WHITE PAPER

On Behalf of ARM

# Digital Engines for Smart and Connected Cars

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## SUMMARY

Interest in advanced car electronics is extremely high, but there is a great deal of confusion about what a "smart" car or connected car really is. Part of the reason is that there are numerous ways to think about and define intelligence and connectivity when it comes to automobiles. Key technologies, such as ARM-based processors and microcontrollers, are playing a critical role in bringing innovation and excitement back to the auto industry at many different levels, from infotainment to assisted driving. Taken together, these developments are helping to reinvigorate interest from automotive consumers, and are helping to drive the car industry forward.

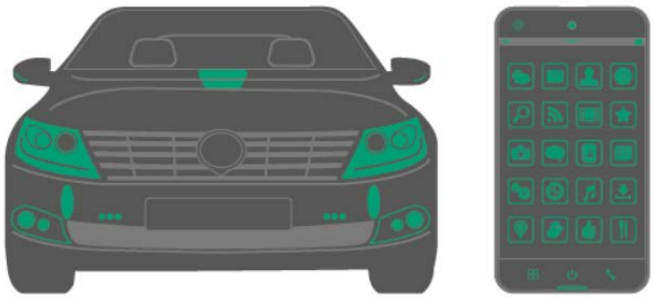
"Automobiles present some of the most challenging requirements of any device or any activity that consumers engage in, so the need for tremendous processing capabilities is going to make tomorrow's digital engines as essential as today's analog ones."—Bob O'Donnell, Chief Analyst

## INTRODUCTION

If there was any message that came out of the recent CES Show in Las Vegas, it was that cars are sexy again. Of course, auto enthusiasts may argue that has always been the case, but for the general population, there is a new enthusiasm growing for cars, particularly as consumers start to realize how much technology is being incorporated into today's vehicles.

Given the renewed fervor, it should come as no surprise that the US auto industry is coming off its best year ever, and that automotive markets around the world are enjoying a new sense of optimism. After years of relatively modest advancements, carmakers are now offering significantly more eye-catching and genuinely useful technological improvements in their new vehicles, and that is encouraging consumers to open their wallets in a meaningful and measurable way.

Part of the excitement is around electric vehicles and hybrids, which point to a future of cleaner air and reduced dependence on foreign oil. Many electric cars, such as the Tesla Model S, also have some of the most advanced electronics, as tech-savvy early adopters have been drawn to this powerful combination of gasoline-free drivetrains, and upgradeable, consumer-device like electronic architectures. In fact, one of the key innovations that Tesla first brought to the auto marketplace with its Model S sedan was a level of technology integration that was well beyond what traditional carmakers had offered until then. In a sense, they brought the smartphone and tablet experience into the car, thanks in part to the integrated 17" touchscreen display, but equally importantly, because of the powerful but efficient processors and graphic chips driving that user experience.



Of course, advancements in car electronics are not restricted to fully electric drivetrains. In fact, many important automobile electronics improvements are occurring in traditional fuel-powered cars, which are expected to be the majority of the market for many years to come.

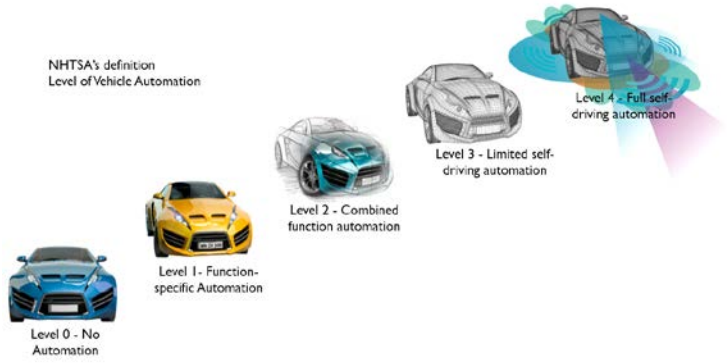
At the heart of many of these developments is critical silicon component technology—much of it with roots in smartphones, tablets, PCs and other smart connected devices—that has been adapted for use in the rough and tumble world of automotive subsystems. These "digital engines" and the systems they enable are at the heart of everything from advanced infotainment systems, to engine performance tuning and monitoring, to advanced driver assistance systems (ADAS), and much more.

