



January 2020

THE AUTOMOTIVE OVER-THE-AIR UPDATE ECOSYSTEM

CON633-20

About SBD Automotive

Management & technology consultants to the automotive industry for over 20 years



Our expertise:

Connected

Autonomous

Shared Mobility

EV

Cybersecurity

Anti-theft

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out more

Our role:

As our industry
faces...

We provide our
clients with...

Uncertainty



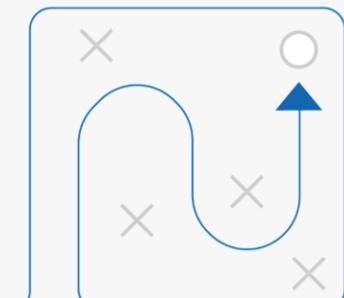
Data



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Introduction



As vehicle platforms modernize, **perhaps the most important technology enabler is the ability to remotely update software and firmware on the vehicle's electronic components**. Colloquially attributed as over-the-air (OTA) updates, this technology was first widely used by Tesla with the launch of the Model S in 2012. Ten years later, by 2022, all global OEMs will have integrated some level of remote software update technology to their vehicle platform portfolio.

Given the complexity of extensive legacy platforms, **most OEMs have taken a cautious approach to integrating OTA update capabilities to their platforms**, largely inhibited by legacy technologies, cost constraints, limitations of internal combustion engine platforms (versus electric vehicles), and cybersecurity concerns.

At the same time, most **OEMs have boosted research and development in electrification programs, often acting as lead platforms for a given OEM's entry into the OTA update space**. Examples of this include Volkswagen's ID platform, General Motors' new digital nerve center platform, and Volvo's Polestar platform.

This report provides a **360-degree view of how OTA updates are disrupting the automotive industry**, including both OEM and supplier activities and perspectives as well as deep insights on regulatory activities, industry organizations, overall risks, forecasts, and trends. Our hope is that this guide helps you better plan, design, build, and operate your own piece of the OTA update value chain, and we would be happy to partner with you further in the development of your OTA program or platform.

Have Questions?

To answer any questions about the content of this guide or to request additional information, please email SBD at info@sbdautomotive.com.

Questions answered:

- What are the different types of OTA updates and how are they delivered to the vehicle?
- Which OEMs have integrated OTA update capabilities into their vehicle platforms?
- What companies offer OTA platform or engineering solutions?
- What are some of the main regulations either in effect or in development affecting OTA?
- What are the most important industry organizations developing OTA standards or open source software?
- What are some of the main challenges and risks associated with OTA, and how can OEMs update their development process for OTA?

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Executive summary



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What is an over the air update?

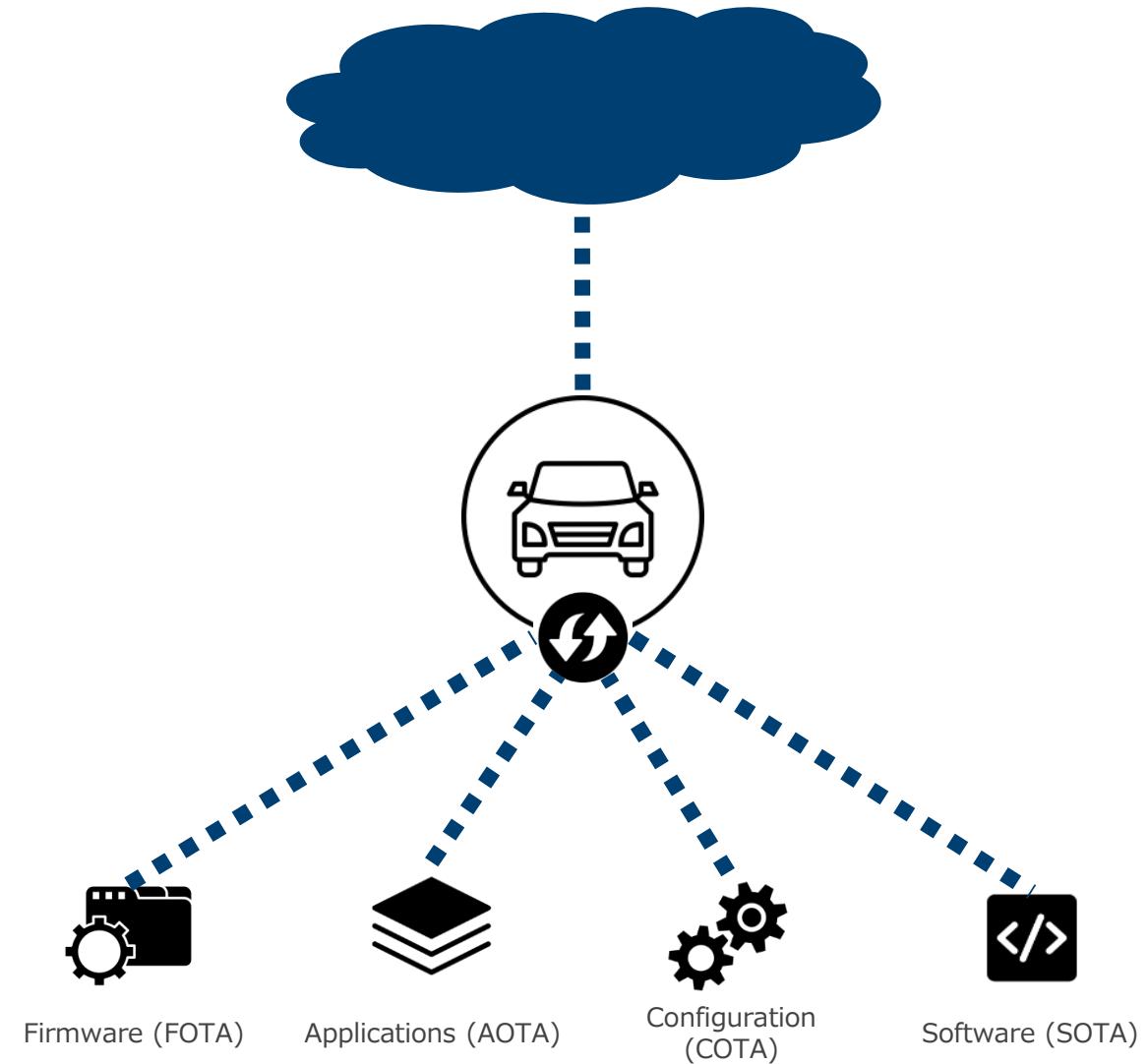


An **over the air update**, or **remote programming**, is the modification of a piece of software without the use of a physical update medium, generally delivered through some sort of connection to a network.

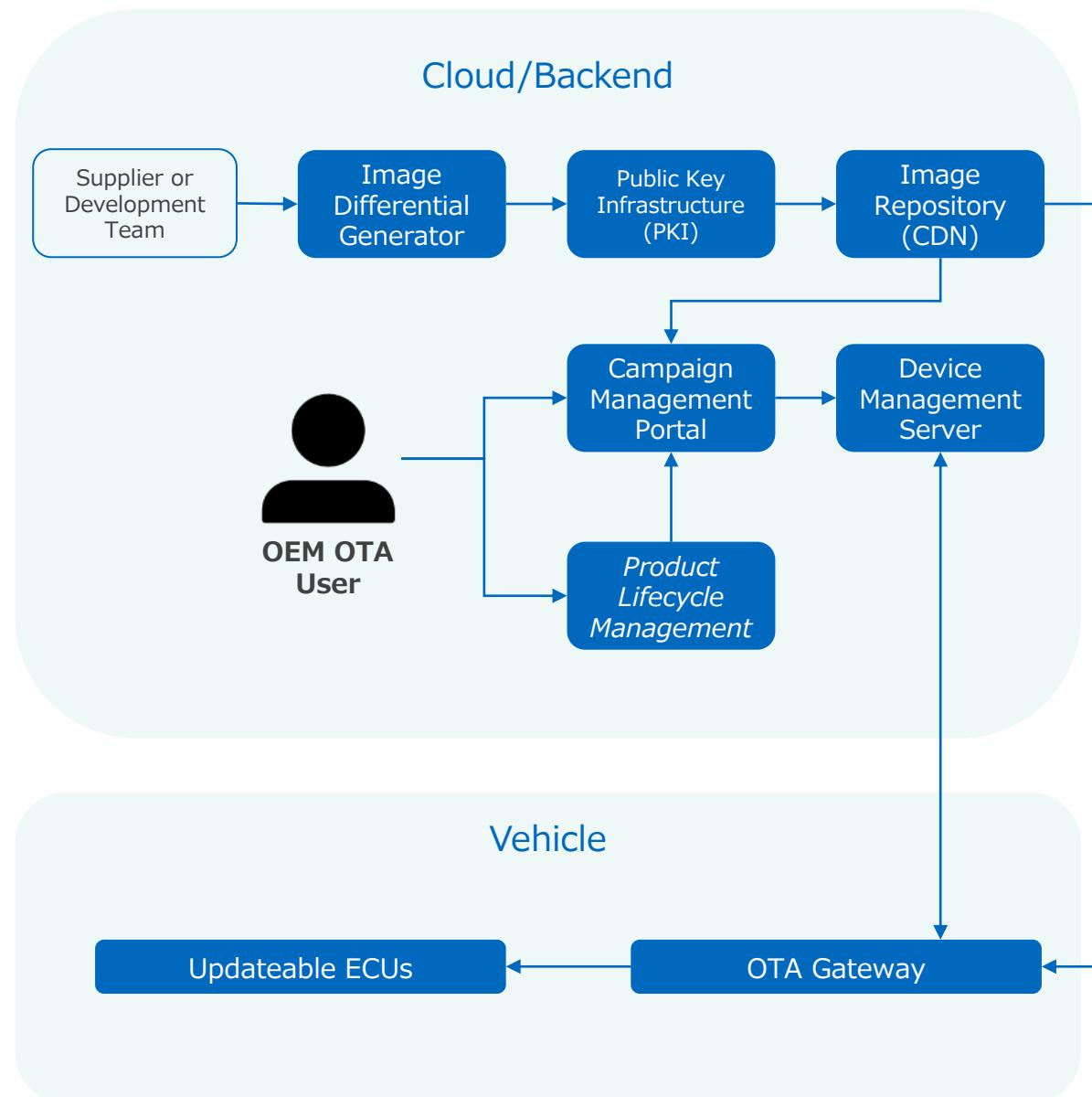
In the automotive industry, over the air updates are used to update vehicle software. The earliest usages of this type of software were used to update phone projection applications such as Pandora and iHeartRadio, through platforms such as Airbiquity's Choreo and UIEvolution (now Xevo).

