Easy, low risk, cost effective and scalable: The future of building in-vehicle infotainment systems.

Whitepaper
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Executive summary

TomTom Digital Cockpit is the world’s first open in-vehicle infotainment (IVI) software platform. It provides carmakers, system integrators, software development companies and content providers with an open and secure environment to develop software and apps for automotive applications.

With TomTom Digital Cockpit, carmakers now have more control over how they provide their drivers and passengers with delightful and safe in-vehicle experiences.

Automotive-focused digital service providers are empowered to integrate their services with the platform natively. While this will deliver a great experience for the driver, the platform also allows service providers to develop, test and demonstrate their products in a fully operational infotainment context.

Not only is the route to market faster, it’s simpler too. Carmakers and service providers need only build and integrate their services once, allowing them to reach multiple brands and car lines with one development effort.

Introduction

This white paper explains how the TomTom Digital Cockpit platform architecture allows infotainment software developers to create unique brand user experiences with less effort, less project risk and in a shorter time than traditional production processes allow.

It also demonstrates how carmakers, original equipment manufacturers (OEMs), Tier 1s and developers can stay in full control of their code and product success throughout its lifecycle, when using TomTom Digital Cockpit.

Even though this paper is intended for an audience of carmakers, and primarily focuses on TomTom Digital Cockpit’s value for them, it will also illustrate the platform’s benefits to other parts of automotive industry’s digital supply chain, including service and app providers from the mobile space.

The descriptions, explanations and examinations in this paper are conceptual to explore the potential of TomTom Digital Cockpit from a high level. Examples aim to be simple and easy to understand to make this paper approachable to a non-technical audience.
The automotive challenge

The automotive industry struggles to produce compelling in-vehicle systems that are on par with leading user experiences from other industries, such as the extensive and always up to date user experience we see in the mobile phone industry.

The automotive world has been using the term “software defined vehicle” for over a decade. However, car brands are losing their drivers to the smartphone as a result of stagnant user experiences. This is particularly surprising since the smartphone has a smaller screen compared to typical embedded in-vehicle screens.

What’s more, even when the phone’s screen is mirrored to the in-vehicle display, it’s still not sufficiently integrated with the car to provide a truly convenient and safe experience while driving.

The main reason why the attractiveness of the in-vehicle user experience lags behind the smartphone is largely a result of the fact that systems are built in a project-by-project development cycle. Each car brand undertakes a completely new development project, from scratch, for new vehicles.

Foundational components are repeatedly, and unnecessarily, rebuilt. These then need to be integrated into the vehicle and a completely new UI needs to be designed, which leads to long and costly development cycles. This doesn’t have to be the case, though.

Core components shouldn’t need rebuilding, integration shouldn’t happen more than necessary and user interface elements should be reusable between products, so designing them again and again, shouldn’t always be required.

To speed up the overall development cycle, it’s common for software development and its integration activities to be executed in parallel by different parties or integrators. This is a complex task, especially because the different parties are often restricted by strict budgets and timelines. It makes development cycles challenging for carmakers. The time or budget for user testing may suffer from delays elsewhere in the project and carmakers don’t have much opportunity to actively learn throughout the development cycle.

Like phones, modern competitive in-vehicle systems should be continuously improved. The traditional carmaker software development process doesn’t support that. If changes to the software are required these usually follow a bureaucratic change request route that’s taken in direct communication with the software integrator and other software component providers. It’s not a process that can happen reactively. The complexity of the change process effectively kills the ability to make iterative improvements to the software as part of the development cycle.

Most integrators have become market leaders by excelling in operational excellence, rather than product leadership. This has led manufacturers to focus on optimizing the quality of the production process, rather than developing a high quality and consistent product for end-users. With the advent of the software defined car, however, they must take digital product development as seriously as they take hardware development.

Increasingly, carmakers are waking up to the limitations of their software development processes and are taking control of their digital cockpit experience by moving software development in-house, bringing it closer to hardware development in the process. This reduces the complexity of dealing with different software integrators and speeds up the change request process by cutting external dependencies. But this doesn’t address the issue of redeveloping software components for each brand or car model.

In response to this, Herbert Diess, CEO of German carmaker Volkswagen Group, recently set out his ambition for the company to “own” (develop, integrate, and deploy) around 60% of the software in its vehicles. A sea change from today’s vehicles where a significant majority of the software is written by suppliers.

Next to the long development cycles, there is another aspect to the problem of automotive software development. To provide an experience that can compete with a smartphone, a carmaker’s digital cockpit platform requires a similar level of contribution from (third-party) service providers. Most automotive platforms today suffer from being closed systems that don’t allow third parties to develop apps and functionalities for them, making their experiences limited and narrow in scope.

