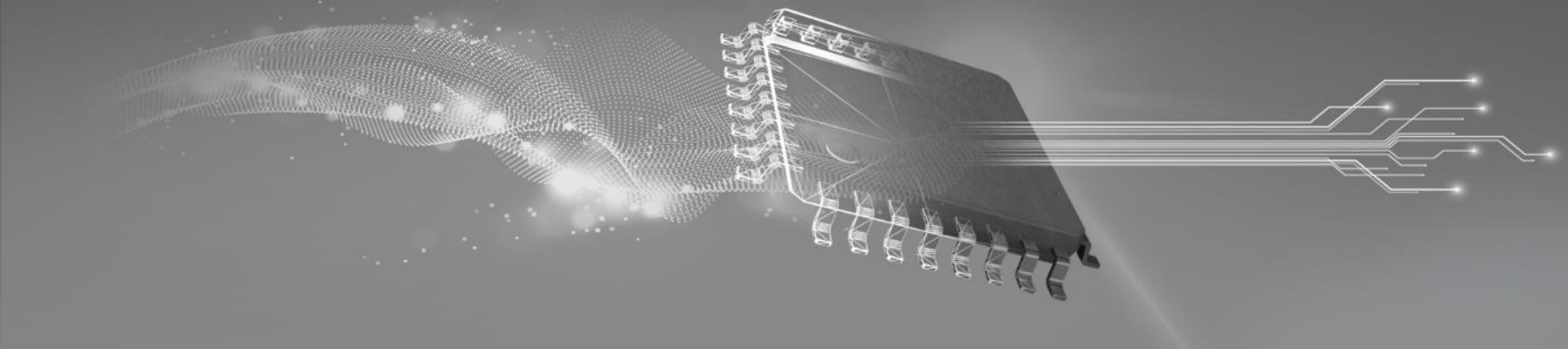
TI TECH DAYS



Optimizing your automotive system with Jacinto™ 7 SoCs and MCU integration

Eric Best

Texas Instruments

Texas Instruments

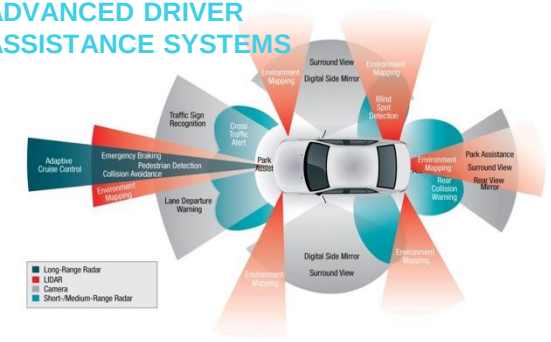
Jacinto™ 7 SoCs

TDAx SoC family

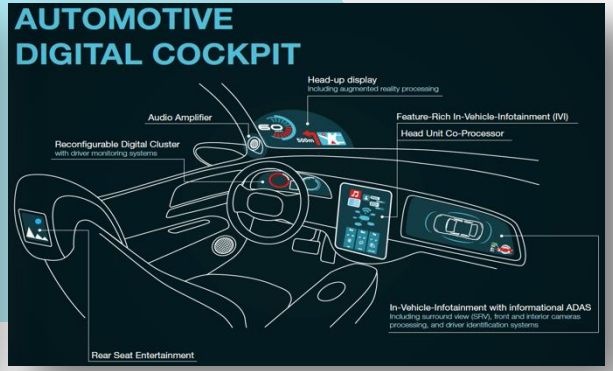
DRAx SoC family

Common IP, software & Tools
Safety & Security

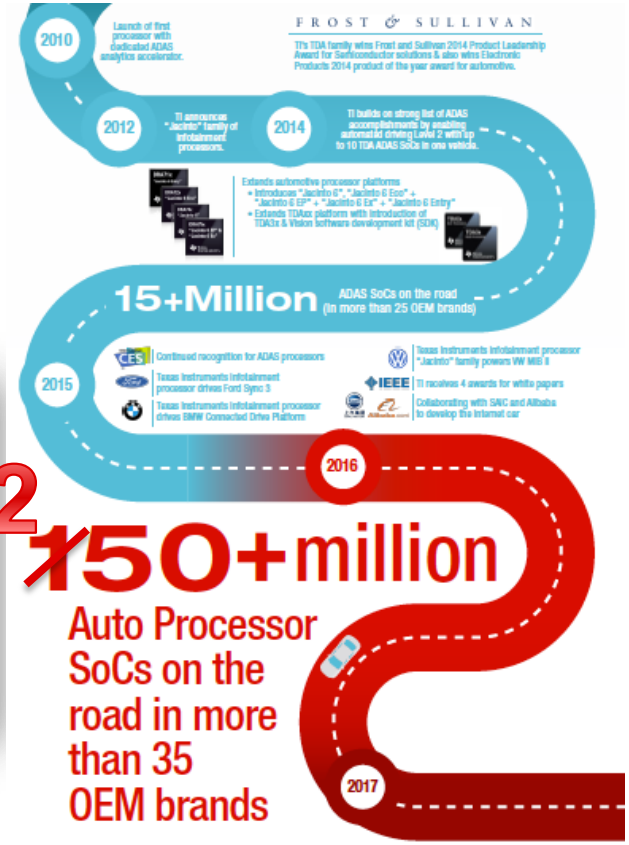
ADVANCED DRIVER ASSISTANCE SYSTEMS



AUTOMOTIVE DIGITAL COCKPIT



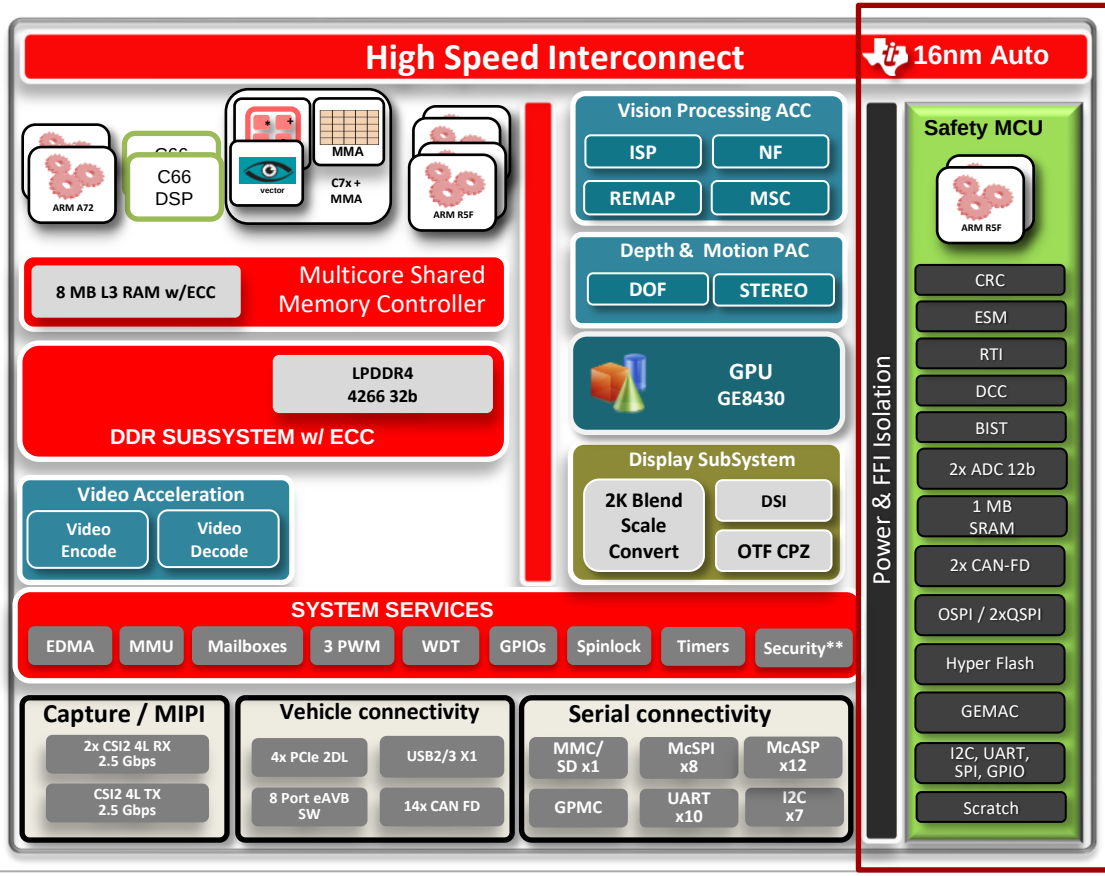
Front Camera	Driver Monitoring	Integrated Cockpit	Digital Cluster
Surround View	CMS / Mirror Replacement	Center Stack HMI	Heads-Up Display
Sensor Fusion / Domain	Lidar / Time of Flight	Silverbox	V2V / V2X
Radar	Rear Camera	Rear-seat	Vehicle compute, Gateway



Texas Instruments strong history with signal processing has produced strong results in the automotive industry, and will continue to enable the leading integrated digital cockpit and autonomous driving solutions of the future.

TDA4V-MID
Integrated Safety MCU

Available Now



Processing Cores
- 2x ARM Cortex A72 @ 2GHz
- 1x C71x DSP + MMA @ 1GHz
- 2x C66 DSP @ 1GHz
- Up to 8 MB Shared on-chip memory w/ECC
- 3x ARM Dual Cortex R5F dual/lock-step
- Vision Acceleration – VISP, VPAC, DOF, SDE
- 1x GE8430 GPU (100 GFLOPS)

Video / Vision
- 2x CSI-2 (4 lane) x 2.5Gbps Camera interface
- 1x CSI-2 TX Output interface
- Multiformat encode/decode (H.264 Encode up to 180 MP/s for 1080P)
- DSS: Scale, Blend, Convert
- 1x 2.5K, 1x 4K Display OTF composition, increased number of layers/flexibility
- 4L DSI interfaces