In the last five years, essentially all major OEMs have adopted a long-term automotive software strategy which hinges on the ability to update vehicle software directly through varied means of connectivity.

The widespread adoption of OTA signals a sea change in the industry, not just in how automakers build and maintain their platforms, but also in consumer expectations within their mobility investments.



Components of an automotive OTA solution

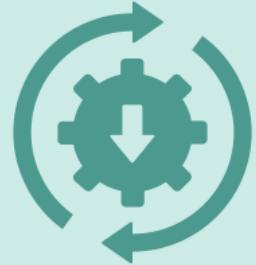


The basic components of an OTA platform include software-based applications responsible for the orchestration, management, storage, and secure delivery of updates to the vehicle.

The server components provide two basic functions: management of the update files, and orchestration of update campaigns.

The in-vehicle components are responsible for applying updates to the vehicle software and providing updates back to the server.

These components are described in more detail in the *Technical Topics* section of this report.



ADOPTION

- **In 2020**, all (14+) major global OEMs will have either launched or are currently engineering their first generation of vehicles which support over-the-air updates to firmware or software
- **By 2022**, all (14+) major global OEMs will have integrated some level of over-the-air update technology into their portfolio

REGULATION

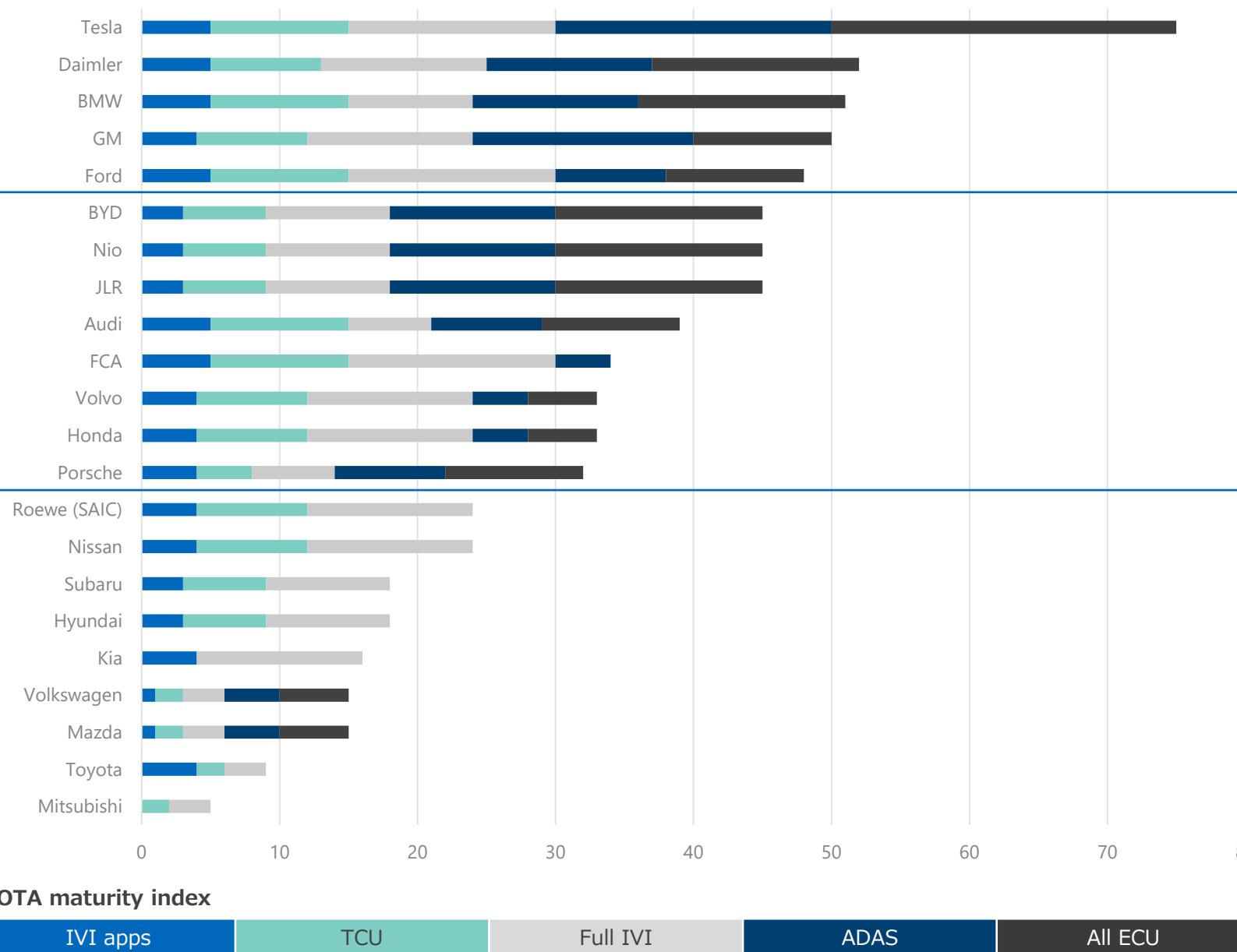
- The United Nations will soon publish new type approval guidelines for vehicles which support over-the-air updates, with countries such as Japan likely becoming first adopters of published guidelines
- Other economic superpowers such as China and the United States will consider how to adapt their own derivative version of type approval standards and regulation of software updates in vehicles
- OEMs will begin adapting internal governance structures to meet published regulations



SEGMENTATION

- **Becoming established:** OEMs will differentiate their software update strategy based on powertrain, infotainment, and vehicle ownership type, supporting the level of connectivity and feature updates in accordance with associated revenues
- **Emerging:** Customers will see the initial versions of feature-as-a-service and other types of update-enabled services with the goal of creating new, valuable user experiences while exploiting new potential revenue streams

OEM OTA maturity index



Leaders

Tesla is well-known for its pioneering application of OTA across all vehicle systems. The others have only recently begun updating systems other than IVI but are now starting to use OTA as a more strategic channel.

Fast-Followers

OEMs at this position in the ranking have been applying OTA to TCU and IVI for less time than the leaders and are now starting to implement updates to other systems in the car.

Laggards

Most OTA use cases are about remedial updates to apps, IVI and TCU, and typically are only recently launched or planned.

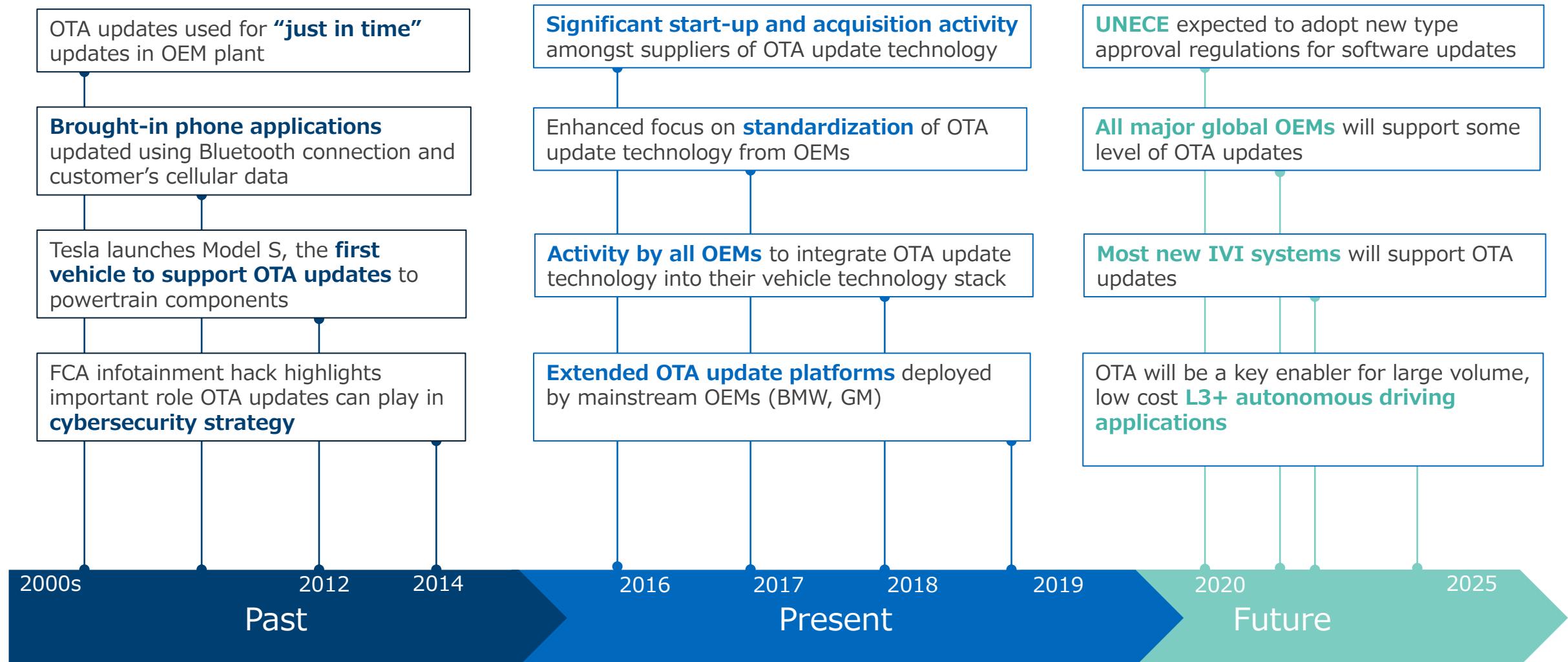
SBD's maturity index ranking is based on the reach into the vehicle (e.g. IVI apps = basic, all ECU = complex) and the time that each update type has been in market.

