arm

Co-Creating the Future of Vehicle Electronics:

Challenges and Opportunities for Ford

Introduction

Has there ever been a time of greater disruption and excitement for automotive electronics?

Why Arm?

- The average 2021 production car contains 18 Arm processors, increasing to 27 by 2025.
- >90% of smartphones are powered by Arm.
- The world's most powerful supercomputer is based on Arm.
- 7.3 billion Arm-based chips were shipped in the first 3 months of 2021.

Consider:

- The rapid development of multiple new models of electric vehicles.
- The accelerating era of the software-defined vehicle.
- The transition to powerful centralized computing architectures.
- The customer demand for new experiences from electronics in their vehicles.
- The societal demand for fewer traffic accidents and increased safety features.
- New competition in the automotive industry.

Exciting and disruptive indeed, but it's not just the breadth of this change that is challenging; it's the pace, and that pace is straining the traditional structure of the automotive supply chain. In short, new methods and technologies are needed to rise to these challenges.

In this brief document, we show you that Arm is uniquely positioned to help Ford tackle these challenges and accelerate its vision of delivering platforms faster and more profitably with the world's most advanced and efficient computing technologies.

Many of today's most successful technology companies and automotive manufacturers realize that to stay ahead they must be much more deeply involved in the definition of both their software stack and the computing hardware that it runs on. This enables them to optimize their designs, innovate faster, and differentiate their vehicles.

We've compiled this report because we believe that through a strategic relationship with Arm, Ford can define a new and disruptive roadmap for technology introduction that is bold but commercially and technically achievable.

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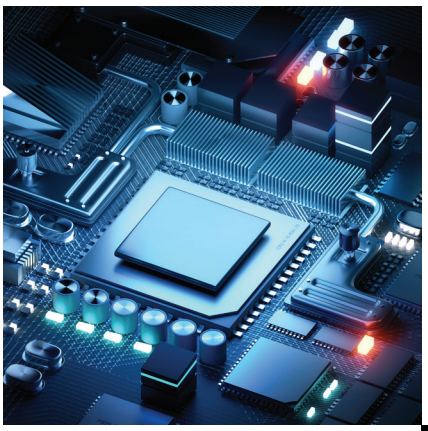
Section 1

A Path to Technology Leadership and Differentiation

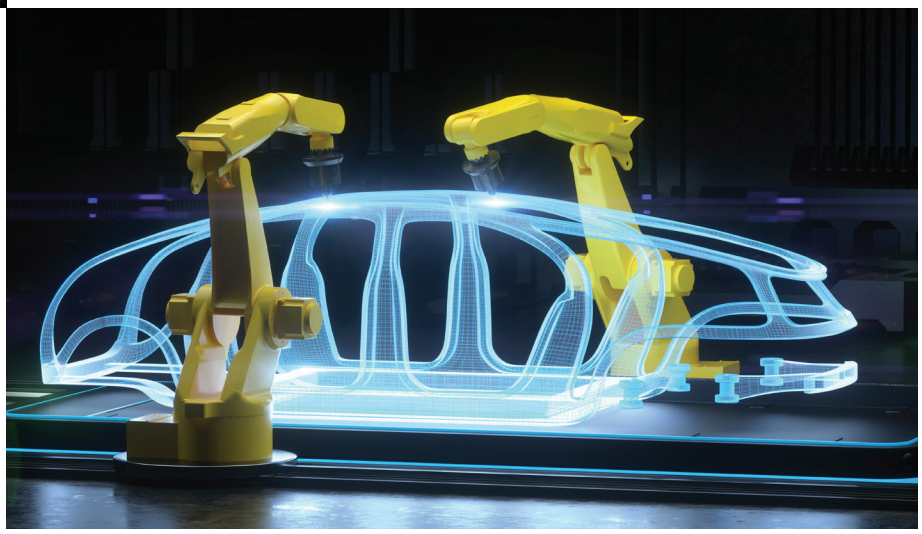
The Smartphone Computing Revolution Comes to Automotive

