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App integration: The future of how smartphones interface with infotainment systems

The average driver today is an avid smartphone app user, and most want to use some, or all, of these apps in the car. However, most consumers find using their smartphone in their car while driving distracting; 82% of new car buyers in the United States, the United Kingdom, Germany, and China told IHS this in its Connected Car consumer survey. Controlling smartphone apps via the car's human machine interface (HMI) does not eliminate all distraction problems, but is certainly an improvement.

The solution is smartphone app integration software platforms, which are now so plentiful that two hands are needed to count the various contenders. There are basically two ways of doing this:

- ***Modify the smartphone operating system (OS)***: Makes the smartphone's OS interface with an in-vehicle infotainment (IVI) system's HMI. These are often called ***screen projection mode solutions*** or ***screen mirroring solutions***. This will also require specific middleware on each infotainment system that uses this variant of smartphone app integration. This middleware will implement restrictions on what content can be shown while driving to reduce driver distractions. The main advantage is that there will be minimal or no change needed by the app developers. Typically, this type of solution requires minimal updates by developers to extend their apps to work with these projection mode technologies, through an application program interface (API). Apple CarPlay and Android Auto take this approach.

- ***Create an intermediate app platform***: Connects the smartphone to the in-vehicle HMI. These ***interoperability framework solutions*** require slight modifications to each smartphone app. There will also be middleware in the infotainment systems in a similar manner as described previously. There are many platforms emerging—SmartDeviceLink (SDL), MirrorLink, and Aha by Harman are the three leaders. All three have many OEM design wins and are forecast to succeed. The main threat is from the first approach, where screen projection eliminates extensive app alteration by developers.

There is no question that most apps in the car will come from smartphone app integration, and every OEM is sorting out what approach and what product(s) they will use. This smartphone integration platform segment will be a fierce battle in the next few years. Multiple winners are expected, but some products will disappear or become niche players. An important trend making app integration feasible is the use of software platforms as the basis of the architecture of IVI systems. This software platform is usually divided into segments.

Automakers are embracing app integration by implementing various in-vehicle platforms that allow users to use familiar music, messaging, and navigation software solutions often found in the mobile space. OEMs are facing growing challenges implementing these app integration solutions. Fundamentally, two different solutions ecosystems seem to have emerged:

- ***Screen projection mode solutions***: a smartphone's operating system and apps are streamed from the mobile device to the vehicle's HMI, which includes using its display, mic, controls, and metadata, such as sensor and engine data.

- ***Interoperability framework solutions***: an intermediate app platform that connects the smartphone to an in-vehicle software core that handles user interface (UI) implementation and communications with in-vehicle controls. Typically, this core can have enhanced interoperability compared with screen projection through increased control of vehicle functions through a controller area network (CAN).

App integration solutions are becoming prevalent in the marketplace, and thus far, there are a few clear winners. Those include Apple CarPlay, Android Auto, Baidu CarLife, and SmartDeviceLink, which are expected to be the top sellers by 2023, in that order.

The other competing smartphone app integration platforms cannot match Apple's and Google's clout and will fall behind in this race, but can have some success.

Market Analysis

Apple CarPlay

Apple CarPlay is Apple's interoperability standard for display audio or navigation units in the car. Apple CarPlay was first mentioned as "iOS in the car" in May 2013. At the 2014 Geneva Motor Show, Apple unveiled the full Apple CarPlay system.

The original iteration gave drivers access to music, podcasts, audiobooks, and iTunes Radio with control through the vehicle's built-in human-machine interface (HMI) or by asking Siri to play specific music. Siri also helps users access contacts, make calls, return missed calls, or listen to voicemails. CarPlay also works with Apple Maps to anticipate destinations based on recent trips via contacts, emails, or texts, and provides routing instructions, traffic conditions, and estimated time of arrival (ETA).

As far as apps go, Apple has some advantages and disadvantages compared with Android Auto. Apple originally supported only audio apps, whereas Android Auto was originally announced with support for both audio and messaging apps. With iOS 10, CarPlay added support for messaging apps and voice over IP (VoIP) apps and promotes those alerts and notifications—at the 2016 Apple Worldwide Developers Conference (WWDC), Apple displayed this feature by showing Slack and WhatsApp for messaging apps, and Spark, Vonage, and Skype for VoIP. No messaging apps have been deployed as of this report, however.