Introduction



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A timeline of OTA in the automotive industry



How OTA has positively disrupted the automotive industry



OEM Business



By releasing additional content and services throughout the lifespan on the vehicle, automakers can capitalize on **new aftersales revenue** through connectivity – something that was almost impossible before the advent of OTA updates



OTA can enhance the **value of subscription-based services** through iterative product development and releases, whereas today's connected subscription models have generally low consumer appeal and adoption rates



OEMs can **engender greater loyalty** by using OTA updates to deliver delightful experiences without creating poor user experiences, while today's infotainment systems often create more issues than they solve

OEM Operations



OTA is one of the primary tools in an OEM's arsenal of **cybersecurity** weapons, providing a means to patch vehicle systems that have been compromised, whereas it previously would have required an expensive recall campaign



It is impossible to ship a defect-free solution, and so with OTA, OEMs can work with their development partners to deliver **continuous improvement**, resolving customer or safety-related software issues over time – something that was only manageable through dealership updates before



Using specialized software and configurations, OEM can leverage OTA on a targeted basis to **investigate and triage** tricky or corner case issues, something that would have never been possible before

OEMs are starting to connect OTA with subscriptions



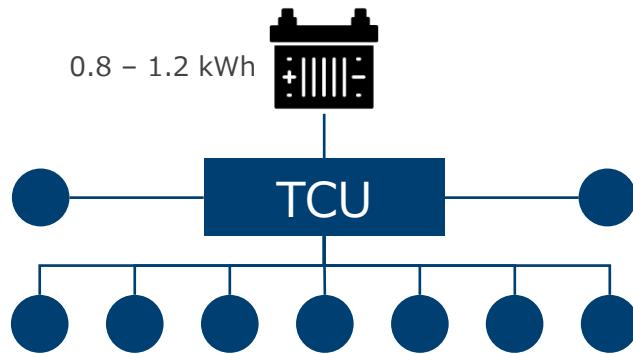
One of the most important OTA enablers is ensuring the customer has activated their embedded connectivity. This allows the OEM to push critical updates to the vehicle without depending on the customer to connect the vehicle to a Wi-Fi network. Below we have illustrated the lifecycle of a vehicle, specifically indicating how OTA, connectivity, and connected services subscriptions play into each other throughout.

	Dealer Demo	Activation	Free Trial	Paid Conversion	Second Owner
Explanation	Vehicle is on dealer lot and may be used to demonstrate features. All vehicles should be in demo mode to receive all major updates prior to vehicle sale	Customer activates connected services on the vehicle in accordance with the complimentary/included period with the new vehicle purchase	Customer is registered for connected services, meaning the SIM activated and can be used for OTA updates. Often, this trial includes multiple years of one or two key services to ensure the modem stays on for anywhere from 3 to 10 years	Either in addition to the free trial, or to continue services locked behind the free trial, the customer must subscribe to a certain package. Depending on the OEM, this may include the ability to receive OTA updates via the embedded modem	If the vehicle is sold, the second owner may need to be recaptured by the OEM or otherwise engaged to receive safety critical or urgent updates. OTA can be a key tool to engage with and capture second owners
Vehicle Owner	Dealership	Customer (handoff from dealership)	Customer	Customer	Second-hand customer or used car dealership
Critical Update Connectivity	Embedded (4G)	Embedded (4G)	Embedded (4G)	Embedded (if subscribed) Wi-Fi (if not subscribed)	Wi-Fi in most cases until recaptured
Non-Critical/Regular Update Connectivity	Wi-Fi (Dealership)	Embedded (4G) Wi-Fi (Dealership/Home)	Embedded (4G) Wi-Fi (Home)	Wi-Fi (Home)	Wi-Fi (Home)
OEM Revenue	Vehicle sale to dealership	None	Upselling new features	Subscription fee	Subscription fee
OEM Costs	Active SIM Critical update data costs	Active SIM Embedded data costs	Active SIM Embedded data costs	Active SIM Embedded data costs (if sub.)	Active SIM Embedded data (if sub.)
Important Considerations	<ul style="list-style-type: none"> Procedure could be established for dealership to connect all vehicles on lot to local dealership Wi-Fi Demonstration of OTA update process may be valuable to sales staff to demonstrate process to customers Campaigns may be configured separately for vehicles in dealer demo lifecycle state 	<ul style="list-style-type: none"> Major dependency on dealerships ensuring vehicle sales data is properly and promptly submitted to OEM for processing as the SIM may need to be deactivated if customer does not accept terms & conditions Customer must accept terms & conditions before updates are provided 	<ul style="list-style-type: none"> Most trials will not include all connected services OTA updates through embedded connection may be locked as a paid feature on top of the free trial, except for safety-critical updates New features updated OTA may be locked behind subscriptions, but with short trial periods 	<ul style="list-style-type: none"> If modem is disabled without a paid subscription, OEM may try to recapture paid subscription through Wi-Fi updates & free trial services Most premium OEMs will leave SIM active for full vehicle lifetime but lock embedded connectivity for OTA behind a paid subscription in order to subsidize data costs 	<ul style="list-style-type: none"> Most OEMs do not know when a vehicle is sold to a second owner. OTA can be used a means to engage with second owners if they can be driven to connect the vehicle to their home Wi-Fi network OEMs should consider adding IVI capability to detect if a regular Wi-Fi network has not been connected to over a long period of time (e.g. two months) and can proactively check customer status

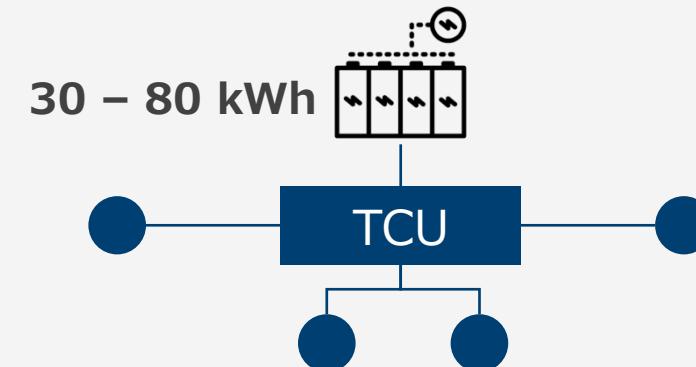
OTA is much easier on an EV platform vs. ICE



Internal Combustion Engine (ICE) Vehicle



Electric Vehicle (EV)



Characteristic	Impact on OTA	Mitigation
Small battery	<ul style="list-style-type: none"> Large updates cannot be safely applied while the ignition is off Large updates cannot be downloaded while ignition is off Risk of “bricking” if power lost during update or rollback 	<ul style="list-style-type: none"> Download update silently while vehicle ignition is on Engineer sufficient storage to allow for in-place or A/B updates to powertrain and ADAS ECUs (at higher cost)
More ECUs	<ul style="list-style-type: none"> Increased complexity of developing and testing updates to powertrain, ADAS, and other features which require multiple ECUs, particularly powertrain More complex dependency management, including rollback procedures More time required to both develop and apply updates 	<ul style="list-style-type: none"> Leverage vehicle network simulators to thoroughly test any powertrain updates Only update powertrain capabilities when absolutely necessary

Characteristic	Advantage over ICE
Large battery	<ul style="list-style-type: none"> OTA updates can be applied without user supervision and without major risk to fully depleting the battery Updates can be applied while vehicle is plugged in
Fewer ECUs & simpler powertrain	<ul style="list-style-type: none"> Software can be better abstracted to allow for more thorough quality assurance while lowering overall development complexity Software abstraction results in looser coupling between hardware components, allowing for more complex services and features to be developed in software Simple powertrain results in much safer and efficient updates to engine, battery, and any other powertrain-related controller

Customer experience



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Why the customer experience of OTA matters



While the experience of managing software updates on personal computing devices such as laptops and mobile phones can be intrusive and annoying, they can also be seamless and simple if done well.

However, an experience that may be simply frustrating on these devices could lead to much more dissatisfaction with vehicles. People rely on functional vehicles to arrive at their destinations punctually and safely, and if an update interferes with the user's ability to meet their obligations, it could be a major driver of dissatisfaction and quality complaints.

When done well, however, a vehicle with OTA completely changes the dynamic of the relationship between the automaker and the customer. With well-designed customer touchpoints, allowing for simple configurability while setting clear expectations on functionality, customers can often be delighted by surprising new features. This further creates opportunities for monetization of new services, or perhaps monetization of the OTA service itself if enough value is created for the user.

In this section, we will take a deeper look at some of the important touchpoints in the OTA user experience. In addition, we will define the overall workflow, constraints and some of our recommendations on how to design an overall experience that results in satisfied users.

Quotes from dissatisfied Tesla forum users

*"The last update may have **bricked** my car."*

*"An OTA update for the Model 3 seems to have **broken Autopilot**..."*

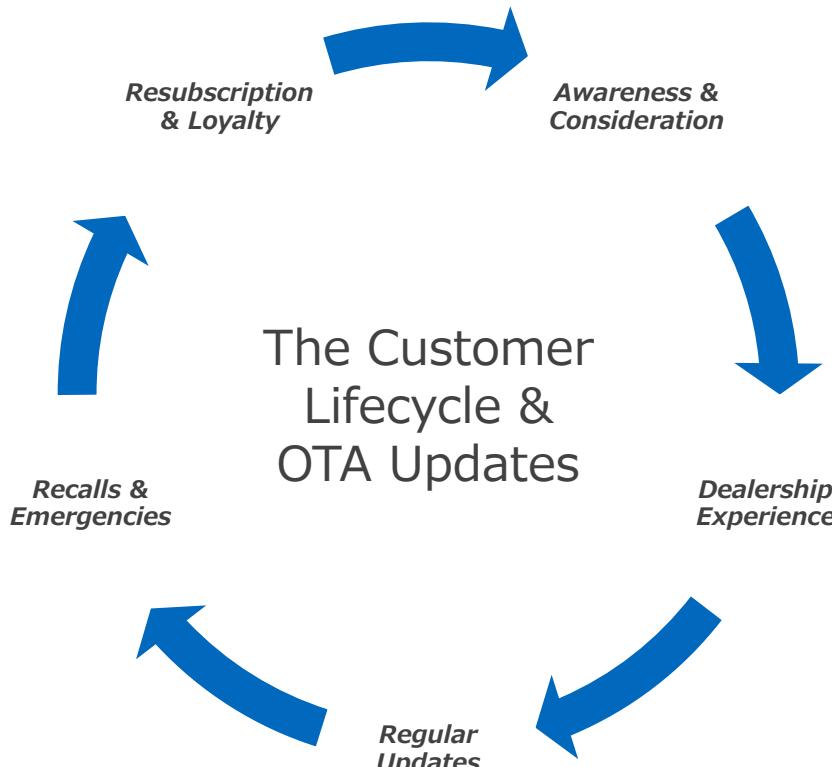
*"Getting pretty annoyed with the **nearly useless updates** that have been pushed to my car lately."*

*"After reading all of the horror stories with these updates, **I'm glad I stopped them last year.**"*

*"My system has apparently been **updated three times for only one feature**: chess."*

