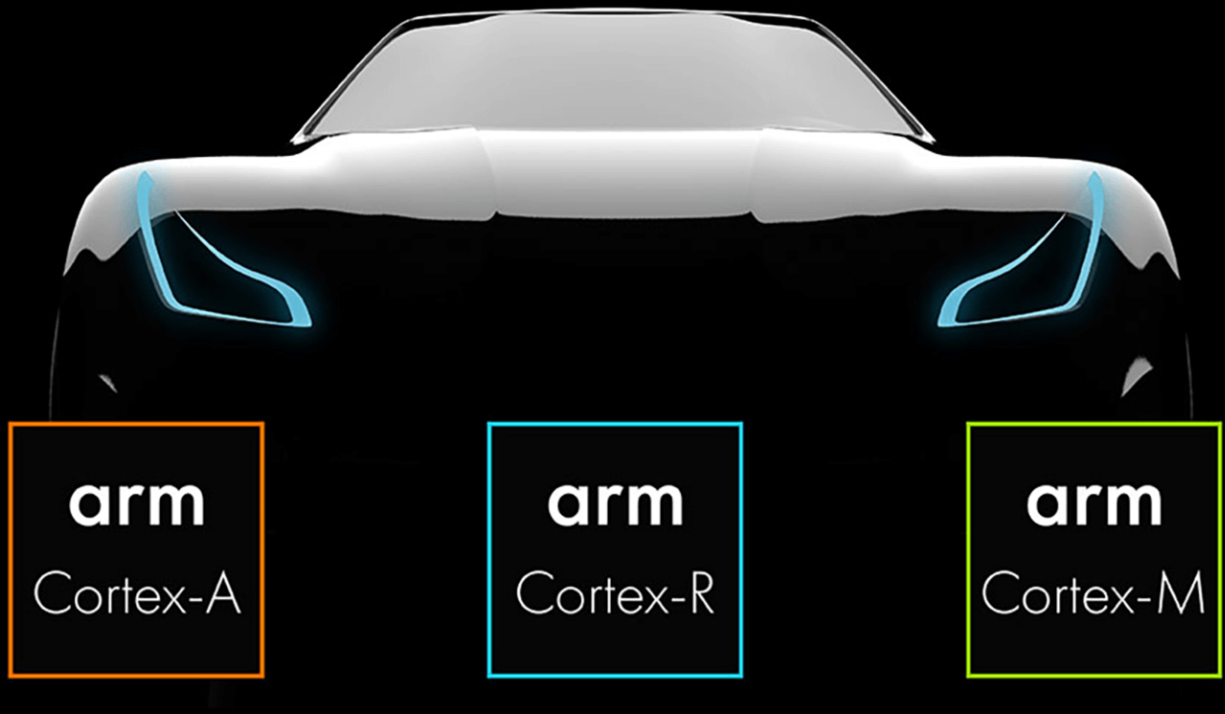
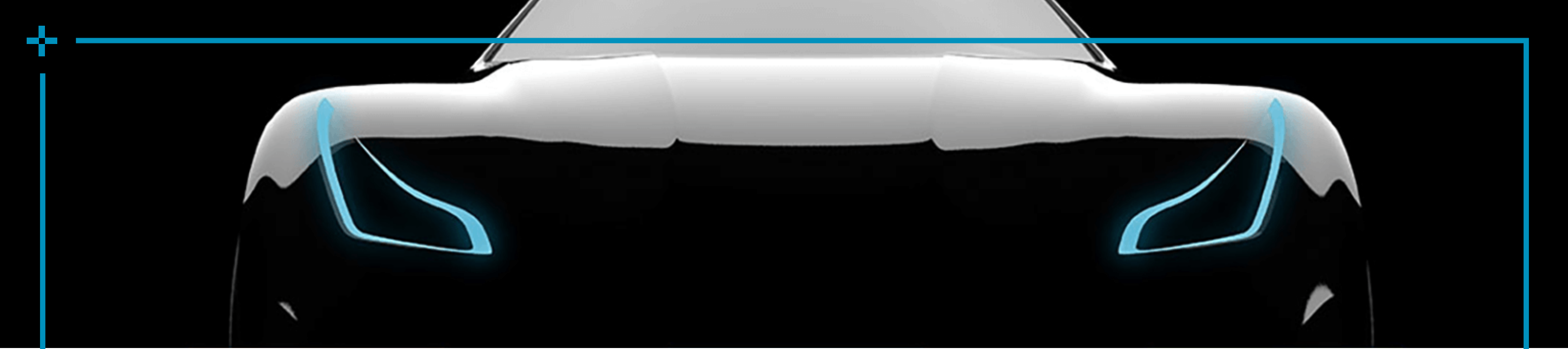
A Starter's Guide to Arm Processing Power in Automotive





The automotive industry is rapidly transforming, with technology driving innovation, automotive standards shaping requirements, and consumer preferences changing demands.

