AURIX™ TC4x Overview Non-NDA

ATV MC

Infineon's MCU Portfolio

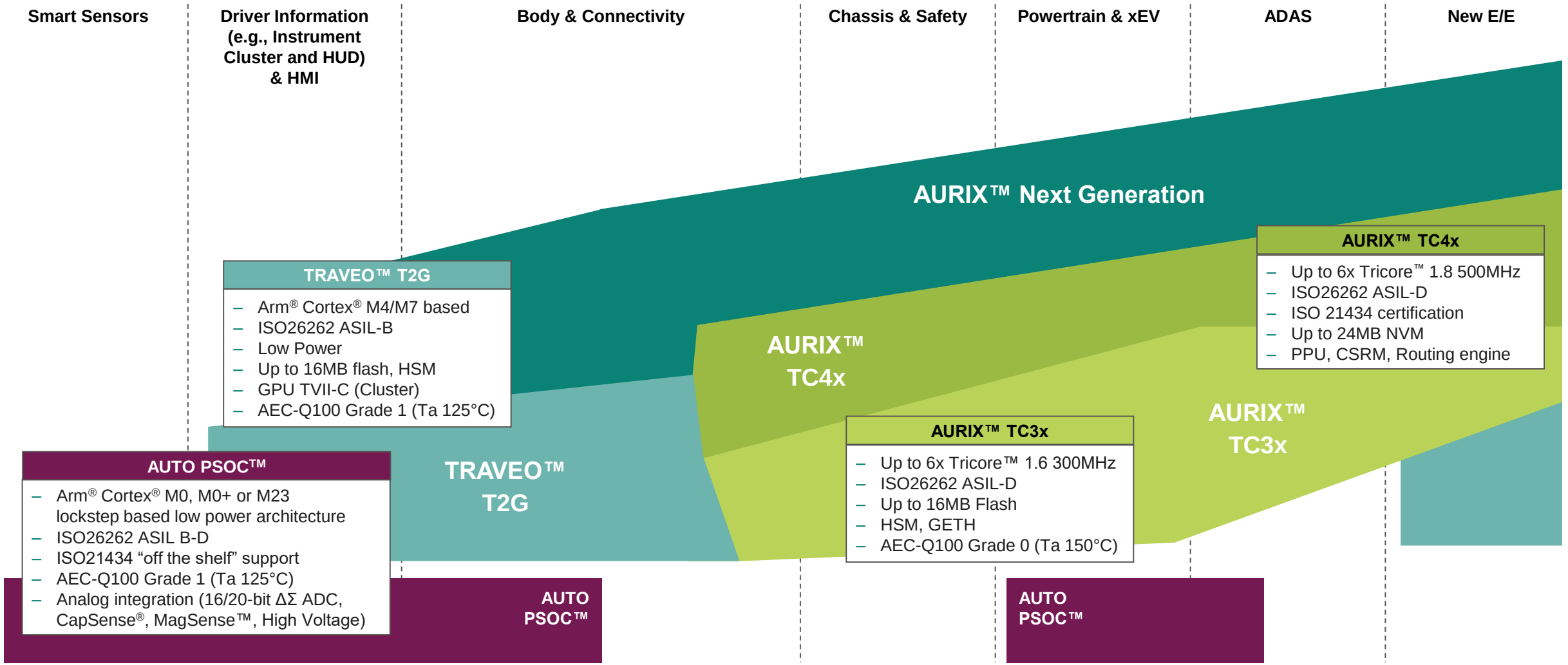
Automotive

Industrial

Consumer

8-bit/SoC	32-bit Arm® Cortex®-M0/M0+	32-bit Arm® Cortex®-M3	32-bit Arm® Cortex®-M4	32-bit Arm® Cortex®-M7	32-bit TriCore™
PSOC™ Multitouch MCU integrated Touch Controller SoC Touchscreen, Slider, Touchpad Wet-finger tracking	**Auto PSOC™** Cortex M0+ ASIL-B Up to 384kB Flash CapSense / Magsense	**MOTIX™** Cortex M0/M3 ASIL-B Up to 256kB Flash Motor Control SoC		**TRAVEO™ T2G** Dual Cortex M4 / M7 ASIL-B Up to 16MB Flash HSM, GPU (Cluster)	**AURIX™ TC4x** Up to 6x Tricore ASIL-D Up to 24MB NVM PPU,CSRM,Lockstep,PCIe,RE
PSOC™ Fingerprint MCU integrated Touch Controller SoC Capacitive fingerprint solution Support multi surface usage solution	**Auto PSOC™ HV** Cortex M0+ ASIL-C Up to 384kB Flash Up to 42V tolerant MCU				**AURIX™ TC3x** Up to 6x Tricore ASIL-D Up to 16MB Flash HSM,GETH,Lockstep,CAN FD
	XMC1000 • CPU up to 48MHz and 200KB Flash • CORDIC Math co-processor • CCU8 timer	**FM3** • CPU up to 144MHz and 1MB Flash • Basic Motor Control	**XMC4000** • CPU up to 144 MHz and 2MB Flash • Motor and power control	**XMC7000** • Dual Cortex®-M7 and M0+ • Up to 350 MHz and 8MB Flash • Motor and power control	**AURIX™ TC2x** Up to 3x Tricore ASIL-D Up to 8MB Flash HSM,ETH,Lockstep,CAN FD
			FM4 • CPU up to 200MHz and 2MB Flash • High Performance Motor Control		
PSOC™ 3 • CPU up to 67 MHz and 64 KB Flash • High performance analog • Programmable logic integration	**PSOC™ 4** • CPU up to 48MHz and 384KB Flash • Industry leading CAPSENSE™ and mixed signal functionality	**PSOC™ 5** • CPU up to 80MHz and 256KB Flash • High-precision analog • Programmable logic integration	**PSOC™ 6** • Dual Cortex®-M4 and M0+, up to 150 MHz and 2MB Flash • Ultra-low-power with hardware based security		
PSOC™ 1 • CPU up to 24Mhz and 32KB Flash • CAPSENSE™ and application specific mixed signal functionality	**FM0+** • CPU up to 40MHz and 128KB Flash • Entry level USB				

