eMCOS

Multikernel RTOS Platform for Mixed Criticality System

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eSOL in a nutshell

eSOL Europe SAS
Soissons, France
Düsseldorf, Germany

eSOL Co., Ltd.
eSOL TRINITY
Tokyo, Japan

Embedded software vendor
- Professional services
- RTOS platforms (inc. MW)
- Embedded SW tools

- **Automotive**
- Industrial
- Medical
- Consumer electronics

eSOL software products
deployed in +100M devices

Tokyo headquarters
Established since 1975
500+ people
$90M revenue

- Listed at **Tokyo stock exchange Prime Market** (4420.T)
- 2 affiliates
  - eSOL TRINITY
  - eSOL Europe

eSOL

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Global player at embedded standards

Working on the standardization
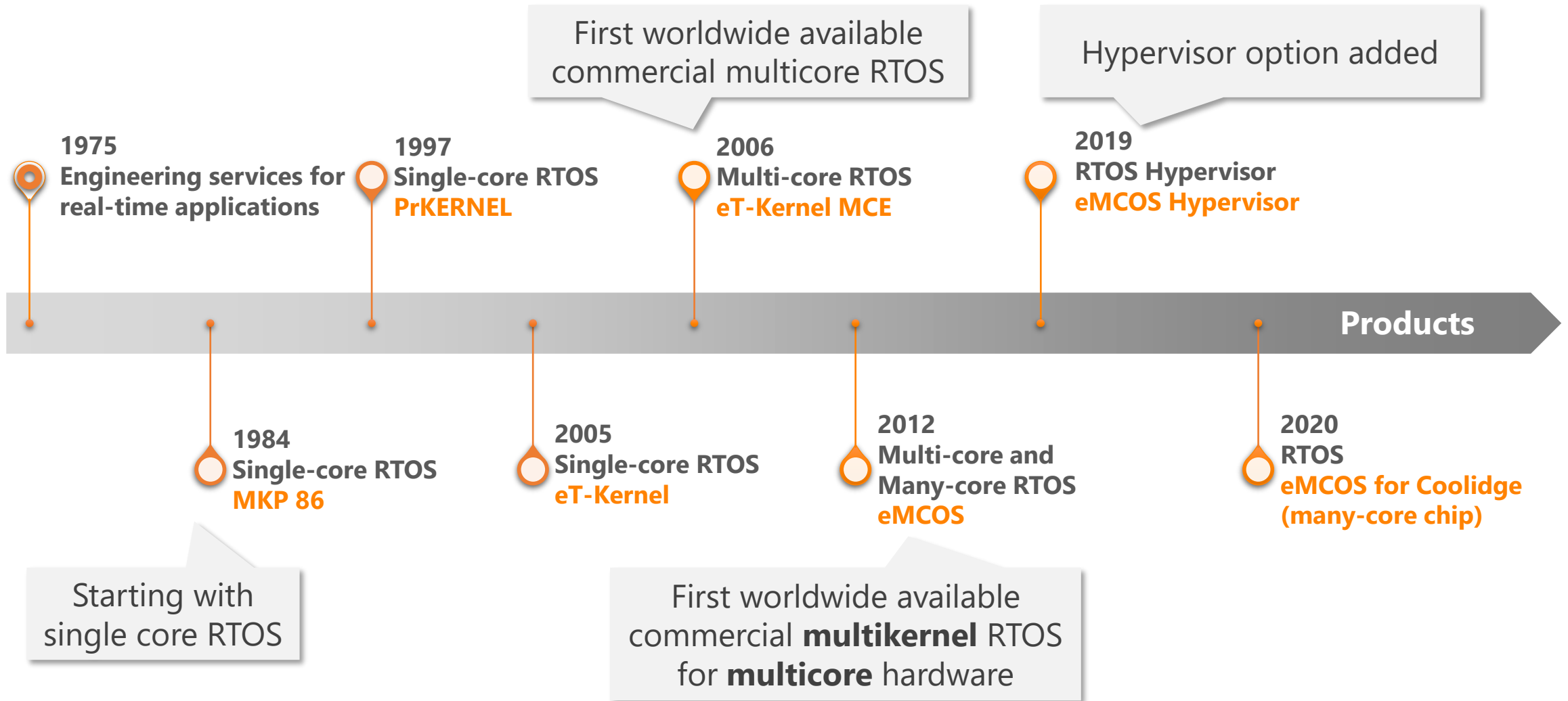of multi/manycore software

