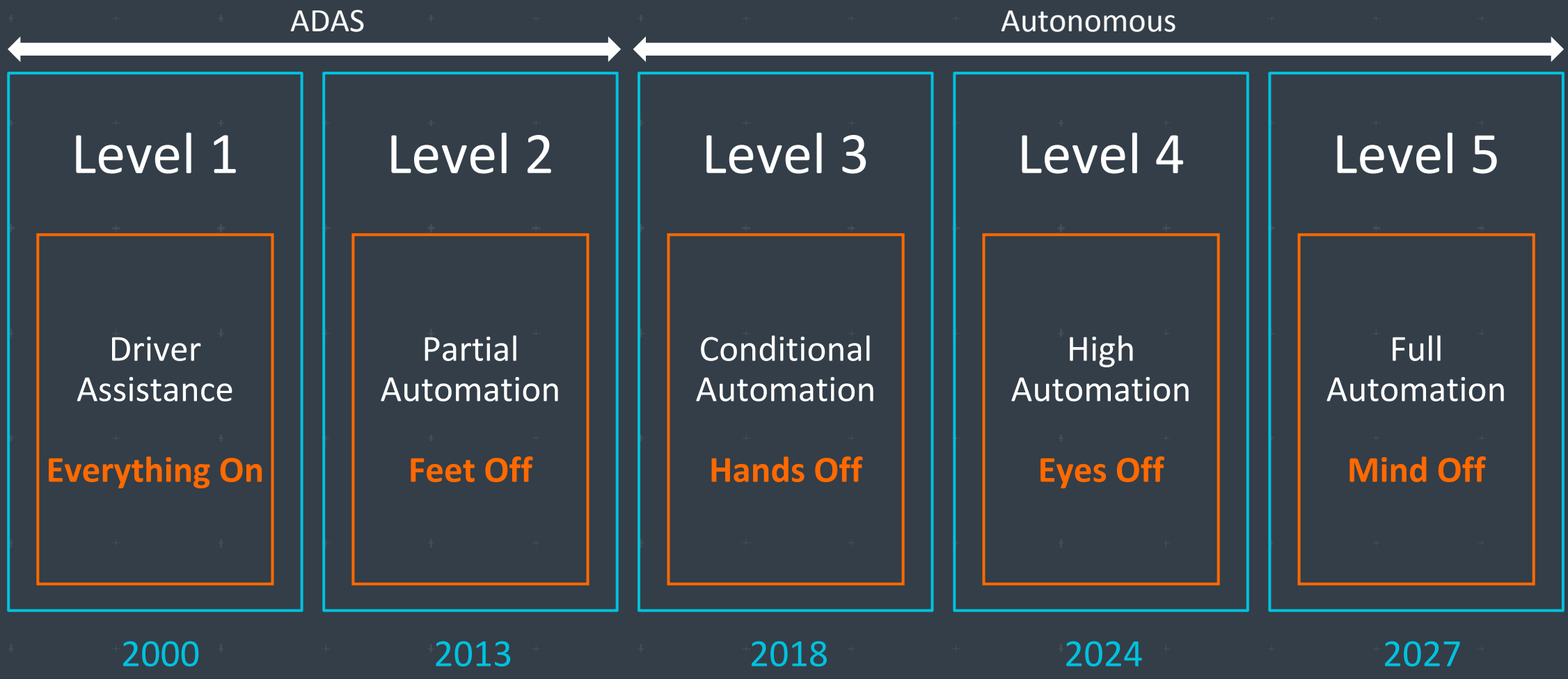
Flash Memory Summit

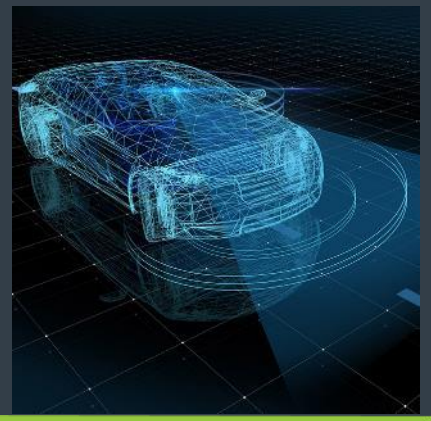
What's different about Automotive Storage?

Neil Werdmuller
Director of Storage Solutions

Advanced Driver Assistance Systems Evolving to Autonomy



Assessing the Compute Capabilities for Autonomous Systems



Sense

- Multiple sensor technologies required for L3+ autonomy
- Range of sensor types with increasing number of sensing points as autonomy rises
- Sensor fusion will also rely on accurate and consistent V2X data

Perceive

- High levels of scalable amounts of compute required for perception processing
- Large data set needs multiple stages of processing
- Accelerators aid in deep learning algorithms

Decide

- Demand for increased level of functional safety in decision making
- Decision making shared between application processing and real time processing with highest safety level

Actuate

- Changes to the vehicle's lateral / longitudinal dynamic response must be at the highest functional safety level and must be real time and deterministic.