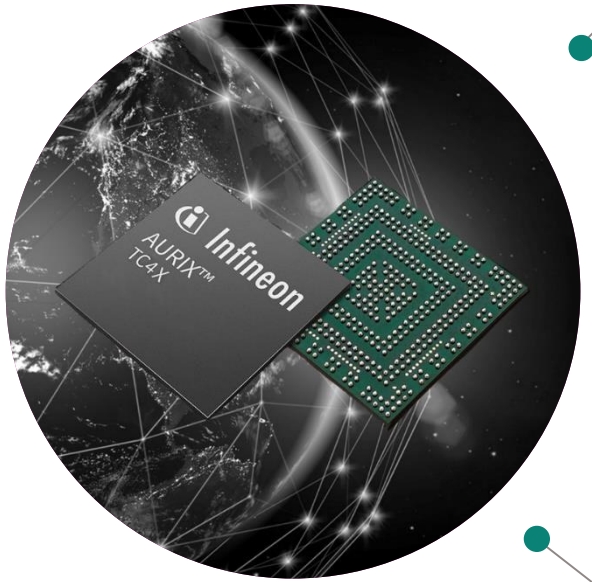
PSOC™, TRAVEO™ & AURIX™ Family Overview
Successfully covering the entire range of auto applications



What does the future car need?

Headroom to grow	– OEMs and Tier 1's need performance headroom to build the smart car of the future
High Performance with AI	– More performance needed for highly efficient e-mobility and autonomous driving – AI is further enabling this transformation
New E/E architecture	– The E/E architecture is changing to reduce complexity – Resulting in adoption of zone-based architectures
Fully connected and secured	– The future car is fully connected, always online and therefore needs outstanding communication and security features
Fast Time to Market	– Technology is changing fast, the market must respond faster than ever before, while R&D resources are limited

The AURIX™ TC4x meets these future needs and more, providing the industries most extensive major upgrade path for auto MCUs



Whilst ensuring **dependability**

Headroom to grow

- Feature rich to offer applications headroom to grow
- Scalable family HW and SW concept for platform reuse

High Performance with AI

- More processing power from TriCore™v1.8 with virtualization support and new AURIX™ Accelerator Suite
- Parallel Processing Unit (PPU) for affordable AI

New E/E architecture

- Optimized devices for Zone and Domain control,
- Optimized devices for complex sensor and actuator control

Fully connected and secured

- Enhanced connectivity, new high-speed interfaces
- Data Routing Engine for efficient communication
- Cutting edge security features to protect with future post quantum cryptography → ISO/SAE 21434 certified

Fast Time to Market

- Seamless "Ease of Use" tool chain and software offering
- Model based design for reduced R&D effort
- Early development support based on virtual prototyping

AURIX™ TC4x

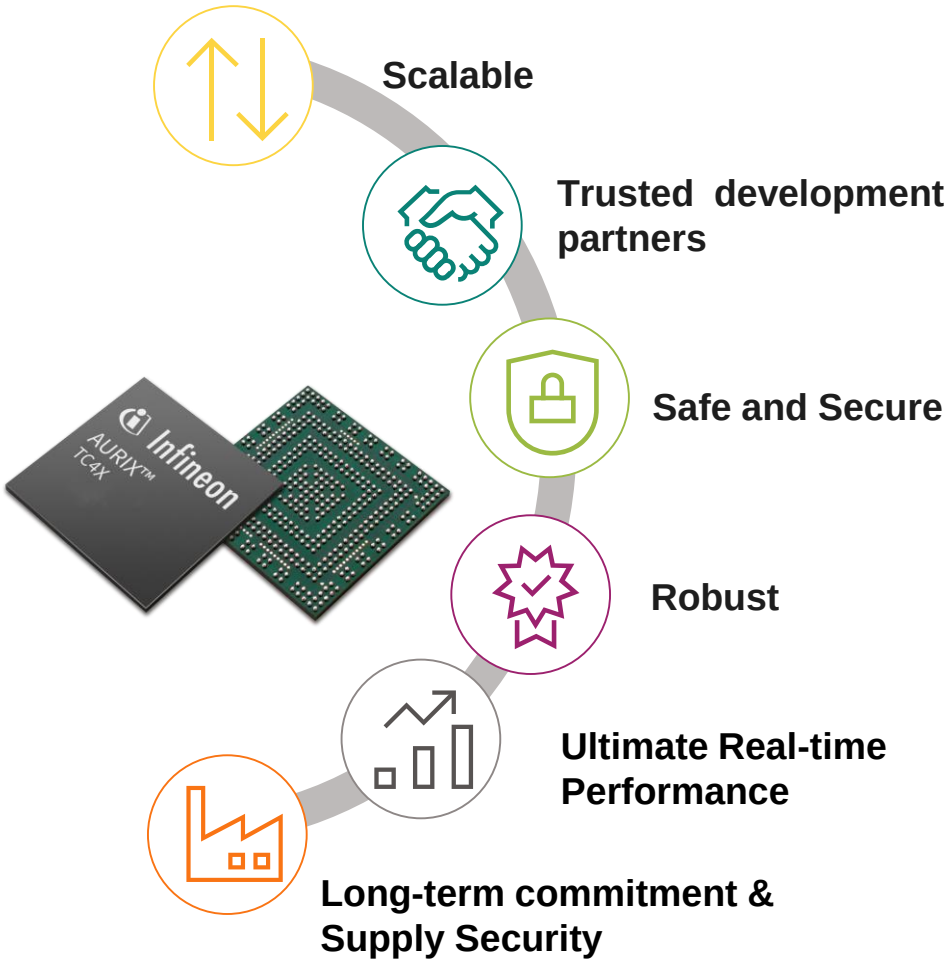
The start of a new era…

Automotive market is facing two simultaneous, fast paced, paradigm shifts:

- **E/E architecture innovation has brought new requirements to microcontrollers**
  - More ASIL-D performance
  - Increased security & connectivity
  - New SW development methods

- **Trend toward Electrification further accelerates**
  - Emissions legislations towards Zero Emission
  - Major OEM with clear focus on Battery Electric Vehicle
  - Hybrid vehicles are also in focus.

AURIX™ “Dependability” a long-term value proposition
More than 1 billion TriCore™ shipped at benchmarking quality



- **Best in class AURIX™ family concept** further improved and continued with the AURIX TC4x family
- Dependability is **more than a set of technical features** and system properties
- Robustness of an architecture has a strong **fundament in product and engineering quality**
- Constant **innovation in safety and security technologies** is important for highly dependable MCU families
- **Technical and commercial scalability** is a key advantage in dynamic markets
- Continuous quality improvement to **0.22 ppm in 2022**

We are innovating 28 nm Automotive together with TSMC
Introduction of RRAM-NVM based on 10 years of experience

- We are **safeguarding capacity in 28nm** by partnering on next generation NVM technology with the leading foundry TSMC
- AURIX™ TC4x is the **first product family in Automotive** to integrate **RRAM-NVM**
- RRAM-NVM is **less complex than eFlash**, uses same SW interfaces with identical functional behavior and doesn't need to be refreshed
- This innovation paves our way to **future shrinks** in µC

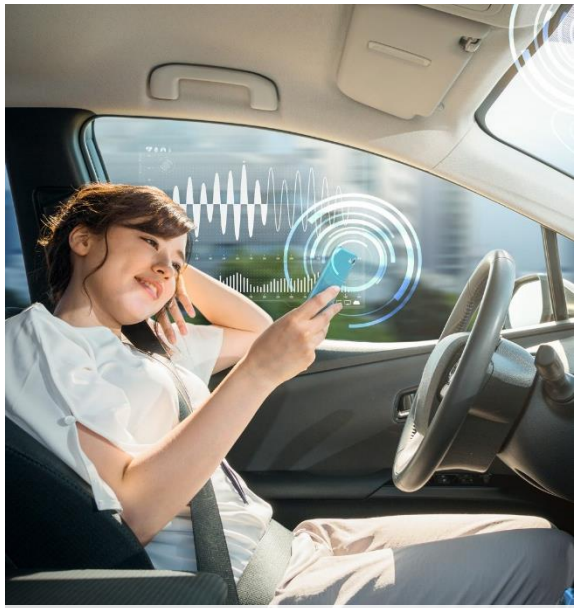
AURIX™ TC4x comprehensive portfolio tailored serving major market trends in our focus applications

Electrification

- Inverter
- Power Conversion
- Battery Management System

Zone Controllers & ADAS

- Next generation zone controllers in Domain
- Companion MCUs for Central car computer



Radar

- Radar cascading

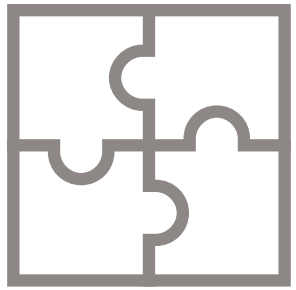
VMO / Chassis

- Vehicle Motion Domain Controller
- Braking / Steering

AURIX™ TC3x to TC4x synergies enable a smooth migration within and between the product families

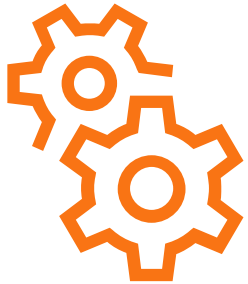
Speed of Development

- Strong architecture similarities
- Evolution of TC3x peripherals enables high degree of re-use
- Proven eco-system including SW & tooling



SW & HW compatibility

- Binary compatibility between TC1.8 & TC1.62
- Integration of new TC 1.8 instructions
- High degree of pin compatibility between TC3x & TC4x packages



Safety concept synergies

- AURIX™ TC4x safety concept built on proven TC3x
- New/ enhanced safety
  PPU, DMA, Comms, Security
- Strong reuse:
  TriCore™ lockstep, eNVM/SRAM diagnosis, supply & clock monitoring

Dependability

- AURIX™ TC3x is ultimate benchmark in robustness
- Functional availability and component reliability
- Trusted partner and long-term commitment
- Holistic architecture based on deep application know-how

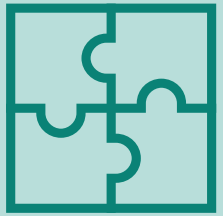
AURIX™ TC4x defines the next controller standard for safe & secure ECUs with strong networking capabilities

Higher Performance

- **New 500MHz TriCore™ 1.8**
- PPU: Private scalar core + **256bit wide vector unit** with up to 48 GOPS
- SPU3: High-performance **radar processing sub-system**
- A/D Converter sub-system **with integrated DSPs**
- **Data Routing Engine** for CAN – Ethernet - Mem communication
- Improved Timers, HR-PWM