# AUTONOMOUS DRIVING

One of the most compelling applications of advanced automotive electronics is the autonomous or self-driving car. Nearly every other day, it seems, there are news stories about how cars will soon be transporting us to our destinations with little to no intervention necessary on our part. In reality, some of those visions may be a bit further off than the stories appear to suggest, but there is no question that they are being worked on at a vigorous pace and will appear at some point in the future. In fact, the US government recently announced that it was planning to invest $4 billion over 10 years in efforts targeted at assisted and autonomous driving.

In the near term, we are more likely to see a series of incremental steps that take us on a structured path from the reality of today's driver-led vehicles to the future visions of complete automation. The primary government organization in the US that is managing the path to those developments is the National Highway Traffic Safety Association (NHTSA), an agency that creates important automotive industry standards, such as the 5-Star safety ratings, among others.

Back in 2013, NHTSA outlined five steps, numbered 0-4, that lead to autonomous driving. These steps move from no automation and complete driver control of every system in Level Zero, through several levels of increasing driver assistance, such as advanced cruise controls, automatic lane centering, etc., all the way to fully autonomous driving in all conditions in Level Four.




Several automakers have announced ambitious plans to reach Level Three in the next few years, but big steps towards Level Three, which offers partial automation, are what we will likely see throughout the remainder of this decade.

Regardless of the specific level, however, the amount of compute power and sensor integration, as well as video, radar and LIDAR (a type of radar that uses light) analysis necessary to pull off any level of truly safe automation is tremendously high. On top of that, because these technologies are deployed in a moving vehicle that could be hazardous to both the occupants as well as other vehicles and pedestrians around it, the need for security is even higher.

In order to tackle these challenges, automakers and tier-one and -two level suppliers to the automotive industry need to consider technology suppliers that can not only meet the extremely demanding computing, graphics and connectivity requirements of automotive applications, but do so through a variety of flexible options and in a very secure way.

## THE TECHNOLOGY

Today's automobiles, and many more in the planning stages, already host a wide array of semiconductor components from a range of different companies including Texas Instruments, Renesas, NXP (Freescale), Xilinx, nVidia and Qualcomm to name just a few. Despite their competitiveness, what ties all these companies together is that they are all users and licensees of processing developed by ARM Holdings, a UK-based firm that has been creating critical chip architectures and designs for more than 25 years.

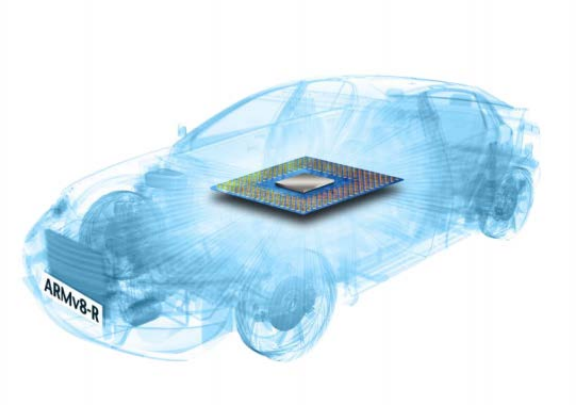
ARM-based designs are the dominant microarchitecture used in mobile phones, tablets and the largest of all mobile computing devices—today's cars. ARM processor cores provide the engine at the heart of everything from infotainment systems to assisted driving functionality.


Critical players in the automotive tech supply chain leverage ARM processor cores and add their own unique advantages and combinations of technology to those cores. This has enabled ARM to become a significant player in the current automotive market, and more importantly, has positioned them to become an even more significant supplier as the technology in cars continues to advance.

ARM-based SoCs from companies like Renesas and Texas Instruments are already powering many of the advanced driver assistance systems (ADAS) features—such as automatic lane centering, parking assistance and much more—on today's cars. Moving forward, the chips harboring these cores will become the building blocks for autonomous driving.