Automotive: Enabling the New Pace of Automotive

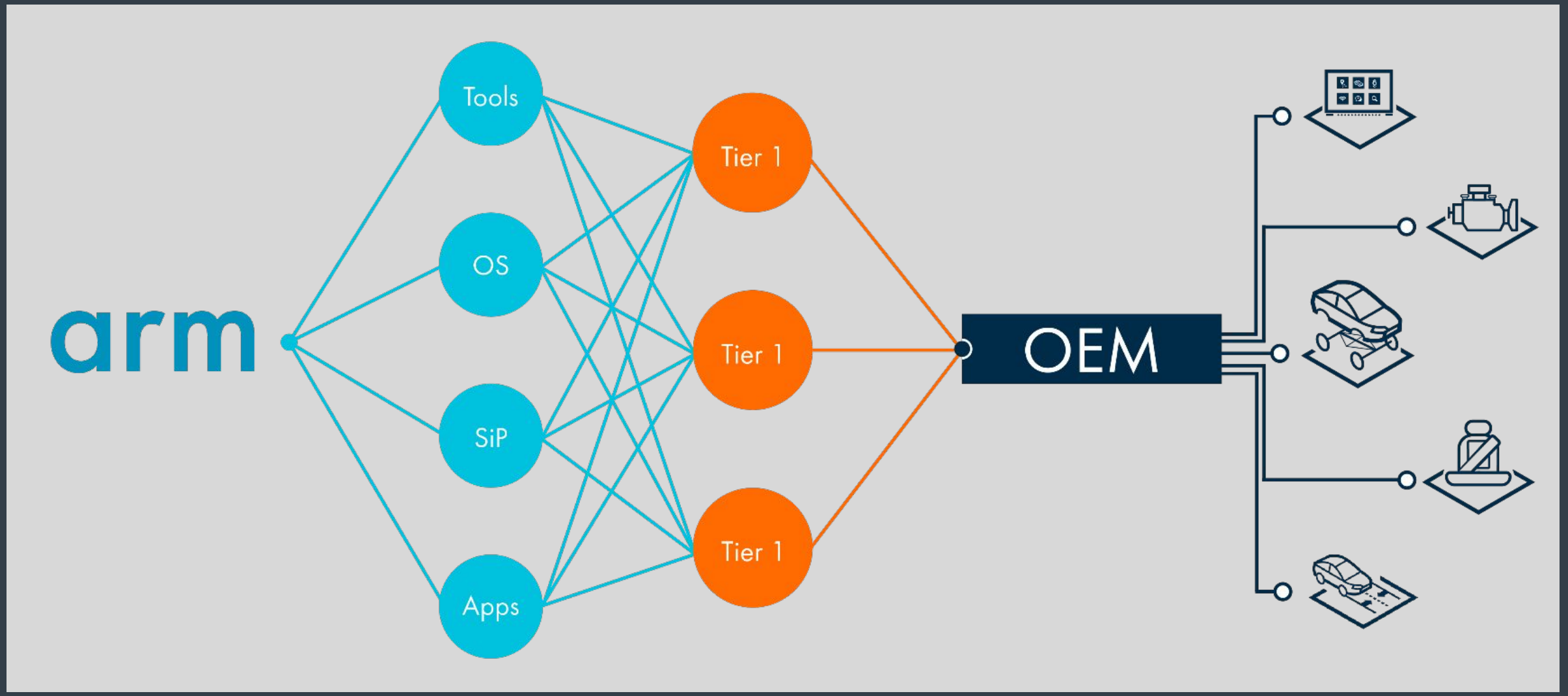
- Focus on key application areas in automotive
- **Relationships with OEM/Tier 1s and Automotive Ecosystem are key for understanding the requirements for next generation automotive solutions**
- **Automotive grade storage required across all of these areas**