These factors are significantly impacting all automotive applications from Advanced Driver-Assistance Systems (ADAS), autonomous drive, In-Vehicle Infotainment (IVI) and digital cockpit, to powertrain and chassis. Arm offers a broad range of different classes of processor, specifically designed to address the needs of each of these automotive applications.

To help you take advantage of this processing power, here is a guide to how Arm's different classes of processors can be applied to various automotive applications.

Classes of Arm Processors for Automotive

Processor Class	Designed For	Automotive Applications
Arm Cortex-A	• High performance • Optimized for rich Operating systems and hypervisors	• ADAS Vision • Autonomous • IVI • Digital Cockpit • Connectivity
Arm Cortex-R	• Optimized for high performance • Hard real-time deterministic applications and RTOS	• Autonomous • ADAS radar • Connectivity • Powertrain • Chassis
Arm Cortex-M	• Smallest area and lowest power • Optimized for discrete processing and microcontrollers	• Body electronics • Gateway • SoC management • Sensors

Vehicle Motion & Dynamics
Cortex-R52+
Real time
Homogeneous multicore

ADAS
Cortex-A65AE, Cortex-R52+
Mali-G78AE
Heterogeneous multicore
Sensor Fusion
Scalable

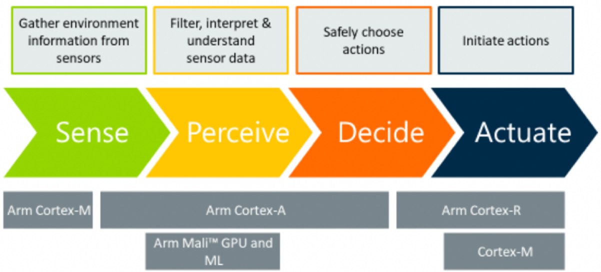
Navigation & Infotainment
Cortex-A78AE, Cortex-A55, Mali-G78AE
OS
Virtualization
Security

Autonomous driving
Cortex-A78AE, Mali-G78AE
Mali-C71AE, Cortex-R52+
High Single-thread Performance
Scalable to multicore and multichip
ASIL-D/SIL-3 Functional Safety

Central body control
Cortex-M7, Cortex-M0
Low power
Efficient performance
Scalable

Four Automotive Applications Designed with Arm Processing Power ADAS/Autonomous Driving

There are typically three types of ADAS systems in an autonomous vehicle: camera, LIDAR and radar systems. Depending on type and class, these ADAS systems can be powered by a combination of Cortex-A, Cortex-R, and Cortex-M processors. Arm categorizes the application of processing power in the following four stages for autonomous processing:



1. Sense

This stage involves gathering information about the environment through a range of sensors. Depending on the type of sensor, the data collection systems within the vehicle can be powered by Cortex-A, Cortex-R, or Cortex-M processors. For example, in a forward-facing vision system, the sense part is likely to use an image signal processor (ISP) and a computer vision accelerator combined with a Cortex-A processor, and possibly a Cortex-R or Cortex-M. Radar is another sensory system which can be addressed with different processing capabilities. Generally, radar and LIDAR are supported well by Arm Cortex-R processors but can also be supported by Cortex-A processors, such as Cortex-A65AE with Split-Lock, and Cortex-M. Simpler sensor points throughout the vehicle all combine to provide a wider picture of the state of the vehicle and its environment – detecting and measuring the vehicle's actuation, speed, and condition, as well as inputs from others, such as ultrasonic sensors, which are used in parking and close range maneuvering. These are generally applications based on Cortex-M.

2. Perceive

In the perceive stage, the system is filtering and interpreting the data, to understand what can be learned about the environment from the sensor data. The types of workloads seen in this stage are throughput sensitive which is why the Cortex-A processors play a predominant role here. A lot of data in ADAS and autonomous systems is parallelizable, that is, it can be processed at the same time. For this reason, Cortex-A processors are usually closely coupled with GPUs and ML processors, thus enabling a large amount of sensor data computation.