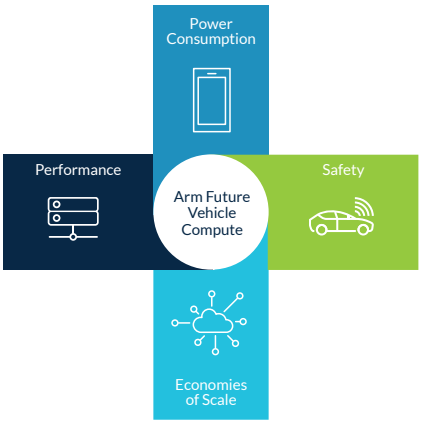
Arm sparked a revolution in smartphone design by delivering highly efficient, compact computing for battery-powered devices where power consumption is critical. This capability, coupled with a global ecosystem that blossomed around that innovation, has put our technology at the heart of more than 90% of the world's smartphones. Along the way, that revolution in smartphone design prompted new, more efficient ways of building compute in infrastructure and IoT. And now, it's come to automotive.



Calling cars "smartphones on wheels" may be a cliché, but there are lessons from the evolution of smartphones that could benefit the auto industry:

- The smartphone industry and Arm have demonstrated an ability to evolve incredibly fast, delivering year-on-year improvements in performance features and power consumption.
- The smartphone pioneered heterogeneous compute. This breaks down different types of software tasks and runs them on different types of processors – all on the same chip for optimum performance and power efficiency. The automotive industry is embracing this and driving it further by incorporating functional safety into designs.



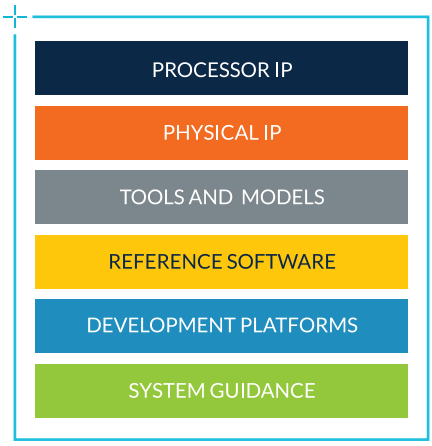


Supercomputer-Level Processing for Vehicles

The same computing architecture that put the connected world in your hand and helped usher in the era of heterogeneous compute is now disrupting the high-performance computing industry in datacenters and supercomputing.

In 2020, the new Arm-based Fugaku supercomputer was ranked the world's most powerful supercomputer. It was also one of the world's most power efficient. Similarly, Amazon Web Services (AWS) has offered 40% improved price-performance to their customers by developing its Arm-based "Graviton" chip in house. James Hamilton from AWS describes the innovation here.

Why does this matter to the automotive industry? For several reasons: as vehicles move toward higher levels of autonomy, the computing power requirement increases exponentially; plus, increasing levels of electrification in fleets means that the automotive constraints of power consumption, heat dissipation, and limited space become even more severe. In addition, functional safety is now a key requirement throughout vehicle design. General-purpose, off-the-shelf processors cannot meet all these demanding requirements.

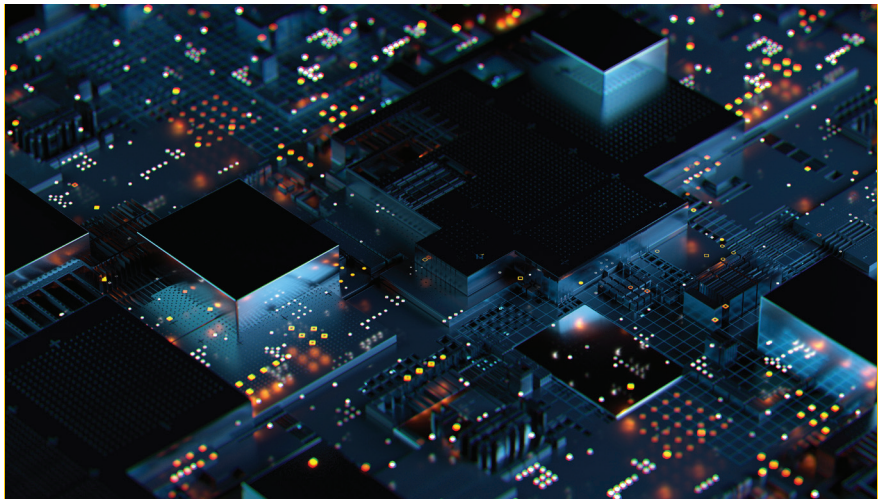


Automotive Investments: Building on a Strong Base

Arm already has a strong global presence in automotive electronics. Arm experts estimate that the average production vehicle in 2021 contains 18 Arm processor cores and that is expected to increase to 27 by 2025. More than 60% of ADAS and cockpit infotainment systems are estimated to use Arm processors.