Working on the Open-source
real-time OS specification "TRON"

Working on the standardization
of open standards
for the software defined vehicle

eSOL's RTOS product history

First worldwide available commercial multicore RTOS

Hypervisor option added

1975
Engineering services for real-time applications

1997
Single-core RTOS
PrKERNEL

2006
Multi-core RTOS
eT-Kernel MCE

2019
RTOS Hypervisor
eMCOS Hypervisor

Products

1984
Single-core RTOS
MKP 86

2005
Single-core RTOS
eT-Kernel

2012
Multi-core and Many-core RTOS
eMCOS

2020
RTOS
eMCOS for Coolidge (many-core chip)

Starting with single core RTOS

First worldwide available commercial **multikernel** RTOS for **multicore** hardware

eSOL RTOS platforms

RTOS and IDE features	eMCOS	eT-Kernel
eSOL RTOS platform type	Modern multikernel architecture	Traditional microkernel architecture
RTOS API	POSIX	T-Kernel + Extensions
Supported core architecture	Single/multi/manycore	Single/multicore
Supported CPU architecture	Armv8, Kalray MPPA (TriCore, RH850)	Armv7
Virtualization	Hypervisor add-on	-
Safety Certification	ISO 26262 (core component)	ISO 26262, IEC 61508
Middleware	AUTOSAR Classic/Adaptive, Autoware, ROS 2	-
Filesystem	(ex)FAT, Transactional Filesystem	(ex)FAT
Connectivity	TCP/IP, IPsec	USB, TCP/IP
IDE	eDEVS	eBinder
Compiler	Arm (FuSa) C, C++	Arm (FuSa) C, C++
Development-PC OS	Windows, Linux	Windows
Build mechanism	CMake/Ninja	eBinder project
Debug interface protocol	eDEVS/eMCOS and GDB	eBinder/eT-Kernel
OSS debug support	dash, gperftool, toybox, tcpdump, coredump, iperf3, free, ifconfig, top	-

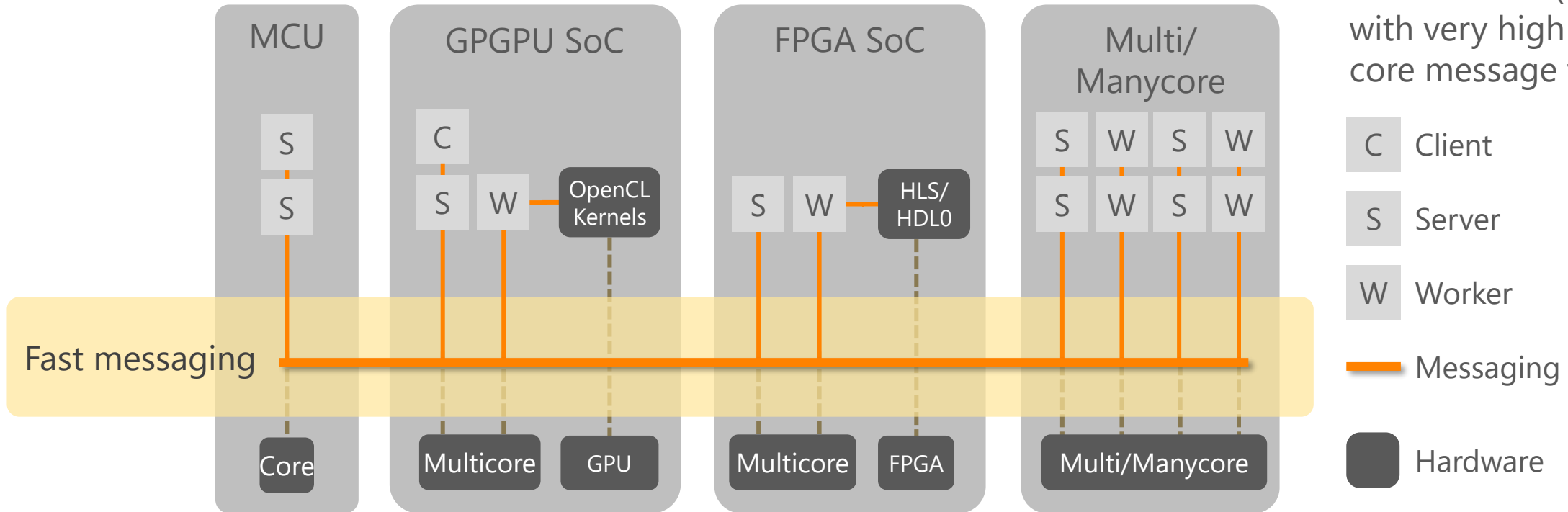eMCOS RTOS platform for mixed criticality system