3. Decide

During the decide stage, the system safely chooses the correct action for the vehicle to take. There are increased levels of performance, latency sensitivity, and safety required. Cortex-A, in particular the new Split-Lock enabled Cortex-A76AE, plays a critical role as a high-performance decision and planning engine. Its superior ability in cognitive processing through Arm DynamIQ technology makes it a perfect fit for autonomous vehicles, where more powerful machines are needed. Cortex-R also comes into play here, particularly from a functional safety perspective. It acts as a sense check on the decision made by higher level processing power before reaching the actuation stage. The Cortex-R52+ is a good example of this due to its focus on redundancy and determinism.

4. Actuate

The actuate stage is where the vehicles dynamic behavior is modified by the decision reached in the earlier processing stages. At this point, messages are distributed across the vehicle that require deterministic behavior and real-time responsiveness. Cortex-R is a natural fit for this step in the processing pipeline, particularly where there is demand for highly intelligent control and communication. Depending on the

complexity of the control tasks and the actuation demands, Cortex-M processors can also handle some specific and simple actuate tasks. Functional safety requirements in this stage are rapidly growing from ASIL B, which is causing a migration from the use of Cortex-M processors, to Cortex-R processors at this stage. To achieve Level 3 autonomous drive, ASIL B requirements must be met by the system, while for Level 4 and Level 5 autonomous drive, ASIL D requirements must be met by the system particularly in the higher compute point in the process. The functional safety Standard ISO 26262 defines different levels of functional safety in terms of ASIL with the highest level being ASIL D. Functional safety is an important requirement for autonomous applications with increasingly higher demands on the ASIL moving from ASIL B and ASIL D as the autonomy increases. Arm understands the importance of building functional safety into designs right from the start – visit our functional safety web page to find out more on how Arm is enabling functional safety technology and the solutions we offer. Arm's Safety Ready program helps to reduce risk and ensure its ecosystem delivers safer automotive products to market faster.

In-Vehicle Infotainment (IVI) / Digital Cockpit

IVI/ digital cockpit is one of the largest growing markets for vehicles and is seeing significant innovation advancements.

Historically, IVI systems were the radio and media player, but in recent years and into the future are now the digital cockpit. The digital cockpit provides many more complex experiences, such as navigation, media streaming, and AI assistants, alongside traditional driver information capabilities like digital cluster and heads-up display. Making all of these experiences digital, and trying to match the capabilities of mobile phones, result in ever-increasing demands for performance, as well as safety and security.

Putting smartphone technology and experiences into the cockpit requires new security and performance requirements, alongside more traditional automotive safety requirements. The recently announced Cortex-A78AE is the latest high performance CPU alongside Mali-G78AE GPU, to offer both high performance and safety to power the growing number of displays and graphics complexity within the car.

The inclusion of the cluster, which displays instrumentation and control for the vehicle's operation, mean that digital cockpit systems have mixed-criticality from a functional safety perspective. Moreover, these systems also demand increasing levels of performance. Cortex-A CPUs such as Cortex-A78AE provides a 30 percent performance boost over its predecessor and is designed on a rigorous design flow to avoid systematic faults.

Mali-G78AE brings the new flexible partitioning feature alongside safety, to enable mixed criticality from a single GPU IP, allowing designers to separate out safe and non-safe workloads within their systems for ease of integration and certification.

This merging of what have been traditionally separate systems brings interesting changes and challenges for both hardware and software developers. The software stack now needs to be able to run safety-critical and commercial applications on the same System-on-Chip (SoC) and present these different applications safely on their respective displays. The latest Cortex-A processors provide the performance required to run a rich OS next to a safety-oriented RTOS or Autosar stack, and the Cortex-A78AE offers hardware support for the hypervisor platform that enables such mixed safety-critical systems. The level of functional safety in such systems has been typically more ASIL B than ASIL D.