Apple CarPlay: Key Facts

Apps	Compatible OS	Navigation GPS	Total OEMs	Models with Middleware
100+	iOS	Apple Maps	21	179

Apple's only available navigation app for now is Apple Maps; the application is much improved from launch, but there are many iPhone consumers who would like the ability to use Waze or Google Maps. The latest iOS 10 updates specific to CarPlay include the ability for turn-by-turn navigation to be displayed through the center gauge cluster, as well as other CarPlay functionality. The new "parked car" marker drops a pin locator for the last CarPlay or Bluetooth session with the car, too. The latest version of Apple Maps also includes new traffic updates en route, and the system will proactively send you alternative routes if there is a backup. If the head unit has a built in global navigation satellite system (GNSS) receiver, Apple encourages the supplier to let Apple Maps have access to the receiver to enhance its mapping system's accuracy. Apple recommends vehicle wheel speed/yield information and latitude and longitude (when available) be sent to CarPlay for dead reckoning on Apple Maps.

Apple CarPlay is now supported in 25 countries, including China (which has full Apple Maps and Siri support, too). China is a critical country missing in Android Auto's repertoire. Carmakers such as Geely and Mazda have released vehicles in China with CarPlay, for instance.

Developers interested in CarPlay need to work closely with Apple. Even if the specific app is approved, the user experience (UX) and user interface (UI) will need to be standardized by Apple, which does not leave much room for differentiation—a possible detriment for app developers when it comes to marketing their content. Unlike Google's Android Auto, the API for CarPlay is not public, and third-party audio and messaging apps need to be invited to have their app integrated.

Interestingly, although Android Auto locks the user from the smartphone, Apple deliberately has chosen to allow users to use both CarPlay and the iPhone interface simultaneously—the logic is that the lock will hurt the user experience and many may opt to not use CarPlay or unplug their phones to use restricted content and apps. With iOS 10, users can rearrange the order of apps on CarPlay, independently of how they are ordered on their smartphone, and they can remove apps. This functionality is done through the user's iPhone, shown in the following illustration.

Apple's CarPlay is expected to succeed and become one of the few leading smartphone app integration solutions for auto OEMs. IHS Markit expects it will dominate the market for iPhone app integration for car owners with iPhones. By extension, we expect vehicles sold in North America and Western Europe, where Apple penetrations are the highest, will have higher rates of deployments.

Android Auto

Android Auto allows owners to operate their Android phones—the most popular OS globally—through the vehicle's infotainment system using the touchscreen, steering wheel controls, or voice controls. It is not an operating system in and of itself, merely a car- optimized extension of the Android experience from a user's smartphone.

Android Auto: Key Facts

Apps	Compatible OS	Navigation GPS	Total OEMs	Models with Middleware
53	Android	Google Maps Waze	26	195

In December 2015, Google introduced its Android Auto API and SDK (software development kit) for building auto-enabled apps for audio and messaging. The introduction of APIs helped developers work on extending their existing apps targeting Android 5.0 (API level 21) or higher. The one set of APIs and HMI standards will let the apps work in the car without worrying about vehicle-specific hardware differences and gives developers wide reach across manufacturers, models, and regions. App developers do not need to invent a new HMI layer— instead, a standardized UI (with some basic customization for background image, color, icons, etc.) is available to app developers for music apps. For messaging apps, Android Auto primarily allows developers access to Google Voice, where a sequence of commands are used.

Currently, Android Auto supports audio and messaging apps and is working with partners such as iHeartRadio, Joyride, Kik, MLB.com, NPR, Pandora, PocketCasts, Songza, SoundCloud, Spotify, Stitcher, TextMe, textPlus, TuneIn, Umano, and WhatsApp. Altogether, there are currently more than 50 music and messaging apps available on Android Auto. Native apps on Android Auto include Google Music, Google Hangouts, and Google Dialer.

At this year's Google I/O (May 2016) conference, the software developer announced it would bring its traffic program, Waze, to its navigation portfolio on Android Auto. Having two very popular navigation apps is a leg up against competitors such as Apple CarPlay, which typically have just one native navigation application. At the same event, Google announced it was bringing wireless control of Android Auto through direct Wi-Fi protocol—similar to Apple CarPlay wireless—and its touchless "OK Google" voice activation, which should enhance convenience in the car.

One potential limitation for Android Auto is the requirement to download the launcher app in order for the app to work with the infotainment interoperability middleware. Thus far, only about 1 million users have downloaded Android Auto, compared with the nearly 800 million Android phones that are currently compatible with Android Auto. If Android Auto for the car can reduce driving distractions, then more users may download the app launcher, which in turn would encourage more developers to integrate their apps with the Android Auto API.

Android Auto is currently available in more than 31 countries, including Australia, Brazil, Canada, France, Germany ,India, Japan, Korea, the United Kingdom, and the United States. Android Auto's big weakness is the Chinese market. Android Auto is not officially supported in China. Google moved out of China more than six years ago. Google Services, including Google Maps, are constantly disrupted in China, resulting in a very bad user experience for Chinese consumers. In addition, many popular Chinese device makers use forked versions of Android, similar to Amazon's Fire OS, which are not compatible with Android Auto.