Advanced Driver Assistance Systems

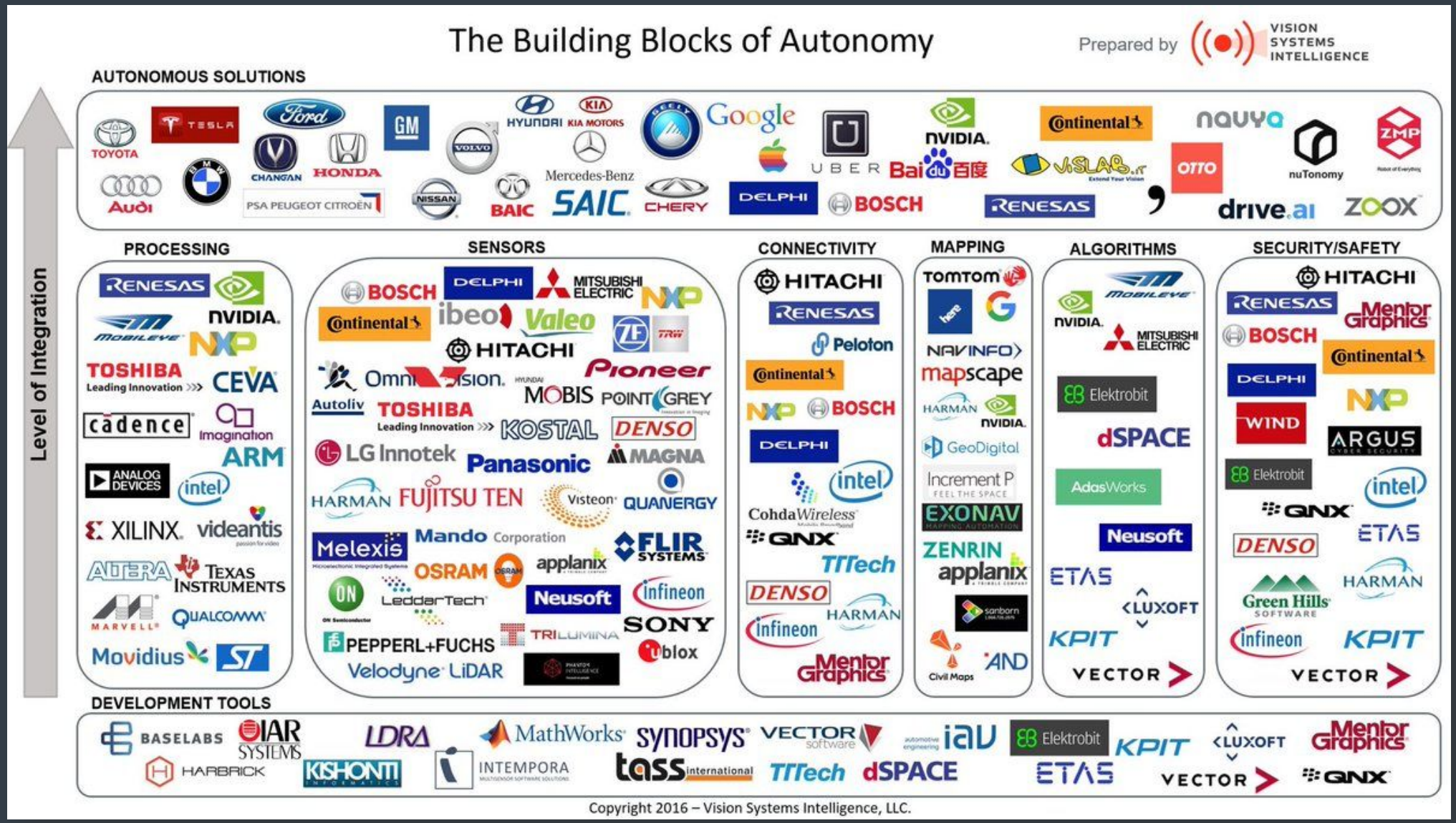
IVI & Digital Cockpit

Autonomous Driving

Automotive Supply Chain



Automotive Ecosystem: Complex and Broad



Software Complexity for Full Autonomy

14m
lines of code

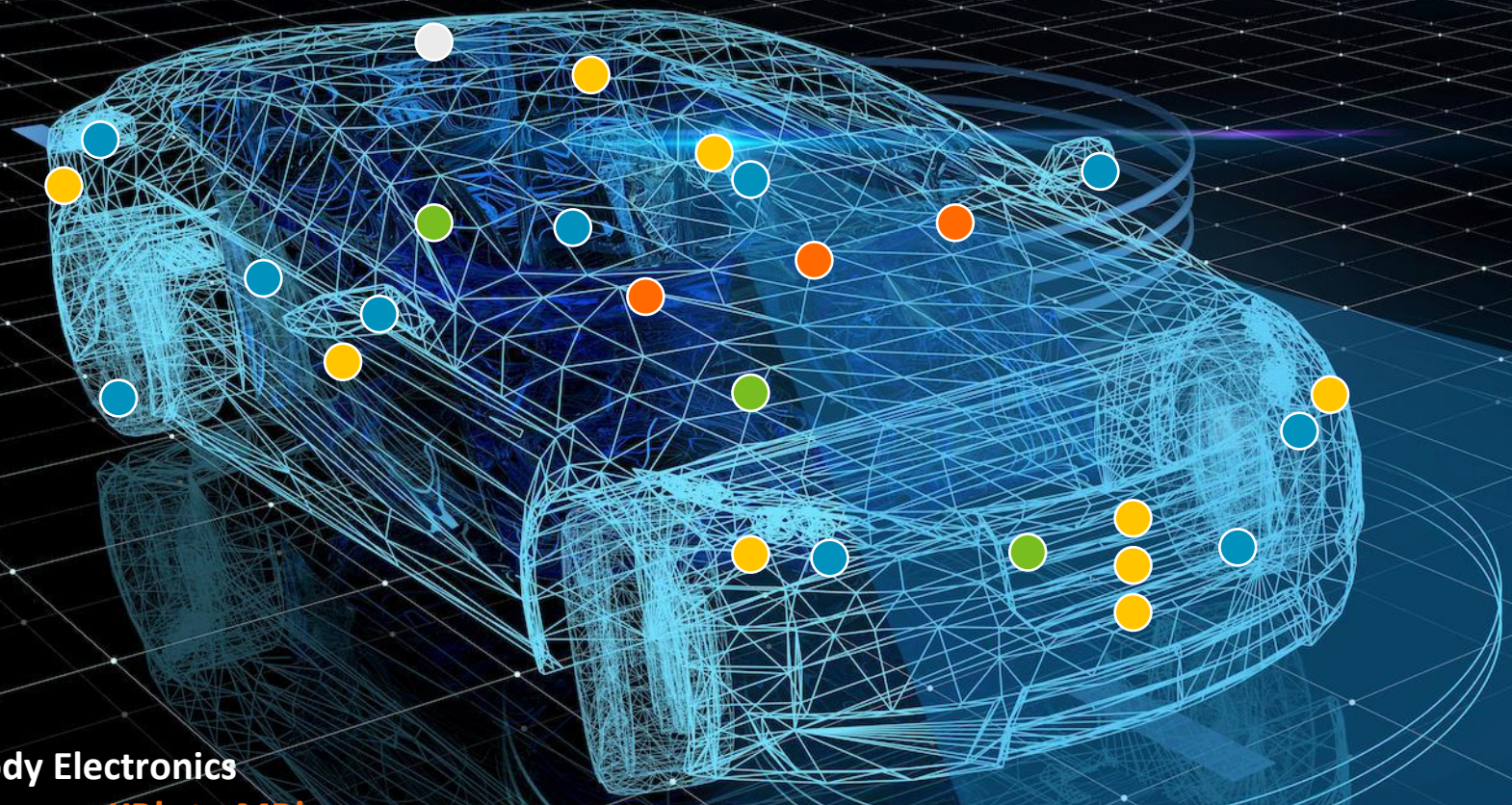
Boeing 787 Dreamliner

1bn
lines of code

Autonomous car (Level 5)

Source: Informationisbeautiful.net & Talisman Executive

Automotive Storage Requirements



Cockpit

Storage: GB's to TB's

~50,000 DMIPS

Audio Visual, Maps, Traffic, Toll payment, Google services Rear entertainment, Voice recognition, Gesture control, Cluster and HUD

Semi Autonomous

Storage: GB's to TB's

~350,000 DMIPS

Level 3 autonomy, Radar / image processing, Collision avoidance, Pre-crash, Cruise control, Lane departure, Parking, **Black box recording, HD mapping**

Connected Gateways

Storage: KB's to MB's

~20,000 DMIPS

LTE 5G, WiFi, Bluetooth connecting to CAN FD, LIN, Flexray, Ethernet

Body Electronics

Storage: KB's to MB's

<10,000 DMIPS

HVAC, Lighting, Doors, Electric seat, Windows, Mirrors, Cameras, Seat belt, Air bag, BCM

Chassis

Storage: KB's to MB's

~15,000 DMIPS

EPS, ABS/EBS, Active VDC, EPB

e-Powertrain

Storage: KB's to MB's

~15,000 DMIPS

Main Motor control, Transmission, Engine control, Generator/E-water pump Battery management