Why only multi-core hardware increases performance

- While **Moore's Law** (transistors/chip) held true for more than 50 years, **we're not able to harvest its advantage** in the same way as before

- **End of Dennard Scaling** forces us to a constant max. **CPU frequency** since year 2006

- And **Pollack's Rule** limits the **performance of a single CPU** on a chip

- Consequently, the CPU industry's **transition to multicore architectures**, creating significant **challenges for OS suppliers and application developers**
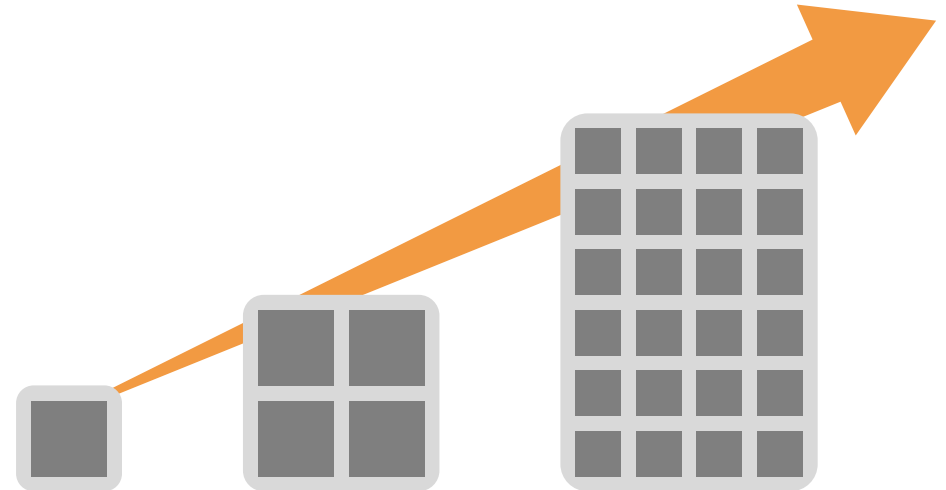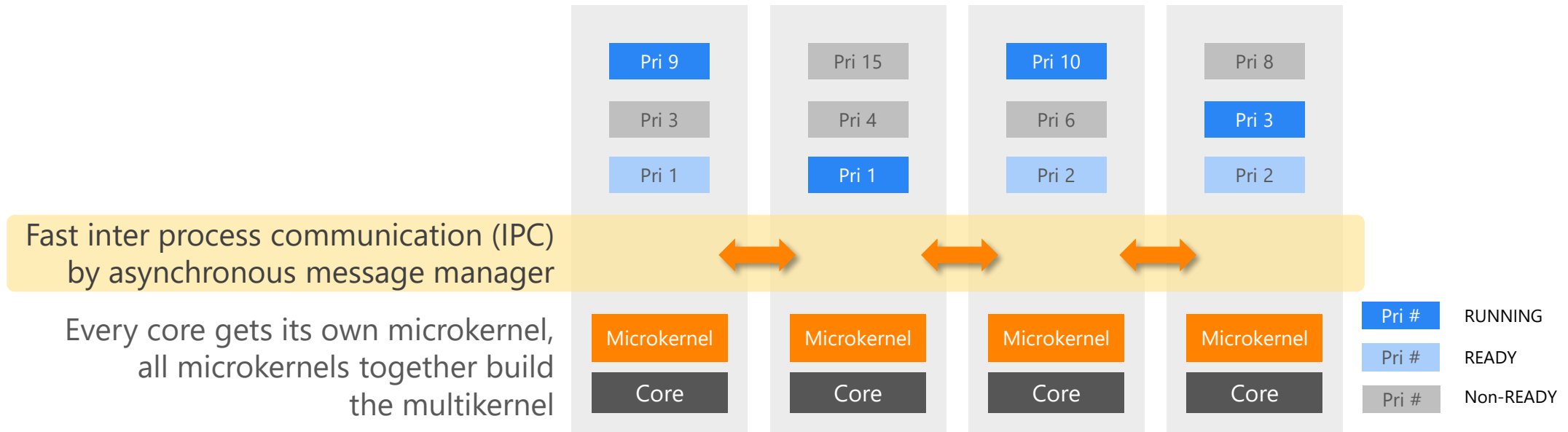
Modern software defined architecture (SDA)

