

Developing In-Vehicle Infotainment Systems



Bsquare has a unique depth and breadth of experience in IVI system development. We can help you deliver the connected car promise of convenience, safety – and “Wow!”

In personal relationships, first impressions are important. The same is true for consumer auto purchases. When designed and deployed correctly, a “connected” experience in the car can trigger a “Wow! How cool is that!” response – the kind of response that increases demand and loyalty.

There is a huge and growing market opportunity for In-Vehicle Infotainment (IVI) systems that create a superior in-car user experience. The interlacing of the car’s IVI system, the driver’s mobile device and applications can help achieve that “connected car” experience. But, the complexity in designing and developing those kinds of IVI systems can be very challenging. To provide a truly innovative and differentiated connected car experience, development teams need to ensure they have the maximum design and development process expertise.

This paper briefly discusses the most important aspects of bringing superior IVI systems to market. The information provided here is based on the unique trifecta of experience Bsquare has – in the automotive value chain, in IVI design and engineering and in developing mobile applications across all device types and operating systems.

Best Practices for IVI System Development

Consumer expectation and demand for connected cars is increasing. It’s now no longer a “frill” to offer appealing IVI features that let drivers get the information they want on the go, quickly, easily and safely. Drivers immediately notice innovative IVI systems. In fact, most drivers recognize the differences afforded by great IVI features faster than they do different mechanical offerings between vehicles.

However, if you’re like most IVI developers, you’re working to meet the growing demand for optimal consumer experiences within time-to-market demands that are increasingly compressed. The process can get overwhelming in no time.

IVI system development has three major areas: (1) Head-unit HMI development, (2) mobile application development and (3) integration. Within each of these areas there are strategic implementation considerations that can be used to alleviate some of the challenges related to creating industry-leading IVI solutions. For example, with mobile device application development, it’s important to consider developing and testing for various platforms. To fully integrate the HMI with a mobile device application, you must consider numerous connectivity options – from Bluetooth to USB to Wi-Fi – each with its own specifications requirements for interoperability.

When you start considering the countless possibilities and risks, you’ll probably say to yourself, “There’s got to be a better and faster way to get our ideas to market.” Avoiding the potential pitfalls in these three areas of IVI development is critical.

That’s why Bsquare created this paper: To point out some key areas we know are important in the process of developing for the automotive industry – and to help you sort through the challenges of IVI development and integration. With insights gained during our 18+ years of experience with embedded device applications, our intention is to provide some best practices that Bsquare recognizes as critical for successful IVI system development.

HMI Development

Developing the head-unit HMI is one key aspect in creating the connected car.

When Bsquare project teams begin work on a head-unit HMI, the first thing we do is try to understand the ultimate business goal. Before writing or porting even one line of code, we work to identify the features and applications that will have maximum impact on the consumer. We help clients do this by asking questions like, What type of user experience do we want to create? Which mobile devices and platforms do we need to support? Who will the primary users be?

You can use the answers to these types of questions to help define the scope and requirements and to select the best design framework for your project. The answers should also help you clarify the best implementations that will ensure both driving safety and system security.

At the beginning of the HMI development process, Bsquare creates the artwork for the user interface (UI). To ensure an optimal post-deployment end-user experience, we build sample UIs on an actual embedded system rather than a desktop system. Although it's an extra step, it's a critical one. We do this because we have learned that the best way to meet driver expectations is to use a UI framework with a strong graphical foundation. Interesting visuals, like flying graphics, may work great on a powerful desktop PC, but may not translate as expected on an embedded device such as an in-car system and the sample UI can help identify areas of risk within a project. Which UI framework should you use? Each has pros and cons:

Adobe® Flash®. Adobe Flash is widely popular and therefore well supported in the design community. The framework has been in use for 10 years. It is mature and feature-rich, and supports many operating systems, including Android and Microsoft Windows. Its long history and wide use means that design teams can leverage an extensive collection of pre-existing work and also have access to the most mature development tools in the field.

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One thing to keep in mind is that while Flash developers are relatively easy to find, most tend to be desktop developers who may not have a depth of experience with embedded systems. Design of truly stunning desktop interfaces may not always transfer easily to a power-constrained embedded device, and less experienced teams may require additional project support. As an Adobe Scaling Partner Bsquare has extensive Adobe embedded experience and, with access to source code, Bsquare is the go-to shop for companies who want to license, port, and integrate Adobe Flash for connected services.