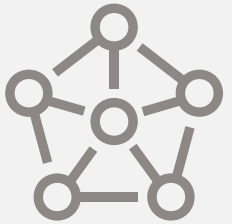
Safety and Security

- AURIX™ meets ISO26262-2018 **ASIL D safety** standard
- **CSRM**: high-performance security module with private CPU, memories and crypto accelerators
- **CSS**: Distributed crypto and hash engines for secure CAN/Ethernet communication
- Security according to **ISO 21434** standard planned
- SAFE AI compliant



Freedom From Interference

- **Hardware isolation** at core and peripheral level
- TriCore™ 1.8 with **up to eight VMs per core (incl. Hypervisor)**
- Ultra-fast **context switching**
- **Enhanced memory protection** for cores and virtual machines
- **Fine-granular access protection** to peripherals
- **Isolated DMA protection**



Rich connectivity

- Up to 2x **5GBit Ethernet** incl. Bridge
- **Accelerated MACsec support** by HW accelerator in CSS and application SW driver
- **4x10/100MBit Ethernet** supporting 10Base-T1S standard
- Up to 2x 8GBit/s **PCIe 3.0** 1x lane
- Up to 20x CAN-FD
- **CAN-XL**

AURIX™ TC4x Architecture
Enhancements compared to AURIX™ TC3x

Performance ASIL-D
Enhanced TriCore™
With up to 6CPUs @ **500MHz**

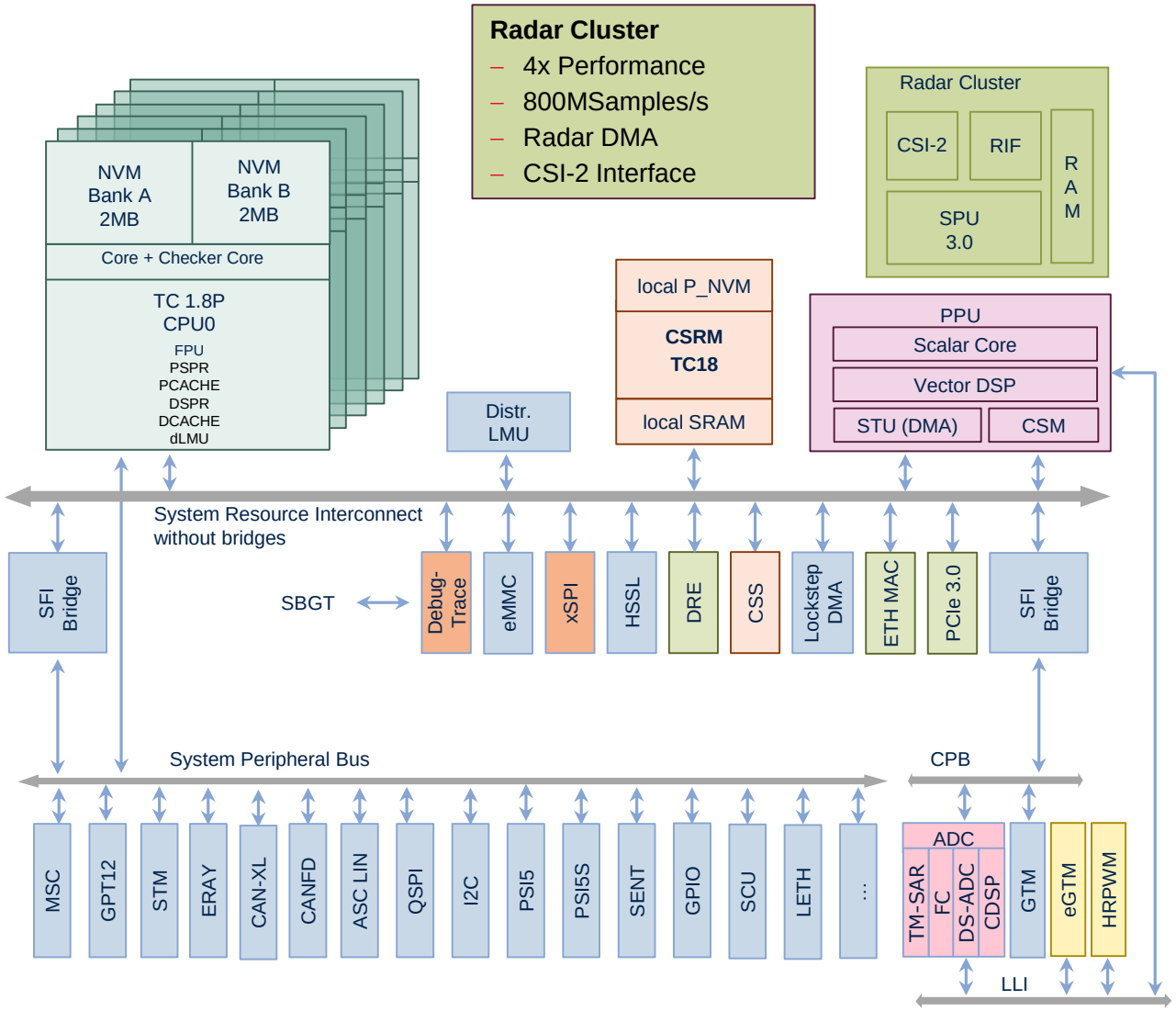
Bigger Tightly Coupled SRAM for increased performance