Disruptive Connectivity

Right-turn collision caution

Emergency vehicle notification

Red light

Communication radar cruise control

Collaborative Intelligence in the Infrastructure

Cloud servers

Training, Inference
Autonomous Models
Servicing Control
…

Regional servers

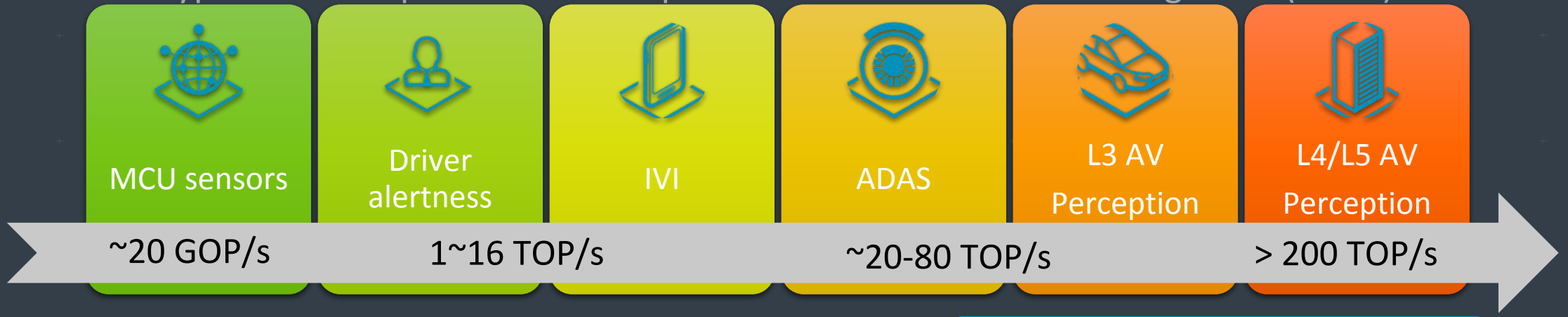
Training, Inference
Local HD Mapping
Traffic Management
…

Edge devices

Sensing, Inference, Actuation
Traffic Light Control
Emergency Vehicle Control
…

Machine Learning for Automotive Applications

Typical market performance requirements for Neural Processing Units (NPUs)



NPU (Microcore)

- Mali-GPU
- Cortex-A
- Cortex-R
- Cortex-M

NPU (Unicore)

NPU (Multicore)

- 2-8 NPU cluster
- Multiple nets each assigned an NPU
- Large nets spread across several NPUs

NPU (Manycore)

- Many NPU arrays
- Enables 100's TOP/s systems
- Multiple networks each assigned an NPU
- Large networks spread across several NPUs

Software Ecosystem for ML/AI Intelligent Solutions

Automotive SW stack is growing exponentially

Vibrant Arm automotive software ecosystem comprised of partners at all levels of SW stack

- Many safety certifiable solutions
- Commercial and open source software solutions

Allows developers to harness the innovation available within the Arm ecosystem

- Formed [Arm Automotive Developer Community] as a central location to start research on any element of a new Electronic Control Unit (ECU)

