ARM processors driving automotive innovation

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The ultimate intelligent connected device

- Driver cockpit / IVI
- Vehicle to vehicle / infrastructure
- 360 deg view
- Lane detection / steer
- Collision avoidance
- Intelligent body apps
The road to autonomous cars

**Level 4**
Full Self-Driving Automation

The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip.

**Level 3**
Limited Self-Driving Automation

Full control of all safety-critical functions under certain traffic or environmental conditions.

**Level 2**
Combined Function Automation

Automation of at least two primary control functions.

**Level 1**
Function-specific Automation

Automation at this level involves one or more specific control functions.

**Level 0**
No-Automation

The driver is in complete and sole control of the primary vehicle controls.

*NHTSA's definition Level of Vehicle Automation*
Can cars see?
Complex compute challenges

ADAS – what the computer sees

Conditions
- DARK: 1.5%
- BRIGHT: 0.0%
- MEAN: 67/255
- GOOD VISIBILITY

Note: The image contains a diagram of a car dashboard with various conditions and indicators.
Connected vehicles

- Cooperative Intelligent Traffic System
- C-ITS

- Vehicle to vehicle, vehicle to highway
- V2X
Making connected autonomous vehicles possible

Foundation of trust: Security and functional safety

Sense ➔ Analyse ➔ Connect ➔ Display ➔ Actuate
ARM architecture profiled for diverse processing needs

**Cortex - A**
Highest performance
Optimised for rich operating systems

**Cortex - R**
Fast response
Optimised for high performance, hard real-time applications

**Cortex - M**
Smallest/lowest power
Optimised for discrete processing and microcontrollers
Cortex-A processors for IVI and ADAS

- High Performance
- High Efficiency
big.LITTLE for in-vehicle infotainment

Temperature
Key to Sustained Performance

Performance is #1

Power efficiency
Important for low thermals & slow battery discharge (EVs)

big.LITTLE is a CPU power optimization technology

Compared to standard SMP systems, a big.LITTLE IVI system delivers:

- **Increased CPU capacity** to handle more advanced, highly intensive IVI features
- **Higher sustained performance** even in adverse thermal conditions
- **Reduced** system **power**, platform **area** and total **BOM cost**
ARM® Cortex®-A portfolio

**Cortex-A15**
High-performance with infrastructure feature set

**Cortex-A17**
High-performance with lower power and smaller area relative to Cortex-A15

**Cortex-A57**
Proven high-performance
64/32-bit

**Cortex-A72**
2016 Premium Mobile, Enterprise & Auto
64/32-bit

**Cortex-A73**
2017 Premium Mobile, Consumer
64/32-bit

**Cortex-A8**
First ARMv7-A processor

**Cortex-A9**
Well established mid-range processor used in many markets

**Cortex-A53**
Balanced performance and efficiency
64/32-bit

**Cortex-A32**
Smallest and lowest power ARMv8-A
32-bit

**Cortex-A35**
Highest efficiency
64/32-bit

**Cortex-A5**
Smallest and lowest power ARMv7-A CPU, optimized for single-core

**Cortex-A7**
Most efficient ARMv7-A CPU, higher performance than Cortex-A5
Cortex-A is everywhere in the embedded market today

>70%

ARM market share in rich embedded

Example market segments and products

### Smart Embedded

- [Image of a printer]
- [Image of a server]
- [Image of a car]
- [Image of a monitor]

### Smart Home

- [Image of a smart home device]
- [Image of a security camera]
- [Image of a headphones]
- [Image of a streaming stick]

### Wearables

- [Image of a smartwatch]
- [Image of a fitness tracker]
- [Image of a VR headset]
- [Image of a sunglasses]

Source: VDC (CPU & SoC unit volume in embedded, excluding mobile, tablets, and networking)
High efficiency Cortex-A32 and Cortex-A35

Cortex-A35: Smallest 64/32-bit processor
- Ultra efficiency for entry mobile, consumer, and embedded
- Less than 1.0 mm\(^2\) core area at 2.0 GHz target in 28nm

Cortex-A32: Optimized for 32-bit ARMv8-A
- More performance and less power
- Scalability for diverse embedded applications
New architectural features for rich embedded 32-bit applications

- Enhanced floating point performance
- Substantially faster software encryption
- Enhanced media performance

**ARMv8-A**

- New 64-bit ISA
- >100 New 32-bit Instructions

**Cortex-A35**
(64/32 bit ARMv8-A)

**Cortex-A32**
(32-bit ARMv8-A)

**Cortex-A7**

**Cortex-A5**

**ARMv7-A**

**ARMv7-A Extensions**
Cortex-A32 boosts 32-bit performance and efficiency

- Higher performance than Cortex-A5 and Cortex-A7
- Same performance as Cortex-A35