1 See also The Value Disciplines Model developed by Michael Treacy and Fred Wiersema.

Contributing to an automotive platform is often only sensible for the contributor if it facilitates access to a high volume of users. For app developers that contribute to mobile platforms, like Android and iOS, the user volume is huge. A single app can work on hundreds of device models, scaling to millions of potential users. However, the number of users of a single car brand, or even an entire automotive group with multiple brands, is small in comparison. This makes it less interesting for third parties to contribute to individual car platforms.

One of Android Automotive’s advantageous features addresses this scalability issue by allowing the same app to run on any Android-compatible vehicle. However, the standard way Android solves this problem does not support the best possible user experience for these apps or the carmaker’s product. For example, the apps cannot be closely integrated with other vehicle functions, and they cannot easily be branded by carmakers.

Focus on what is unique and essential

OEMs can’t solve this scalability problem simply by throwing more money and resources at it. A different approach is required, one best characterized in the words of Steve Jobs, “Deciding what not to do is just as important as deciding what to do.” In that sense, carmakers must focus on what is unique and essential for their product’s success rather than constantly reinventing the wheel in non-differentiating areas.

Many of today’s top tech companies credit their success to their ability to utilize off-the-shelf platforms for non-differentiating components. This strategy enables them to scale massively and bring value to their users quickly and efficiently, allowing them to focus on develop aspects of their product that differentiates them from the competition.

For example, if we look at the technological components of Uber’s taxi hailing app, we see that the company relies on third-party platforms and technologies to power many of its key elements.

Infrastructure is provided by Amazon, so the app can scale massively online and be available all over the world. For mapping and routing, Uber uses TomTom technology, so drivers can take the fastest routes and passengers always know where they are. Uber’s messaging stack is provided by Twilio, ensuring passengers get text messages right when their driver arrives. And its email service, that’s used to send receipts to passengers, is built using SendGrid APIs.
Introducing our solution, TomTom Digital Cockpit

For each of the problems explored earlier, there is a logical explanation for how they came to be, but with the rise and popularity of mobile platforms and modern software development practices, there is no longer a valid excuse to accept them. In principle the solution is simple: we must rethink how the automotive industry approaches software development from the ground up.

Carmakers should focus on what makes them unique and only develop essential features by reusing existing software platforms to increase the efficiency of development. They should make sure to continuously leverage platform improvements. They should invest in scalable software development to roll systems out across entire car lines, models and brands. They should choose and build on a platform that has sufficient market penetration and end-user reach to be an attractive proposition for third-party developers and services providers.

We have developed TomTom Digital Cockpit to provide carmakers with these opportunities. With TomTom Digital Cockpit we provide a tool that helps carmakers overcome the decades old problems of the automotive industry. It is an Android-based, open, flexible digital cockpit development platform.

TomTom Digital Cockpit addresses the challenges the automotive industry faces in four ways.

First, it reduces the lead time and cost of software development by removing the need to invest in non-differentiating aspects of the in-vehicle infotainment (IVI) system. It allows carmakers to focus on what is unique to their brand experience and reuse other applications, services and components off-the-shelf.

Second, by giving carmakers complete control over development, they can fully dictate their product’s success and future. Every reusable component can be completely adapted to their needs with customization options as deep as source code level. As carmakers own all software modifications made on TomTom Digital Cockpit, they will never be locked to a vendor or prevented from reusing those changes in other products or vehicles.

Third, TomTom Digital Cockpit attracts third-party service providers and developers to form an ecosystem of contributed functionality by defining a common platform for all TomTom Digital Cockpit systems. It provides a much larger userbase to contributors than any single OEM can offer.

Finally, TomTom Digital Cockpit addresses industry challenges by combining all of the above into an easy-to-use, intuitive and attractive experience designed for the driver; one which is highly integrated and doesn’t require the driver to switch between apps while driving.

TomTom Digital Cockpit empowers every carmaker to overcome deeply rooted industry challenges in its own way, with its own signature end-product.

The benefits of building blocks

The total lead time and development cost of an IVI system are a function of how many features need to be designed and developed, the time needed to define and develop the user interface, the complexity of integrating the IVI system with other vehicle or cloud systems and the test effort needed to make sure the system works as intended.

Out of the box, TomTom Digital Cockpit addresses this issue by offering a wide range of applications and services that can be used as building blocks for a complete IVI digital cockpit system. This means that next to standard Android libraries, the carmaker now has access to a huge collection of reusable, commercial grade, applications and services, specifically designed and developed for use in-vehicle.

The carmaker can “assemble” its IVI system from these building blocks, rather than having to develop it from the ground-up. This allows the carmaker to focus its time and resources on making it unique.

All of TomTom Digital Cockpit’s components are thoroughly tested in-house and have already been used in real-world systems. Project risk is reduced significantly as a result.