Memory IO
- 1x 32b LP-DDR4X-4266
- 1x MMC/SD/SDIO: 1x UHSI 4b, 1x eMMC v5.1
  1x SDIO 4b SD s4.0, SATA: 1 lane
- 1x OSPI (166 MHz SDR / 80MHz DDR) / 1x HyperBus™

High-Speed IO
- 4x PCIe Gen 3, USB3.1, USB2.0

Automotive IO
- 16x CAN Controllers supporting CAN A&B, FD
- 8 Port Ethernet Switch

Safety
- Up to ASIL D safety MCU
- High Security** Version

Package: 24x24mm BGA, 0.8mm pitch
Power Dissipation Typical Range: 12 to 20W @ 125CTj

History of TI's Integrated Safety MCU

Mature IP

- The MCU island leverages mature core and peripheral IP blocks (R5F, UART, SPI, RAM,ECC, DCC, etc) ,which are all well proven on many devices within TI's broad family of SoC's.

ASIL D Heritage

- The MCU island is technology based on TI's Hercules™ TMS570 stand-alone Safety MCU family, which has shipped millions of automotive units over 15+ years. These devices are TÜV SÜD certified IEC61508 SIL3 and ISO26262 ASIL D microcontrollers for automotive and industrial applications. TI is leveraging the same safety concept and ISO26262 design methodology in TDA4. See: http://www.ti.com/microcontrollers/hercules-safety-mcus/overview.html

Robust Safety Case

- The MCU Island is already available on several 28nm processor derivatives addressing applications with heavy functional safety requirements. The IP is validated, robust and delivering performance to spec.
  - Safety documentation, MCAL, and AUTOSAR availability.
  - AUTOSAR (R5F) and Adaptive AUTOSAR (A53) demo first shown on DRA804M at CES19.

Family Approach

- The Jacinto DRA82XX/TDA4x family of devices leverages the same IP in the 16FF process node, enabling software re-use and scalability for functional safety with superset device first sampled in May 2019.

Vehicle MCU requirements increasing over time

- Increased compute power, to satisfy higher compute needs of complex software
- Increased embedded flash memory size to handle more complex software.
- Increased high speed memories to accommodate large software (both data and instructions)
- Increased shared data with the system application processor
- Multiple Ethernet ports to support multiple networks
- Greater number of I/O interfaces (such as CAN, LIN, ADC, etc…)
- Up to ASIL-D safety support to meet the system safety goals
- Autosar for integrated MCU

