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Infotainment and Telematics

# In-vehicle Infotainment - The Automotive Cockpit of the Future

*Automotive Multimedia and Communications (AMCS)*

**Automakers across the globe are designing vehicle cockpits with an ever-growing number of advanced features, many of which are influenced by the wide array of new technologies that consumers are using on a daily basis. In addition, the auto industry is rapidly adding advanced safety features to cars, many of which will be essential to achieve automakers' goals to enable vehicles to drive autonomously. Its in this context that the cockpit of the future is evolving. This future cockpit will require advanced processing capabilities to meet consumer demands for connectivity, safety, and future mobility. This white paper provides a view of what features consumers are looking forward to in new vehicles and what technologies are required to support these features.**

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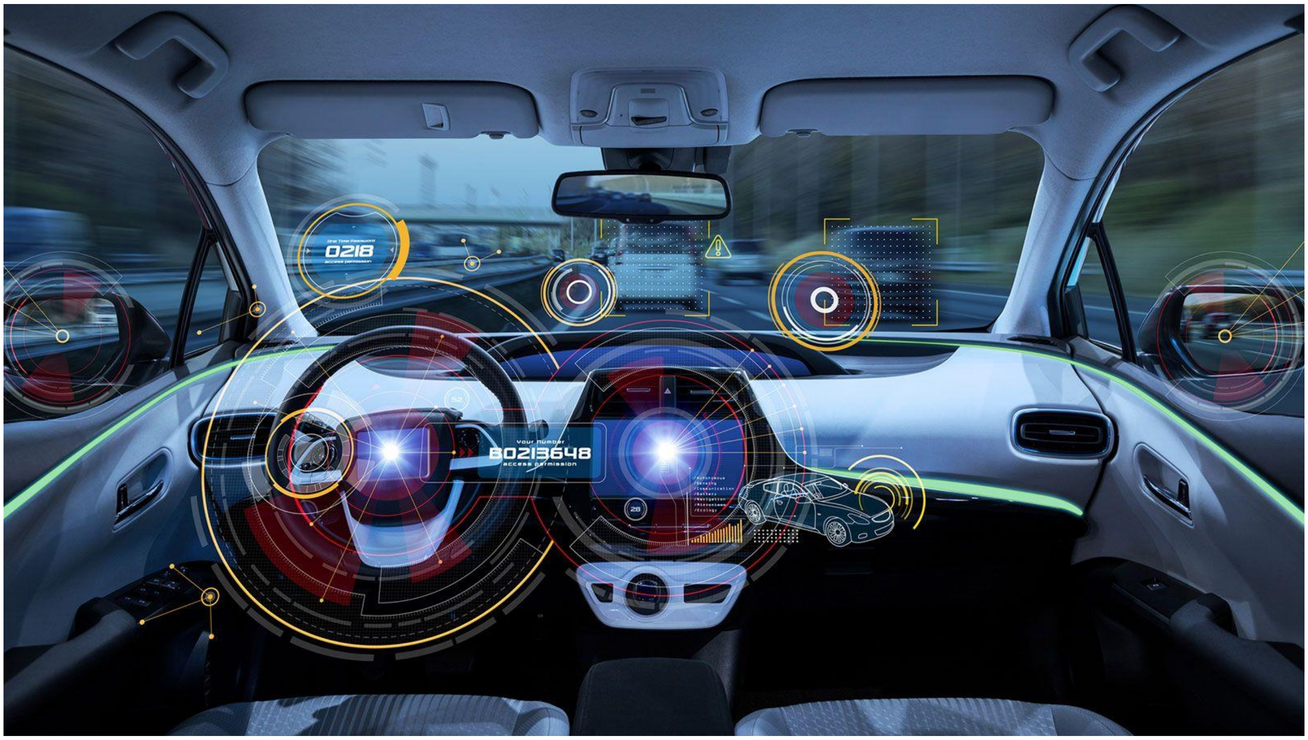
# 1. The Cockpit of Today and Tomorrow




Vehicle buyers and owners are increasingly interested in high-tech features in cars. These include advanced safety systems designed to prevent accidents by taking control of a vehicle in an emergency situation. They also include infotainment system features that use wireless connectivity to stream media content, to enable the use of voice-based digital assistants, and to provide automakers' other connected services.