Future embedded SDAs will be based on A **service-oriented architecture** (SOA) with very high inter-core message traffic

Multikernel (distributed microkernel)

Pri 9	Pri 15	Pri 10	Pri 8
Pri 3	Pri 4	Pri 6	Pri 3
Pri 1	Pri 1	Pri 2	Pri 2

Fast inter process communication (IPC) by asynchronous message manager

Every core gets its own microkernel, all microkernels together build the multikernel

| Microkernel | Microkernel | Microkernel | Microkernel |
| Core | Core | Core | Core |

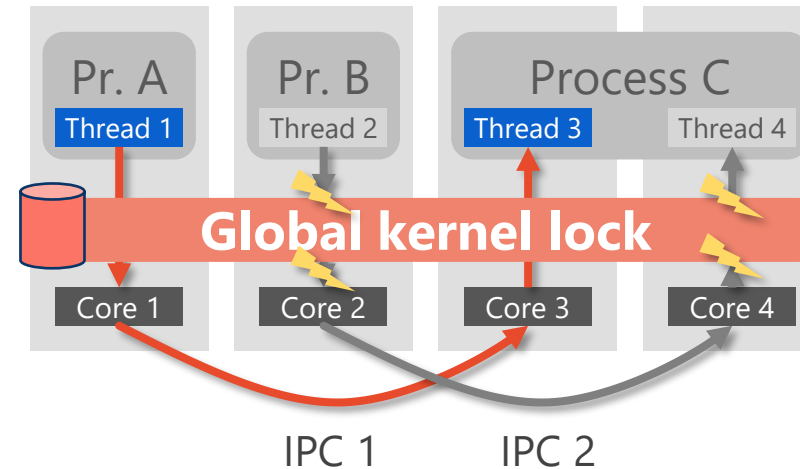| Pri # | RUNNING |
| Pri # | READY |
| Pri # | Non-READY |

