens Healthineers

#1 market position in industry

PAVE360 Multi-Division Team

Siemens Software   Motion Control   Process Automation   Customer Services   Factory Automation

Leader in digitalization, automation and electrification

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Siemens Software continues to expand its portfolio with huge investment to combine the real world with the virtual world

> 10 billion € investment

12,700 software engineers are shaping the digital transformation

Siemens EDA

ESTEQ

mx mendix

Mentor Graphics®

COMSA

LIGHTWORKS

timeseries

SAAB

ultraSoC

Virtual world
Software

POLARION

Bentley[1]
Advancing Infrastructure

tass International
A Siemens Business

Industrial software #1

IBS

LMS®

CD-adapco
www.cd-adapco.com

CAMSTAR

VISTAGY

Selection of acquisitions

innotec
innovation worldwide

UGS
The PLM Company

Real world
Automation

Automation #1

[1] Cooperation

2007

2021

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Shift left

To ensure software maturity using digital models

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'Shift Left'
Develop software on accurate digital twin before hardware is available

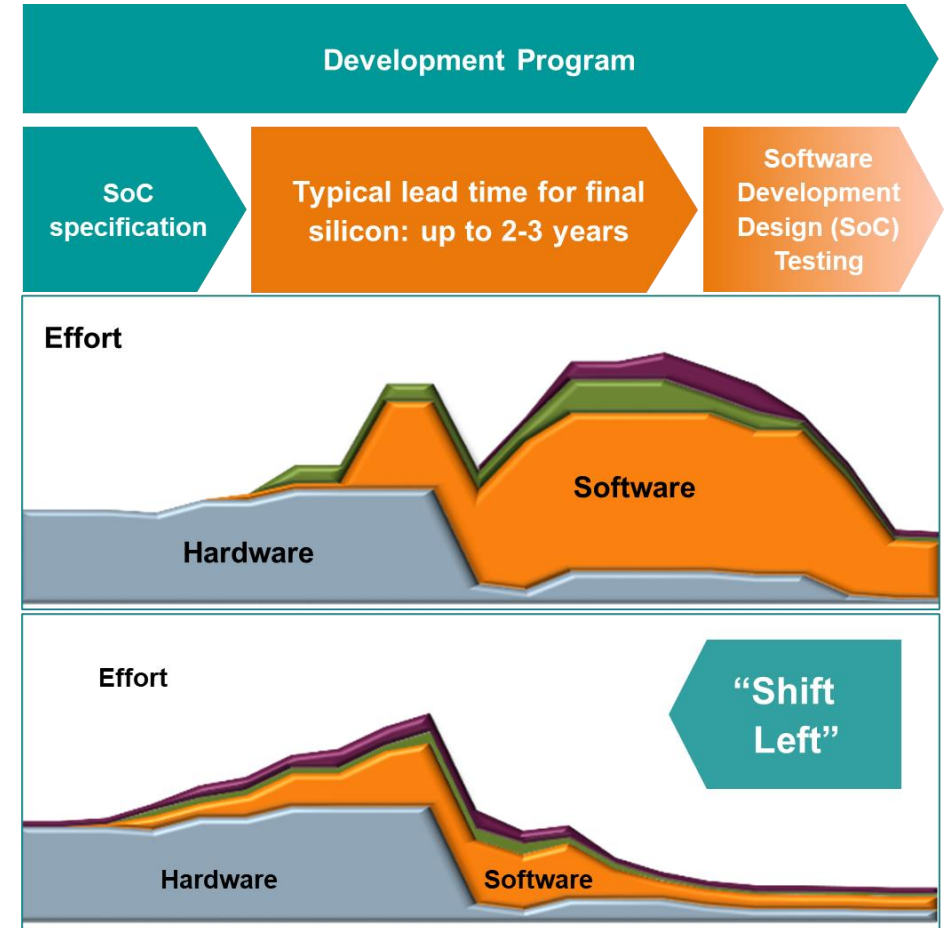**!** Waiting for silicon/boards delivery before starting SW development would be an expensive mistake