Maintenance costs for these components are reduced too, as TomTom provides a continuous stream of functional improvements, bug fixes, and security patches for all TomTom Digital Cockpit’s core provided components. Carmakers merely need to rebuild their application with the latest libraries to benefit from any updates. Carmakers merely need to rebuild their application with the latest libraries to benefit from any updates.
Seperation of user interface and application logic

As TomTom Digital Cockpit uses a strict model-view paradigm for applications, user facing software components are separated from their application logic components. This allows the carmaker to modify the user interface as they require — creating its own unique product — while still being able to reuse the prebuilt and tested application logic as-is from TomTom.

Carmakers can modify the application logic as well — if they require more control over the application’s functionality. This would, however, come at the expense of losing automatic updates from TomTom for that specific functionality.

The driving experience

For the driver, TomTom Digital Cockpit simplifies the in-car experience by consolidating vehicle feedback and infotainment applications into a consistent and easy to understand experience that operates across all vehicle screens and even integrates the driver’s mobile phone.

In TomTom Digital Cockpit, communication, productivity, entertainment, navigation, advanced driver assistance systems (ADAS) and vehicle functions don’t compete for screen space and driver attention. The experience is holistic in the sense that the nature and purpose of each of these apps is understood, appreciated and designed to work alongside other apps without distracting the driver. This gives TomTom Digital Cockpit the power to combine TomTom’s core products with a wide range of fully functional third-party apps to take the in-vehicle experience to the next level without compromising vehicle safety.

Drivers can complete actions intuitively via touch, voice or hardware controls. TomTom Digital Cockpit offers full, off-the-shelf integration with personal assistants, such as Alexa and Cerence, providing a hands-free experience for drivers and passengers. The carmaker can extend the personal assistants with customized skills that interact with TomTom Digital Cockpit or directly with the vehicle. TomTom Digital Cockpit empowers drivers to interact with their vehicle in a way that best suits them at any given moment. It ensures they can keep their hands on the wheel, their eyes on the road and their attention where it needs to be.

Smartphones versus TomTom Digital Cockpit apps

Smartphones offer great user experiences, but not while driving. When compared to a phone-in-a-car experience, TomTom Digital Cockpit is quite different.

TomTom Digital Cockpit is built to provide safe and intuitive experiences for digital services that are essential to drivers. The goal is to provide a connection to their digital life and smartphones, in such a useful way, that they will have no reason to pick up their phone when in control of the vehicle. It's not trying to mimic the phone experience in the car. It's making the phone experience obsolete while driving. This of course doesn’t mean that TomTom Digital Cockpit will provide an integrated experience for every digital service available on the smartphone — just the essential ones.
TomTom Digital Cockpit is Android-based, so it can easily be extended with standard Android Automotive applications from a third-party app store. For those not engaged in the driving task, such apps can offer an entertaining experience through additional screens in the passenger compartment. Content may include video streaming or even conferencing. These apps are particularly useful when charging an electric vehicle and the driver wishes to make use of their waiting time.

User interfaces for safety

TomTom Digital Cockpit’s system UI brings driver safety to the next level. Relevant information is always visible and non-time critical events are presented to the driver only when it is safe to do so. Safety-critical information takes precedence.

For example, active streaming services are paused when there is an incoming call, at the same time, navigation instructions guiding the driver to merge onto the highway will remain visible.

All of these services interact with the driver in a non-distracting way and without the driver ever losing sight of any vital information.

TomTom Digital Cockpit’s 3D augmented navigation integrates ADAS feedback with a view of the road ahead. This modern approach to navigation is enabled by platform services that not only capture vehicle sensor data, but also make it easy to integrate that data with key TomTom technologies, such as lane level guidance, traffic, other connected services and high-definition (HD) maps.

Our own research shows that users find this presentation of ADAS information much easier to understand than many of today’s digital cockpits which are saturated with features.

TomTom Digital Cockpit’s ability to integrate ADAS feedback deeply into the overall digital user experience prevents drivers from receiving conflicting instructions. For example, current in-car systems may instruct the driver to take a highway exit, while simultaneously presenting them with a blind spot warning light that tells them not to move out of their lane. This type of contradictory information leads to a high cognitive load and presents a stressful situation where the driver is required to check their car’s speed, estimate distance to the exit and plan a safe path.

This potentially dangerous situation results from the lack of integration between the infotainment system and automated driving systems. They both focus on their own tasks (navigation or blind spot detection) without communicating with each other. With TomTom Digital Cockpit, such systems can communicate with each other allowing them to integrate and provide a single, consistent user experience.
Platform modularity: A collection of building blocks

TomTom Digital Cockpit runs on Android Automotive Operating System (AAOS) across the vehicle cockpit. Its user interface is displayed directly on the center stack and passenger displays. It also facilitates a connection to the cluster and heads-up display, to mobile companion apps and even to Android or non-Android-powered screens for rear passengers.