Outside of cars consumers are surrounded by voice and touchscreen experiences on other devices that generally provide better experiences. From smart speakers to smartphones, consumer expectations for the quality of the interactions they have with devices, and the features those devices provide, continue to rise. Strategy Analytics' In-vehicle User Experience practice has surveyed consumers in the United States, Europe, and China and found at least 30 percent of consumers surveyed consider smartphone projection solutions as a must-have feature for their next vehicle. In the U.S. market, two-thirds of those vehicle owners who have infotainment systems with support for smartphone projection solutions, such as Android Auto and Apple CarPlay, use it for most or all of their media and navigation needs. In addition, in the U.S., which is by far the top market for smart speakers, 40 percent of all consumers are very or extremely interested in having Amazon Alexa functionality integrated into their car.

Wi-Fi is everywhere, in cafes, in restaurants, hotels, obviously in consumers' homes, and increasingly this feature is in cars. As a result consumers are increasingly interested in Wi-Fi hotspots in cars. In the U.S., Strategy Analytics found that 54 percent of consumers are very or extremely interested in having a Wi-Fi hotspot in their car. In China interest is even higher, at 61 percent of consumers being very or extremely interested.

Moving beyond infotainment features, advanced driver assistance systems, commonly abbreviated as ADAS, are becoming increasingly important for consumers when purchasing a vehicle. In the U.S., 54 percent of consumers would pay more for a blind spot detection system when shopping for vehicles. In addition, 48 percent of consumers in the U.S. would pay more for a vehicle with a collision avoidance system than one without it. These systems involve displaying warnings to drivers, often via the instrument cluster, and in some cases taking action if the driver is unable to act in time to avoid a collision.

One area that automakers are working to enhance, that ties all of these features together, is personalization. The concept of a "driver profile," where the vehicle can learn each driver's preferences and therefore change the type of information displayed to that driver, is beginning to enter the market. An example of this is Mercedes-Benz's MBUX infotainment system, which uses an AI model to learn the user's preferences and to alter menu structures and the information displayed to the driver based on those preferences. As noted previously, voice-based digital assistants are also using this approach to personalize how they interact with drivers, not only in the car but in all walks of life where consumers use smart devices.

As consumer expectations have continued to rise, automakers have faced rising costs and greater complexity. Looking for solutions, many OEMs are now considering a different strategy for enabling this broad group of features by changing the in-vehicle electronics architectures in most vehicles today to more streamlined, centralized designs in future models. The cockpit is one of the first areas where automakers are beginning to consolidate in-vehicle systems in order to both simplify their designs and at the same time support growing consumer demand for high-tech features.

It's in this context that Tier 1 suppliers are beginning to integrate infotainment systems with safety systems in vehicles, starting with the instrument cluster. Instrument clusters are safety critical systems since they display to a driver crucial information about how the vehicle is operating. This is playing out in two ways. First, automakers are displaying navigation and media information in fully digital instrument clusters. Audi's Virtual Cockpit is an example of this approach. Second, automakers are showing instrument cluster information and infotainment information on the same display. Tesla's Model 3's infotainment system with a single, 15-inch display is the most well-known example of this approach.

To enable each approach, automakers are relying on a mix of more powerful processors in general and on more centralized control of these features. As automakers seek to transform the instrument cluster into a full-fledged display in the vehicle that can show safety critical and infotainment information, a number of Tier 1 suppliers, such as Aptiv, Bosch, Continental, Denso, Harman, Faurecia, Panasonic, and Visteon, have created a new category of electronic control unit (ECU), commonly called a Cockpit Domain Controller (CDC), to provide both infotainment and instrument cluster functionality. The CDC is being used to drive multiple displays and functions with a single (ECU). CDCs are just one of the new technologies emerging to enable features in future vehicles.