Android Auto is still in the process of amassing automaker and app developer support. While Apple CarPlay seems to have beaten Android Auto with launching on a major vehicle and has wider country availability, Android Auto still has many advantages that may position it as the preeminent smartphone integration solution in the long term. Google is taking an all-of-the-above approach to the car (with an embedded OS, smartphone, and screen projection solution), which has the potential to give the middleware solution a leg up when it comes to available apps.

Android Auto seems to be extending itself quickly to third-party developers and with smaller regional automakers. Android Auto requires users to download a standalone app that is available on Google Play. In the IHS view, this is a poorer user experience compared with Apple CarPlay, which works without a separate app. Android's latest excursion into in-car infotainment OS may lead to more car-centric apps for Android Auto and further erode any sort of competitive advantage a third- party alternative such as SmartDeviceLink or MirrorLink could have in the market. Google's inability to operate or compete in China lends space for Baidu Carlife to flourish with Android users, however.

Technology Overview

OS Platforms

The IVI general-purpose OS ties all the software together and is therefore the most important software platform in the car. Building competency in an operating system platform is the best way to gain software expertise, because the OS platform has become the most important building block for infotainment systems. In the automotive space, there are three dominant general-purpose operating systems (GPOS): QNX, Microsoft Embedded Windows (several versions with different names), and Linux (which also has multiple distributions). QNX is the clear leader, while Embedded Windows is on a long-term decline owing to its higher cost structures than QNX, without the support or innovation. Software platforms for applications have traditionally been linked or dependent on the OS platform, although recently that has changed through new middleware solutions such as Apple CarPlay and Android Auto.

QNX's Neutrino OS kernel has a significant advantage over Microsoft and Linux however. QNX is not actually a GPOS—at its core, its infotainment operating system runs off a real-time operating system (RTOS) kernel that can be used far more extensively in the car than current Linux, Android, or Windows versions. RTOS powers time-sensitive automotive-grade modules, which often need to execute tasks in the milliseconds, including telematics control units (TCUs), gauge clusters, navigation, and core controllers used in active and passive safety systems, emissions control compliance, advanced driver assistance systems (ADAS), and other embedded systems. QNX's technology has been used to manage nuclear power plants and military applications such as unmanned aerial vehicles (UAVs). QNX is also certified ISO 26262 compliant—a nearly universally adopted international standard for functional safety in safety-critical embedded systems—something neither most Linux distributions nor Windows can claim.

Linux is clearly making an impact as an OS platform for in-vehicle infotainment (IVI) systems. Linux currently has three strong contenders: GENIVI-complaint Linux, Automotive-Grade Linux (AGL)/ Tizen, and Android. The GENIVI Alliance has led automotive Linux activity since 2009, when it was founded. Most Linux activity has been concentrated on building automotive-grade middleware to use with Linux. Custom development of automotive middleware was needed previously. However, this custom work proved too expensive, time-consuming, and error-prone.

The GENIVI community developed a large portion of what was needed. This middleware can now be deployed, reused, improved, and reused again and again, resulting in lower cost, shorter time to market, and more reliable code. Nearly all major tier-1 suppliers are in the GENIVI Alliance; many are board members. Several tier-2 and/or software companies are also board members, including Mentor Graphics, Pelagicore, Symphony Teleca, and XS Embedded. The Automotive-Grade Linux (AGL) group is a second Linux organization that is emerging as a part of the Linux Foundation. AGL uses Tizen OS (a Linux OS developed by Samsung), which is also a GENIVI-complaint platform. AGL is primarily organized by Asian car manufacturers. Among those OEMs, Toyota plays a leading role in forming and guiding the direction of AGL.

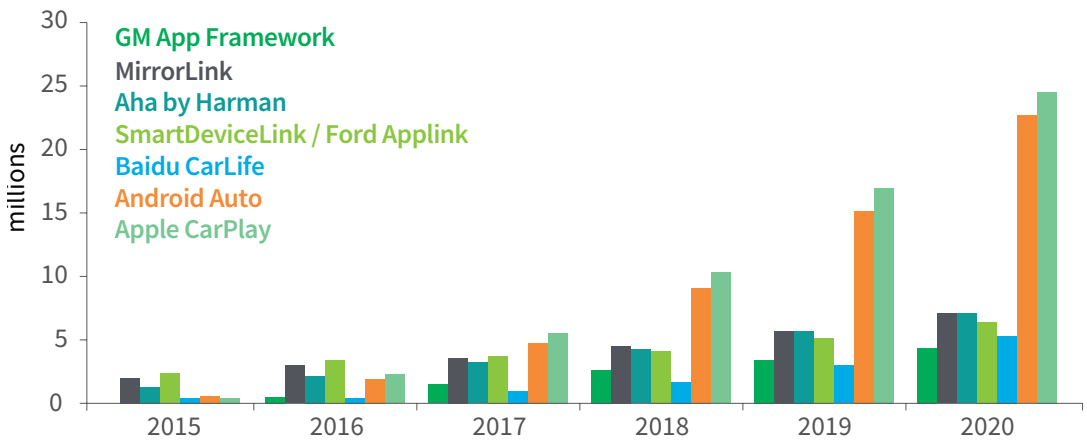
In 2016, Google announced at its developers conference, Google I/O, that Android 6.0 (codenamed N), the latest variant of Android, will have an auto-centric variant that can be used as an infotainment operating system (OS). "Android Automotive" implementation (as Google refers to this variant of Android 6.0/N for cars) refers specifically to a vehicle head unit running Android as an operation system. Google says all features in a modern IVI system and gauge cluster are supported, including things like AM/FM radio, Bluetooth, and others.