TomTom Digital Cockpit provides off-the-shelf UI components for cluster displays, such as map view and turn-by-turn instructions, that can be integrated as-is into the cluster view. Reference implementations for cluster displays and mobile companion apps are included as standard.

The system architecture of TomTom Digital Cockpit is highly modular and consists of two layers:

- The application platform layer is the foundation for building features and applications.
- And a collection of off-the-shelf, fully tested applications on top of the platform.

The application platform layer provides an extensive and coherent set of APIs for developers to build TomTom Digital Cockpit applications on top of. These services include an IPC framework, mobile communications support, analytics, support for software updates, UI controls, VPA support, a flexible system UI, theming capabilities and more.

On top of the application framework is the TomTom Digital Cockpit applications layer. This layer contains applications that offer customizable solutions for many user domains, such as calling, media, search, navigation, heating, ventilation and many more.
When you start working with TomTom Digital Cockpit you don’t have to worry about whether these applications will work as they are already fully tested and ready for production.

The number of applications in this layer grows as the partner ecosystem grows. These partners provide TomTom Digital Cockpit-tailored applications for services that benefit from the highly integrated system UI of TomTom Digital Cockpit. This means the user no longer needs to switch to and from the partner’s own stand-alone Android application. Developers can integrate their service into the workflow of the user.

For example, a parking service app may automatically suggest a parking lot and manage payment, while the user remains in navigation mode, meaning there is no need for a separate parking app. The user interaction of the parking service is integrated by the parking services provider as part of the navigation experience – something that is impossible on competing Android IVI systems.

The modularity of the architecture allows carmakers to kick-start their development cycle by choosing as many off-the-shelf components from TomTom Digital Cockpit as they need and assembling an initial working product. From there on, they can replace or customize any individual module as they require.

TomTom and its ecosystem partners provide regular updates of their services and applications, for the benefit of carmakers, developers and Tier 1s. The updates can be automatically retrieved, assembled and tested by the carmaker and its updated product can be distributed over-the-air. TomTom Digital Cockpit offers out-of-the-box integration with a range of app stores for safe and seamless software updates. Carmakers are also free to integrate their own software update mechanisms.
The power of the ecosystem, platform partners

As with any platform, mass adoption by developers (in this case carmakers), will drive contribution to the platform from third-party service providers. This network effect also works the other way around. Having many user-desired services readily available on the platform should drive adoption by carmakers. In order to drive contribution from service providers (the partner side of the TomTom Digital Cockpit platform), the barrier of entry should be as low as possible and partner value should be as high as possible.

Fast and flexible
OEMs decrease their time to market, with broad choice of pre-integrated partner experiences.

TomTom Digital Cockpit provides value for service providers in three ways:
1. By enabling them to create better user experiences.
2. As a quick prototyping, end-user testing and pre-sales demonstration tool.
3. And as a scalable and fast route to market.

The flexibility of the TomTom Digital Cockpit platform allows for deeper integration between applications and the vehicle. Partner applications and services can communicate with each other and with TomTom’s location services, leading to a more integrated experience for the driver. For example, a VPA provider, EV services provider and music streaming provider can independently integrate their services with TomTom Digital Cockpit and the driver will experience them as a single system. The driver is less distracted and more satisfied, leading to greater user attraction and retention.

Partners can use the TomTom Digital Cockpit platform and its native applications to develop, test and demonstrate their services in a full driving infotainment context. Partners find it very valuable to have a full experience to put in the hands of end users to develop, test, iterate, refine and test again.

It also helps with partners’ pre-sales cycles. Showcasing a video-on-demand service in context as part of a fully working infotainment system at public shows or private meetings with car brands is much more compelling than the artificial demo videos and prototypes typically used today.

With a single development effort, partners can reach multiple brands and car lines.

TomTom Digital Cockpit removes the main barrier to entry — the development effort required to create a fully functioning digital cockpit — through elegant and easy to use APIs and a comprehensive set of tools and resources for developers.
Summary: The value proposition of TomTom Digital Cockpit

TomTom Digital Cockpit offers value to all stakeholders:

- Carmakers: by helping reduce development cost, time-to-market and project risk. Not just before launch, but continuously throughout the car’s lifecycle. The platform is open for any partner to join, offering carmakers full freedom in the selection of pre-integrated services and commercialization of their products. As carmakers own all software modifications, they will not be locked to a vendor or prevented from reusing what they develop.

- Drivers: by allowing carmakers to provide an always up-to-date, safer, more intuitive digital experience while driving, due to TomTom Digital Cockpit’s unique integration capabilities for applications.

- Digital services providers: first, by offering more control over the user experience. Second, by providing a valuable tool for demonstration and user testing. Finally, by supporting a fast and scalable route to market.

- Developers: by making it easier to develop and maintain IVI systems through the broad choice of pre-integrated customizable apps and services, supported by a host of developer tools.