Series of microkernels working together as one system of systems
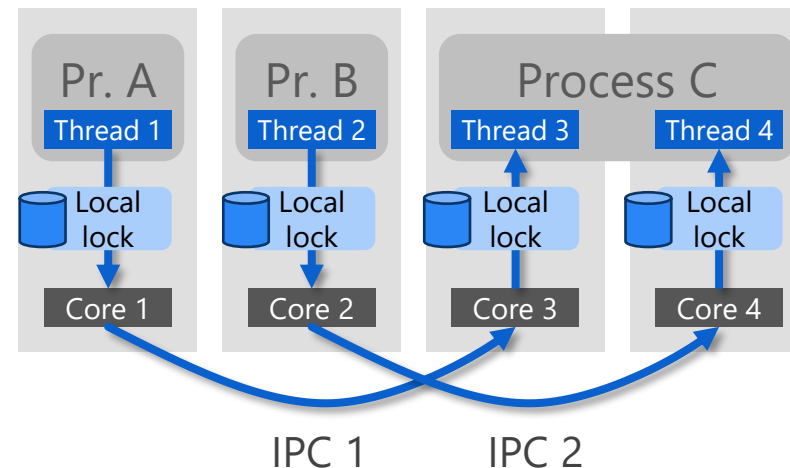
Why multi-core systems need multikernel RTOS

- Today **SMP**-RTOS is used for high embedded performance applications

- For inter process communication (**IPC**) on different cores a **SMP-RTOS must block all cores**, to guarantee its real-time integrity

- **Multi**kernel uses the technology of **distributed microkernels**

- **Multikernel avoids global kernel locks**

- RTOS architecture with **local lock mechanism** is needed to increase **performance and freedom from interference** (**FFI**)

Microkernel SMP RTOS

Pr. A	Pr. B	Process C	
Thread 1	Thread 2	Thread 3	Thread 4

Global kernel lock

| Core 1 | Core 2 | Core 3 | Core 4 |

IPC 1   IPC 2

Slow and low FFI at multicores

Microkernel Multikernel RTOS

Pr. A	Pr. B	Process C	
Thread 1	Thread 2	Thread 3	Thread 4
Local lock	Local lock	Local lock	Local lock
Core 1	Core 2	Core 3	Core 4

IPC 1   IPC 2

Fast and high FFI at multicores

e∶MCOS

e∶SoL

Software scalability supported with standard RTOS APIs

Reuse available AUTOSAR and POSIX applications

OS App	OS App	OS App
AUTOSAR Classic	**AUTOSAR** Classic	

Process	Process
AUTOSAR Adaptive	

Process	VMM*
AUTOSAR Adaptive	Linux Guest

AUTOSAR SC1	AUTOSAR SC3	Multi-process POSIX	POSIX Hypervisor
eMCOS AUTOSAR	**e**MCOS AUTOSAR	**e**MCOS POSIX	**e**MCOS Hypervisor
Single/Multi-Core	Single/Multi-Core	Single/Multi/Many-Core	Single/Multi/Many-Core

*VMM: virtual machine manager

e₹SoL
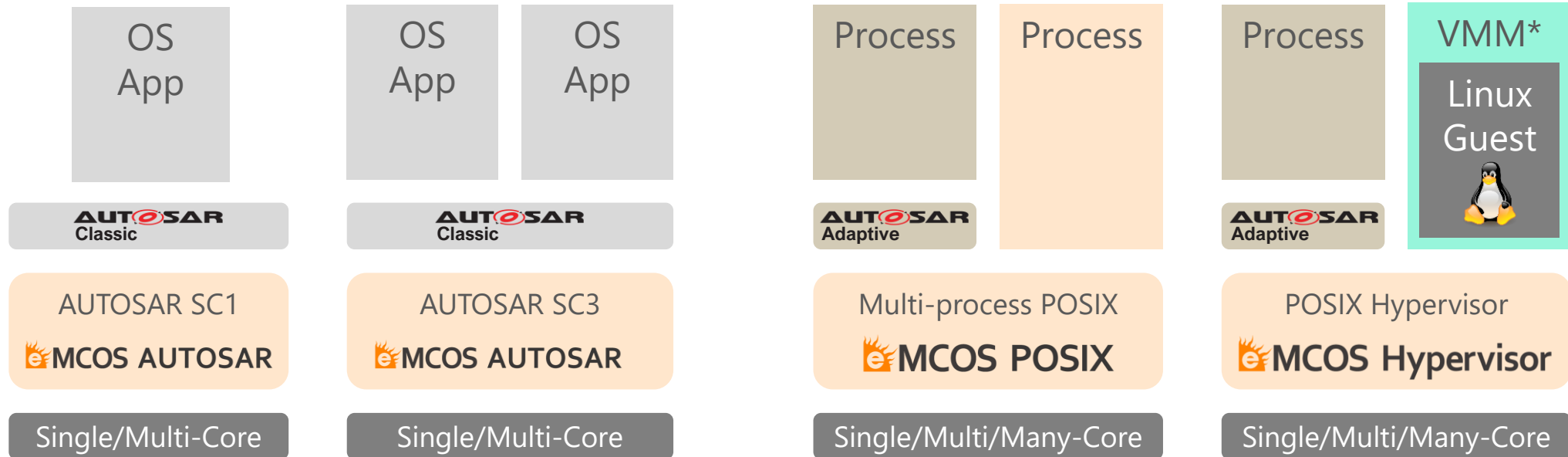
Further multi-OS consolidation by hypervisor option