Source:
<https://forums.tesla.com/forum/forums/annoying-useless-updates>

Customer touchpoints in an OTA ecosystem



Touchpoint	Channel	Customer Inputs
<i>Awareness & Consideration</i>		
Press Releases	Television, Web, Mobile, Print	None
Advertisements	Television, Web, Mobile, Print	<ul style="list-style-type: none"> • Cookies (Targeted advertising)
<i>Dealership Experience</i>		
Demonstration	In Vehicle, Tablet, Mobile	<ul style="list-style-type: none"> Touch input to test OTA experience
Setup	In Vehicle, Web, Mobile	<ul style="list-style-type: none"> • Name • Email • Telephone number • Address • Consent (terms) • Payment (optional) • Update preferences
<i>Regular Updates</i>		
IVI Settings	In Vehicle, Mobile App, Web	<ul style="list-style-type: none"> • Update preferences • Subscriptions • Update scheduling • Wi-Fi authentication
IVI Update Notification	In Vehicle, Email, SMS	<ul style="list-style-type: none"> • Update scheduling
Mobile App Update Notification	Mobile App	<ul style="list-style-type: none"> • Update scheduling
Update in Progress	In Vehicle, Mobile App	<ul style="list-style-type: none"> • Update controls
Update Completed	In Vehicle, Mobile App	<ul style="list-style-type: none"> • Acknowledgement • Link outs
<i>Recalls & Emergencies</i>		
Force Update IVI Notification	In Vehicle, Mobile App, Email, SMS	<ul style="list-style-type: none"> • Acknowledgement
Special Diagnostics	In Vehicle, Mobile App, Email, SMS	<ul style="list-style-type: none"> • Acknowledgement
<i>Resubscription & Loyalty</i>		
Feature Updates	In Vehicle, Mobile App, Email, SMS	<ul style="list-style-type: none"> • Subscription information
Dealer Redirect	In Vehicle, Mobile App, Email, SMS	<ul style="list-style-type: none"> • Local dealership • Scheduling

How we can help you design your OTA customer experience

Our global experts have benchmarked OTA customer experiences from all production vehicles and have developed a variety of best practices, user stories, and risks associated with the OTA customer experience.

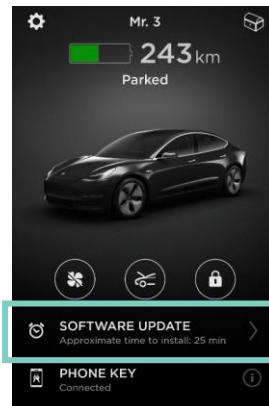
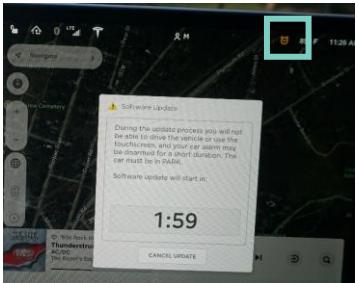
For more information on how we can partner with you to design your OTA customer experience, please contact your SBD sales representative for a complimentary consultation with our experts.

Reference: Tesla customer experience



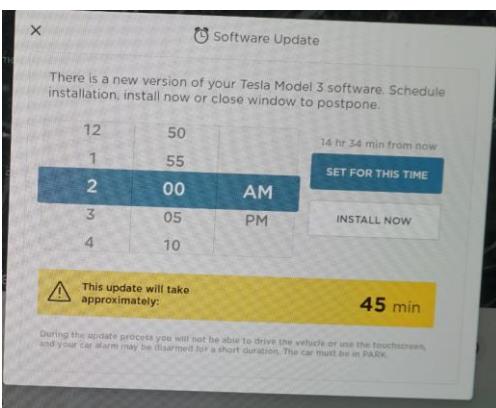
1. OTA Update notification

Notification of update shown on both the phone and infotainment system



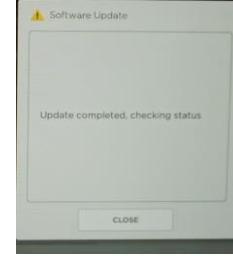
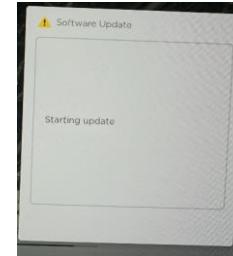
2. Initiating the Update

An option is given to the user to begin the update or schedule for later



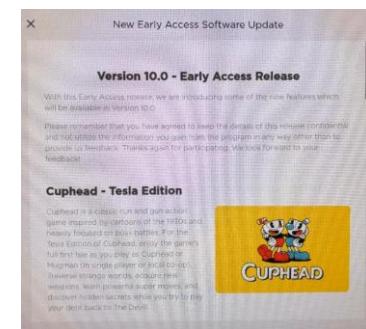
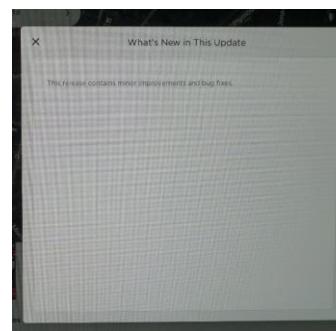
3. OTA Update process

Notifications of the update status are shown throughout the update process with infotainment functionality inaccessible



4. After OTA Update

When the update is completed, descriptions of the update are given



Reference: BMW customer experience



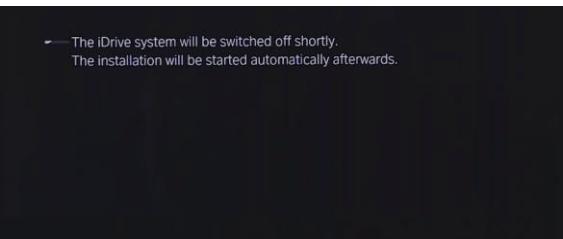
1. OTA Update notification

Notification of update shown on the users phone or in the vehicle IVI



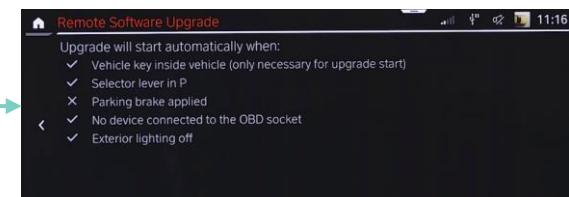
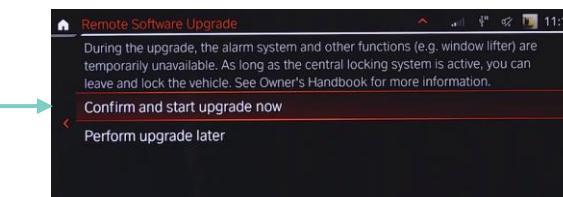
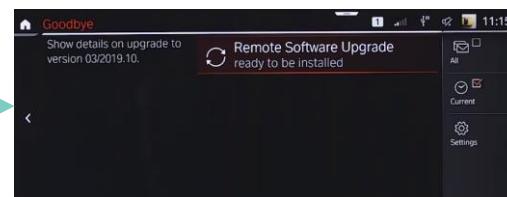
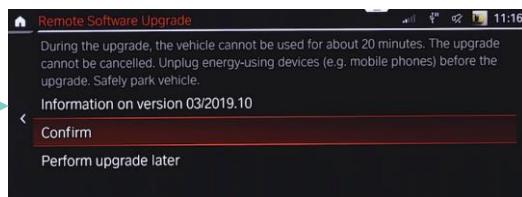
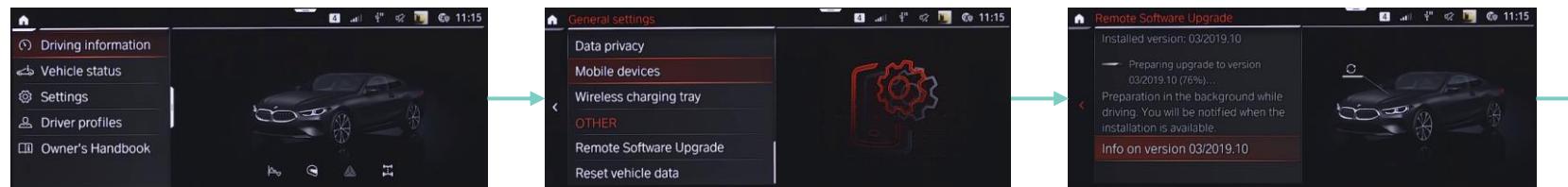
3. OTA Update process

The infotainment system is turned off and is inaccessible during the OTA update process



2. Initiating the Update

The user must initiate the update by accessing the option through the settings menu



SBD view of the ideal OTA customer experience



Educate dealerships	Set preferences at vehicle sale	Leverage mobile app	Publish concise release notes
<ul style="list-style-type: none">Dealerships must be trained, incentivized, and motivated to teach customers about how software updates workPart of this process is demonstrating the value of software updates to dealerships, particularly through lead generation for service, maintenance, and repair	<ul style="list-style-type: none">When the vehicle is sold, the dealership should walk the customer through the process of setting up the mobile app and setting preferences for their software updatesThis process would include elements such as enabling auto-updates, establish preferred times for updates, and how to setup connectivity to the home Wi-Fi network for downloading updates	<ul style="list-style-type: none">While the in-vehicle infotainment is the best day-to-day way to get consent from customers, also using the mobile app for software update configurations provides a better customer experience as it allows the customer to manage their preferences at any time and placeThe mobile app also allows the OEM to engage with the customer via push notifications, requesting action at any time as well as enabling a secondary mechanism for customer outreach for urgent updates	<ul style="list-style-type: none">Customers will get frustrated quickly with constant updates, particularly if they result in vehicle downtime, and even more so if the customer isn't informed of what is being updated or whyTherefore, we recommend establishing guidelines for how release notes are authored and syndicated to customers for each update, providing enough information to be informative without providing so much information that it's unintelligible to the average consumer
Establish predictable release cycles	Limit deferral options	Minimize downtime	Explain new features
<ul style="list-style-type: none">Customers will quickly disable updates if their vehicle is constantly unavailable due to updates, particularly if they are for minor issues or features which the customer doesn't useUpdates should be packaged into major releases which are scheduled every few weeks (1-2 month cycles), with only urgent updates related to safety recalls or cybersecurity incidents being released outside of the cycle	<ul style="list-style-type: none">Given the option, many customers will infinitely defer updates. Therefore, if customer consent or scheduling is required, limited options should be provided in order to ensure prompt installation of the updateExamples include "next time the car is turned off", "tonight", or "tomorrow" – avoid "dismiss", "disable", or "remind me later" options if possible	<ul style="list-style-type: none">A major customer frustration for current OTA software updates is the amount of time the vehicle is not available while the update is being installedHardware and software engineering choices should consider resource requirements for software updates to minimize downtime while also managing costIn-place or A/B updates are ideal, but may not always be feasible to implement at the desired cost of the bill of materials	<ul style="list-style-type: none">If new features or changes are made available due to an update, highlight them natively when they become available using the native IVI user interface, mobile app notifications, and release notesEven if features are locked behind a subscription, offer short trial periods for value-added services to drive additional subscription or feature-based revenue – this gives the customer a sense of how they can benefit from the feature while also driving additional subscription revenue