TI's solution is to integrate the vehicle MCU

Lower Cost

Smaller Board Area

Higher Performance/Watt

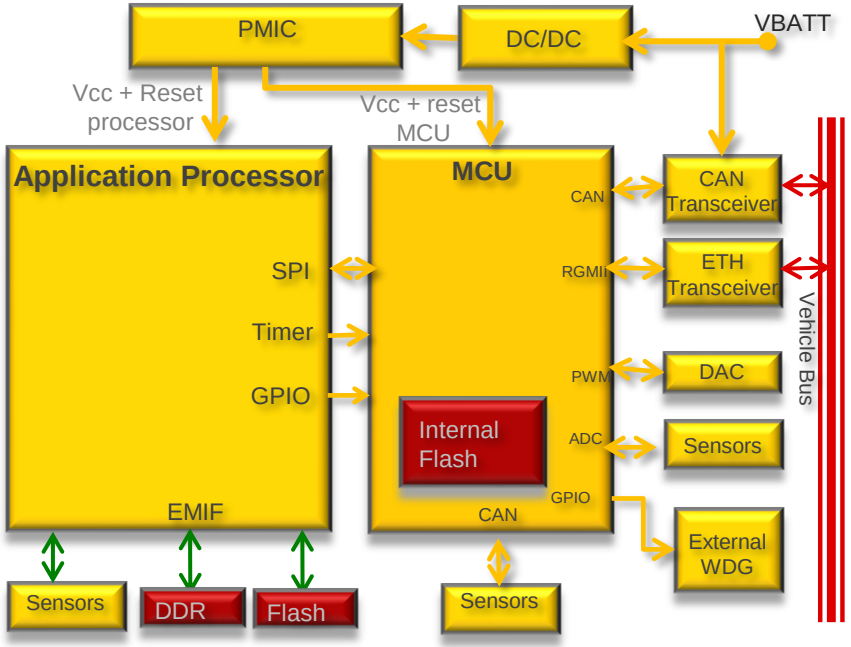
Higher CPU and Memory Capacity

Summary – External MCU vs TDA4 MCU integration

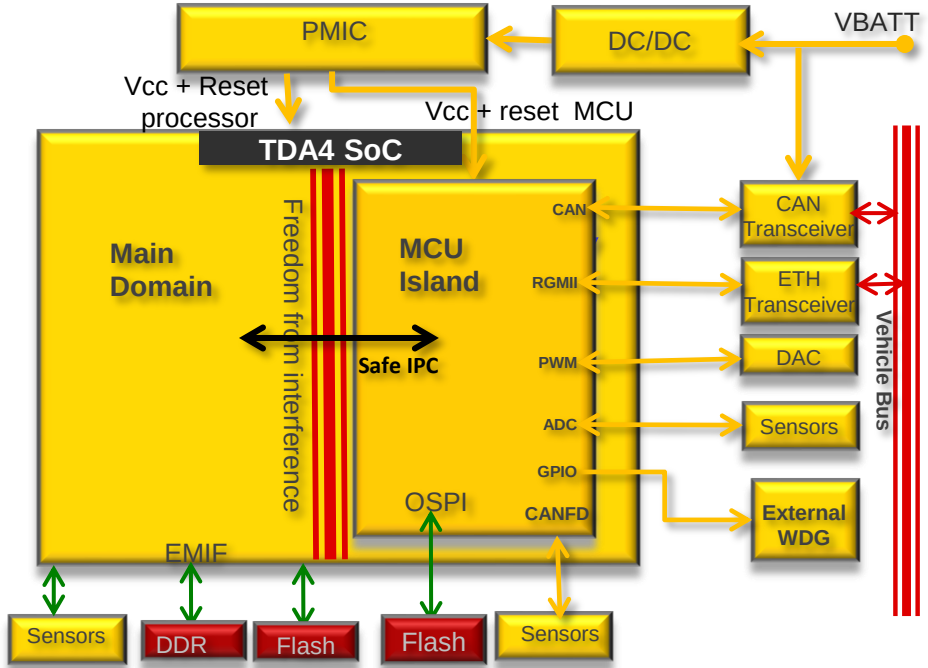
Features	External MCU	TDA4x MCU Integration
Processing cores	Microcontroller cores limited by embedded FLASH access time. Typically 300MHz max with proper wait states	Higher performance cores executing from RAM Multiple R5F cores @1GHz
IO support	CAN, ADC, SPI, GPIO, PMW, Ethernet, I2C	CAN, ADC, SPI, GPIO, PMW, Ethernet, I2C
Power	Meets low-standby current	Meets system level low power requirements. Companion PMIC includes functionality to manage standby current.
Wake-ups	Large number of wakeup sources	Multiple options to support wakeup sources
System BOM	Cost related to flash size, functional safety requirement etc.	Provides significant system BOM saving due to integration of external MCU and decreased PCB area
Boot	Can meet 50-100ms boot time for CAN response	Can meet 50-100ms boot time for CAN response. • 30mS general purpose • 42mS secure
Software development	Separate software development kits	Unified software development with application processor
Flash	Internal flash	External flash (QSPI, OSPI, Hyperflash) XIP Supported. Can support cost effective larger external flash
Apps processor communication	Serial port (i.e. SPI, I2C etc.)	128 bit wide internal bus interface with end to end ECC
Functional safety	Up to ASIL-D	Up to ASIL-D, simplifies safety case for mixed criticality applications.