Linux	Bridge (shared device drivers)	Android	POSIX real-time applications	ROS/ ROS 2	AUTOSAR Adaptive Platform
virtio		virtio		Autoware ∷ROS ∷2	AUTOSAR
VMM		VMM			

MCOS Hypervisor

MCOS POSIX

MK	MK	MK	MK	MK	MK	MK	MK
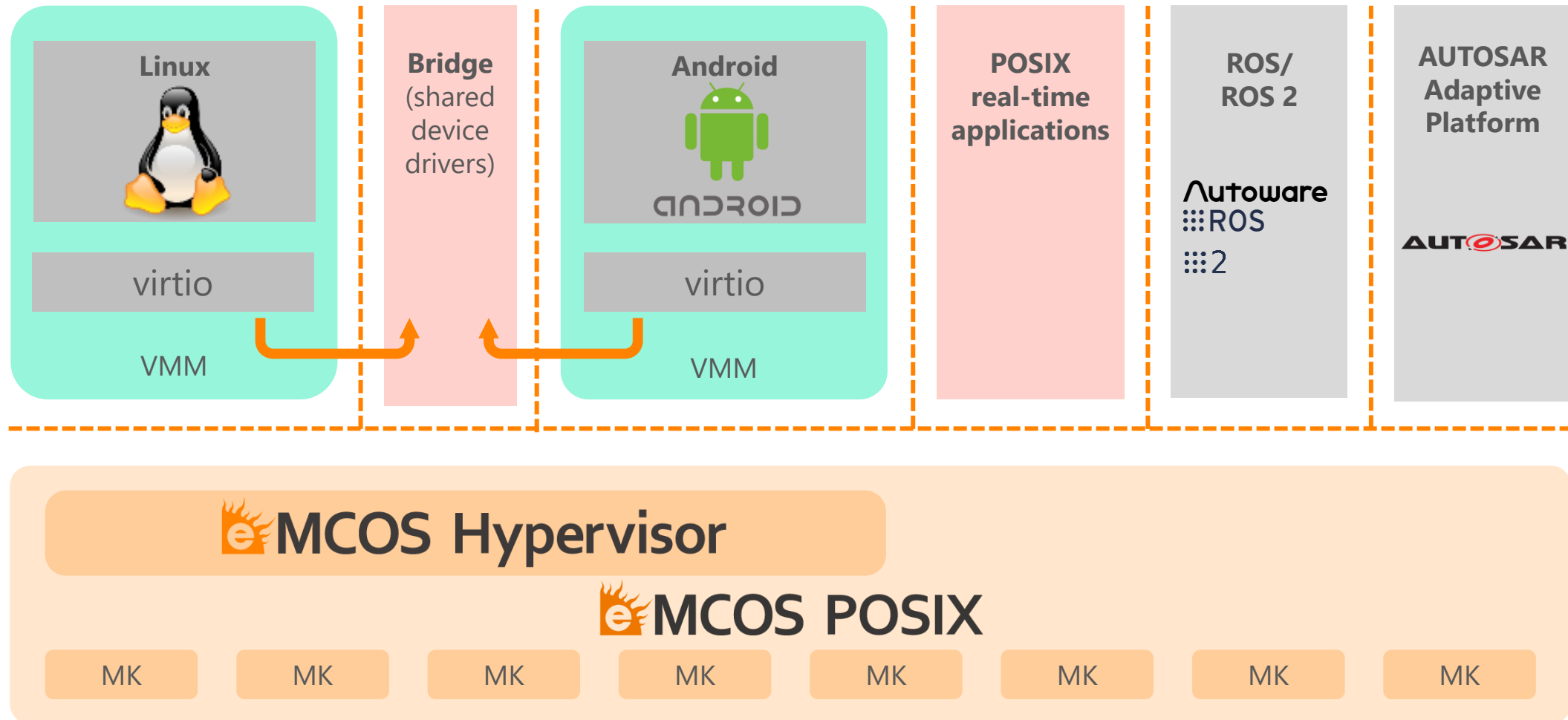
MK: microkernel of multikernel
VMM: virtual machine manager