OEM strategies & case studies



Executive Summary	Introduction	Customer Experience	OEM Strategies & Case Studies	OTA Suppliers
<ul style="list-style-type: none">• OTA definitions• Primary report takeaways	<ul style="list-style-type: none">• OTA timeline• OTA in automotive• Subscription strategy• EV vs. ICE differences	<ul style="list-style-type: none">• Importance of customer experience• Touchpoints• OEM examples• Recommendations	<ul style="list-style-type: none">• OTA timeline• Connectivity methods• OTA use cases• Overview of OEMs	<ul style="list-style-type: none">• Overview OTA suppliers
Pages 6-10	Pages 11-15	Pages 16-21	Pages 22-47	Pages 48-83
Governance	Technical Topics	Connectivity Strategy	Regulatory Activity	Industry Activity
<ul style="list-style-type: none">• Importance of OTA governance• OTA release process• OTA governance for organization	<ul style="list-style-type: none">• OTA solution architecture• OTA E/E architecture• Software sourcing trend• Cybersecurity	<ul style="list-style-type: none">• Types of connectivity• Connectivity challenges• OEM strategies• SBD view on OEM strategies	<ul style="list-style-type: none">• UNECE WP.29• European Union• United States• Other major federal activity	<ul style="list-style-type: none">• Uptane• Open Mobile Alliance• GENIVI• eSync Alliance• AUTOSAR• ISO/SAE
Pages 84-89	Pages 90-102	Pages 103-108	Pages 109-115	Pages 116-124

OEM OTA introduction timeline



Year introduced	2013	2015	2014	2015	2016	2017	2015	2016	2018		2012		2016	2015	2018	2012	2017	2020 (EU)	2015	2019		2018
All ECUs	2020	2019		2020	2020				2018				2020			2012			2020	2019		2018
ADAS	2020	2019		2020	2018				2018				2020			2012		2020 (EU)	2020	2019		2018
Full IVI	2020	2019	2019	2015	2016	2017	2015	2016	2018		2017	Futu re	2016	2020		2012			2015	2019	2017	2018
TCU	2014	2015	2019	2015	2016	2017	2015		2018		2017	Futu re	2016	2020	2018	2012			2015	2019	2017	2018
IVI Apps	2013	2015	2014	2015	2016	2017	2015	2016	2018		2012		2016	2015		2012	2017		2015	2019	2017	2018

Key

2012	2013	2014-2015	2016-2017	2018-2019	2020+
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OEM connectivity method for OTA



Connectivity	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G	Wi-Fi	4G/Wi-Fi	4G	4G	4G	3G	4G	Wi-Fi	4G/Wi-Fi	Paired Device	4G	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Security	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G		4G/Wi-Fi		4G		3G		Wi-Fi	4G/Wi-Fi		4G EU	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Recall	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G		4G/Wi-Fi		4G		3G			4G/Wi-Fi						4G/Wi-Fi
Features	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G	Wi-Fi	4G/Wi-Fi		4G		3G		Wi-Fi	4G/Wi-Fi		4G EU	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Maps	4G	4G			4G	Wi-Fi					4G		3G	4G		4G/Wi-Fi			4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Apps	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G	Wi-Fi	4G/Wi-Fi		4G		3G		Wi-Fi	4G/Wi-Fi	Device		4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Bugs	4G	4G	4G	Wi-Fi	4G	Wi-Fi	4G		4G/Wi-Fi		4G					4G/Wi-Fi		4G EU	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi
Plant																						
ADAS					4G	Wi-Fi			4G/Wi-Fi		4G					4G/Wi-Fi		4G EU	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi	4G/Wi-Fi

Key

4G

3G

Wi-Fi

Paired Device

Use cases for OTA & OEM penetration rate



Use case	Comments	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Security	For many OEMs conservatively deploying OTA update capabilities, security is the primary use case for the capability within their connectivity module and infotainment units. In some cases, the OEM may not use the OTA capability at all unless a security concern arises. Any OEM with OTA will use it as a security countermeasure.										
Recalls	Like security, one of the core value propositions of OTA is to resolve software-related recall issues with the toolset. For any recalls that <i>can</i> be remediated by OTA updates, we expect OEMs to leverage the technology to do so. For many, this is limited only to infotainment or connectivity-related recalls, but as the technology evolves, this will expand to ADAS & powertrain.										
Features	Once updates are available for infotainment units and the connectivity module, OEMs are leveraging the technology to deploy new features for customers. Tesla has done this from the start, but others have done so as well, including GM and FCA's launches of Marketplace and BMW's rollout of the "Hey BMW" virtual personal assistant.										
Maps	While CarPlay and Android Auto have severely disrupted the embedded navigation supply chain, many OEMs still offer embedded SD maps and will continue to do so in some fashion. Any OEM that offers these types of maps in the future will likely leverage OTA to update the map data selectively.										
Bugs & Continuous Improvement	All OEMs in some way now recognize the vehicle not just as a static, off the shelf product, but also a multi-year service through which a customer engages the brand and its services/products. Therefore, all OEMs which adopt OTA will use it to resolve customer issues & bugs as well as enhance the user experience over time.										
Just in Time/ In-Plant Updates	Volume manufacturers such as Ford already use JIT software updates in their plants to upload the latest software versions to vehicles at line-side. This practice is likely to increase as it offers flexibility to the supply chain.										
ADAS Features	SAE level 2 and level 3 vehicles contain highly complex advanced driver assistance systems (ADAS). These vehicles will use semi-HD (lane-level) maps as part of their assistive/autonomous systems and will be updatable over the air. Production levels of vehicles with HD maps will be low and are likely to remain below 5% of vehicle build for the next 10 years, but any vehicle with ADAS functions that behave at SAE level 3 or above will have the ability to be updateable over the air.										

LEGEND

Penetration today Next 5 years

Note: % is of global OEM brands, i.e. 30% of global OEM brands support feature updates via OTA updates

Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Audi's first use of OTA was to deploy an INRIX-powered parking service utilizing OTA channels in 2013. This expanded to map updates via OTA through its embedded 4G LTE modem or customer SIM card since 2014. In January 2019, Audi announced a subscription service "Functions on Demand" on the new e-tron, allowing users to enable new features and services via OTA update via a smartphone app. This service was first shown to also be initiated using the in-vehicle infotainment system.

The new e-tron will also support software updates for the infotainment system.

Use Cases

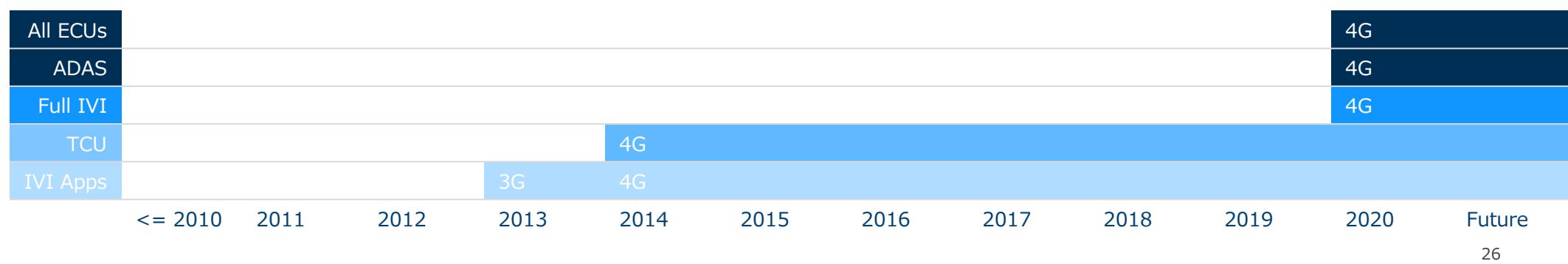
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	

SBD Insight & Predictions

Audi's e-Tron represents its first major foray into more wide-scale support for OTA on its vehicle platform and will likely look to leverage Volkswagen's new vw.OS platform to support OTA updates more broadly on its portfolio of ICE & EV models in the future.

While Audi has not supported updates for its MMI infotainment system to date, SBD anticipates that Audi will join its competitors in its near future, offering OTA updates to most of its MMI variants on all models equipped with connectivity. Audi's biggest limitation to date appears to be the lack of E/E architecture for its ICE vehicles which can support sufficient functional safety & security engineering for OTA.

OTA Capability Timeline



OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2013+	Q4			✓
	2014+	A4			✓
	2016+	All models			✓
	2017+	All models			✓
	2018+	All models			✓
	2019+	All models			✓
EV	2019+	E-tron			✓

News & References

Headline/Reference	Year
Audi considers subscription service, plans over-the-air updating system	2018

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

BMW's first public acknowledgement of its OTA update capability was in 2015 when a recall-related issue was resolved using an OTA update.

In 2018, BMW only offered updates for navigation services but mentioned the necessity of including additional services in the future.

In early 2019, BMW announced a subscription service to purchase new features in the vehicle and updated its infotainment system with its off-board voice activated personal assistant feature via over the air update.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	✓

SBD Insight & Predictions

BMW announced in 2017 that OTA updates will be available for all cars in the "near future". SBD expects BMW to build on its present support of map, infotainment, and TCU updates over the next 3 years, potentially including powertrain ECUs, similar to Tesla.

BMW will be a market leader in the OTA update space, in particular with its support for ICE vehicles. ICE vehicles pose a larger engineering challenge than updates for EVs, and BMW will likely be the first to address many of these engineering challenges such as battery performance and management, as well as user experience considerations.