Integration in TDA4

Typical ECU architecture

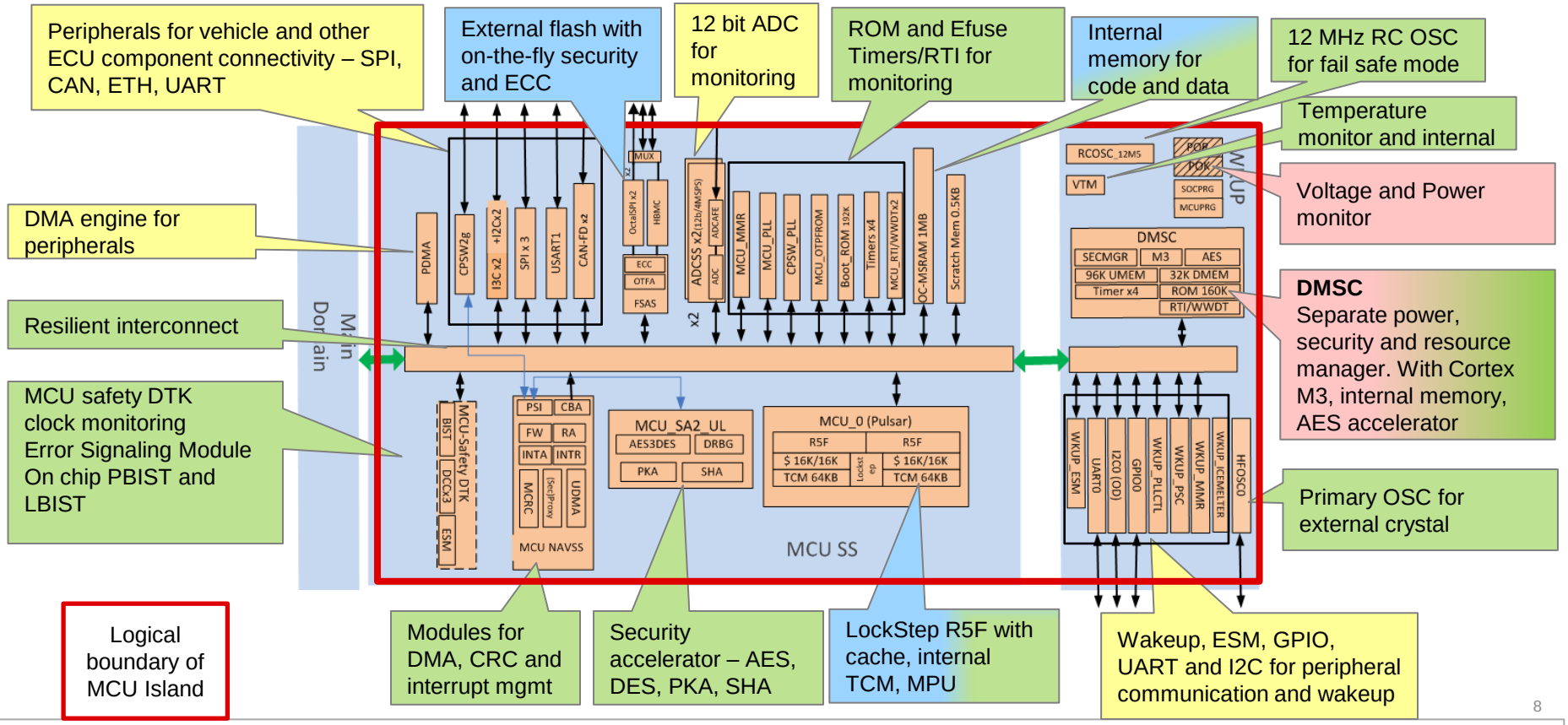


Integrated micro with TDA4 - ECU architecture



- Lower system BOM
- Safety and isolation
- Parity with external micro
- Simplifies HW and SW arch

TDA4 MCU Island



Safety & Security | Connectivity | Power | Performance

AUTOSAR highlights

AUTOSAR available now from multiple suppliers

- Vector and KPIT official releases in Q1’20

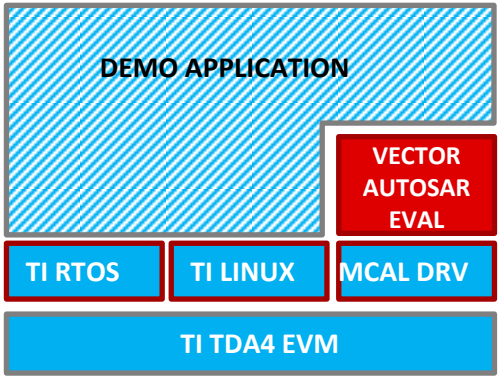
Multiple R5F subsystems allow for flexible architecture

- AUTOSAR on one pair, or across multiple pairs with core partitions

High capacity cores for large headroom

- 2-3x capacity of typical external MCU
- Up to 6GHz of R5F processing

Vector AUTOSAR pre-integration on TDA4x



AUTOSAR evaluation on TI EVM

Vector TDA4 AUTOSAR eval package in definition today

- Subset of available AUTOSAR features to enable basic application
- Includes AUTOSAR OS for R5F, limited set of integrated MCAL drivers
- MCAL drivers from Vector or from TI SDK

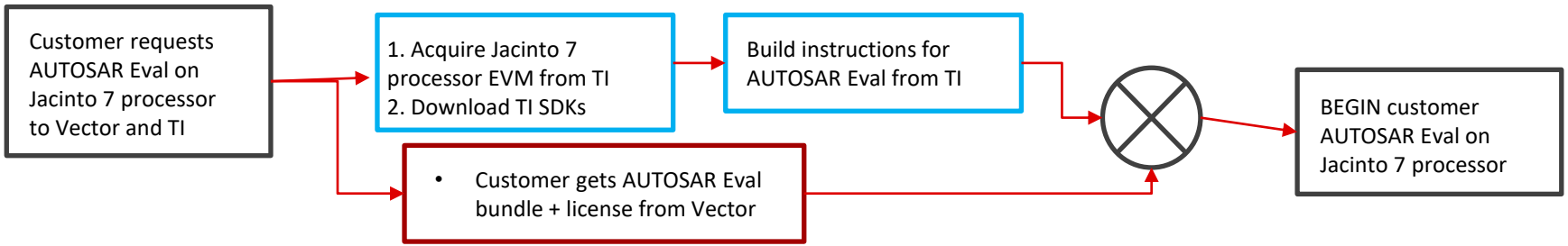
TI Linux and TI RTOS on processing cores