Full AB-Swap Support

Debug and Trace
Safe and the secure in field

xSPI
External Memory Interface

ADC
Dedicated DSPs
Enhanced ADCs



CSRM
New high performance Security Modules with QM support

CSS
Dedicated communication security satellites

New Programmable HW Accelerator - PPU
SIMD Vector DSP + Scalar Core for Modelling and Precise Control – **ASIL D**

New high-speed comm Interfaces:

- PCIe 3.0
- 100Mb- 5 Gbps Ethernet

New 10 Mbit Ethernet and CAN-XL

New communication routing accelerator:

- DRE- Data Routing Engine

New eGTM timers and **High Resolution PWM** with **low latency interconnect (LLI)**

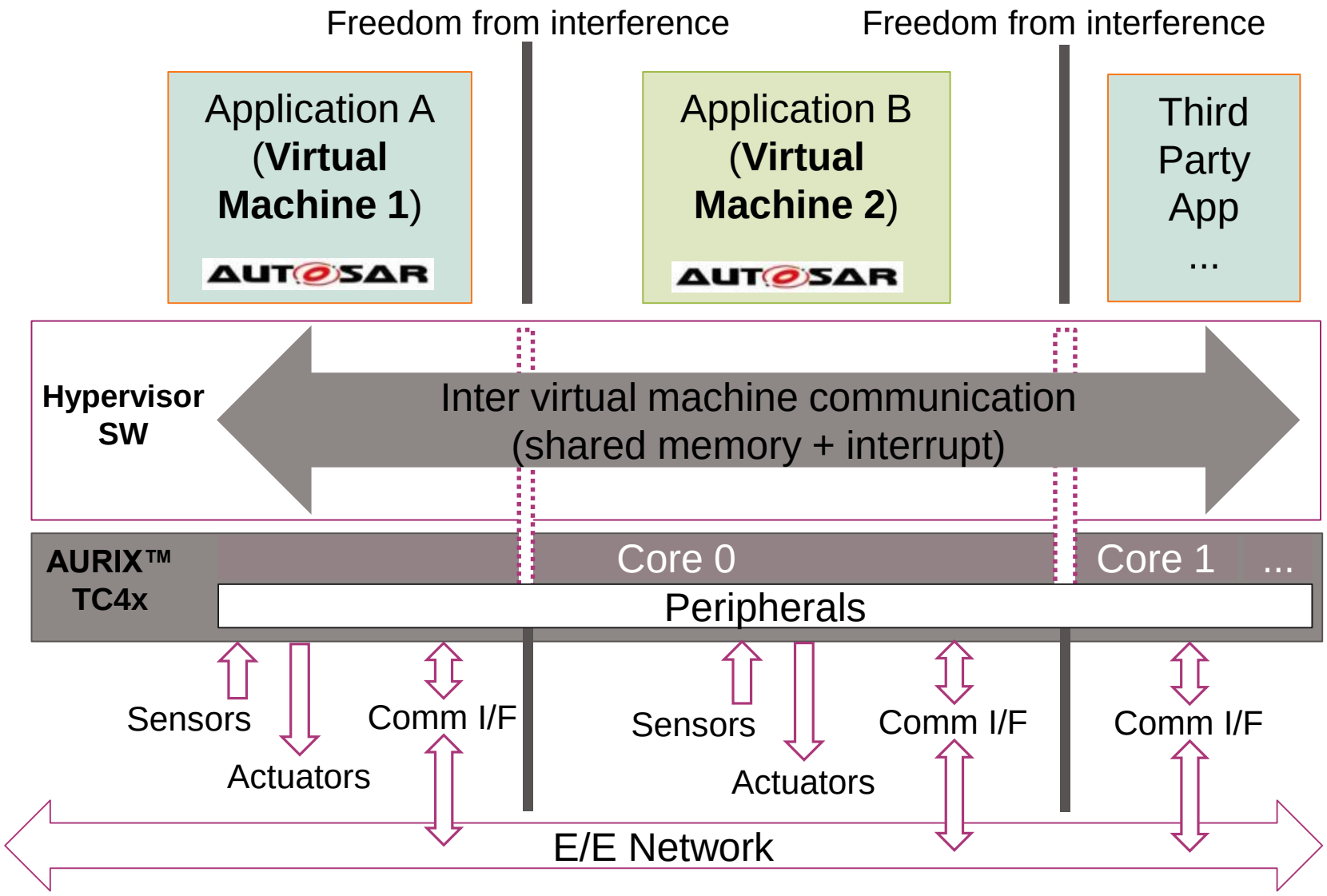
TC4x provides virtualization enhancement to allow efficient isolation and separation

New and improved TriCore™ with Hypervisor Mode

- TriCore™ Hypervisor (HV)
  - New execution mode, with new instructions
- Memory Protection Unit (MPU) with 2 levels
  - 2nd level only for Hypervisor mode
- Virtual Machines (VMs)
  - Upto 8 per TriCore™, thereof 7 VM for customer usage (1 VM is hypervisor)
  - Assign peripheral resources with fine granularity
- Extended interrupt scheme
  - Now includes direct routing of interrupt to VM

New features enable isolation and separation

Multiple applications can be executed in isolation using Virtual Machines, Hypervisor SW and the AURIX™ TC4x Hypervisor



AURIX™ TC4x TriCore

Each core supports up to 8 virtual machines

Access Protection Unit (APU)

Provides isolation features at the peripherals

Virtual Machines

With complete AUTOSAR stack & assignment of own peripherals

Hypervisor SW

Via partners

As E/E architecture evolves, the need to minimize latency, and to facilitate diverse use cases and communication protocols increases

Further needs met by an enhanced security cluster

Minimize latency & maximize throughput for “In Vehicle Network” (IVN) communication: between Zones, end-nodes and with central vehicle computers – Get ready for Ethernet!