OTA Capability Timeline

All ECUs								4G	5G			
ADAS								4G	5G			
Full IVI								4G	5G			
TCU						3G	4G		5G			
IVI Apps						3G	4G		5G			
	<= 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Future

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2019+	2 Series			
	2019+	3 Series			✓
	2019+	4 Series			
	2019+	5 Series			
	2019+	8 Series			✓
	2019+	X5			✓
EV	2019+	i3			

News & References

Headline/Reference	Year
BMW now offering over-the-air updates for certain models	2019
BMW adds Intelligent personal assistant via OTA update	2019
First OTA updates to iDrive 7	2019
BMW announce that they will be cautious with OTA updates	2018

Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

FCA's OTA program for Uconnect VP3/VP4 is unique in that they may update apps which run on a Java virtual machine. A number of functions and apps on the head unit can be updated, including the telematics client, diagnostics reporting, and certain apps such as the in-vehicle user guide. Given the wide range of apps available to be updated, the OTA program is utilized frequently. All apps are updated through the embedded 3G/4G modem in the combined infotainment and telematics component. FCA first introduced firmware updates for its infotainment platform in 2013.

In 2019, FCA announced that they would add a new in-car commerce feature to the system via OTA, indicating that they have now launched full firmware updates for their IVI components.

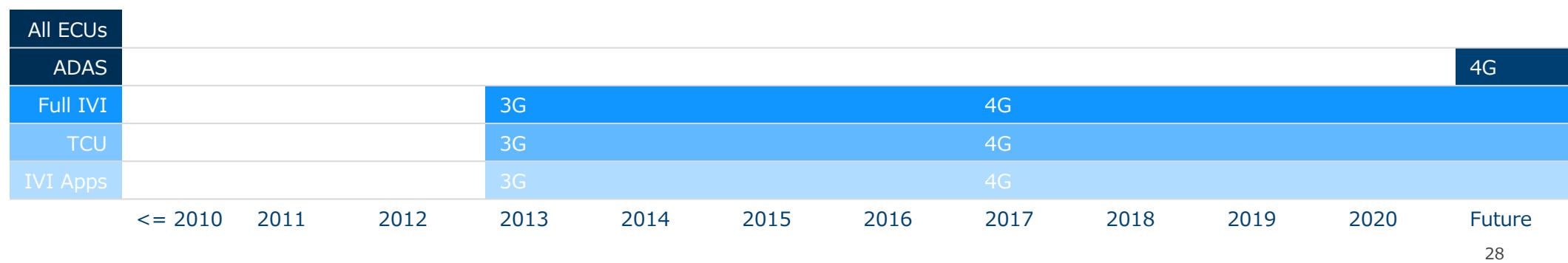
Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓		✓	✓		

SBD Insight & Predictions

SBD estimates that up to 5-10 app updates are performed per month amongst the various trim levels and product lines, while the firmware update capability is utilized every few weeks.

SBD does not expect significant additional development for FCA's OTA ecosystem until more advanced autonomous driving features are available on FCA brands, but with the rollout of full firmware updates for the IVI, we do expect FCA to leverage OTA to deploy new features and services on vehicles equipped with Uconnect embedded services.

OTA Capability Timeline

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2014+	Chrysler models			✓
	2014+	Jeep models			✓
	2014+	Dodge models			✓
	2014+	Ram models			✓

News & References

Headline/Reference	Year
FCA vehicles to have OTA updates in partnership with Harman	2019
FCA to add marketplace feature via OTA update	2019
Uconnect update causes system crashes	2018
OTA update overview on Uconnect	2017

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

The primary method for updates on Ford's infotainment and telematics platform is via Wi-Fi. Any accessible Wi-Fi network may be used to perform an update. The customer must connect SYNC to the Wi-Fi network, then it will automatically download updates, and notify the customer when the update is complete. Somewhat uniquely, the vehicle does not need to be running while these updates are being processed. If the vehicle is running, SYNC can be used during the update process. It is also possible to configure the system to update via the customer's mobile network through a tethered connection with their personal phone. Ford announced that they will be offering advanced OTA updates in 2020 with the first updates made six months after the release. Use cases announced include updated features.

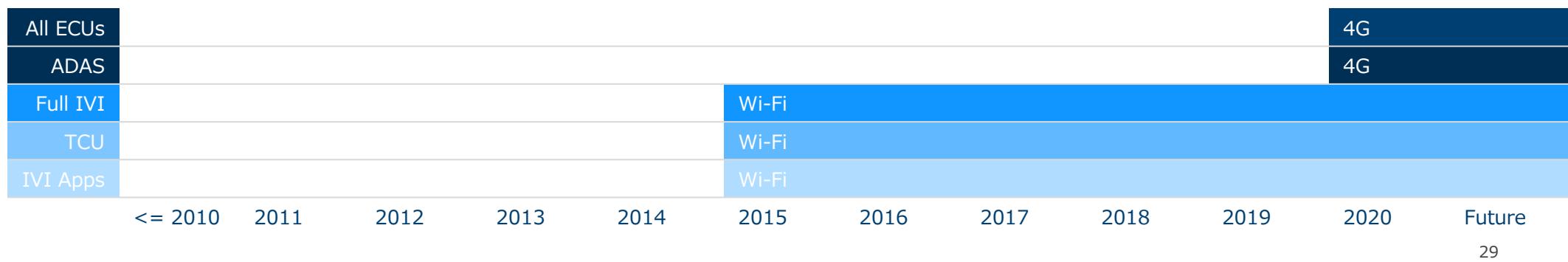
Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓		✓	✓		

SBD Insight & Predictions

Wind River's public announcement that it is working with Ford to deliver OTA updates indicates that OTA is a key part of Ford's current engineering lifecycle and product roadmap.

In addition to full-vehicle OTA updates for the forthcoming Mustang Mach-E, Ford is equipping all SYNC 4 vehicles with OTA update capability for the infotainment and connectivity units, providing the mechanism to support the delivery of new features and services to connected vehicles. Our expectation is that Ford will use this capability initially conservatively, but will begin launching new features and services for the SYNC 4 platform in 2021.

OTA Capability Timeline**OTA Fitment**

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2015+	Fiesta, Focus		✓	
	2015+	Escape, Expedition		✓	
	2016+	All models		✓	
	2020+	"Most vehicles" announced			✓
EV	2015+	Focus EV		✓	
	2016+	Fusion		✓	

News & References

Headline/Reference	Year
Ford Mustang Mach-E begins "new era" of software updates	2019
Ford to equip most vehicles with OTA updates in 2020	2019
Ford selects Wind River for OTA updates	2018
Ford adds Android Auto and Apple CarPlay to 2016 cars	2017
OTA update process on SYNC3	

Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

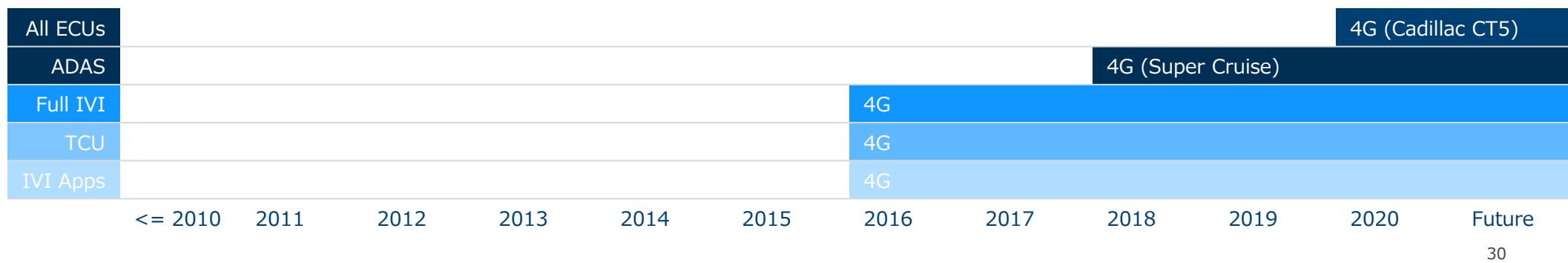
GM currently deploys OTA updates for firmware on the TCU. This capability was announced as part of the Bolt EV launch in 2016. Apps on the myLink infotainment platform may also be updated over the air. While security was the initial focus for GM's OTA program, they added the Marketplace app to systems for free via OTA update in 2017. ADAS OTA updates are also available strictly for the Cadillac CT6 equipped with Super Cruise. In 2019, GM announced that they will introduce Google Automotive Services in the coming years which SBD expects at minimum will include full infotainment software updates to be leveraged to keep the Android OS and attendant applications up to date.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	✓

SBD Insight & Predictions

GM has conservatively and iteratively built up its OTA platform. The Bolt presented the first opportunity to launch software updates more broadly for GM at lower volumes – a key step which helps an OEM understand the OTA update process, including stakeholders, quality assurance processes, and any risks associated. We expect GM to go all-in on OTA updates with its new E/E platform, positioning itself as one of the volume leaders supporting OTA software updates for entire vehicle platforms. The new platform will roll out on the 2020 Cadillac CT5, with expansion into the rest of GM's brands and models by 2023. We also expect full infotainment updates when implementing Google Automotive Services in the future.

OTA Capability Timeline**OTA Fitment**

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2017+	Chevrolet models			✓
	2017+	Cadillac models			✓
	2017+	GMC models			✓
	2017+	Buick models			✓
EV	2016+	Bolt EV			✓

News & References

Headline/Reference	Year
GM new digital nerve system will enable OTA on all vehicles	2019
OTA updates for all main modules on 2020 Cadillac CT5	2019
GM to add Amazon Alexa via OTA update	2019
GM Marketplace shows OTA update capability	2017
OTA update overview	



Global Brands
Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Honda first introduced OTA updates on the MY2018 Honda Odyssey, providing updates to the infotainment system using a paired Wi-Fi network.

Functions that Honda have updated include apps and features such as digital cockpit alerts, input HMI functionality and display information throughout the infotainment system including navigation features.

Use Cases

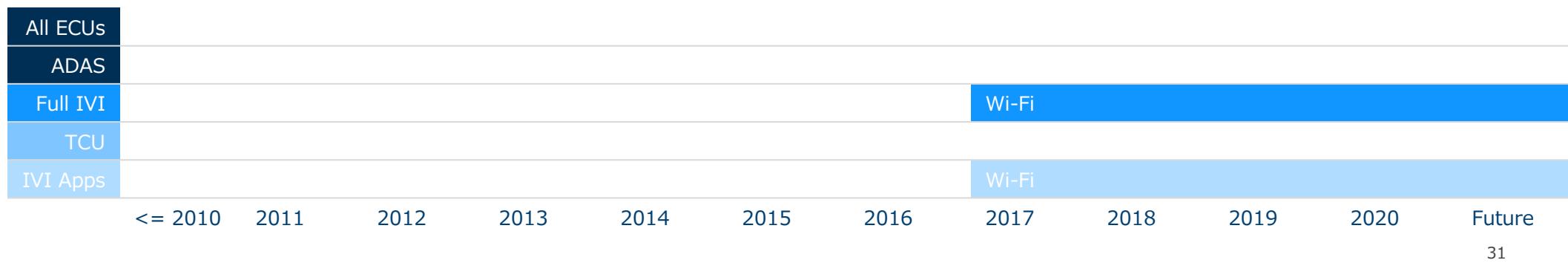
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓		✓	✓		

SBD Insight & Predictions

SBD expects Honda to take a somewhat slower approach to OTA updates than most other OEMs, only recently supporting any type of update through the Wi-Fi and tethered options.