- Enables quick path to Vector AUTOSAR evaluation

Simple AUTOSAR communication DEMO app in definition

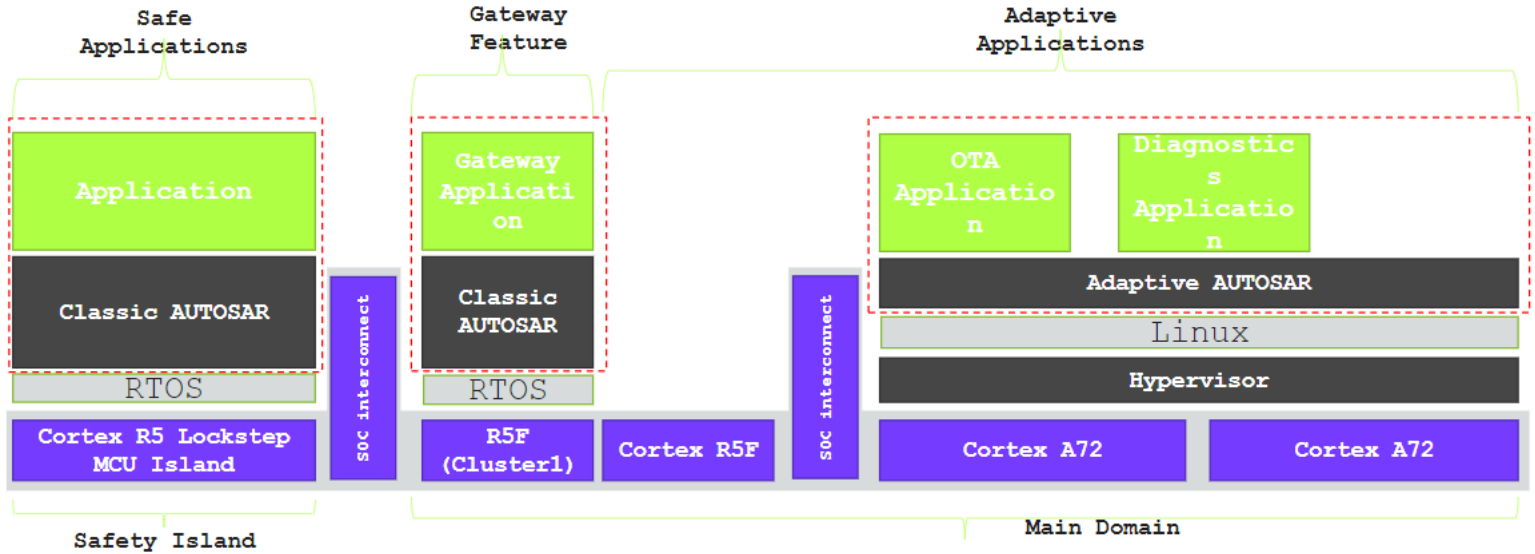
- Easily re-created by customers with SW packages from Vector and TI

Enabling Customer Eval on TDA4x – *In work*



KPIT AUTOSAR pre-integration on TDA4x

AVAILABLE TODAY



AUTOSAR Classic

- Gateway (CAN TO ETH) on R5F Cluster (Main Domain)
- AUTOSAR Classic on R5F (Safety Island)

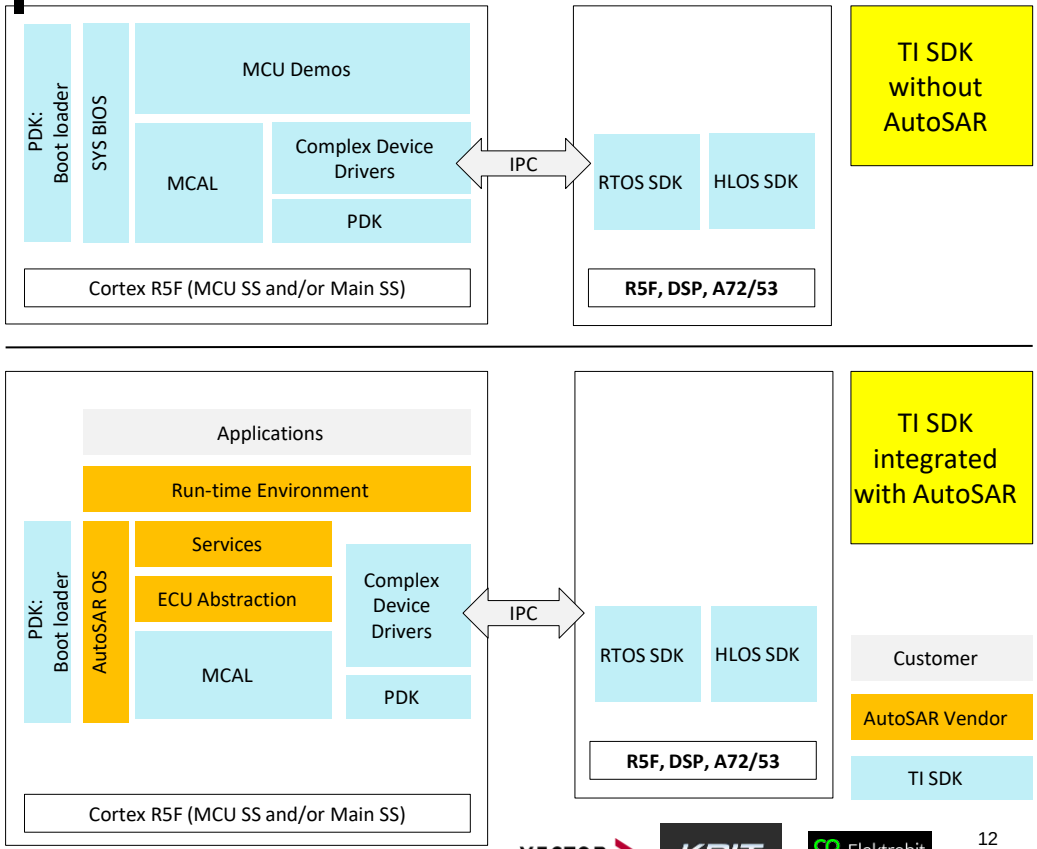
Adaptive AUTOSAR on A72

- OTA
- V2X stack and applications integration with Adaptive
- Onboard diagnostics services