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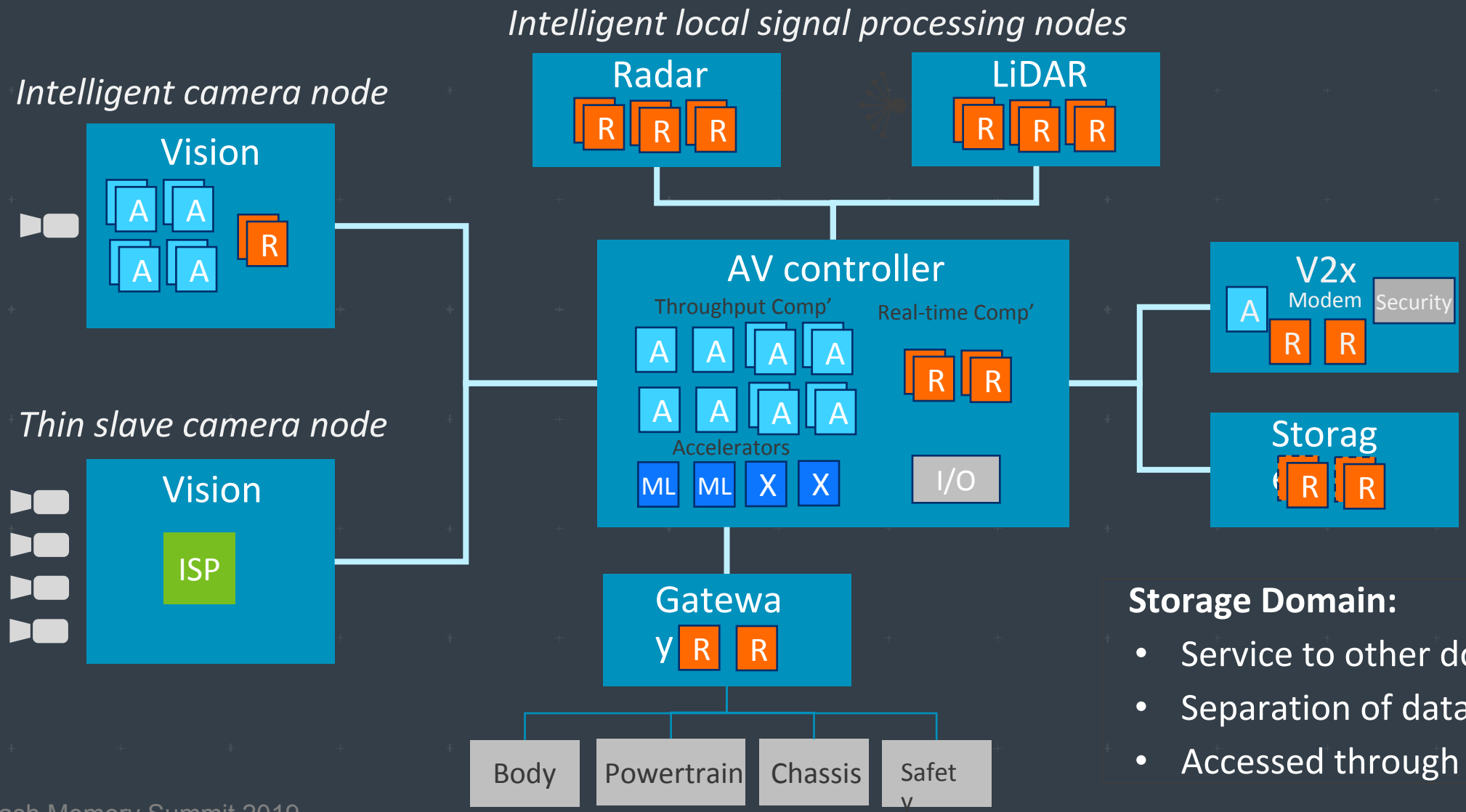
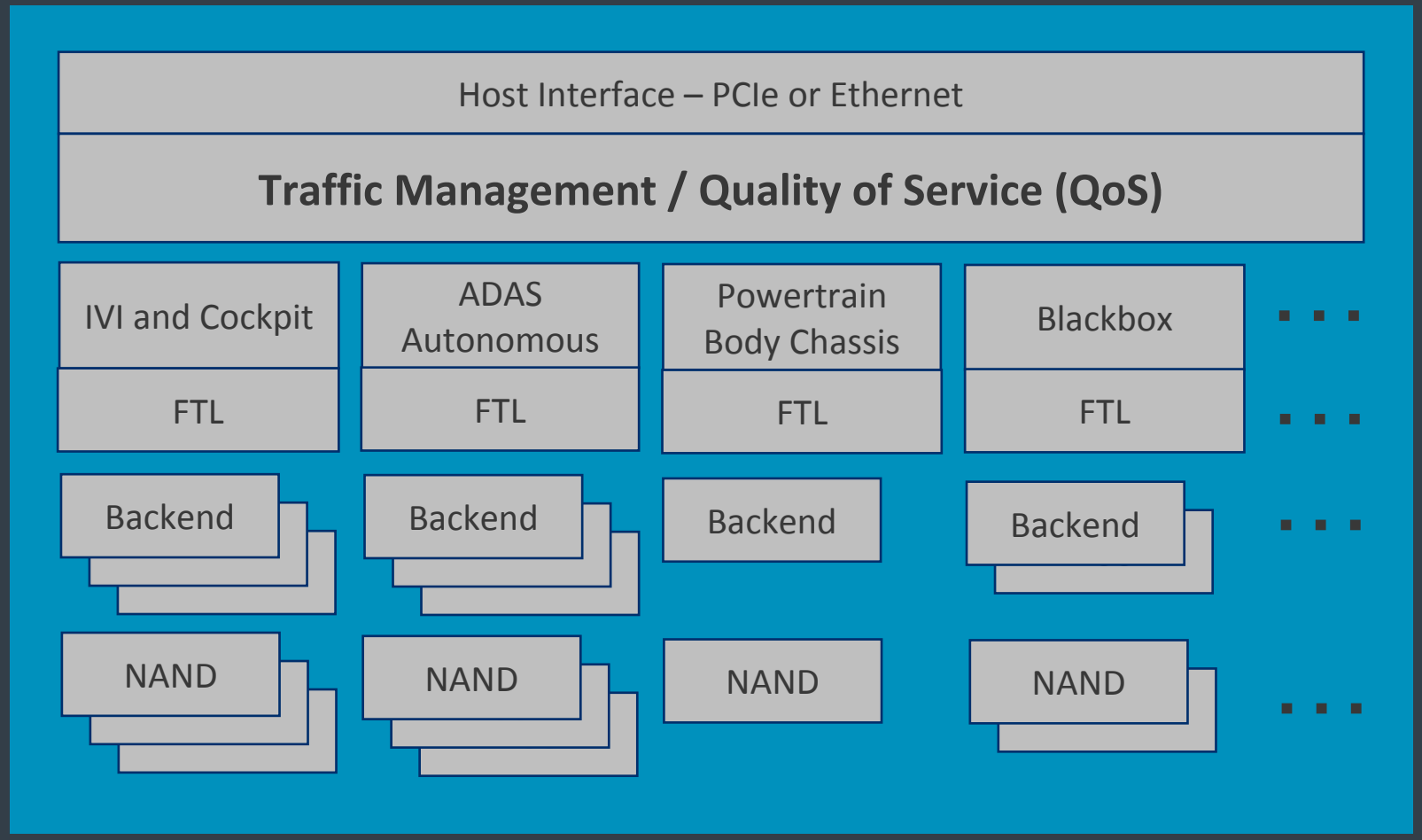
Autonomous Requires Heterogeneous Compute and Storage



Storage Domain:

- Service to other domains
- Separation of data
- Accessed through PCIe/Ethernet

Storage Domain Controller Example – Domain Isolation



NVMe / NVMe-oF

Isolation of zones

Sub-domain controller

NAND management

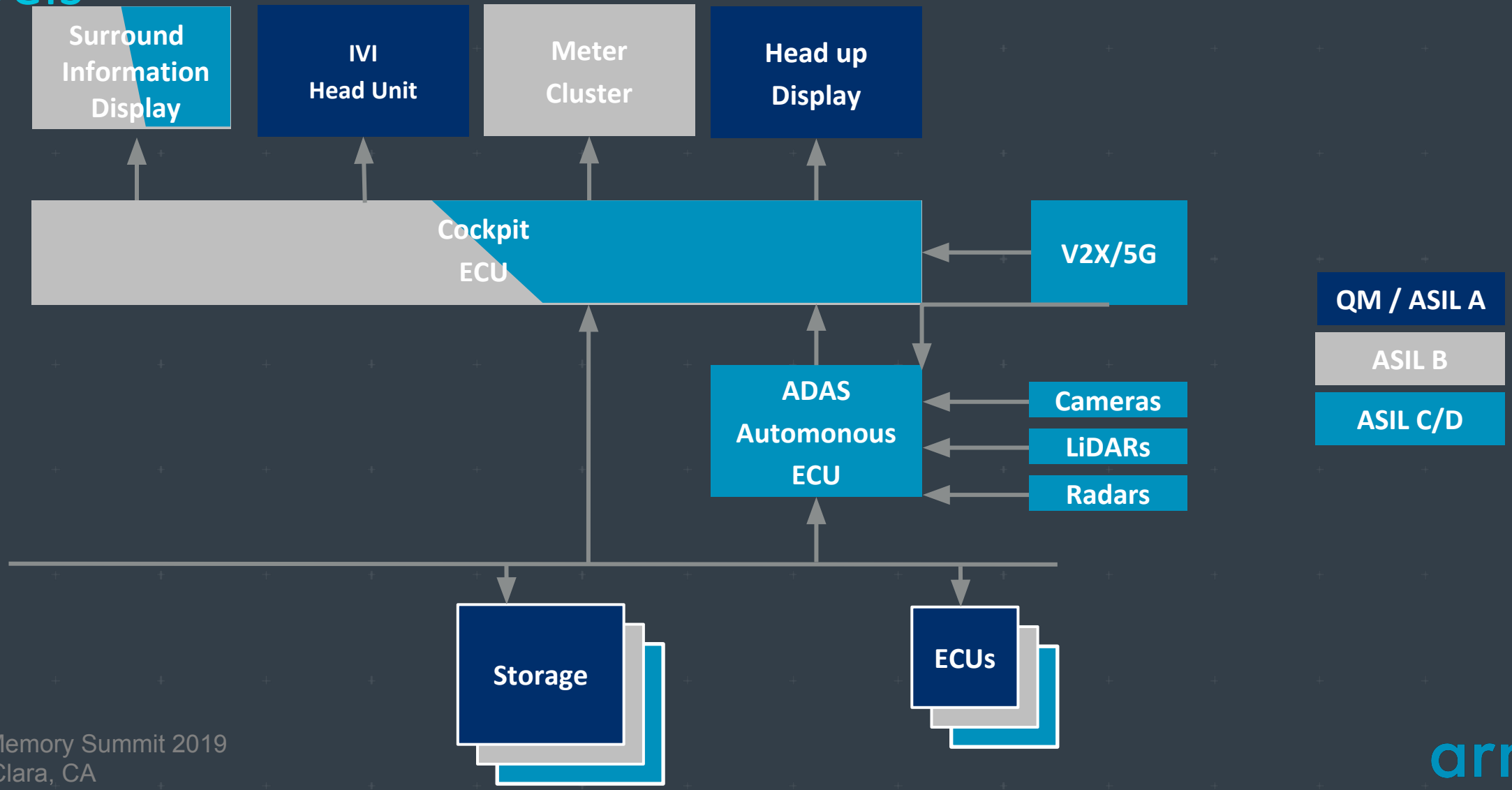
NV memory

Functional Safety

"Absence of unreasonable risk due to hazards caused by malfunctions"

- Systems must function correctly
  - Faults must be detected and controlled
  - Products must be properly specified and developed accordingly
- Safety critical
  - Systems relied upon to always function
  - High risk of hazard and loss of life
- Safety 'nominal'
  - Systems that are helpful rather than essential
  - User can act to avoid hazards if aware of fault

Example automotive ASIL (ISO26262) safety certification levels



Data Storage in Automotive

Safety Levels: ISO26262 for ASIL A, ASIL B, ASIL C and ASIL D

Major functionality areas	Safety critical (ASIL C/D)
IVI	No
SD/HD mapping and GPS	Yes for autonomous
Dashboard	Partially (tell-tales, camera viewers…)
Logging / blackbox recording	No (but must be reliable)
ADAS / autonomous	Yes
Domain controllers / Gateways	Yes
Powertrain and chassis	Yes

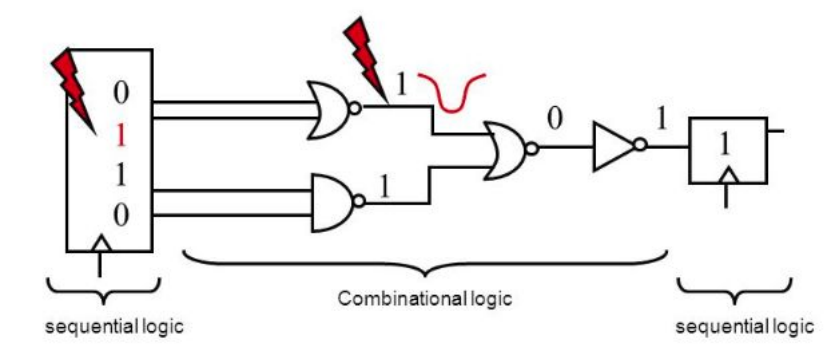
What Faults Need to be Detected in a Storage Controller?

Preventing Flash Translation Tables (FTL) corruption

Single Event Upset (SEU)