Safety Display

Heads-Up Display

Safety/Non-Safety Display

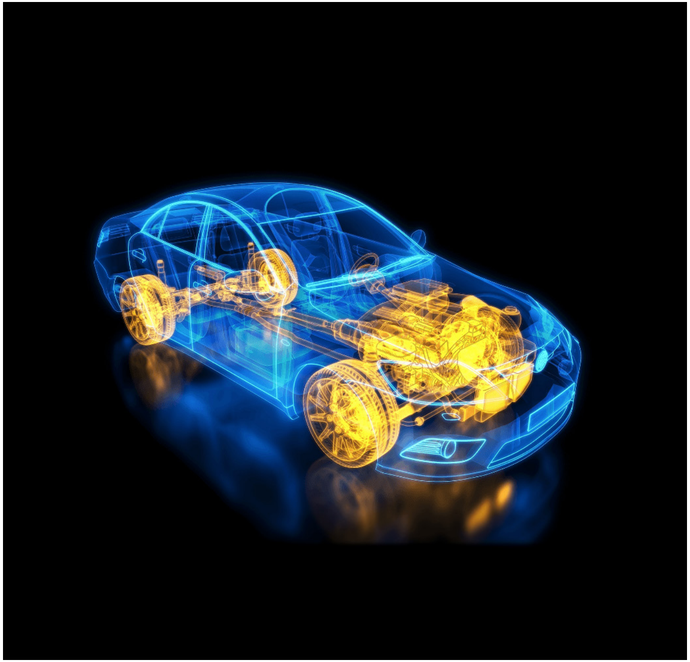
Digital Cluster

Non-Safety Display

Infotainment

Powertrain

Due to the growing demand for cleaner and more efficient vehicles, the largest growth area for powertrain is in its electrification.



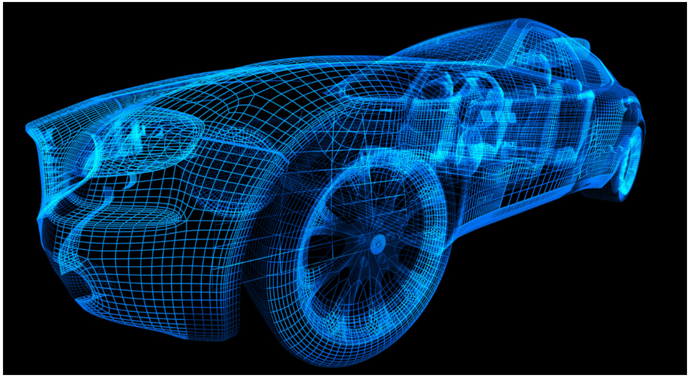
Conventional internal combustion engines (ICE) will continue in production for years to come with yet tougher, demanding emission controls, but increasingly in hybrid configurations. Full electrification adoption remains dependent on energy storage technology and infrastructure for charging points and energy distribution, but over time we'll see the balance move to electric drives with higher power battery management.

There is high demand for both ICE and electrification and so solutions to meet these needs are essential. Arm can address the needs for both ICE and electric drives.

- ICE: High performance, determinism, and real-time requirements are required to control the combustion efficiency and after treatment for both gasoline and diesel engines. Cortex-R processors provide the high-performance multicore configurations and functionality demanded by these challenging applications.
- Electrification: Efficient field-oriented motor control to optimize range together with functional safe operation, charge management and energy storage for large high-voltage battery packs. Both Cortex-M and Cortex-R processors offer a range of solutions to meet the needs of electrified systems.
- Functional safety is a critical part in drivetrains a requirement which can be addressed through the use of a processor with systematic capability for ASIL D, such as the Cortex-R52+.

Body

Body electronics applications are ubiquitous, covering the entire vehicle.



Body applications range from simple, small sense and actuation nodes, such as door locks, temperature and position sensors in Heating Ventilation Air Conditioning (HVAC) control, to more complex central body control unit applications, sometimes incorporating vehicle network control. With a range of different Tier 1 suppliers going into many different vehicles, being able to build multiple applications onto a single platform based on a common architecture gives the flexibility, scalability, and improved reuse of both tools and software. Arm's Cortex-M class of processors delivers a simple programming model and well-supported ecosystem of tools and software, together with highly configurable options to tailor the hardware. This reduces development cost and time to market while meeting the demanding needs of these systems.

Many of these applications are key-off, meaning they need to remain operational when the car is parked. Low energy consumption is important both at run time and during these "key off" periods to maintain battery life. Cortex-M processors enable body applications to wake up, complete an action and go back to sleep rapidly, with the ultra-low energy sipping power normally associated with wearable applications. Cortex-M processors easily meet these needs, and also benefit from a supportive ecosystem, tools, and software that allow easy implementation, which improves efficiency and reduces development cost.

Security is increasingly important across a broad range of automotive applications and this includes those in body control. The introduction of Arm TrustZone within the Cortex-M family offers an opportunity for added security support in this profile of processors for these applications.

Cortex-R processors also offer a flexible solution for high performance centralized body control systems and network controllers. The desire to keep a check on the increasing number of ECUs in the vehicle makes Cortex-R processors an ideal fit where consolidation of functions into fewer ECUs is needed by simplifying the migration of multiple applications into a single processor and maintaining their isolation.

Arm provides total automotive compute capability for every application within the vehicle, helping to meet increasing demands in innovative new ways, even in this incredibly fast-moving and changing industry.
Find out more at:

arm.com/automotive