IPC communication between Classic/Adaptive

Foundational Software | MCU Software

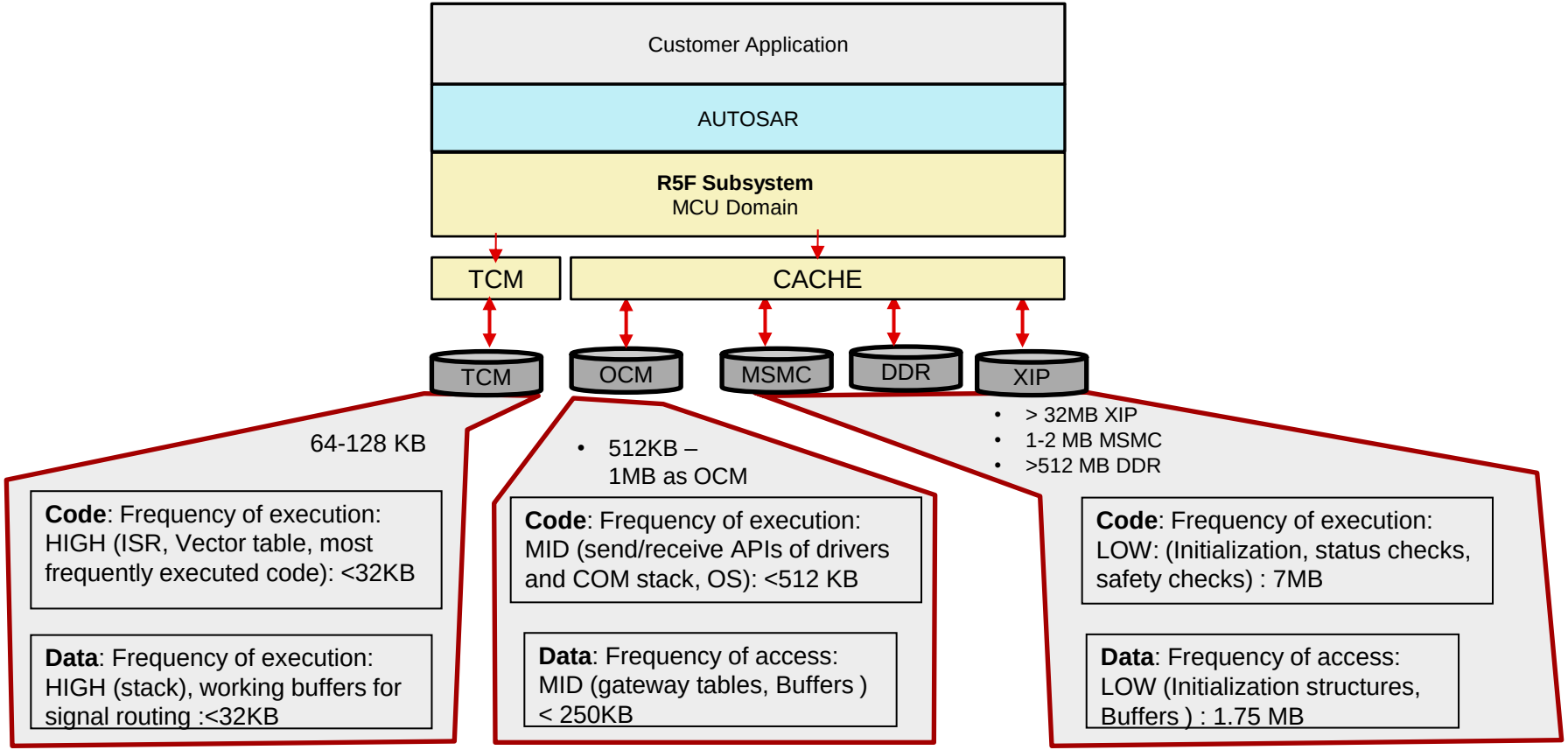
- Part of **Processor SDK RTOS Automotive**
- TI deliverables enable prototyping with MCAL and without AUTOSAR
  - Inter-Core communication using mailbox and SPI
  - Routing/switching over CAN and Ethernet
  - Reference bootloader for fast boot, XIP execution
  - Other MCU functionality like ADC, PWM in application context
  - Measure CPU load / latency
- AutoSAR integration of TI MCAL available with most AutoSAR vendors
  - **Multi-core AutoSAR support also available**
- MCAL and Complex Device Driver (CDD) delivered by TI
  - ADC, CAN, ETH, ETHTRCV, GPT, PWM, SPI, DIO, WGT
  - CDD: IPC (Inter Processor Communication)
  - EB Configurator tool
- TI MCAL support for functional safety
  - TI MCAL developed with process certified to be compliant with ISO 26262 2018.
  - TI MCAL provided with Compliance Support Package