'Shift Left' and start early

Parallelize HW and SW development timelines and shift left for:
- Prototyping
- Workload characterization
- Development
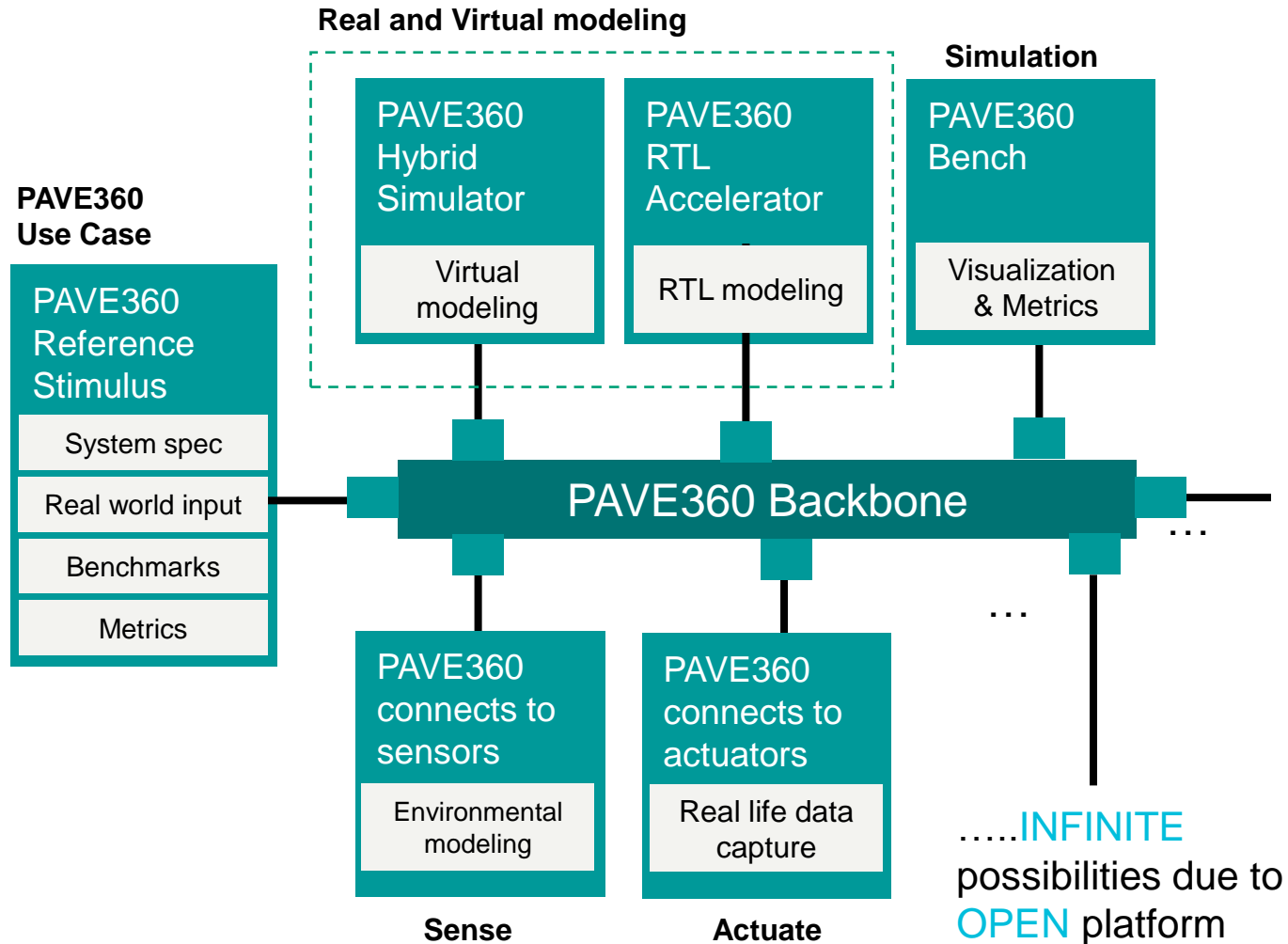- Verification
- Benchmarking
- Optimization

For a significant head start

- Provide development and test environment with models to SW team 12-18 months before the HW is available
- Results can be fed back to HW development, ironing out initial bugs and performance gaps, saving time and money

Development Program

| SoC specification | Typical lead time for final silicon: up to 2-3 years | Software Development Design (SoC) Testing |

Effort

Hardware

Software

Effort

Hardware

Software

"Shift Left"

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PAVE360 OPEN Digital Twin Platform
Backplane connects automotive systems to build system view

Real and Virtual modeling

Simulation

PAVE360 Use Case

PAVE360 Hybrid Simulator

Virtual modeling

PAVE360 RTL Accelerator

RTL modeling

PAVE360 Bench

Visualization & Metrics

PAVE360 Reference Stimulus

- System spec
- Real world input
- Benchmarks
- Metrics

PAVE360 Backbone

…

PAVE360 connects to sensors

Environmental modeling

PAVE360 connects to actuators

Real life data capture

…

…..INFINITE possibilities due to OPEN platform

Sense

Actuate

PAVE360 connects…

Automotive clients built on standards

- **Domains** – electrical and mechanical..
- **Systems** – ECU to ECU…
- **Protocols** - Ethernet, CAN, FMU/FMI…
- **Tools –** visualization, simulation tools….

In both real and virtual worlds

- Mix all levels of fidelity (virtual prototypes, RTL, actual hardware)
- Use real life scenarios and simulation data

At various stages of development

- By mixing fidelity in real-time, early virtual prototypes can interact seamlessly with final HW