SBD expects Honda to eventually introduce embedded TCU updates via the 4G modem, but perhaps not until 2021 or 2022.

OTA Capability Timeline



OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G/4G
ICE	2017+	Odyssey		✓	
	2018+	All models		✓	
	2019+	All models		✓	

News & References

Headline/Reference	Year
OTA Update list on the Passport model	2019
OTA Update list on the Odyssey	2018
Honda Odyssey to be first vehicle with OTA updates	2017



Global Brands

Audi

BMW

FCA

Ford

GM

Honda

Hyundai

Kia

Jaguar Land-Rover

Mazda

Mercedes-Benz

Mitsubishi

Nissan

Porsche

Subaru

Tesla

Toyota

Volkswagen

Volvo

Selected Chinese
Brands

NIO

Roewe

BYD

Summary

Hyundai first public use of its OTA capability was in late 2016 to add Android Auto functionality through its BlueLink telematics program in the United States. The system also currently supports OTA map updates. Hyundai also announced that it will offer OTA infotainment updates on its premium Genesis brand vehicles.

Hyundai has publicly indicated that the development of its Connected Car Operation System (ccOS) includes research into over the air updates. Additionally, Hyundai announced its collaboration with Wind River in 2019 to develop its next-gen platform with OTA updates.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓		✓	✓		

SBD Insight & Predictions

SBD believes Hyundai will take a more conservative approach towards implementing further OTA update capability, reserving the capability for priority operational matters such as security.

If Hyundai introduces additional capabilities, it will likely continue to be introduced on the Genesis brand first and potentially the Ioniq EV.

OTA Capability Timeline

All ECUs													
ADAS													
Full IVI							3G	4G					
TCU							3G	4G					
IVI Apps							3G	4G					
	<= 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Future	

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2015+	Azera			✓
	2016+	Sonata			✓
	2016+	Veloster			✓
	2019+	All models			✓
EV	2019+	Genesis models			✓
	2019+	Ioniq			✓

News & References

Headline/Reference	Year
Hyundai with Wind River develops next-gen system with OTA	2019
Hyundai announce plan OTA updates soon at CES 2019	2019
Hyundai adds Android Auto via OTA	2016

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Currently the UVO3 system allows update via a USB device, with the download made on the user's computer.

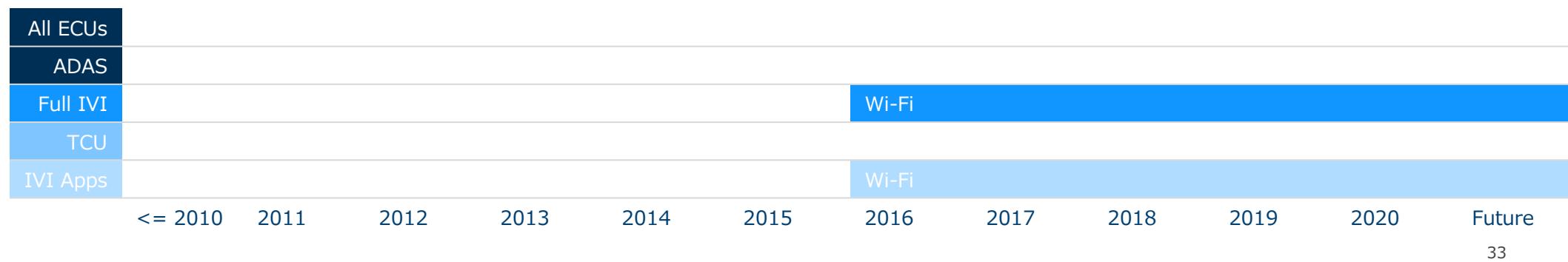
The Luxury Services only currently offered on the K900 model allows OTA updates through connection to a paired device or connection to a Wi-Fi hotspot.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
		✓		✓			

SBD Insight & Predictions

SBD expects the Kia brand to lag behind Hyundai's OTA connectivity deployments.

OTA Capability Timeline**OTA Fitment**

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2016+	K900	✓	✓	
	2019	Forte			
	2019	Sedona			
	2019	Sorento			
	2019	Sportage			
	2019	Cadenza			
EV	2019	Soul EV			

News & References

Headline/Reference	Year
Hyundai with Wind River develops next-gen system with OTA	2019



Global Brands
Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

As an early pioneer in the OTA space, JLR collaborated with Arynga for a SOTA proof of concept in 2013. While JLR was previously active in GENIVI's Remote Vehicle Interaction SOTA project, the lack of active development on the project since HERE's acquisition of ATS indicates that JLR is not invested in the open source project.

In Q1 2018, Jaguar announced the new I-PACE will be the first vehicle with OTA updates but will require customers to opt into the OTA updates. In December 2019, Jaguar deployed a software update which made UI improvements to the I-PACE and improved battery performance by 8%. IVI OTA updates are also available for ICE vehicles with InControl Touch Pro.

Use Cases

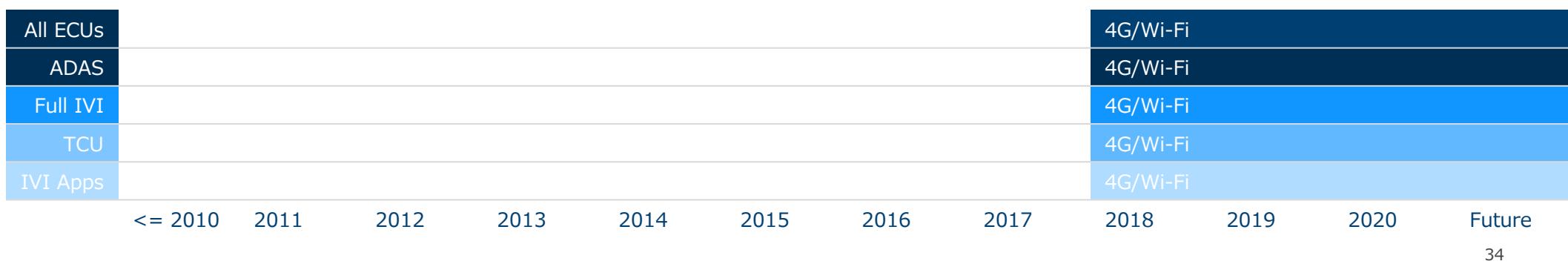
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓		✓	✓		✓

SBD Insight & Predictions

JLR has clearly used the I-PACE to build its internal OTA capability on a low-volume vehicle with lower complexity before integrating with its higher volume models. With the ability to update not just infotainment but also powertrain and ADAS systems, JLR is one of the few OEMs which has actually performed production updates at the same level as Tesla.

While the new InControl Touch Pro system supports OTA updates to the infotainment unit, we expect it will be a few more years until JLR supports OTA updates for any ADAS applications on its ICE vehicles.

OTA Capability Timeline



OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G/ 4G
ICE	2019+	I-Pace		✓	✓
	2019+	E-Pace		✓	✓
	2019+	F-Pace		✓	✓
	2019+	F-Type		✓	✓
	2019+	XE		✓	✓
	2019+	XF		✓	✓
	2019+	XJ		✓	✓

News & References

Headline/Reference	Year
Jaguar unlocks higher range in I-Pace with OTA	2019
Land Rover OTA update process	2019
JLR and ATS continue GENIVI SOTA development	2016
JLR contributed to GENIVI RVI SOTA project	2013

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Mazda does not currently offer any OTA update capability.

In late 2017, Mazda announced a partnership with Toyota which will include sharing a next-gen infotainment platform. In theory, this could include OTA updates, but there has been no public discussion or mention of this capability.

Use Cases

Security Recalls Features Maps Apps Bugs Plant ADAS

SBD Insight & Predictions

Mazda has yet to introduce competitive connected services using embedded connectivity in the US market. However, its partnership with Toyota can enable the utilization of Toyota's platform, which may eventually deliver OTA updates. SBD predicts an overhaul of Mazda's connectivity and infotainment solutions in the next few years, which could include OTA updates.

OTA Capability Timeline

All ECUs
ADAS
Full IVI
TCU
IVI Apps

<= 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 Future

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2018+	CX-3		Not currently available	
	2019+	CX-5		Not currently available	
	2019+	CX-9		Not currently available	
	2020+	Mazda3		Not currently available	
	2020+	Mazda6		Not currently available	
	2018+	Mx-5		Not currently available	

News & References

Headline/Reference	Year
Toyota partnership with Mazda for next-gen infotainment	2017



Mercedes-Benz

Mercedes-Benz



Global Brands

Audi

BMW

FCA

Ford

GM

Honda

Hyundai

Kia

Jaguar Land-Rover

Mazda

Mercedes-Benz

Mitsubishi

Nissan

Porsche

Subaru

Tesla

Toyota

Volkswagen

Volvo

Selected Chinese
Brands

NIO

Roewe

BYD

Summary

Mercedes-Benz introduced app OTA capabilities with its mbrace 2 system in 2013. It has also provided advanced features through its SOTA program since 2017.

In 2018, Mercedes-Benz released its MBUX system with OTA updates. These updates are installed without any user intervention. Instead, customers who have an mbrace account receive a notification informing them that their mbrace system will be updated over the air at some point in the future. Mercedes-Benz customers can view installed updates and release notes on the Mercedes Me portal.