VECTOR KPIT Elektrobit

Texas Instruments

Customer SW architecture – recommended mapping for MCU/Main R5F



TDA4 R5F 1x1GHz performance vs 4x300MHz Flash MCU

1 x lockstep R5F of TDA4 compared to 4 x lockstep cores of non-TI highest performing MCU

TI TDA4

1 pair x R5F in Lockstep@ 1GHz ~ 2K DMIPs

AUTOSAR benchmark on TDA4 R5F

Setup: RTOS, 16 task, I$ miss rate: 3.5M/sec

Typical Flash MCU

4 pair cores in lockstep @ 300MHz ~ 2.4K DMIPS

Estimated AUTOSAR benchmark on Other MCU

Setup: RTOS, 16 task, I$ miss rate: 3.5M/sec

- DRA82x baseline
- R5F cache size (32KB)
- TCM 64KB

- Baseline configuration: Other MCU have similar cache and TCM config
- Baseline performance: The time taken to execute the benchmark code is normalized as 1 for OCM RAM

MCU R5F	
OCM	XIP
1	1.8

- Baseline configuration: Other MCU have similar cache and TCM config
- Latency slightly better than TI as they operate at lower frequency
- Flash latency similar to OCM latency for code access

MCU R5F	
OCM	XIP
0.7	0.8

- Performance impact due to multiple core

No impact

- No Impact

1	1.8

- Impact of 30% due to function split into multiple cores (Amdahl's law)

30% degrade

0.91	1.04

- SW Architecture – Code placement, DMA
- Lockstep TCM: 64 -> 128KB

- Code with higher frequency of access in TCM and OCM RAM : 75%
- Code with lower frequency of access in Flash/XIP

Frequency of access	
75%	25%
	1.2

20% performance degradation compared to OCM code execution

- Code with higher frequency of access in TCM and OCM RAM : 75%

Frequency of access	
75%	25%
	1.0

Similar performance compared to OCM code execution

- **1 x lockstep R5F pair has XIP performance just 20% worse than 4 x lockstep cores (highest performing external MCU)**
- **TI TDA4x has up to 3 x R5F lockstep cores: ~ 2.5x more performance than typical high performing MCU**

Software and tools - overview

AUTOSAR MCAL + Configurator

ASIL D capable MCAL for AUTOSAR BSW integration

Bootloader

QM Bootloader given as reference for device boot sequence and operation

Code Composer Studio

Code Composer Studio™ IDE is an Eclipse-based development environment

Emulators

HW emulator for easy debug from multiple vendors- Spectrum Digital, BlackHawk, Lauterbach

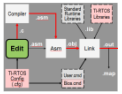
Diagnostic Library

ASIL D capable SW diagnostic library for checking the correctness of all checkers

Reference MCU PDK

Reference PDK SW demonstrating MCU Island operation and interaction with Main Domain

Compiler



TI Compiler for various cores of MCU Island – used with CCS or command line

HW Simulation platform

VLAB SoC Simulator from ASTC

Low level Drivers

```
01001000
01100101
01101100
01101100
01101111
```

ASIL D low level drivers for peripherals, power management and device control

Flash Programming

Flash programming tool for external flash using standard interface

Compiler Qualification toolkit

Qualification tool kit for meeting safety requirements

TI partner Network

Extensive 3P network for AUTOSAR, Safety OS, Hypervisor, Services, Application

TI TDA4A MCU benefits

TDA4x for mainstream ADAS Safety

- **Native Safety Support**
  - **ASIL-D Systematic Capability**
  - **Internal diagnostics (up to ASIL-D)**
  - **Certification and collateral**
- **Mixed Criticality**
  - **Firewalls, Voltage, Clocks, Interconnect**
- **MCU island**
  - **High FFI**
  - **External MCU replacement**
- **Extended MCU**
  - **More ASIL-D DMIPS**
  - **DDR**

Lowest risk

- Proven technology node; reliable execution → development can start today!
- TDA4x backed by a team of 600+ TI engineers & domain experts
- Proven support in Automotive

Best cost of ownership

- Lower BOM with integration of safety MCU
- Reusable: Common micro and SW platform from L1 ➔ L4, gateway/vehicle compute, cockpit
- High performance MCU subsystems
- Architected for lowest external DDR footprint
- Low power to reduce thermal management costs

Automotive heritage

- TDA4x leverages TI's extensive history in automotive processors (15+ years across 35 OEMs, over 250 Munits)
- Automotive Safety heritage: Over a decade experience with ASIL-D processing (TMS570)
- System level solutions designed for Automotive: SoC, interface and power

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