HTML5. The latest standard for cross-platform development is HTML5. Like Adobe Flash, HTML5 enables considerable animation support and graphics capabilities. There are a number of advantages of HTML5. This high-performance tool delivers faster rendering and works within the capabilities of the browser. Another clear advantage to HTML5 is that no certification process is required for applications. Again, we're speaking from experience here. The Bsquare HTML5 Rendering Engine tool offers a general application framework for deploying all types of rich applications on mobile and embedded devices. Our tool allows designers to quickly deliver high-performing custom browsers and innovative UI experiences that are portable and reusable across platforms. Having created this high performance rendering engine tool, we know how to get the most out of HTML5. For example, even though web standards are a moving target, we can implement HTML5 within an IVI system that optimizes performance and maintains consistency over the entire product lifecycle.

Microsoft Silverlight. As a Microsoft Gold Certified Partner, and a recognized leader in the embedded industry, Bsquare knows Silverlight very well. The Silverlight framework is gaining traction – and market share on the desktop. It is also the framework for developing and designing applications on Windows Phone 7. The framework is very well integrated with Windows and the Visual Studio development tools, and is available for Microsoft Windows Embedded for Automotive and Windows Phone.

Design for driving safety

When designing IVI systems, safety must remain a paramount concern. The stakes are dramatically higher for IVI applications than any other consumer application. Developers must ensure the security of their own system while implementing designs that are intuitive and minimize driver distraction.

A heavy burden of safety is placed on the shoulders of application developers and, to some extent, the car OEM. In the U.S., some states have adopted safety-related legislation around mobile device use while driving. This trend is being seen in other countries as well. The various changes in legislation have encouraged development of safer systems.

When it comes to safety, it's not just phone calls and texting that can distract a driver. User Interface (UI) properties such as flow, responsiveness and stability, and UI element size, color and readability can all affect driver distraction and safety. Surprisingly, there are no current U.S. regulations or industry standards for HMI design and interaction. As a result, there are no UI guidelines for OEMs and requirements vary widely. It is crucial that your development partner be familiar with the guidelines of specific car OEMs. Therefore, when developing an IVI system, it is imperative to partner with a company such as Bsquare that can guide you through designing the overall system – as well as all facets of system integration and application development.

Because safety is of paramount concern, it is essential to carefully create best practices and guidelines. Here are the top three implementation guidelines Bsquare adheres to for ensuring safe deployments of IVI systems:

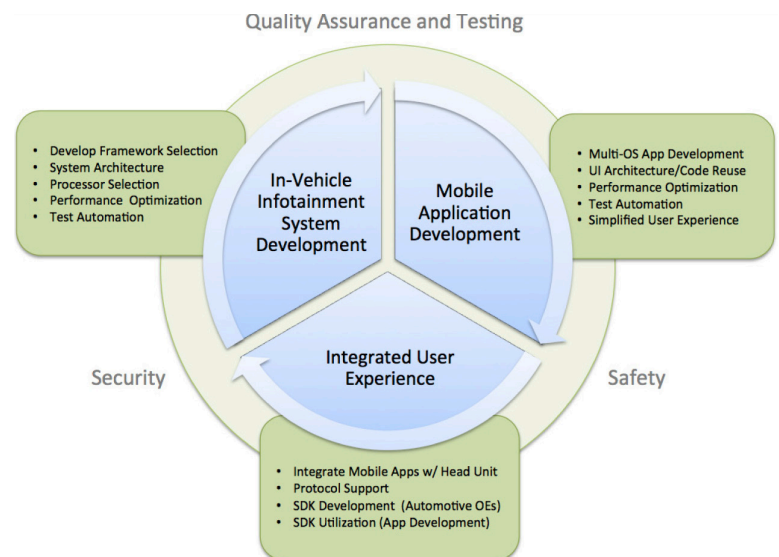
- User interfaces must be easy to use, with key functions visible at a glance. UIs must always follow the car manufacturer's safety design guidelines. Bsquare knows each car OEM's requirements and can guide you through this development with best practices for devices gained over years of embedded system development.
- Voice recognition should be used whenever possible to minimize driver distraction. A system that is integrated with vehicle controls and automatically transitions from touch interface to voice response when the car changes from "Park" to "Drive" is an example of technology that can ensure driver safety.
- Access to functions and features that may be distracting to drivers must be restricted when the vehicle is in motion. For example, watching a video on the in-dash display is permitted only when the vehicle is parked.

Design for system security

Driver safety should be affected by external threats. The possible consequences of a security breach (such as a hacker enabling a distracting event while a vehicle is in motion) are serious concerns for all IVI systems. Therefore, it's important to invest in robust security for all vehicle systems.

Although it's expensive, the most secure approach to system security involves complete hardware separation. In this configuration, one system handles the IVI; another completely unrelated system handles other vehicle functions. This approach puts critical vehicle systems out of the reach of the IVI system or any applications running on it. The cost, however, is much higher for hardware.