Enable SOTA use cases, which require secured and safe distribution of SW updates from cloud or within IVN

Serve increased security communication protocols, authentication of >50% and encryption of >15-20% of all IVN messages

Increasing number of security use cases to be covered
Secured key-storage, key management, secured updates, connection to external service providers, Secured boot & onboard communication, device attestation, Runtime manipulation detection, feature activation and furthermore

AURIX™ TC4x Cybersecurity Management System is certified by TÜV SGS according to ISO/SAE 21434

SGS TÜV SAAR

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CERTIFICATE NO.: FS/71/220/24/1375

LICENCE HOLDER

INFINEON TECHNOLOGIES AG
AM CAMPEON 1-15
85579 NEUBIBERG
GERMANY

PROJECT NO/-ID: U2NE

LICENSED TEST MARK: SGS TÜV SAAR CYBER SECURITY COMPLIANT

REPORT NO.: U2NE0002

Tested according to: ISO/SAE 21434:2021 (following ISO/PAS 5112:2022)

Certified Process: "Ensured Compliance Automotive Processors" (ECAP)
Version: ECAP v1.5

Technical Data/Parameter: The evaluation has been performed acc. to ISO/SAE 21434:2021 clause 5.4.7 "Organizational Cybersecurity Audit". The audited process corresponds to the security development lifecycle (SDL) used in practice and follows the understanding of a Cybersecurity Management System as expected acc. to ISO/SAE 21434.

Specific Requirements: The certificate is created for the purpose of providing conformity of the organization development and support process in accordance with ISO/SAE 21434. Changes which are not covered in the audit report have to be reconsidered.

Munich, May 15th, 2024

Certification Body for Cyber Security SGS-TÜV Saar GmbH

Prof. Dr. Karol Niewiadomski

The validation status is documented via SGS Certification Database.

The test mark regulation is an integral part of this certificate.

CERTIFICATE

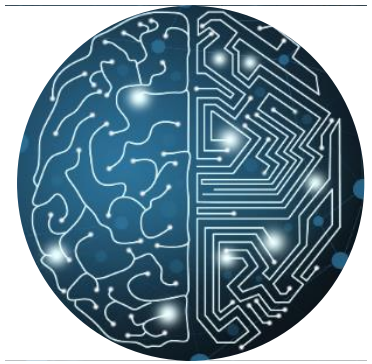
The certification includes:

- Cyber Security Management Continuous Cyber Security Activities (e.g. Monitoring, risk assessment, vulnerability analysis)
- Risk Assessment Methods (e.g. Threat identification)
- Concept Phase (e.g. Cyber security goals)
- Product Development Phase (e.g. Integration and verification)
- Post Development Phase (e.g. Cyber security incident response)

Infineon's position as a trusted partner in automotive security has been proven by an external party

Parallel Processing Unit (PPU) enables affordable artificial intelligence use cases

Artificial Intelligence & Neural Networks



Optimize Automotive Use Cases

› Cost Reduction
› Innovation
› Improve Performance
› Accelerate Time to Market

Automotive AI Use Cases

Domain/Zone Control

› Modelling
› Model Predictive Control
› IDPS & other security methods

ADAS

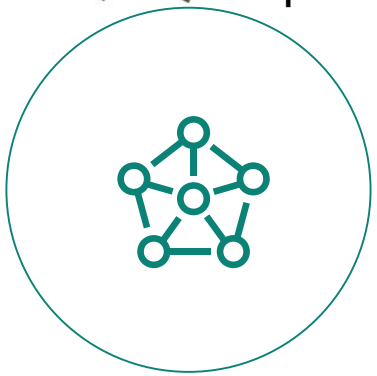
› Object classification
› Advanced Radar Signal Processing
› Sensor Fusion

xEV Applications

› Predictive Control
› Virtual Sensing
› Advance State of Health (SoH) and State of Charge (SoC) algorithms