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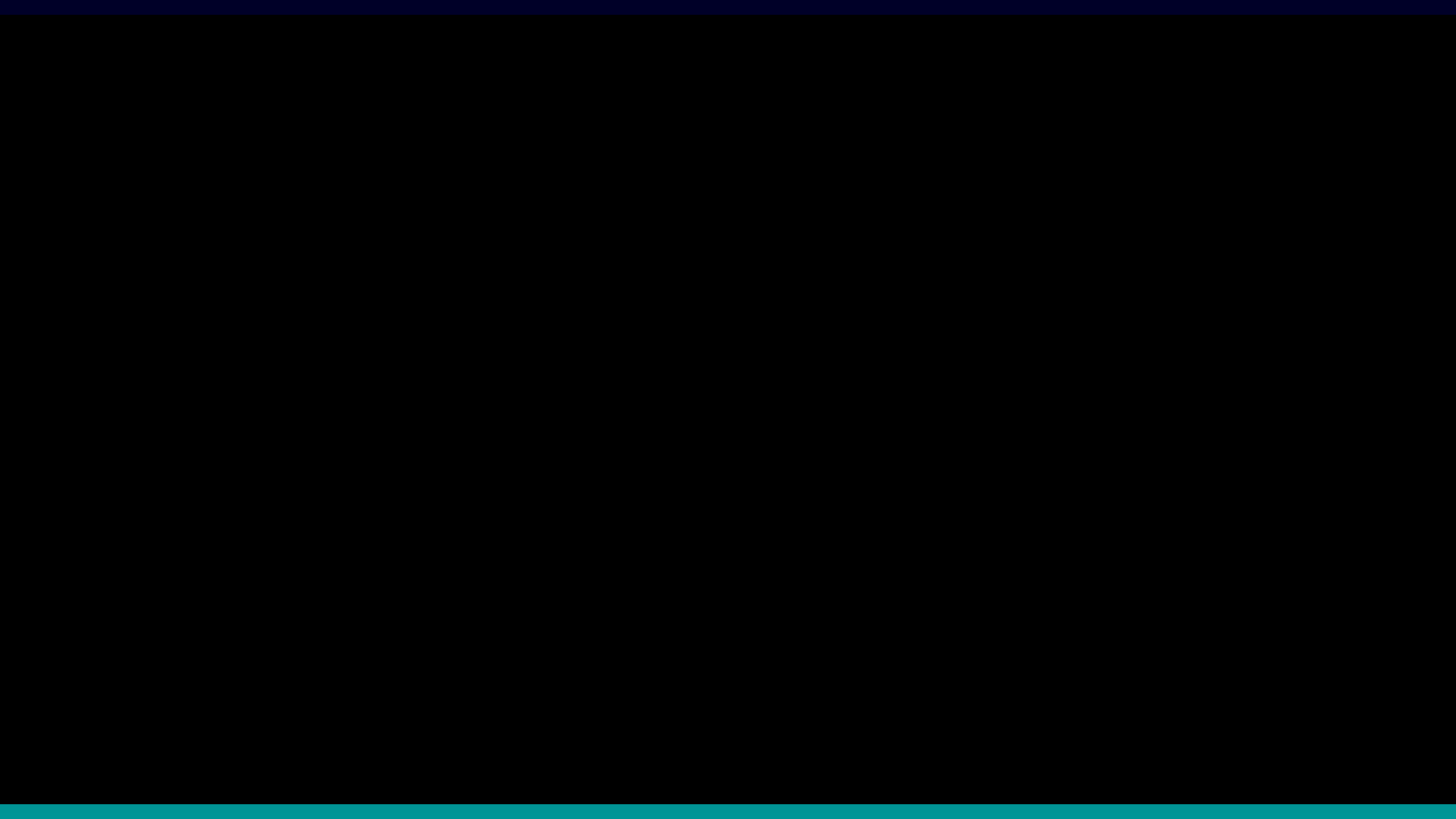
PAVE360 Focus: Modern Methodology for Complex Intelligent Systems

Automotive challenges

- Industry transformation from hardware to software dominance
- Supply chains are broken / entire ecosystems are being reworked
- Stringent safety & continuously changing cybersecurity requirements
- Competitive products force accelerated adoption of new technologies
- HW/SW maintenance is the key cost element of future vehicle platforms

Siemens Solution

- Comprehensive digital continuity concept for complete vehicle life-cycles
- Data-driven ecosystem re-definition and new business models
- Requirements based HW/SW co-design, prototyping and optimization
- Applied model-based systems engineering enabled via digital twins
- Holistic real cost optimized product design including services

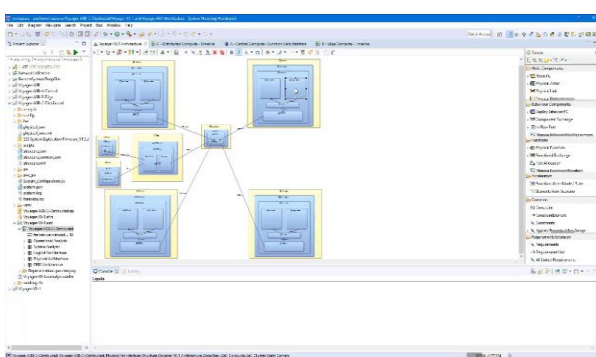## Software Architecture and Validation

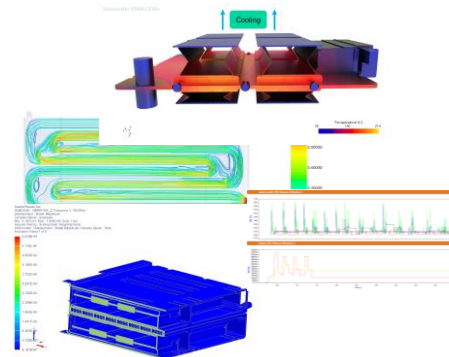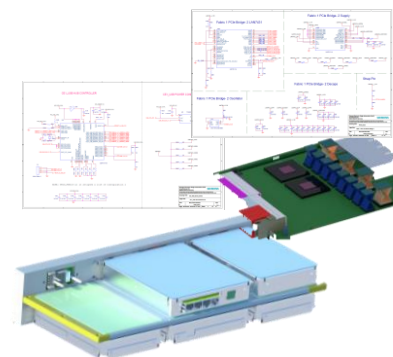Explore ➔ Model ➔ Verify ➔ Design Pre-release ➔ Prototype
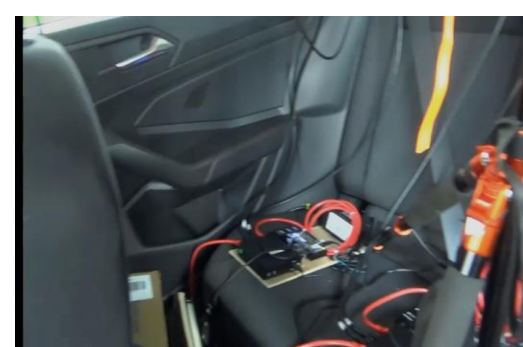