In 2020, Arm announced a new suite of safety-ready processors specifically targeted at providing the auto industry with a robust and economical path to higher levels of vehicle autonomy. But Arm's investments in automotive technology go way beyond processor designs.

For example, in September 2021, Arm and partners from across the automotive industry created SOAFEE, an open standard and reference stack, to bring the benefits of the cloud native development approach to the software-defined car.



Section 2

Developing a Responsive and Robust Semiconductor Supply Chain

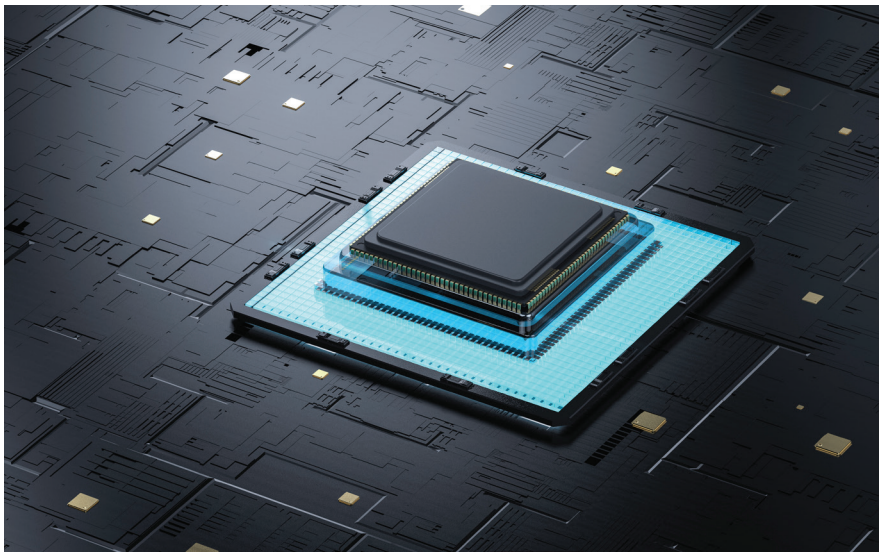
Innovating Faster

In many more advanced applications like ADAS, domain controllers, and the cockpit, the traditional tiered automotive supply chain has challenges with flexibility and agility. The process to bring technology to market is struggling to keep up with demand from consumers who look for technology evolution in their cars that moves almost as quickly as it does in their smartphones.

Engineering tasks are often done in a series that could be done in parallel. A more flexible supply chain could mean software design and validation happens earlier, before production-level hardware is available.

There are also missed opportunities for optimization. Hardware and software can both be improved and simpler if developed together.

On top of that, software is key to leading the autonomous revolution, but software complexity and a sometimes-fragmented supply chain have been challenging. Cloud native development methodologies and architectures are helping to manage this exponentially increasing complexity. Software-defined compute that started with computers and smartphones, has now been redefined by the datacenter and Innovating Faster is reaching even further to automotive.



Engage with Arm for Supply-Chain Robustness

At Arm, we find that OEMs increasingly ask us simple but mission-critical questions: “What are the limits of possible?” or “What new technologies will be ready for production vehicle models in 2024, 2026, 2029, and beyond?”