# 2. Technology Enablers

There are a number of technologies that automakers are using to develop and build not only the cockpit of the future but the vehicle of the future. For automakers, cellular, Wi-Fi, Bluetooth, wireless technologies in general have become absolutely critical to delivering an advanced infotainment experience. Automakers are also in the process of enabling over-the-air (OTA) updates to vehicle ECUs in order to fix security issues, fix problems in existing software code, and to add new features. In addition, automakers are interested in collecting vehicle diagnostic and sensor data. The addition of cellular modems has become fairly common in modern vehicles, with the majority of automakers offering some form of connected services to customers, in many cases with some basic level of functionality for a multi-year trial period. With both B2C and B2B-facing use cases for wireless connectivity in cars existing today, it will only become more important in the years to come. Many automakers are planning to launch on-demand autonomous vehicle-based transportation services, commonly called “robotaxis,” and without connectivity this type of service would be impossible to operate.

In addition to the need for new infotainment features, for advanced safety systems, and for connectivity to enable B2C and B2B functions, automakers are also re-thinking their in-vehicle electronics architectures.

## 2.1 Domain Centralization

The auto industry, from OEMs to suppliers, are seeking to centralize vehicle architectures by using a gateway module to link the diagnostics and telematics control units with a smaller number of more integrated domain controllers, connected on a high-bandwidth network backbone.

The main purpose of this new “Domain Controller” architecture is to limit the growing networking complexity that has resulted from the addition of hundreds of decision-making ECUs that use different networking protocols (CAN, MOST, LIN, Flexray, etc.) and a variety of operating systems and software.

The ECU count in modern vehicles has increased to an almost unsustainable level in the premium sector. There are more than 100 separate ECUs fitted to a typical higher-segment vehicle. (e.g. Volvo’s XC90)

The “tipping point” toward domain centralization is coming from a number of market developments including the recent developments in the area of autonomous driving applications, since they require high levels of sensor fusion and high speed processing — from a growing number of high-resolution sensors, as well as redundancy and functional safety.

As well as limiting the complexity of the architecture, the domain controller architecture limits the high cost and weight of using wiring harnesses and limits the power consumption required by using multiple decision-making ECUs. By consolidating the decision-making data processing in the vehicle to fewer, more integrated domain controllers, automakers aim to enhance data processing efficiency.

In addition, as automotive business models trend toward applications and services, similar to current smartphone offerings, automakers are interested in the greater flexibility that a centralized architecture can provide via the use of domain controllers. Domain controllers would run different applications in software, as virtual machines (VMs), updated over-the-air (OTA). Applications with higher integrity requirements will be backed by lockstep processing cores to ensure functional safety and redundancy.

Other potential benefits to centralization include:

• A reduction in power consumption

• Enabling scalability and economies of scale in networking components

• Enabling greater cooperation across the vehicle, such as sensor fusion in autonomous driving

• The ability to provide a broader array of over-the-air software updates to the vehicle, which closely follows the new automotive business model of add-on services, as opposed to the traditional hardware-centric approach.