Automotive is a harsh environment

Radiation can cause an SEU at any time



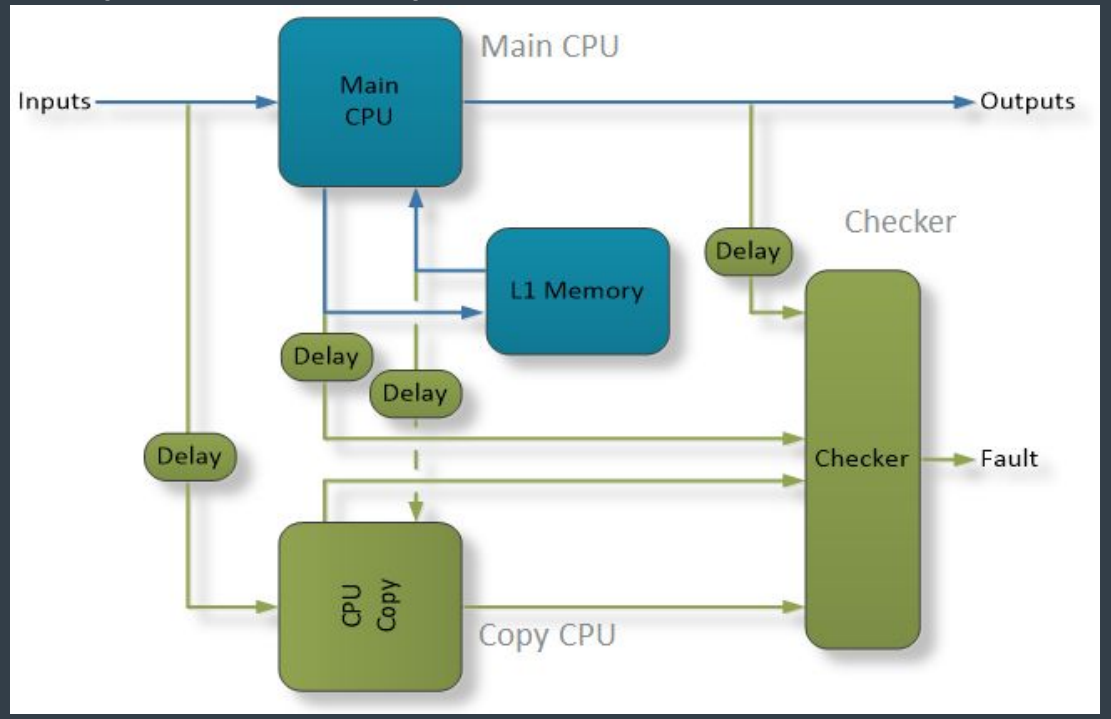
Controllers use ECC to protect memories

Processors / logic are typically not protected

Any corruption could corrupt the FTL

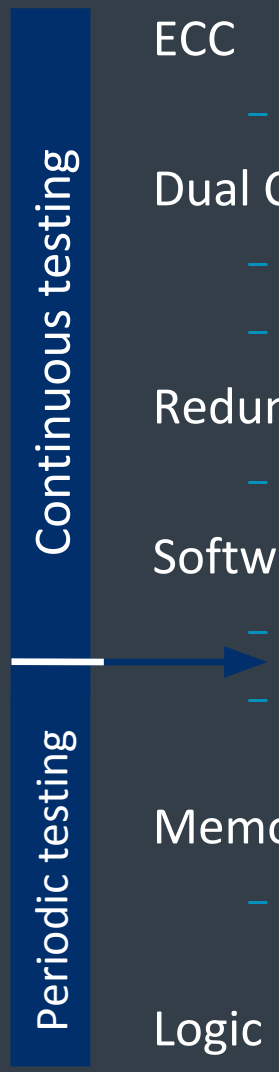
Mitigated by Dual Core Lock Step (DCLS)

CPU protected by DCLS



Interconnect / logic also requires protection

Techniques for Fault Detection and Control in Systems



ECC
- Detects memory faults and corrects if possible. Single error correct / double error detect for all ASILs

Dual Core LockStep
- Near-immediate detection of transient and permanent faults in CPU logic
- Essential for ASIL D and used for ASIL B if a fast fault reaction time is required

Redundant execution
- Application duplicated across clusters, or repeated in time. Can achieve ASIL D on CPUs without DCLS

Software Test Library
- Can detect permanent and latent faults for ASIL B on simpler CPUs and where fault reaction time allows
- Detects latent faults, not exposed by mission software for ASIL D. Coverage challenges on complex CPUs

Memory BIST
- Detects latent faults in memory. Expected for all ASILs. Performance impact minimised by On-line MBIST

Logic BIST
- Detects latent faults in logic. Full coverage but destructive to the application so must reset and reboot

What Happens when an Error is Detected

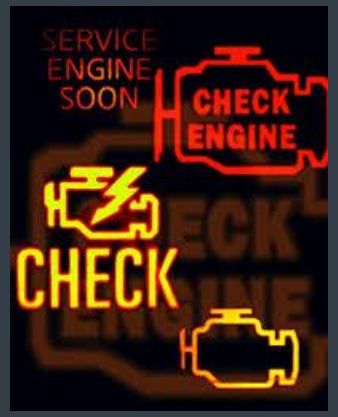
A key question for safety critical automotive storage domains