eSoL

Functional safety support

eMCOS safety certification

Development process
compliant with
- ISO 26262 (automotive)
- ISO 61508 (industrial)
- IEC 62304 (medical)

AUTOSAR Classic Platform:
- eMCOS AUTOSAR SC1 & SC3 multicore
- Certified ISO 26262 ASIL D

AUTOSAR Adaptive Platform:
- eMCOS POSIX planned to be certified
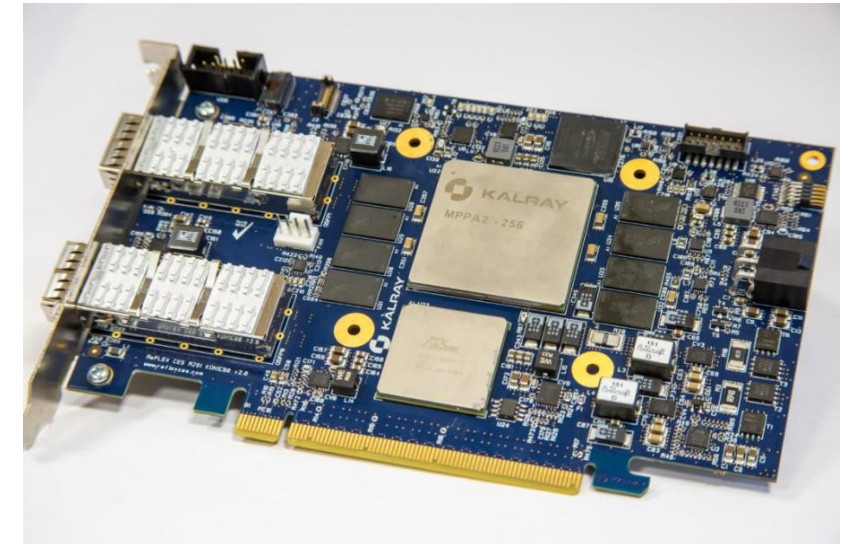 by SGS-TÜV for ASIL B/D in 2021

Autoware on eMCOS (2017)