Early Architecture Exploration

Mixed Fidelity Digital Twin Platform

Digital and Physics-based Modeling and Simulation Tools
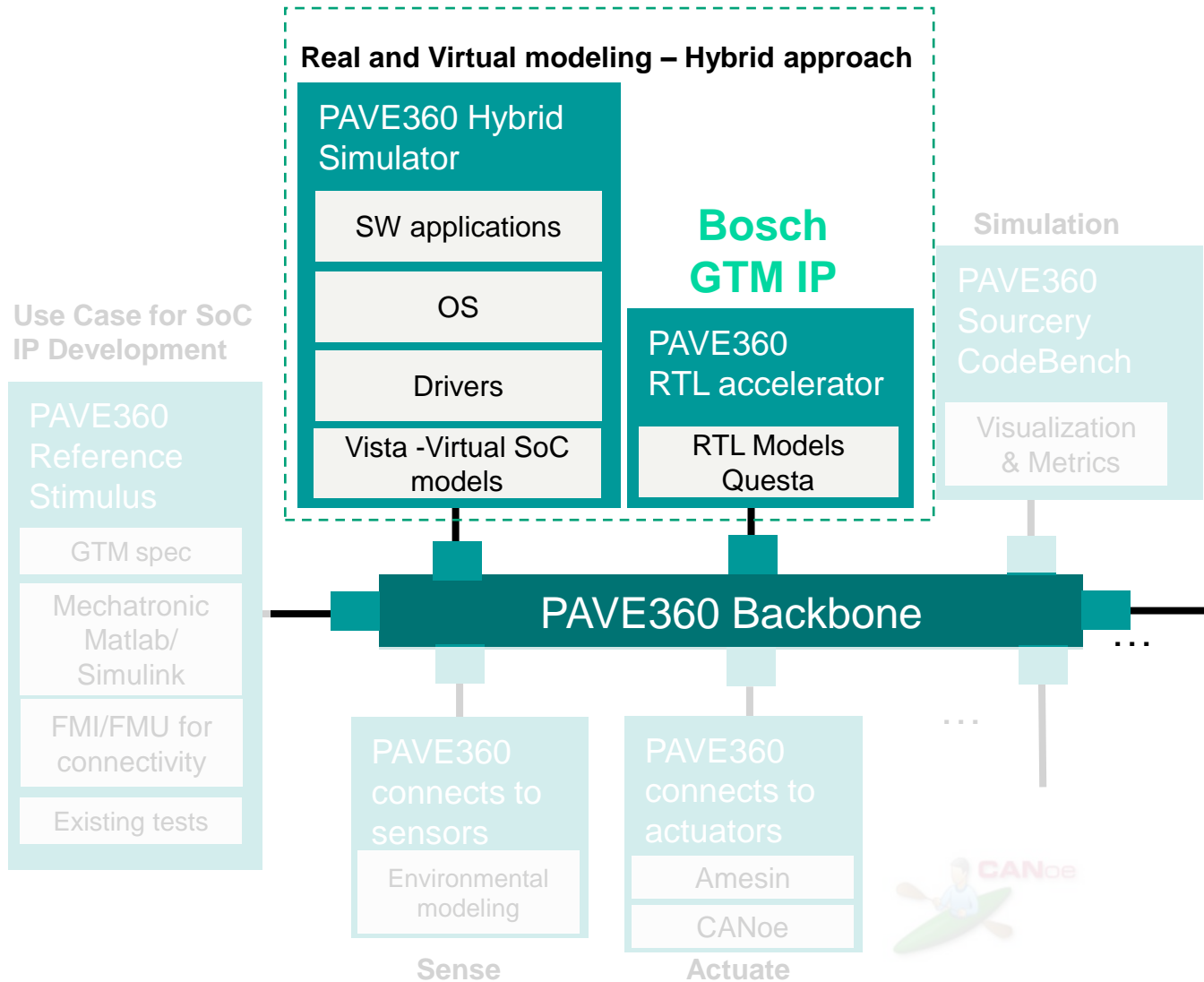
PCB and Enclosure Design Tools

Experienced Siemens Services

PAVE360 OPEN Digital Twin Platform

Connects Siemens EDA Tools, partner IP and partner tooling

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PAVE360 OPEN Digital Twin Platform
Hybrid approach to modeling, finding the right configuration for Bosch GTM

Real and Virtual modeling – Hybrid approach

PAVE360 Hybrid Simulator

SW applications

OS

Drivers

Vista -Virtual SoC models

Bosch GTM IP

PAVE360 RTL accelerator

RTL Models Questa

Simulation

PAVE360 Sourcery CodeBench

Visualization & Metrics

Use Case for SoC IP Development

PAVE360 Reference Stimulus

GTM spec

Mechatronic Matlab/ Simulink

FMI/FMU for connectivity

Existing tests

PAVE360 Backbone

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PAVE360 connects to sensors

Environmental modeling

Sense

PAVE360 connects to actuators

Amesin

CANoe

Actuate

...