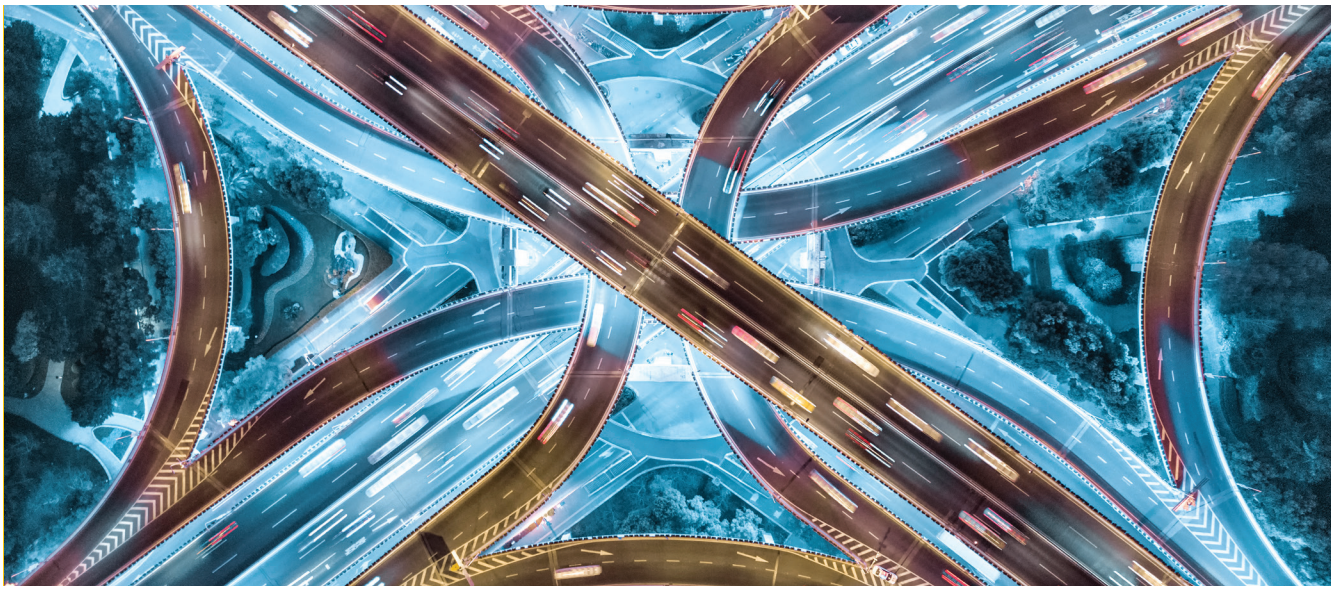
Beyond the capability of the technology, OEMs want to understand maturity, risk, cost profile, and the trade-offs of make vs. buy. They look for technology paths with critical mass, supported by robust ecosystems. The current semiconductor shortages have reinforced this need for supply-chain robustness in the eyes of OEMs.

Choose the Right Path to Silicon

There are several ways to engage with Arm technology, giving you freedom to manage trade-offs such as performance, bill-of-material (BOM) costs, development cost and risk.

Section 3

Here are Three Paths to Arm-based System-on-Chip Semiconductors



1) Select an Off-the-Shelf Chip:

There are thousands of chips already available from hundreds of Arm silicon partners, including most of the big names in automotive semiconductors.

Advantages:

- Known BOM costs.
- Fast time-to-market for near-term innovations.
- Lowest requirement for the Ford team to have deep semiconductor engineering capabilities.
- Best for established functionality and non-strategic projects.

2) Specify a Custom Chip:

Work with your preferred semiconductor supplier to incorporate specific features or innovations. Arm can advise on requirements and help you choose the right partners.

Advantages:

- Good balance of investment vs BOM cost.
- Increased differentiation through performance, security, features that meet your exact requirements.
- Open market benefits: freedom of choice of competitive silicon partners, foundries, and service providers.

3) Develop In-House Architecture:

Some OEMs have built their own semiconductor teams. This complex, long-term investment can provide a competitive advantage in cost or differentiation. Arm offers advice, and evaluation tools to guide decision making, and can also match ecosystem partners to ensure project success.

Advantages:

- Maximum differentiation.
- Best performance and power consumption.
- Closest match of hardware and software.
- Lowest BOM cost at high volume.

Section 4

Functional Safety

Arm listens to the auto industry and the trend is clear, more hardware and software will be considered safety critical in tomorrow's cars. There are two paths to achieving functional safety to the required safety standards for automotive, including ISO 26262. These are:

- **One:** build on a foundation of automotive-grade, safety-ready processors.
- **Two:** use general-purpose semiconductors and add more risk assessment and mitigation at the system level.

The second option is less robust, takes longer to develop, and can be more expensive as it drives component duplication. Arm leads in the industry in investment in safety-ready processors and has an ecosystem of experts and partners ready to help.

