



# Vehicle storage— The challenges of storage

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# Different requirements for Infotainment and autonomous Driving

## Infotainment

### User experience

- Display (Number, Resolution)
- Input devices (Touch, Speech, Gesture)
- User content: Player, Radio
- Fast update cycles
- Combination of On/Off-board content



**Strong CPU and GPU  
+ Memory capacity**

## Autonomous Driving

### Safety is the first goal

- Redundant Hardware
- Sensor centric system
- Sensor fusion (Camera, Lidar etc.)
- Data storage of sensor data for AI training
- Object detection → Heavy AI workload



**Strong CPU and AI capabilities  
+ high RAM Bandwidth**



# Infotainment and ADAS move closer together



## Intuitive Interaction: MBUX

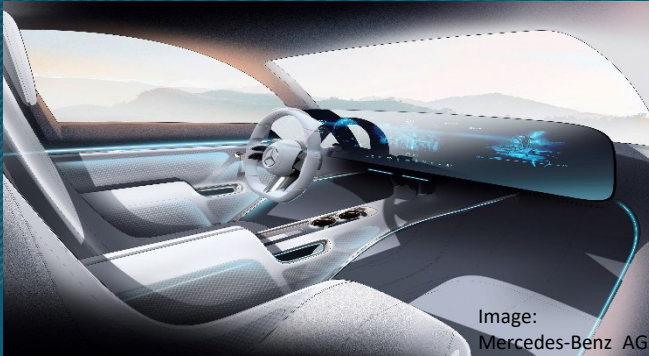


Image:  
Mercedes-Benz AG



## Self-Driving Cars

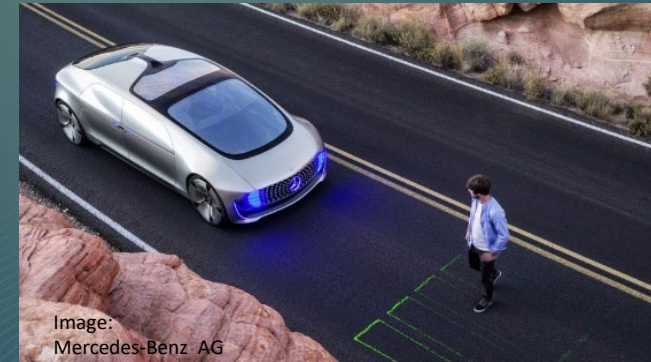


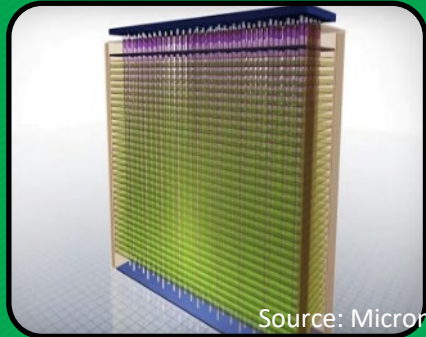
Image:  
Mercedes-Benz AG

## Both application need lot of computing and memory

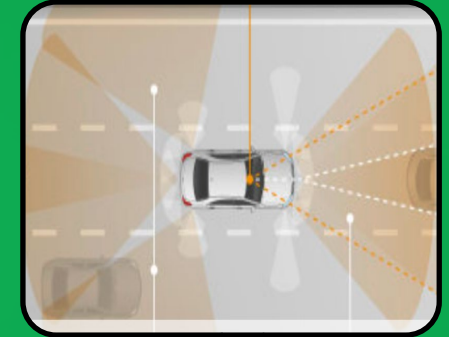
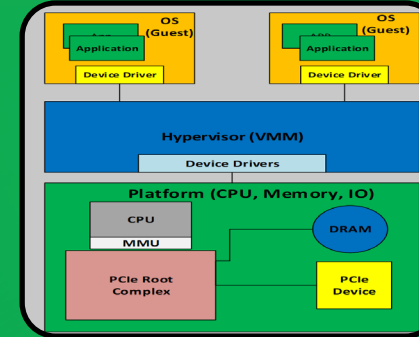
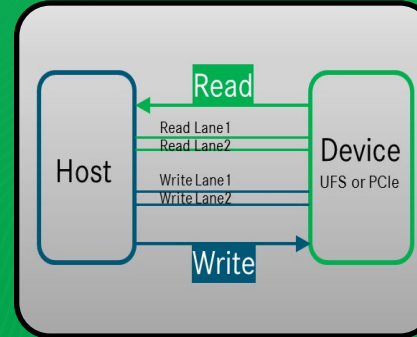
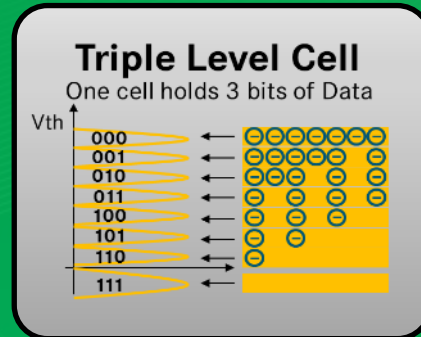
- Infotainment primary goal is to improve User Experience
- Self-Driving creates more free time
- Both fields need Flash memory