Real and Virtual modeling
Mixed fidelity Hybrid approach

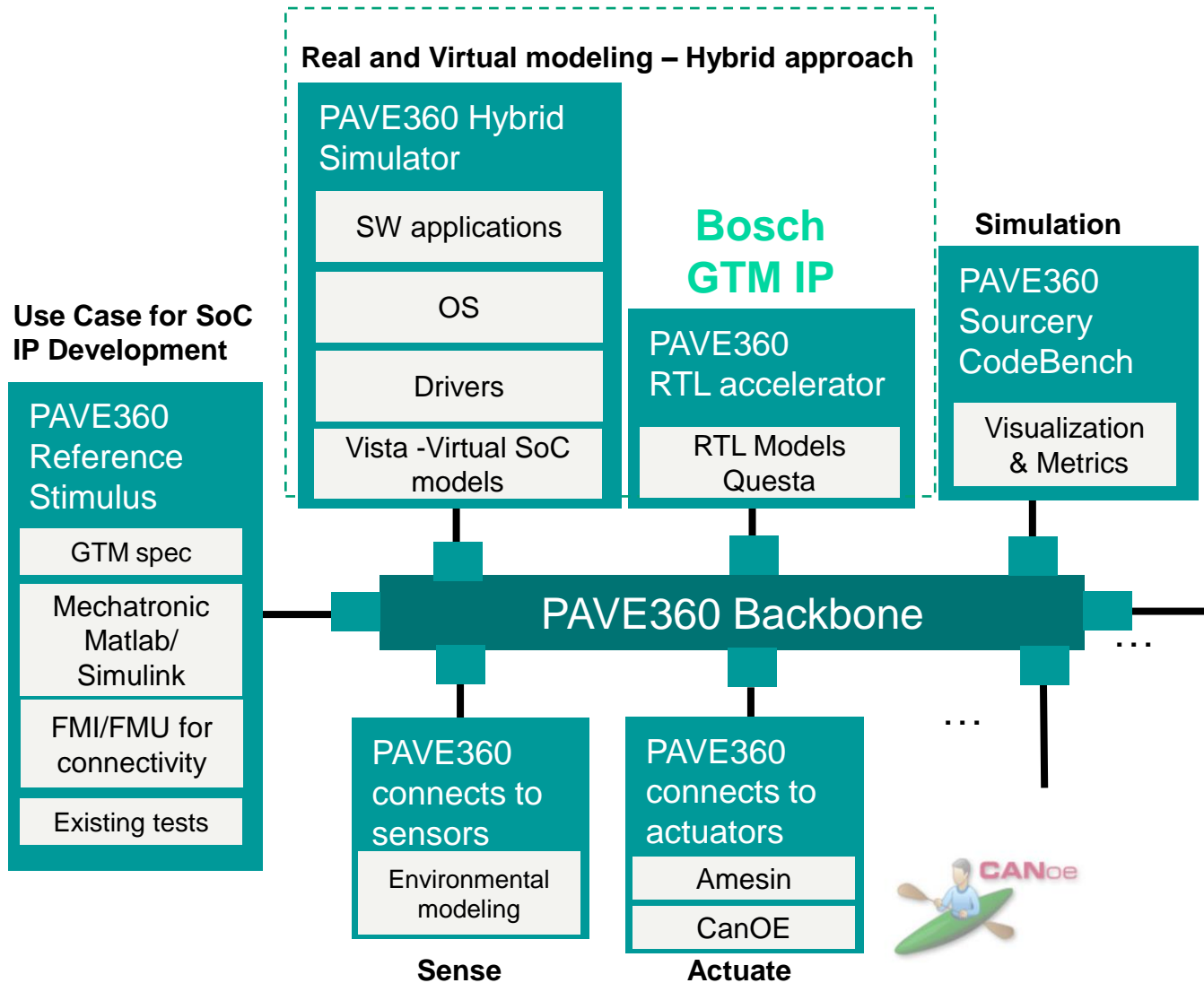Bosch GTM IP was simulated and validated using the following modeling regions:

- Vista to create TLM models for fast analysis
- Questa for RTL IP models for HW verification
- Digital twins from various sources
- The regions can be individually modified, but collectively stress the system

It's adaptable

Each region provides a complete, executing environment, that allows software to execute early, with the flexibility to quickly change the architecture and hardware components

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PAVE360 OPEN Digital Twin Platform
Full Bosch GTM IP modeling configuration