Today's ARM-based SoC suppliers, such as Qualcomm and nVidia, are also driving in-vehicle infotainment (IVI) systems. In fact, 2016 could likely be the year that we will see prototype connected vehicles that bring together a fully-integrated vehicle cockpit merging these IVI

systems with digital dashboards and heads-up display controls, all powered by ARM technology.




In addition, several ARM licensees are already showing the kind of capabilities that future cars will offer. At the recent CES show, for example, nVidia showed off their Drive PX2 platform, designed specifically for autonomous driving. This liquid-cooled supercomputing beast offers 12 ARM processor cores.

As staggering as it sounds, this kind of processing power is necessary to integrate all the data from the sensor hubs starting to be built into automobiles, which take in the video, radar, LIDAR and other sensor feeds from devices all over the car. In addition, things like 360-degree cameras will be used to provide information and context on all the objects outside the car. Expect these kinds of efforts to drive more investments around artificial intelligence in automotive. This is particularly true in the case of self-driving vehicle fleets, which are likely to be some of the first real-world recipients of these technologies.

Another upcoming challenge for autonomous cars is the ability to determine the current context inside the car, specifically with regard to determining the state of the driver and whether or not it's safe to switch into (or out of) autonomous driving mode. Internal cameras will be used to track the driver's gaze, head position, body position and more in order to make these critical real-time decisions.

The bottom line is automobiles present some of the most challenging requirements of any device or any activity that consumers engage in, so the need for tremendous processing capabilities is going to make tomorrow's digital engines as essential as today's analog ones.

## THE DETROIT-STUTTGART-SILICON VALLEY CONNECTION

Of course, offering the right kind of products is essential, but so is a deep understanding of customers' businesses. Given the renewed excitement around automotive, it is not surprising to see numerous companies trying to figure out how to break into the somewhat insular worlds of Detroit and Stuttgart. However, the automotive business is not the same as the tech business. In order to build lasting complementary business partnerships, it is also important to find organizations that appreciate and adapt to those differences as opposed to ones that try to force or strongly encourage their ways onto others.

It is clear to most observers that the future of the automotive industry—while certainly ripe for some degree of disruption—is going to require collaboration between traditional automakers, major automotive suppliers and tech industry participants. The challenge will be to find the kinds of partnerships that drive both the capabilities and safety of new automobiles in the right direction and at the right pace.

We are likely to see the rise of more upstarts in electric vehicles as well. In addition to Tesla, companies like Faraday Future, NextEV, Atieva and more are looking to provide an entirely different take on cars of the future. Who knows, we may even one day see a car with an Apple or Google hood ornament on it.

It is not just about the automobiles either. Many cities around the world, including Ann Arbor, MI with its MCity and Concord, CA with its GoMentum Station, among others, are working to build environments where assisted and autonomous cars can be tested.

## CONCLUSIONS

Consumers are seeing cars in an entirely new way, and the opportunity for meaningful innovation in the automotive industry is at an extremely high level. In addition, for many consumers, the traditional driving metrics of automobiles have become less important, while the desire to connect the rest of their digital devices and their digital lives with their cars has significantly increased. Combining all of these elements creates a perfect storm of positive technological developments for the auto industry that, in turn, should enable a win-win-win for consumers, automakers, and critical suppliers.

Essential technology components, such as ARM-based processors and microcontrollers, are playing a key role in the advances that have already come to market. More importantly, they will likely play an even more significant role in the innovations that are yet to come. In fact, by 2020, ARM believes that cars will, on average, have 120 ARM-based processors per vehicle.

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The computing demands of assisted and autonomous driving are extremely high. In order to achieve the kinds of visions made possible by these technologies, more work needs to be done to develop even more powerful computing components— "digital engines"—for tomorrow's automobiles. At the same time, efforts need to be made to ensure these components are not only integrated into future cars, but also positioned and understood as key drivers of future automotive experiences.