# Vehicle storage: Non volatile Memory / Flash



Source: Micron



## 3D-Cell Technology

- Capacity increase only possible with 3D technology
- Rapid increase of stack: 48 – 64 – 96 – 112 – 176
- Preprogramming is getting difficult
- Increase of minimum capacity
- Cell scale down degrades reliability

## Triple Level Cell Technology

- 3D allow more electrons per cell
- Capacity per die increases
- Price advantage over planar technology
- QLC questionable for automotive

## Emerging NVM Interfaces

- Serial high speed IF dominating: UFS or PCIe
- UFS3.1 entering market, UFS4.x is coming in automotive 2024/25
- Automotive starts to adopt PCIe NVMe

## OS and Hypervisor support

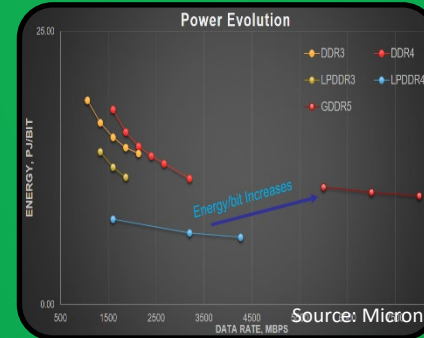
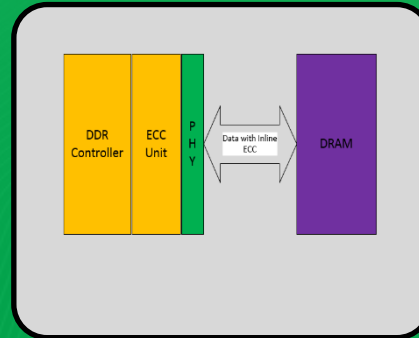
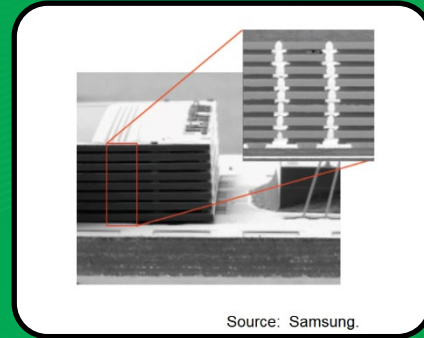
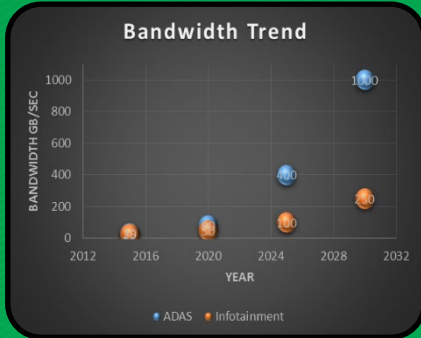
- Support for Multi-CPU and OS systems
- IO-Device support: Hypervisor with SR-IOV pass-through capability

## Functional Safety & Cyber security

- Functional safety is key for autonomous driving
- Cyber security UNECE R155 (CSMS) / R156 (SUMS)
- > Data encryption and protection need



# Vehicle storage: Volatile Memory / DRAM



## Bandwidth increases

LPDDR5 is becoming mainstream, LPDDR5x is around the corner

Support of AI accelerators for AD need more bandwidth

→ GDDR6 or HBM3

## Memory density

Memory vendors move from 1ynm to 1zn node

Shortcut to increase density: Multi-Die package

## ECC

New devices smaller than 20nm need ECC for data reliability

In autonomous driving ECC can be a component for safety

ECC and CRC are necessary to fulfill ASIL

## Power

*Infotainment:*

Optimize for power, standby (Suspend2Ram)

→ LPDDR5x

*Autonomous driving:*

Power is not in focus → Bandwidth more important

## Interfaces

LPDDR5 is the new standard interface

Move to LPDDR5 and LPDDR5x in near future

128 bit mem IF standard in IVI and 256 bit for ADAS

High bandwidth for AI need GDDR6 and HBM3 memory



# Vehicle storage: Removeable memory

## Status

- Known usage scenario at system design, fixed mounted Flash (UFS), USB stick for Dashcam

## Problem

- Usage prediction: streaming, dashcam, gaming, data logging, user app storage

BUT

- Internal memory need to last > 15 years

## Solutions to fix this

- Use replaceable memory

## Storage options

### External

- USB (stick or SSD)
- SD-Card
- SD-Express
- CF-Express

### Internal

- NVMe: M.2, EDSFF, XFM or custom solution

BUT: No automotive ready standard for internal removable



# Vehicle storage: Types of external Flash media

## Pro and cons

Media	Speed / Read GB/sec	Mechanics	Availability	Average Quality in market	Price
SD-Card	0.3	-	++	0	++
USB Stick	.3	-	+	-	++
USB SSD	0.5 – 1.2	+	-	+	0
SD-Express	0.6	-	0	NA	NA
CF-Express	1.6	+	0	+	-

## Panel Discussion



Best option for internal and external removable?

# Summary

- Infotainment and ADAS move closer together
- New cars are data centers on wheels: Car Computers
  - Central storage architecture is a consequence
- Automotive has the need for the latest memory technology in respect to:
  - Density, Interface, Speed and Function (SR-IOV)
- In the future removable media is needed



# Backup