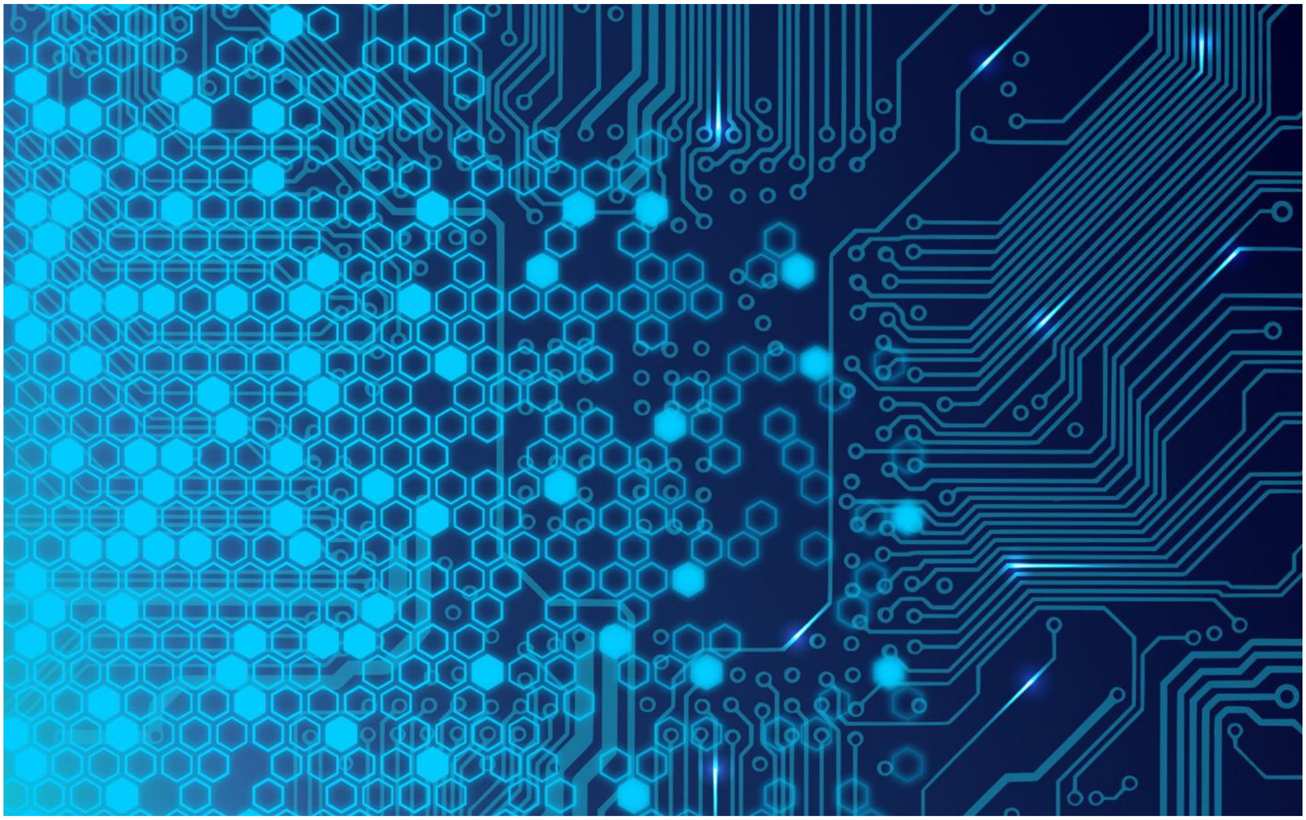
Part of the interest in greater centralization comes from the current state of the technologies required to design and build these more centralized architectures. Those factors include software, which has been a key enabler, as automakers re-purposed their algorithms for future generation domain controllers with open source-software platforms.

Platform virtualization features are essential as automakers deploy in production more centralized domain ECUs. Cockpit domain controllers require some degree of safety separation between the instrument cluster and the infotainment system, so Tier 1s offering these products are turning to hypervisors to enable two different operating systems, one for the cluster and one for the infotainment system. Another example of separation is Arm TrustZone, which enables an ECU to run two different operating systems at the same time on a single core, designating one as the secure OS and the other as the normal OS.

Another key technology development enabling centralization is the recent developments of high bandwidth networking protocols, such as Automotive Ethernet and HDBaseT. Both allow for higher data throughput on the network, which will be critical when vehicle safety systems will rely on processed sensor input to make life-saving maneuvering decisions.

All of these technologies are important, but at a fundamental level, new automotive-grade processors are crucial to enabling all of the technologies and features described thus far.

## 2.2 High-Performance Processors



One of the core trends in the auto industry enabling more advanced features, and more centralized architectures, is the development of automotive-grade, high performance, multi-core processing devices, such as the Arm Cortex series CPU- (Central Processing Unit), emerging GPU- (Graphics Processing Unit) and FPGA- (Field Programmable Gate Array) based SoCs (Systems-on-Chip).

According to the October 2018 update to Strategy Analytics' Automotive Semiconductor Demand Forecast, in 2017, there have been 898.9 million units of 32-bit MCUs (Micro Controller Units) fitted to new light vehicles. By 2022, this will increase to 1.46 billion units, representing an increase of 10.3 percent CAAGR 2017-2022. Fitment of MCUs will increase further to 1.68 billion units by 2024.

In 2017, there have also been 75.2 million units of MPU/DSP/SoC-H (High-End Micro Processor Unit/Digital Signal Processor/SoC) fitted to new light vehicles. By 2022, this will increase to 158.6 million units, representing an increase of 16.1 percent CAAGR 2017-2022. These SoCs will increase further to 217.1 million units by 2024.