Real and Virtual modeling – Hybrid approach

PAVE360 Hybrid Simulator

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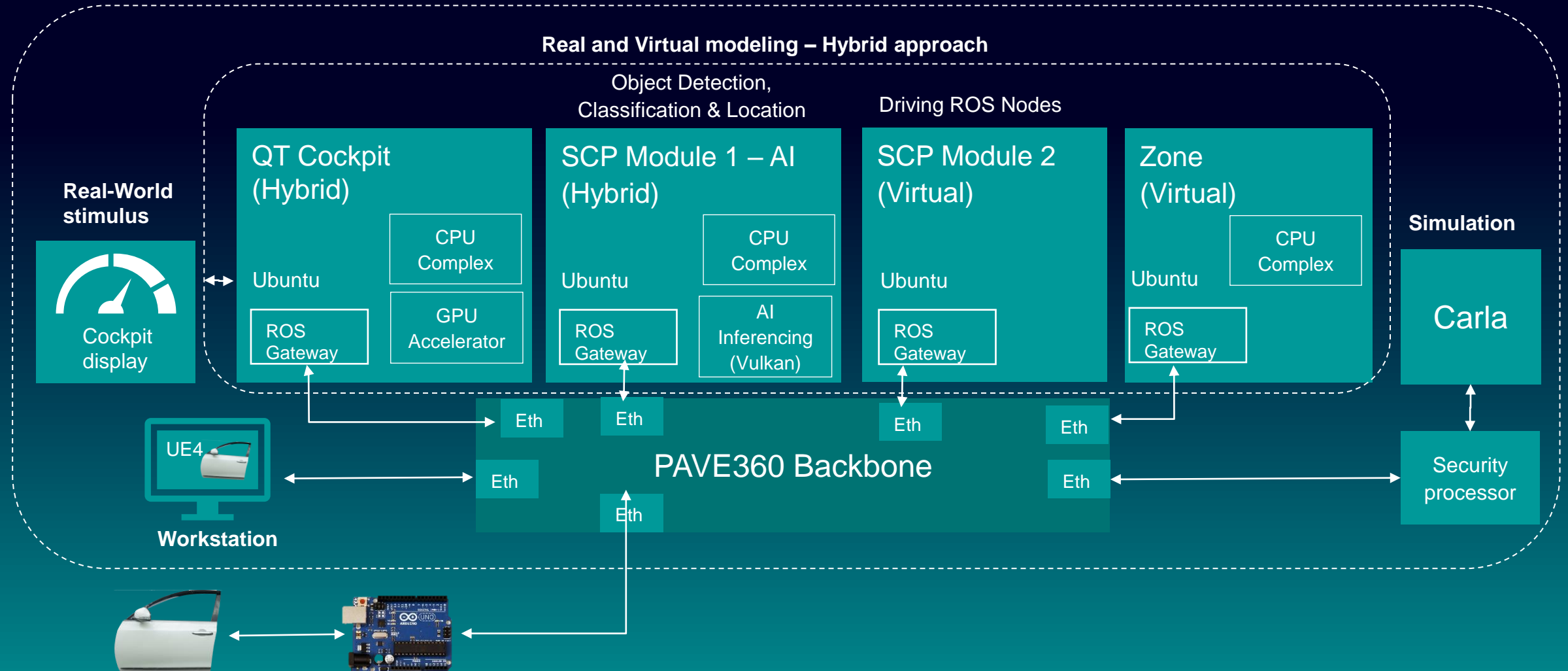**Bosch GTM IP in RTL was simulated and verified in various SoCs:**

- Virtual and RTL models were sourced from various vendors including as NXP S250, AURIX™ TC3x, SnapDragon, N78
- PAVE360 Use Case for SoC IP Development was selected
- Actuation via Amesin together with Canoe
- Real world stimulus from existing tests and mechatronic MATLAB/Simulink
- Simulation results available in Sourcery CodeBench

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PAVE360 Reference Digital Twin Platform - Zone Control example
Mixing fidelity and mixing domains for system level view

PAVE360 Reference Platform

Real and Virtual modeling – Hybrid approach

Object Detection, Classification & Location

Driving ROS Nodes

Real-World stimulus

Cockpit display

QT Cockpit (Hybrid)

Ubuntu

ROS Gateway

CPU Complex

GPU Accelerator

SCP Module 1 – AI (Hybrid)

Ubuntu

ROS Gateway

CPU Complex

AI Inferencing (Vulkan)

SCP Module 2 (Virtual)

Ubuntu

ROS Gateway

Zone (Virtual)

Ubuntu

ROS Gateway

CPU Complex

Simulation

Carla

Eth

Eth

Eth

Eth

Eth

Eth

Eth

PAVE360 Backbone

UE4

Workstation

Security processor

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Strategy

Focus on high-compute, next-generation automotive platforms

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Why trust Siemens PAVE360 to configure and host your high-compute, next-generation automotive reference platform

PAVE360 accesses Siemens Xcelerator

Xcelerator brings together and integrates the entire Siemens Digital Industries Software portfolio

PAVE360 Open Digital Twin platform approach

- Start with what you have today, with industries first truly open platform
- Seamlessly connects mixed fidelity domains, protocols, systems and tools from multiple vendors
- Siemens partnerships with key IP & Modeling Vendors provides fast access to get started quickly

Automotive IC experience for high quality support

- Let us help you with….
    - IC design, Virtual and Hybrid Modeling, Physical Prototyping, Functional Safety, Security and much more!