Android reference guides for Android Automotive also mention over-the-air (OTA) capabilities, and IHS assumes there will be a plethora of microprocessor (MPU)-microcontroller (MCU) support and middleware support, since Android is already used across a wide variety of embedded systems, such as smart televisions. With a large potential library of apps, hardware support, security support, continuous research and development, and customer care support and maintenance, Android will be a formidable challenger in the automotive space.

App Integration Platform Annual Sales Forecast

Looking at seven major app integration platforms, there is clear consolidation happening among these solutions, and the consensus seems to be with Apple CarPlay and Android Auto at the global level. Apple CarPlay is expected to the best-seller among all the solutions by 2023, when 53 million vehicles will be equipped with CarPlay. The reason IHS expects CarPlay to outpace Android Auto is its advantage in developing markets, such as China, where Android Auto does not currently compete. Apple CarPlay had initial success against Android Auto and has succeeded in getting vehicles equipped with its middleware solution, too.

App Integration Platforms - Annual Sales Forecast



Source: IHS Markit

In markets like Western Europe and North America, both Apple CarPlay and Android Auto are expected to become nearly ubiquitous by 2023, with attach rates in those regions ranging in the 80–90% range. Other solutions, such as Baidu CarLife, will do very well at a regional level, whereas SmartDeviceLink will become a powerful OEM-centric alternative to Apple CarPlay and Android Auto. IHS has scaled back its expectations of MirrorLink and Aha by Harman owing to feedback from suppliers and OEMs and because of the slowing of recent announcements in terms of partners, app development, and tech development from those platforms.

Conclusion

Smartphone app integration will be successful and quite common by 2023. Smartphone users want the capability, and it is much safer than using a smartphone without such a solution. Both Android Auto and Apple CarPlay will be very successful in the next seven years and will become the leading products. Both Apple and Google have tremendous clout with their own developer communities, resulting in a flood of Android Auto-compatible and CarPlay-compatible apps in a short time.

The other competing smartphone app integration platforms cannot match the app developer clout from Apple and Google and will fall behind in this race, but they can have some success. Abalta Weblink is a simple solution that has potential in developing markets. MirrorLink has a strong membership, and several auto OEMs favor MirrorLink over other solutions. Google has problems in China, which could make Baidu CarLife and SmartDeviceLink (SDL) stronger there. SDL will provide a large base via Ford and Toyota cars, but it would be much stronger if other OEMs sign up to use SDL. The other solutions will need more OEM design wins to become more than a niche market.

In summary, smartphone app integration is on its way to become a large and influential technology for the auto infotainment industry.

List Of Acronyms And Definitions

- **API**: application program interface – a set of protocols and tools for developers to integrate their apps into a greater software system; in this case, mostly into a smartphone integration solution
- **CAN**: controller area network
- **GENIVI**: a non-profit automotive industry alliance committed to driving the broad adoption of open source, in-Vehicle Infotainment software and providing open technology for the connected car
- **GPOS**: general-purpose operating systems
- **GPS**: global positioning system – created and maintained by the United States that allows for users to determine their location via satellites
- **HMI**: human machine interface
- **IVI**: in-vehicle infotainment – factory-installed head-unit in-vehicle infotainment system in the vehicle that is broken down into three categories of audio, display audio, and navigation
- **OS**: operating system
- **OTA**: over-the-air updates
- **SDL**: SmartDeviceLink
- **SDK**: software development kit – also known as a devkit, the SDK is a set of software development tools that allow developers to create applications for a specific framework, such as Apple CarPlay, or operating system, such as QNX; these can be as simple as how to implement a certain set of APIs all the way to how to interface with a certain coding language such as Java or Swift
- **UI**: user interface
- **UX**: user experience

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Staying abreast of automotive sector/topic-specific developments, trends, and competitive activity can be time-consuming. With many sources available, it is often difficult to find critical and reliable market information that stakeholders of the automotive industry need. Conducting business analysis, product, or market strategy assessments without validated market data is risky.

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