A number of these processors are slated for cockpit electronics. Semiconductor companies have recognized that what the auto industry requires from processors today, and will require in the future, are chips with significantly higher performance requirements than those used in cockpit electronics just a few years ago. Semi suppliers are ready to meet that demand with a number of new products, the majority of which are Arm-based.

## 2.3 Example Processors

Companies such as Nvidia, NXP, Qualcomm, and Samsung have all designed more capable Arm-based processors to meet auto industry demands for higher performance infotainment and safety features. Some examples of specific processors include the following:

**Nvidia Tegra 30:** The Tegra 30 is based on the Tegra 3 series of GPU-based SoCs from NVIDIA. It is deployed on the Audi MIB2+ cockpit domain controller. The Tegra 3 series features a quad-core Arm Cortex-A9 32-bit CPU running at 1.4 GHz.

**NXP i.MX8:** In March 2017, NXP launched its latest i.MX MCU to support cockpit domain controllers in the aviation and automotive sectors. i.MX8 features Arm Cortex-A35 dual or quad core 64-bit CPUs that are based on the latest Armv8 architecture.

**Qualcomm Snapdragon 820A:** This is the automotive variant of the GPU-based 800 Series SoCs more commonly seen on smartphone handsets. 820A can support cockpit domain controllers through virtualization and its high performance, yet power efficient Qualcomm Adreno GPU.

**Samsung ExynosAuto:** The Exynos SoC has been the mainstay chip set for Samsung's own brand of smartphone handsets. It is one of the earliest eight-core CPU devices with 64-bit processing.  The current Exynos 9810 has a clock speed of 2.9 GHz on four custom cores for performance and four additional Arm Cortex-A55 cores, running at 1.9 GHz, for efficiency.

# 3. Preparing for the Cockpit of the Future

Automakers face a more complex engineering environment than they ever have before. More advanced safety and infotainment technologies have been introduced in new vehicles in production today, and next-generation vehicle designs will require even more advanced hardware and software. Even looking just a few years ahead is challenging, but with the development of technologies for autonomous driving, the car itself is set to undergo a fundamental change.

For SAE Level 3 autonomous vehicles, the future will be somewhat like the present — cars will be sold to private buyers via dealerships, and those buyers will want a greater ability to personalize how they use their car and to determine how they can interact with advanced safety systems, for example alert volumes and indicators.

For Level 4 and Level 5 autonomous vehicles, however, the infotainment system will still require the ability to show safety critical information, but transportation agencies around the world have not yet determined what constitutes safety critical information for passengers in autonomous vehicles. It's likely that the auto industry will offer a broader range of vehicle types, from commuter shuttles to premium, luxury vehicles. A commuter shuttle may offer a Wi-Fi hotspot, weather, and route information whereas a luxury vehicle may provide a bespoke experience where the vehicle's cockpit can provide an array of infotainment options customized for each passenger.

Bringing more streaming media services into Level 4 and 5 autonomous vehicles, such as video content, will change the infotainment landscape even further. Providing contextually relevant information and entertainment based on each passenger's profile, location, time of day, weather, and destination is the ultimate goal of future infotainment systems. Tier 1s and OEMs are beginning to conceive of Level 4 and 5 vehicle cockpits that inform, entertain, and meet the personal interests of passengers. The goal of future safety systems is to enable the vehicle to safely transport passengers to any destination, urban or rural. And vehicle connectivity will be essential for not only delivering a wide array of digital services to vehicles but also will enable the operator of an autonomous vehicle-based transportation service to remotely monitor, and manage, its fleet.

Although personally owned vehicles are unlikely to disappear for decades to come, vehicles on roads will be composed of a mixed fleet of manually and algorithmically driven vehicles. Automakers are already imagining what these future autonomous vehicles will look like and the types of experiences they will be able to provide.

Regardless of what the long-term future holds, advanced infotainment systems are already in the market in production models. The trend toward consolidation of infotainment and safety critical features is likely to continue over the near and long term as is the desire for personalization. Enabling all of these advances will require more feature-rich processors and System on Chips (SoCs), which the semiconductor business is working to deliver.