A more common and less costly approach is to use a single hardware system that keeps the IVI system and its applications in a software sandbox. This approach is effective, but requires careful engineering that limits exposure of the sensitive memory locations and applications. Applications should run in a restricted space with few or no rights to access the rest of the system.



UI Code Reuse

Selecting the correct framework can help you simplify UI development for an IVI system. However, “skinning” (rapidly customizing a UI while maintaining a high degree of code reuse) is still an important part of the design phase. Developing from a UI framework makes skinning changes easier. It also reduces the risk that a minor wording or appearance change will break other code. Starting from a portable UI framework also gives you more options to get a return on your development investment.

A word of caution about native code: It is not portable. In fact, one of the biggest challenges of native code is the difficulty in skinning a system for other markets or even other vehicles. For instance, an IVI system designed for an upscale version of a car model line may include more features and have a more luxurious appearance, even if much of the underlying code is the same for all models of the vehicle. Using native code for only the upscale model would mean having to re-write portions of the code to support implementation of the same system in other vehicles in the product line.

Mobile Device Application Development

Developing apps on various operating systems is another key aspect in IVI system development.

There are many good reasons to run applications outside of the IVI systems. Driver convenience is one of them. In fact, extending the vehicle platform to mobile devices makes it much easier to enable certain enhanced

features. For example, remote control functions – such as advanced keyless entry and remote start – can be genuine selling points. Drivers can stay in the house on a cold winter morning with a hot cup of coffee while their car “warms itself up.” Remote functions can also be used to enable easier maintenance and safety checks. For instance, a mobile device application might be used to remotely access a car’s diagnostic information when making a service appointment. Why go all the way out to my car to check my mileage history when I can get that information from my mobile phone or tablet?

Leveraging platform extensions may also provide cost advantages for drivers of cars manufactured without embedded radio modules. In this case, using a mobile device’s existing data plan to send and receive information can be convenient – and can also provide cost savings – when drivers are not required to buy a separate data plan for the vehicle.

Extending the vehicle platform to a mobile device can also extend the useful life of an in-vehicle system. Head-units are designed to last years and IVI systems are created with a 10+ year lifetime in mind. While short leases are certainly common, the average consumer owns a new vehicle for approximately 7.5 years. In contrast, mobile devices are replaced much more frequently. This discrepancy means the in-vehicle system can rapidly become dated unless it is also leveraging the latest technology of mobile devices.

Creating a system with a longer-term useful life requires cross-platform development. Bsquare development teams have a lot of experience in multi-OS applications. We have built cross-platform applications for smart, connected devices running Android, iOS, Linux, webOS and Microsoft Windows Mobile, Windows Phone 7 and Windows Embedded operating systems. That’s why we know that best practices are perhaps even more critical in developing IVI apps than any other kind of application. Program managers need to oversee projects with strict adherence to established program management practices. And, software engineers should embody a disciplined observance of software development best practices and methodologies

Creating the Connected Car - Integrating HMI and Mobile Devices

The third aspect of IVI system development we’ll discuss in this paper – integration – requires as much care and attention as the other two.



To provide truly innovative user experiences, development teams need automotive-grade design and development expertise.

There's lots of buzz in the automotive industry about the "connected car." The excitement is partly fueled by the many ways people now use mobile devices in their cars. From navigation to entertainment, the connected experience has become an expected reality.

Looking ahead, all signs are pointing to continued growth of this market with increased options and enhanced features across a wide range of vehicle types and categories. Drivers are using their mobile devices to enhance their entertainment experience. As the use of this functionality grows, drivers could use an application to tell a car's system what their favorite music selections are, and then carry this intelligence to different vehicles, sharing their tunes on rides with friends.

For road warriors, applications could personalize rental car IVI systems with points of interest, radio station settings, and seat preferences, to name just a few – eliminating the need to fiddle with mirrors and scan through countless measures of the radio spectrum.

Driver convenience is one advantage of extending the IVI platform to mobile devices. For example, a mobile device could access a car's diagnostic information to simplify the way owners stay on top of repair and maintenance details. Why go all the way to my car to check my mileage history and maintenance schedule when I can get that information right here from my mobile phone or tablet?

Beyond the convenience factors, however, are fundamental aspects of integration that may enhance hands-free capabilities. Legislation to limit talking or texting while driving has driven a number of innovations for vehicles. As governments continue to adopt distracted driver laws, vehicle manufacturers will continue to expand features that help minimize distractions for drivers. Imagine getting in your car and being able to seamlessly transfer your phone conversation from your handset to your car speakerphone without so much as a button push. Or, think of the convenience of a vehicle that's intelligent enough to transfer your call back to your phone when you turn off the engine. These may seem like nice-to-have conveniences, but in reality, this sort of functionality can reduce the distraction of managing multiple devices.