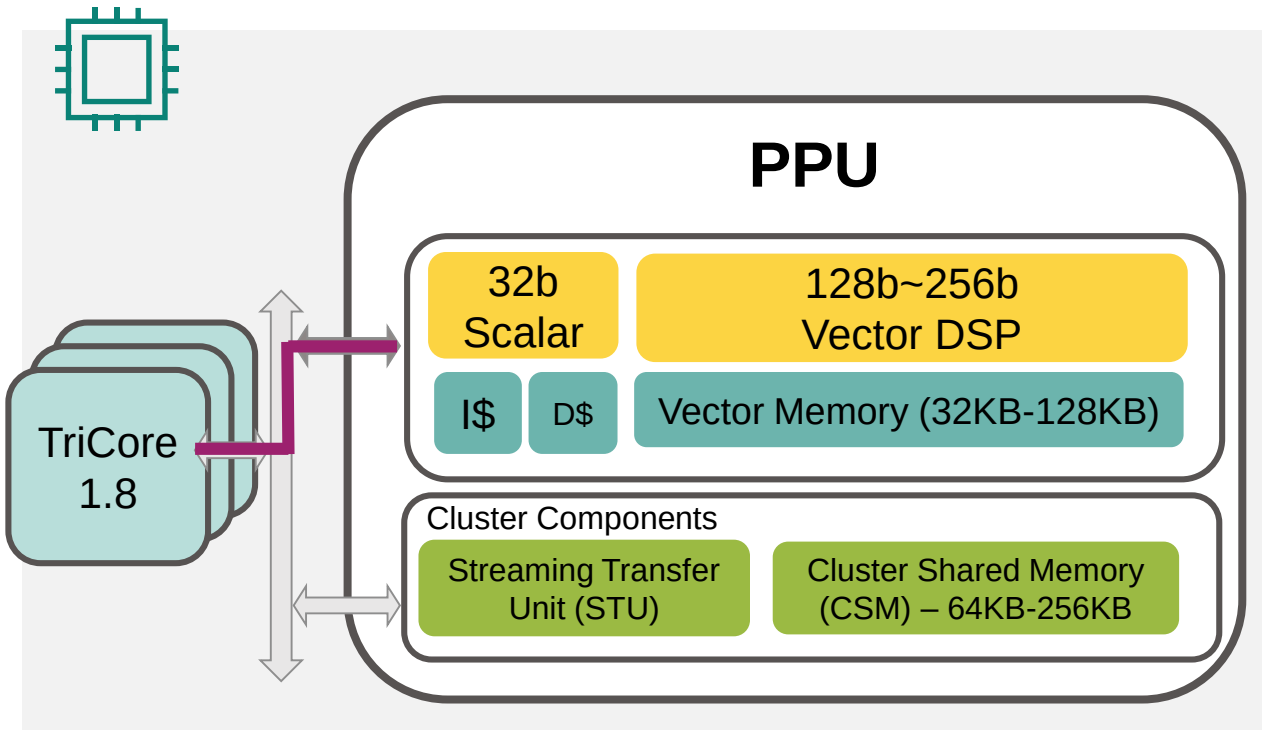
PPU accelerator

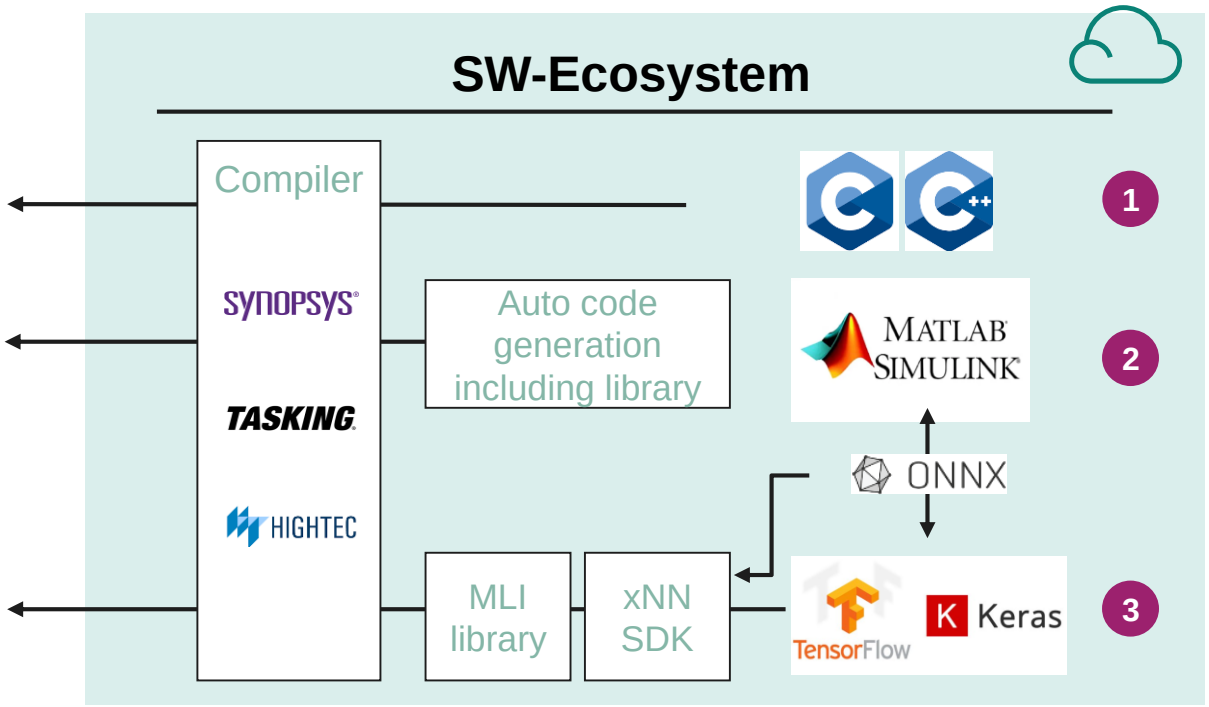
SIMD vector DSP Co-processor



› Data processing of linear algebra (e.g. matrix operations) and signal processing (e.g. filtering, convolutions)
› Ultra fast control loop implementation
› Implemented in low-latency cluster with mixed signal peripherals

AURIX™ TC4x Parallel Processing Unit (PPU): a scalable SIMD Vector DSP & scalar core with a dedicated SW-tool-chain





› **Execution 3x faster** than competitor solutions, **enabling Neural network based** algorithms and **High-speed-control implementations**

› **Unique SW Ecosystem**: Model-based development, connected with latest Machine-learning-tools like Tensor-flow is enabling **easy usage and fast time-to market**