MPPA-256 Bostan offers 634 GFLOPS SP for 25W @ 600Mhz

Autonomous driving nodes such as:
 - NDT matching localization
 - waypoints tracking
 - pure pursuit, etc
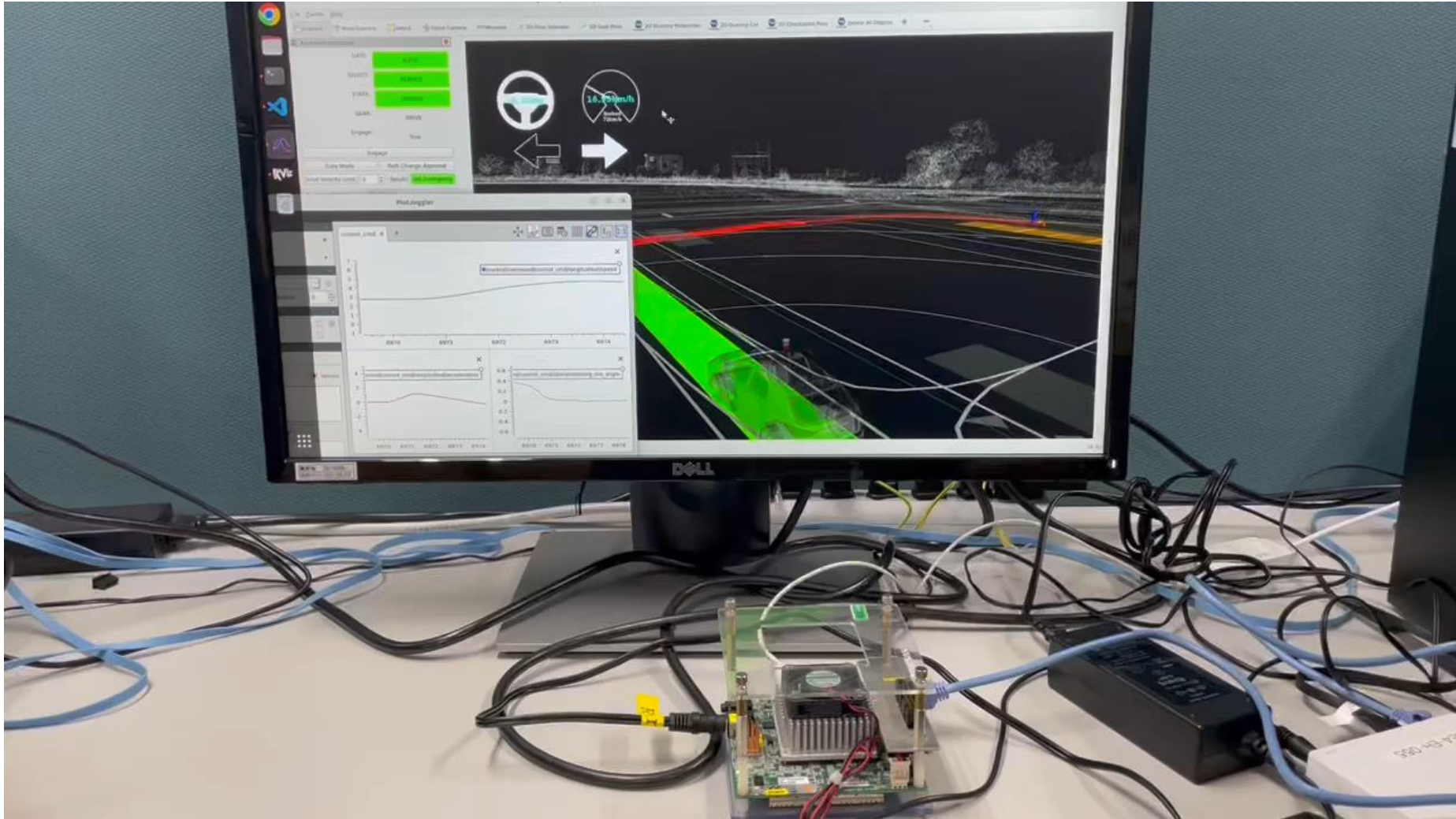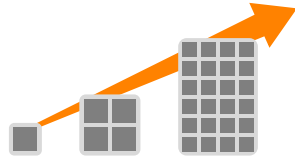
are **running on this embedded board**

https://youtu.be/wZyqF90c5b8

https://www.kalrayinc.com/portfolio/boards/

Autoware.Universe on eMCOS (2022)

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eMCOS summary

HARDWARE SCALABILITY
From single-core MCU
to many-core SoC
to multi-chip systems

HIGH PERFORMANCE
Real parallelism
Low-weight, deterministic MP
Hard and soft real-time

eMCOS

SOFTWARE SCALABILITY
POSIX API, multi-process
like at AUTOSAR CP & AP,
Hypervisor

POSIX API
AUTOSAR

eSOL

Challenge With Passion