Section 5

Execute Faster through Leaner Electronics Development

Critical Assessment Considerations:

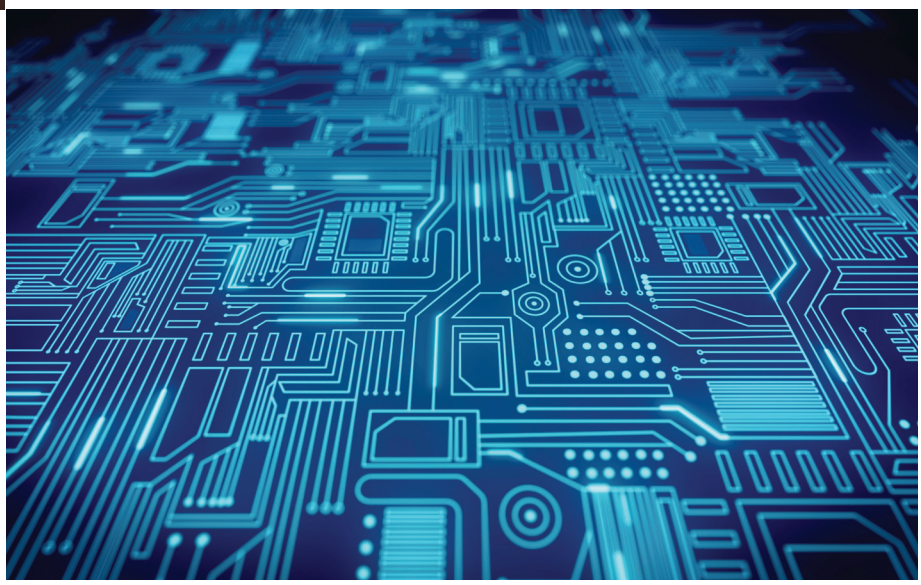
- Do you have **many** concurrent vehicle development projects?
- Is the level of new software and electronic content per vehicle greater than you have previously encountered?
- Do you need to write software, simulate whole systems, and verify your design long before hardware is available?
- Is technology and the market moving so fast that you struggle to define a robust product roadmap?

These are the kinds of challenges we hear from our customers, and they may sound familiar to you.

Advantages of Strategic Alignment with Arm:

- Maintain and enhance technology leadership.
- Innovate and differentiate by discovering technologies that are relevant, viable and affordable for your future vehicle generations.
- Help us to define the technologies that you will need in 7, 10, or 15 years.

Together let's co-create solutions that shape the future of vehicle electronics for decades to come.



Section 6

Where Arm Technology Makes a Difference for Ford

Central Compute

Arm CPUs, including the Cortex-A78AE, provide a safety-ready foundation for high-performance automotive central compute. The hard real-time deterministic processors, including the Cortex-R52+, are widely used in automotive control applications.

ADAS Vision

Arm has developed image signal processors (ISPs) adapted to ADAS front-facing cameras, which have hardware enabled functional safety features. These ISPs can significantly reduce the latency, processing, and bandwidth requirements of downstream systems.

Infotainment and the Digital Cockpit

Arm architecture is a key enabler of automotive technology, with more than 85% of in-vehicle infotainment (IVI) powered by Arm-based chips. This broad adoption is sparked by Arm processor technologies with integrated, safety-ready 3D-graphics engine capabilities that support a rich 3D user-experience. As the in-cockpit experience begins to mirror what's familiar to smartphone users, Arm's long history of innovation in the mobile space brings power efficiency and design flexibility to the digital cockpit.

Physical IP

Ford's recently announced partnership with GlobalFoundries opens new possibilities in semiconductor technology and supply-chain management. Arm is a long-standing partner of GlobalFoundries with a strong and growing combined portfolio of physical IP. Arm Artisan physical IP enables silicon implementations that are reliability optimized for safety-critical automotive use cases.

SOAFEE: A Cloud Native Architecture for Mixed Criticality Automotive Applications

Together with a broad group of automotive industry leaders, Arm has launched the SOAFEE initiative to bring the benefits of a cloud native approach to the specific constraints and requirements of the automotive industry and the software-defined vehicle. In particular, SOAFEE adds functional safety and real-time capabilities.

Furthermore, to enable automotive software porting, prototyping, and development today, Arm has partnered with ADLINK and Ampere to deliver high-performance, SOAFEE-enabled hardware platforms.

If you have any questions, feedback, or would like to discuss any topics raised here, please contact your partner manager, Beth Robbins directly at **beth.robbins@arm.com**