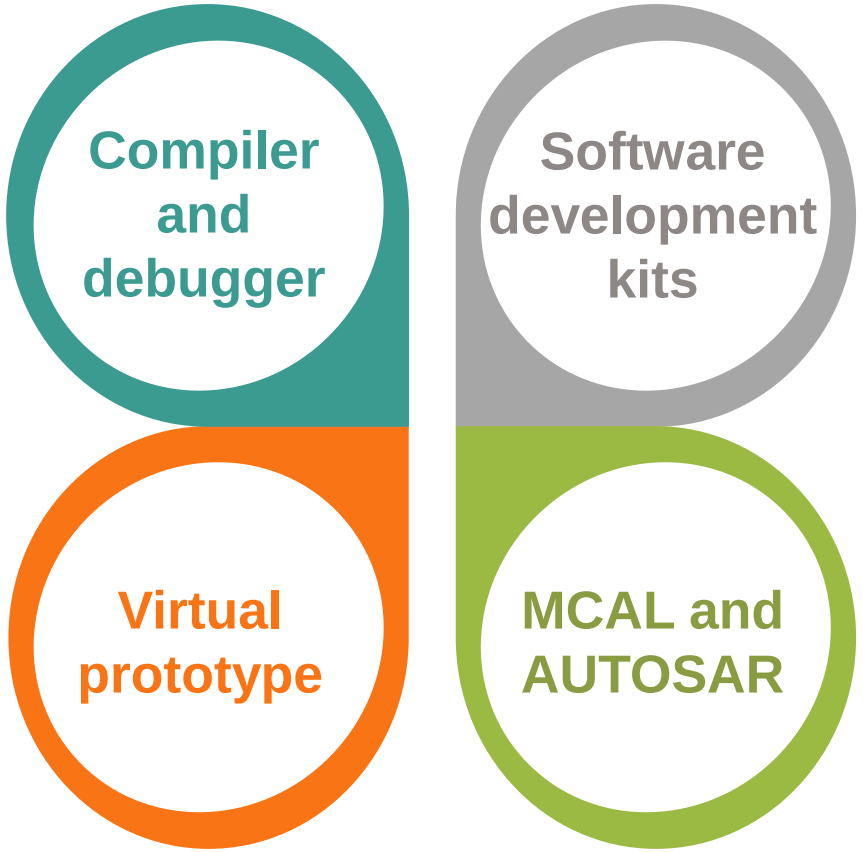
Getting started with AURIX TC4x is facilitated by new SDKs and VP as well as by re-using proven tooling from last generations

Last generation re-use plus support of new computing IP

- **TriCore compiler:**
  - TASKING, Hightec, WindRiver, GHS
- **PPU compiler:**
  - Synopsys, TASKING, Hightec
- **Debugger and test tools:**
  - iSYSTEM, Lauterbach, PLS, Synopsys

Enablement of pre-silicon development

- **Provider:** Synopsys
- Modelling of key AURIX TC4x HW features
- Full debug and analysis support
- Interfaces to Simulink, SABER, CANoe, etc.



Enabling development with new IP plus increased safety support

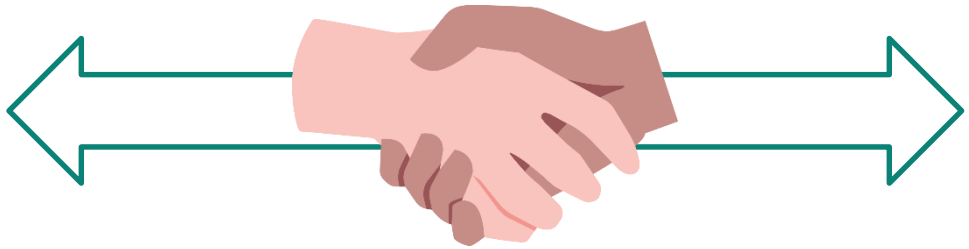
- **PPU libraries and auto code generation:**
  - Synopsys, TASKING
- **AURIX TC4x hardware support package**
  - MATLAB / Simulink
- **Safety software package *(in discussion)***
  - Startup tests and failure checks recommended in safety manual
- **Optional CDSP software toolchain**
  - Synopsys

Increased MCAL offering and AUTOSAR providers incl. hypervisor

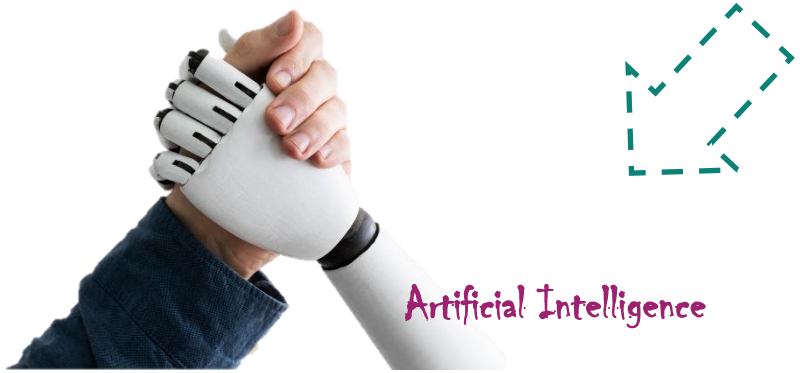
- Proprietary MCAL with ISO26262:2018 compliance for IPs incl. new COM Ips (PCIe, DRE, 10BaseT1s)
- **Hypervisor implementation**
  - EB, ETAS, Opensynergy, SysGo, Greenhills
- **SW stack integration providers:**
  - Vector, Elektrobit, Siemens, ETAS
- **Security SW:** Vector, ESCRYPT, ISS, EB

AURIX™ & TRAVEO ™ microcontroller & OPTIREG™ teaming up for functional safety in automotive applications

Brains



Brawn



Artificial Intelligence

Safety/ ADAS

Sensor fusion · Radar · Camera · Lidar

Conventional powertrain

Engine management · Double clutch transmission · Transfer case · Belt starter generator

Electric drive train

48 V · BMS · Traction inverter · On-board charger

Body

Body control module · Telematics gateway

Chassis

Electric power steering · ESP · Suspension · Brake booster · Electric parking brake

PMIC · SBC


Infineon