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Conclusion

OEM & Tier-1 needs to orchestrate one stop shop for digital twin

Shift left .. We all talk, we need open platforms and not closed on

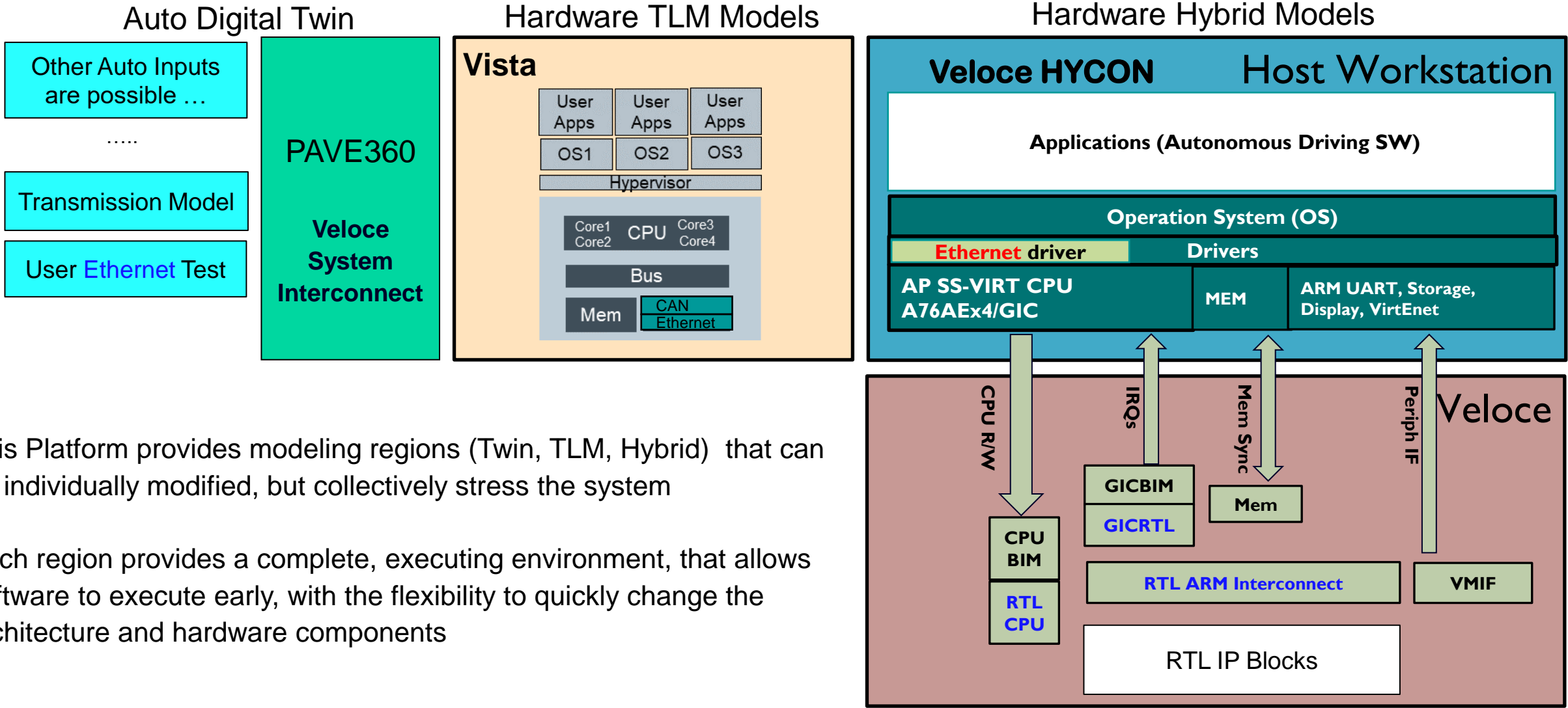**PAVE360 OPEN Digital Twin Platform was used for GTM verification**

Strategy… building trust through open collaboration and reuse

Thank You

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PAVE 360 from Siemens - Automotive Autonomous Vehicle Verification Enviornment

This Platform provides modeling regions (Twin, TLM, Hybrid) that can be individually modified, but collectively stress the system