Quality Assurance and Testing: Protect your reputation
To create a connected car experience that's automotive-grade, you must take great care in how you integrate the HMI and the mobile device application. The HMI needs to be thoroughly tested, as do the device applications – and it's equally important to conduct complete testing of the combination of the two.

Quality Assurance

Your world-class reputation is based on getting it right the first time. At Bsquare, quality assurance and testing begins at the product concept stage with an emphasis on quality that continues through to final production. We recommend you do the same. We have found this approach reduces engineering costs, speeds time-to-market and improves overall product quality with less risk. The Bsquare quality process begins with proof of concept and feasibility studies – and continues throughout the development process. Devices and applications are tested using Bsquare TestQuest, our automated testing platform. Automotive systems require tests for the thousands of possible combinations of passenger and driver actions. To deliver a quality end product, it is critical to ensure that testing for all those possible instances is planned into the development process. This is one reason Bsquare created the Telematics Competency Center – to enable the full breadth of development and testing support required to ensure quality experiences.

Testing: Ensure quality user experiences the first and every time.

When it comes to ensuring a quality experience with IVI systems, the challenges multiply in direct proportion to the increasing complexities of the ecosystem. There are a number of key areas that developers must test in order to maintain automotive-grade quality standards. These include stability testing, drive simulation, random testing and HMI automated testing. Certification also needs to be considered for connectivity technologies such as Bluetooth and USB. Performance of the overall system must also be considered throughout the entire design and development process.

Specific challenges to proper system testing can arise during product development which have substantial impact on product quality and brand. An increasing number of IVI systems are being developed with applications that are integrated into the head-unit and connected to mobile devices and system elements like the CAN bus. While it's generally optimal to develop applications independent of the IVI system, that's not always possible. With concurrent system and application development it is imperative to optimize system and application testing, as well as overall test automation. As a result, developers need alternatives to the manual "button pusher" approach to testing, which is anything but optimal. The costs of manual testing continue to rise and, perhaps worse, quality and test accuracy can suffer due to tester fatigue and human error. This leads to a number of testing challenges, such as trying to reproduce failures to find the root cause of a problem long after the fact.

If you end up feeling that there are not enough hours – or testers – in a day to thoroughly test applications running with your IVI system, you're not alone. In fact, that's why Bsquare invested heavily in automated testing solutions. With TestQuest, and through the Telematics Competency Center IVI Stability Lab, Bsquare can test thousands of scenarios that impact system stability—including power state transitions, application loading and unloading, memory management and dozens of other parameters. Overall Bsquare system testing includes testing integration and compatibility between head- units, applications and consumer devices.

Additionally, every system function has specific test needs. Bsquare TestQuest automated testing platform can check every functional process, no matter how complex it is, or how many times it needs to be repeated in order to thoroughly test it. Unhindered by manual testing limitations and able to be used in a distributed environment, this proven process improves quality without increasing headcount. It results in greater repeatability of failures, which helps determine their root causes more quickly. The end result is higher quality products at a greater speed of execution.



Consumers now expect a “wow” user interface in their vehicle with eye-catching graphics and animation – and PC-like responsiveness and power from every connected device.

Ready to be Part of Making Cars the “Ultimate Mobile Device”?

Devices like the iPhone and Droid have set consumer expectations for application experiences. Consumers now expect a “wow” user interface with eye-catching graphics and animation – and PC-like responsiveness and power from every device. Provide anything less and customers may view your system as inferior. We created this paper to help you avoid the pitfalls, and gain better understanding of the best practices used to build a connected car. Our hope is that all your IVI applications will integrate seamlessly with the vehicle, delight the customer and deliver the “Wow!” that generates more sales.

Can Bsquare Help?

Does any part of this sound like more than you can handle with your existing resources? If so, know that Bsquare can help throughout the development process from design to deployment. Bsquare has proven expertise, processes and tools that get IVI apps to market quicker and with less risk. And, with unique cross-platform application expertise that runs deep and wide, our engineering teams can help you develop solutions that meet the most demanding standards. From the roots of in-vehicle app development, to graphic design and user interfaces— Bsquare has extensive experience under our belt in both the automotive chain and IVI system design and engineering. Our global team of engineers is ready to help you accelerate time-to-market, reduce development costs, and provide a “How cool is that!” experience that will win and keep customers.

Next Steps

Contact your Bsquare Account Manager or call Bsquare at +1.888.820.4500 or +1.425.519.5900

Or email sales@bsquare.com for more information.

For more information, please visit www.bsquare.com. Or email us at sales@bsquare.com

At Bsquare

Bsquare is a solution provider to the global embedded device community. Our teams collaborate with OEMs at any stage in their device development to bring quality products to market faster. Since 1994, Bsquare has been a trusted partner to smart device makers worldwide.

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