Efficiency improvement:
- >25% vs. Cortex-A7
- >30% vs. Cortex-A5
- >10% vs. Cortex-A35

Efficiency defined as integer performance/power (Performance/mW) iso-process (28HPC), iso-frequency, comparisons, identical processor configurations (32KB L1 caches, NEON, IMB L2)
Cortex-A: #1 embedded ecosystem
Automotive applications

ARM processors offer a right-sized fit for all automotive electronics applications

<table>
<thead>
<tr>
<th>ADAS, IVI, Cluster, Connectivity</th>
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<td>Cortex-A for main processors</td>
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<td>Cortex-M and R support functions</td>
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<td>Cortex-R, also Cortex-M</td>
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<td>Safety-related controllers</td>
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<td>Sensors, actuators, comms</td>
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<td>Usually Cortex®-M</td>
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Complementary SoC processor requirements

**High performance compute**
- Infotainment
- Cluster
- Driver assist
- Vehicle interface
- User experience

**Compute, Control, Sense**

**Real-time control**
- Safe
- Secure
- Responsive
- Reliable
- Fast boot

**Cost** **Quality** **Ecosystem** **Temperature**
ARM Cortex-R portfolio

- **Cortex-R7**
  - Real-time
  - High performance

- **Cortex-R8**
  - Highest performance
  - 5G modem and storage

- **Cortex-R4**
  - Real-time efficiency

- **Cortex-R5**
  - Scalability with functional safety

- **ARMv7-R**
  - Automotive

- **ARMv8-R**

**Real-Time Performance**

**Real-time Efficiency**
Functional safety standards and applications

**ARM Cortex CPU**
- Safety Documentation Packages
- IEC 61508
- Assessment
- Fault detection and control features
- Development processes
- BIST
- FMEA
- Compiler qualification

**Functional Safety**

**Computation Automation**

**Sensing**

**Communication**

**Control Actuation**

**ARM® Cortex®-A**

**ARM® Cortex®-R**

**ARM® Cortex®-M**

**Safety and Security**
ARMv8-R architecture

Innovation for the next generation of automotive and industrial processing

- The ARM v8-R Architecture
  - Combining real-time control with functional safety
  - Managing both random and systematic errors
  - Virtualisation for application consolidation
  - Software isolation for safety and security

- Independent research showed that ARMv8-R provides
  - Full comprehensive set of features to support the automotive industry RTOS requirements
  - Full comprehensive solution for supporting AUTOSAR safety features
  - Comprehensive solution for supporting hypervisors with real time capabilities
Cortex-M and SecurCore® portfolio

- **Cortex-M7**: Maximum performance control & DSP
- **Cortex-M3**: Performance efficiency
- **Cortex-M4**: Mainstream control & DSP
- **Cortex-M0**: Lowest cost, low power
- **Cortex-M0+**: Highest energy efficiency
- **SC300**: Performance, anti-tampering
- **SC000**: Optimized area, anti-tampering

**High Performance**
- ARMv8-M

**Mainstream**
- ARMv7-M

**Lowest Power & Area**
- ARMv6-M
Cortex-M: Trusted choice for embedded intelligence

17.1Bn
Total units shipped*

6.4Bn
Units shipped in 2015

3600+
Catalog parts*

360
Licenses*

2015:
32-bit MCU shipments surpass 4/8bit**

* Data up to end Q4, 2015
**The McClean report
TrustZone: The security foundation for billions of devices

Trusted across many applications

- Authentication
- Mobile Payment
- Content Protection
- Enterprise Security

TrustZone for ARMv8-A*
TrustZone for ARMv8-M
TrustZone CryptoCell

* Fully compatible with TrustZone for ARMv7-A and ARMv6
ARMv8-M: Foundation for security

Isolates trusted software, data and hardware

Enables device integrity and system recovery

Example use cases:
- Protection of critical assets
- Safe crypto implementations
- Secure remote firmware update
- Firmware IP protection
- Secure debug
ARMv8-M: Security in small, real-time embedded

- Optimised for small real-time processors
  - Low, deterministic interrupt latency
  - Efficient – every cycle counts

- Hardware based security state switch
  - No hypervisor code and processing overhead

- Fully programmable in C
  - Easy to program, easy to debug

- Transparent to the software developer
  - Transition via a standard function call
ARM technology for automotive

- Performance and architecture leadership for the car of the future
- Comprehensive solutions throughout the vehicle
- Best performance in tight thermal and space constraints
- Safe and Secure with ISO 26262 and ARM TrustZone
- Diverse and competitive supply chain partnership to the automotive industry, supported by a rich ecosystem