Each region provides a complete, executing environment, that allows software to execute early, with the flexibility to quickly change the architecture and hardware components
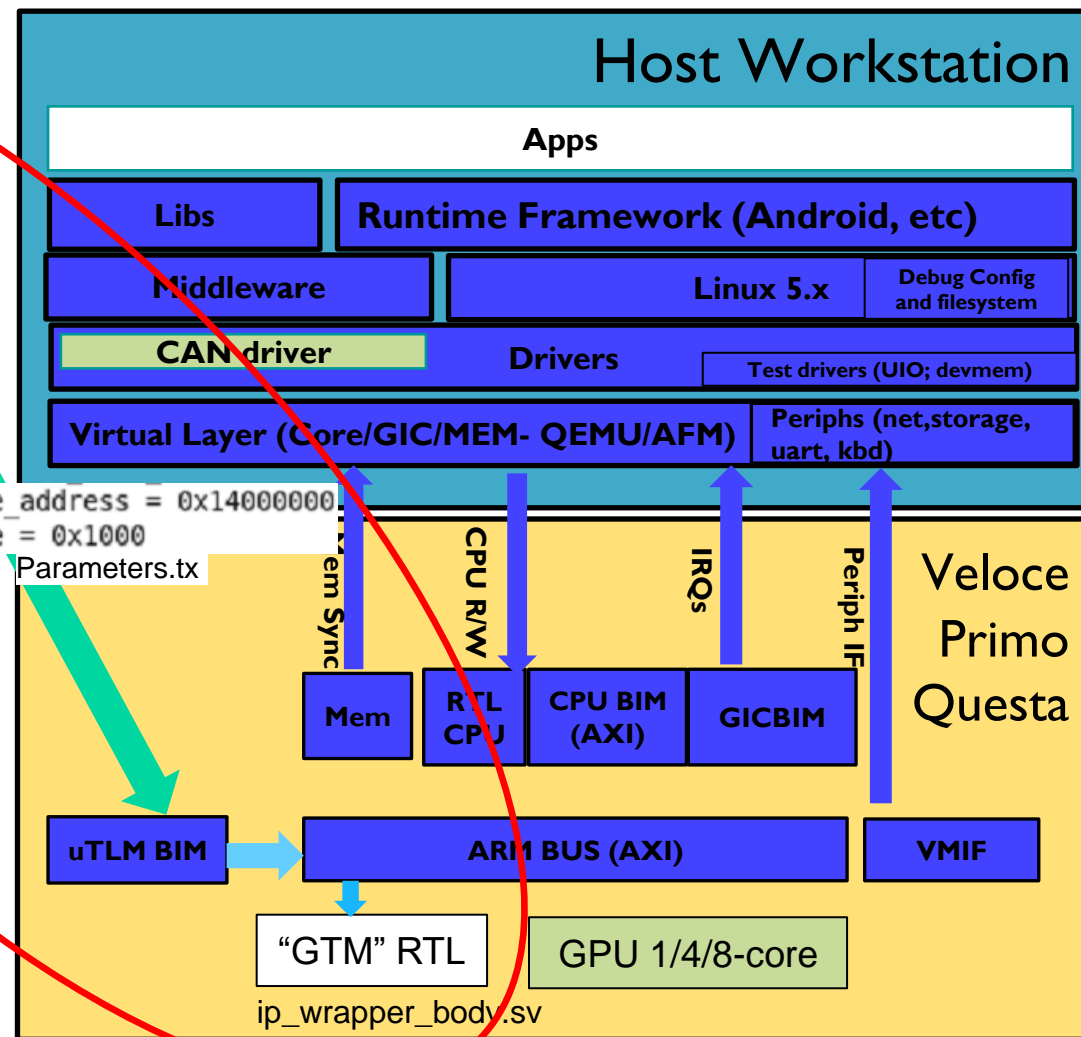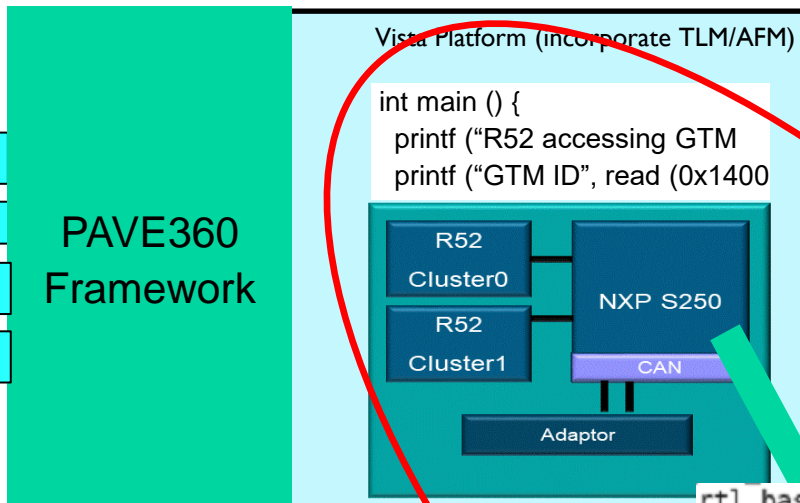
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VE360 VP <-> RTL Demo

PAVE (Digital Twin)   **Vista (custom TLM Models)**   **HYCON Platform (CPU sub-system + RTL)**

Matlab/Simulink

Canoe

Direct Inputs

Existing Tests

PAVE360 Framework

Vista Platform (incorporate TLM/AFM)

```
int main () {
    printf ("R52 accessing GTM
    printf ("GTM ID", read (0x1400
```

R52 Cluster0

R52 Cluster1

NXP S250

CAN

Adaptor

```
rtl_base_address = 0x14000000
rtl_size = 0x1000
```
Parameters.tx

Host Workstation

Apps

Libs

Runtime Framework (Android, etc)

Middleware

Linux 5.x

Debug Config and filesystem

CAN driver

Drivers

Test drivers (UIO; devmem)

Virtual Layer (Core/GIC/MEM- QEMU/AFM)

Periphs (net,storage, uart, kbd)

Customers can interact with RTL peripherals at anytime:
- S250 writes to a peripheral
- Vista Platform sends the write, via mem-map, to RTL.
- RTL **uTLM** accepts the write and forwards to IP.
- IP responds.

IP can be changed modified, via ip_wrapper_body.sv file.
VP can change parameters.txt file, to adjust where writes go.

Mem Sync

CPU R/W

IRQs

Periph IF

Veloce Primo Questa

Mem

RTL CPU

CPU BIM (AXI)

GICBIM

uTLM BIM

ARM BUS (AXI)

VMIF

"GTM" RTL

GPU 1/4/8-core

ip_wrapper_body.sv