Fail-safe

Enter ‘limp-home’ mode

Error notified

Functions with reduced capabilities

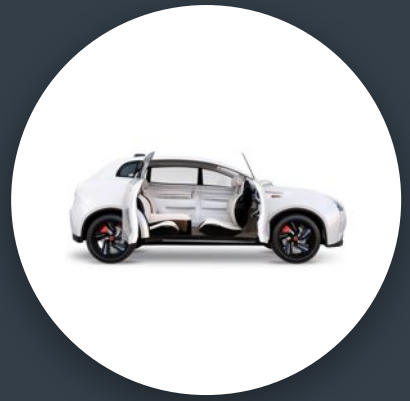


Fail Operational

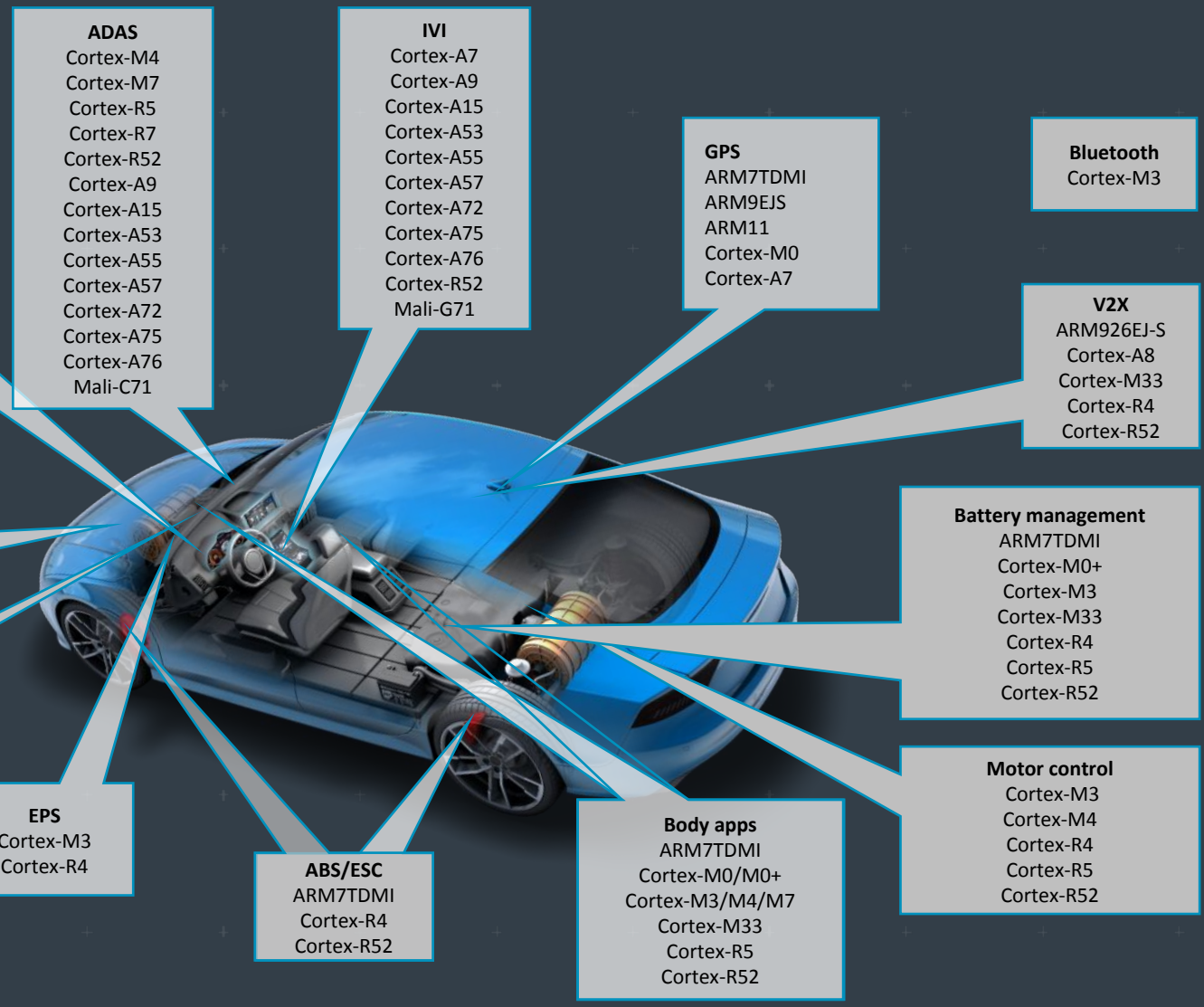
The system must be able to continue

System must recover quickly

Full functionality regained



The World Drives on Arm Based Technologies



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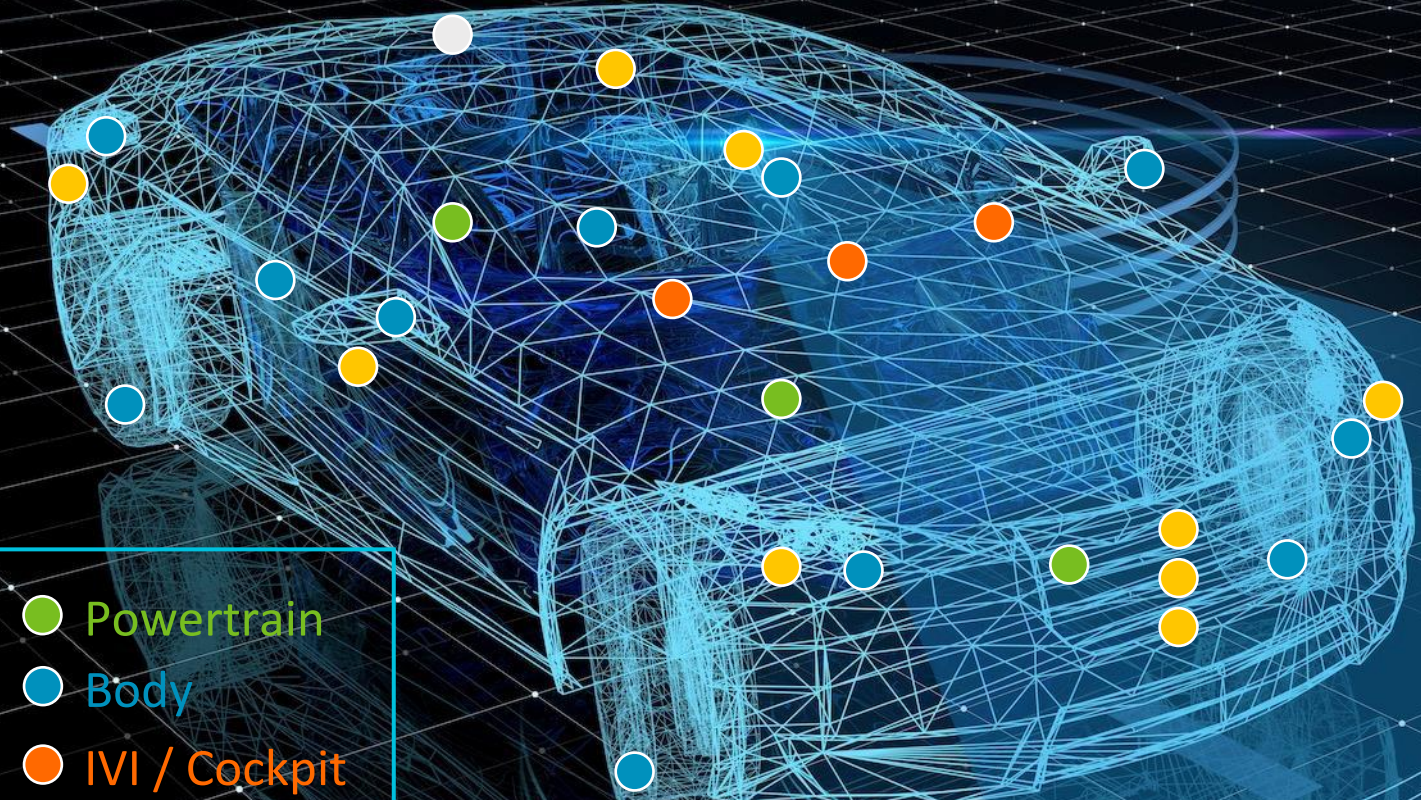
Arm in Automotive, Fender to Fender



- Powertrain
- Body
- IVI / Cockpit
- ADAS / Autonomous
- Connectivity

Continuously supporting the automotive market since **1996**

>85% share of IVI application processors

>65% share of ADAS application processors

80% Share of ADAS + IVI application processors

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Arm is Helping Enable the Pace of Automotive Change

Arm has focused on the future needs of automotive electronic design with a dedicated automotive line of business

- Focus on ADAS/Autonomous, IVI/Cockpit, Electric Powertrain

Functional safety and security are key elements of Arm's automotive portfolio

Arm has created a vibrant automotive ecosystem to enable faster design

Arm will enable the successful mass deployment of higher levels of vehicle autonomy

- High performance, power and thermal efficient solutions

arm

To Learn More…

I'll be here all week

For more information, visit **storage.arm.com**

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Thank you