Use Cases

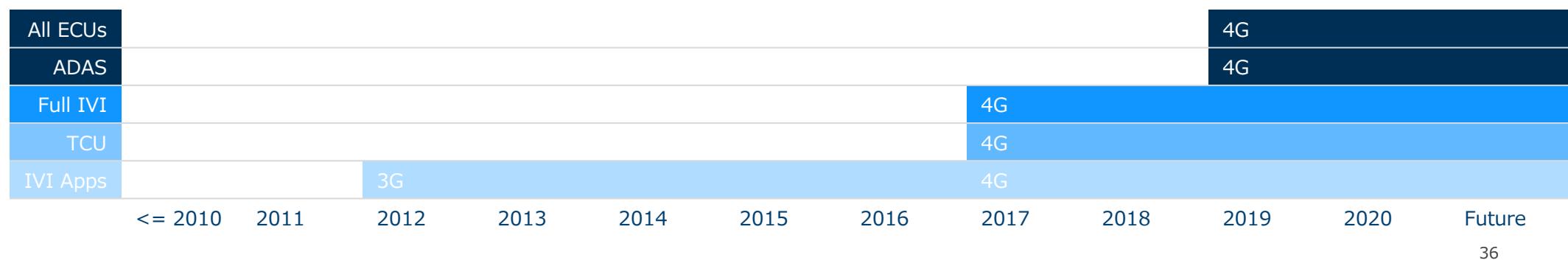
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	✓

SBD Insight & Predictions

Beyond its current OTA capability, the 2017 E-class is shipped with V2X communication hardware installed but not enabled. An OTA update, which is said to become available at a later date will enable V2X features, indicating support for additional updates to ECUs beyond infotainment and telematics.

MBUX is Daimler's first production attempt at multi-ECU OTA updates, and we expect Daimler to build on its experience with MBUX to match the software update capabilities of its domestic competitors, Audi and BMW.

OTA Capability Timeline



OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2017+	E-Class			✓
	2017+	All models			✓
	2019+	GLR			✓
	2019+	A-Class			✓
EV	2019+	GLC			✓

News & References

Headline/Reference	Year
MBUX system to have OTA capability	2019
Mercedes-Benz selling vehicle upgrades through MBUX	2019
Mbrace2 telematics gets OTA updates	2012



Global Brands

Audi

BMW

FCA

Ford

GM

Honda

Hyundai

Kia

Jaguar Land-Rover

Mazda

Mercedes-Benz

Mitsubishi

Nissan

Porsche

Subaru

Tesla

Toyota

Volkswagen

Volvo

Selected Chinese Brands

NIO

Roewe

BYD

Summary

Mitsubishi currently does not have any OTA capability. In 2018, Mitsubishi unveiled their embedded telematics solution, Mitsubishi Connect, which enables the potential for OTA updates.

The Renault-Nissan-Mitsubishi alliance launched the “Alliance Intelligent Cloud” using Microsoft Azure in 2019. The announcement further indicated that the brands consolidated on the platform will include over-the-air software updates.

Use Cases

[Security](#) [Recalls](#) [Features](#) [Maps](#) [Apps](#) [Bugs](#) [Plant](#) [ADAS](#)

SBD Insight & Predictions

No public announcements have been made recently making it difficult to predict when Mitsubishi will adopt the Alliance OTA update capability. However, the announcement of the Alliance Intelligent Cloud as well as Mitsubishi’s current embedded platform does portend that Mitsubishi will be offering OTA updates in the coming years.

SBD expects Mitsubishi’s OTA update product plan to closely follow Nissan’s given the wide-ranging technology sharing agreement within the Renault-Nissan-Mitsubishi Alliance.

OTA Capability Timeline

All ECUs
ADAS
Full IVI
TCU
IVI Apps

<= 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 Future

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G/4G
ICE	2019+	Mirage		Not currently available	
	2019+	Outlander		Not currently available	
	2019+	Eclipse Cross		Not currently available	
✉ >	2019+	Outlander PHEV		Not currently available	

News & References

Headline/Reference	Year
Renault-Nissan-Mitsubishi launches Alliance Intelligent Cloud	2019

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

In 2016, the Nissan Connect Apps smartphone integration solution built on Airbiquity's Choreo platform was announced to have OTA update capability for apps. In 2019, Nissan announced OTA via an embedded connection on its Leaf EV vehicle.

Additionally in 2019, the Renault-Nissan-Mitsubishi alliance launched the "Alliance Intelligent Cloud" using Microsoft Azure which includes an OTA update capability.

The Infiniti brand currently offers OTA updates via Wi-Fi

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓			

SBD Insight & Predictions

SBD expects Nissan's OTA update product plan to implement further features as part of the Alliance Intelligent Cloud platform. Nissan will take a conservative approach to OTA updates, lagging behind implementations from German and some American OEMs.

This approach will allow Nissan to apply the basic successful formula developed within these leading programs to ensure a comprehensive – and most of all, safe – software update capability is deployed as software update capabilities extend deeper into Nissan's E/E platforms.

OTA Capability Timeline

All ECUs	ADAS	Full IVI	TCU	IVI Apps	Wi-Fi	4G				
					Wi-Fi	4G				
					Wi-Fi	4G				
					Wi-Fi	4G				
					2016	2017	2018	2019	2020	Future

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2016+	Infiniti vehicles		✓	
	2016+	All Nissan vehicles		✓	
EV	2019+	Nissan Leaf			✓

News & References

Headline/Reference	Year
Renault-Nissan-Mitsubishi launches Alliance Intelligent Cloud	2019
Nissan Leaf first Nissan vehicle to introduce OTA	2019
OTA updates for apps on Airbiquity's Choreo platform	2016



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Porsche offers limited over the air update capabilities. Customers may enable map updates through a Wi-Fi or tethered connection, but there are no other remotely programmable functions.

In early 2018, the head of Porsche electrics/electronics announced plans to introduce OTA updates on future vehicles, citing security and continuous improvement as key motivations. With its Taycan EV model announcement in 2019, Porsche indicated it will offer OTA updates to the platform.

Use Cases

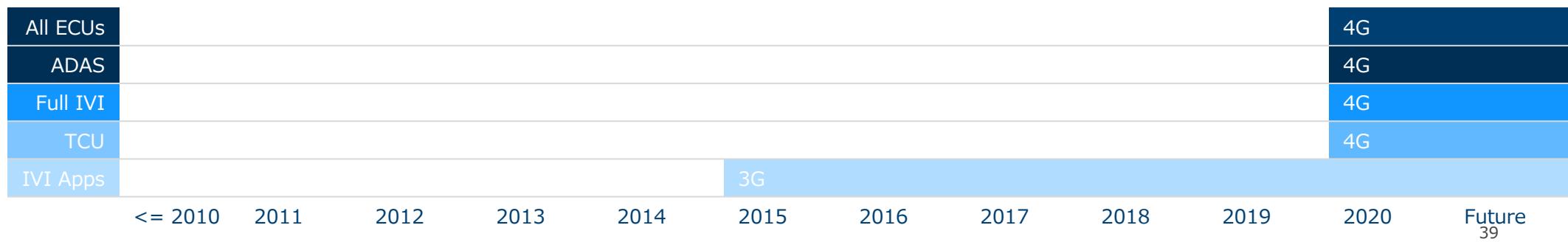
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
			✓				

SBD Insight & Predictions

SBD believes it will be some time before Porsche adopt additional OTA capabilities outside of their EV portfolio.

It is possible that Porsche is waiting to see how the market develops before rolling out any product or solution, but given its brand position, the perceived return on investment may be minimal.

OTA Capability Timeline



OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2018+				
ICE	2019+				
ICE	2019+				
EV	2020+	Taycan			✓
EV	2020+				
EV	2018+				
EV	2020+	Taycan EV			✓

News & References

Headline/Reference	Year
Porsche Taycan supports OTA	2018
Porsche Mission E to have OTA updates	2017
Porsche offers Map updates over the air	2016



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Subaru released OTA updates on its StarLink infotainment system through Wi-Fi on the Outback model in 2018. Updates via Wi-Fi are limited to features and apps on the infotainment system. OTA update functionality expanded to MY19 vehicles with the StarLink infotainment system.

Subaru has not made any other public comment about additional OTA update capability. If any further developments occur with Subaru's OTA update system, it will likely be deployed in the United States first.

Use Cases

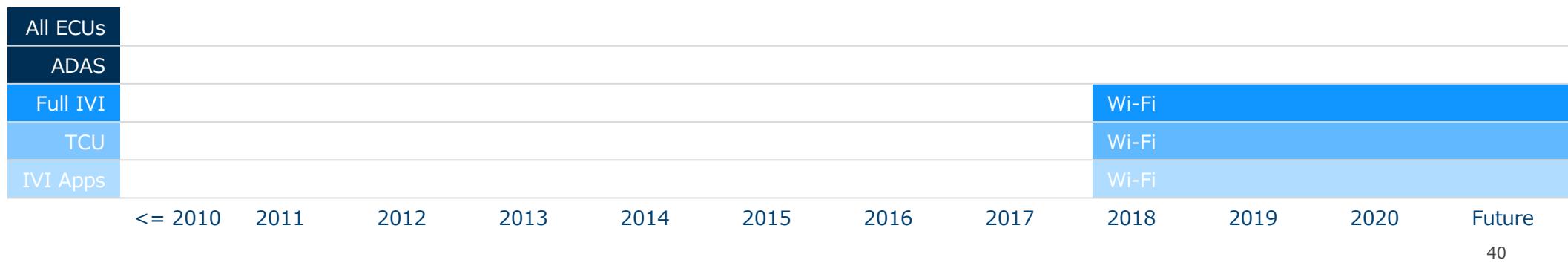
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓		✓		✓			

SBD Insight & Predictions

Subaru released OTA software updates via Wi-Fi on its StarLink infotainment system mid 2017 and rolled out services on future models with the same system. Subaru has been the first Japanese OEM to launch OTA update capabilities to production.

Given Subaru's brand loyalty and EyeSight brand recognition, we expect Subaru to consider implementing OTA updates in particular for its future ADAS platforms.

OTA Capability Timeline



OTA Fitment

ICE	Year	Make	Paired Device	Wi-Fi	3G / 4G
	2017+	Outback		✓	
	2018+	Forester		✓	
	2018+	Crosstrek		✓	
	2018+	Ascent		✓	
	2018+	BRZ		✓	
	2018+	Impreza		✓	

News & References

Headline/Reference	Year
Subaru OTA update process (Video)	2018
Subaru releases OTA updates on Outback	2017

Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Tesla is one of the first OEMs to deploy updates for powertrain ECUs. Tesla's over the air updates are downloaded over Wi-Fi or the embedded cellular connection if subscribed to Premium Connectivity Package. Updates are scheduled by the customer via the in-vehicle infotainment system and the customer can choose a specific time for the installation to occur. Many updates can take up to two hours to complete, and during this time the vehicle is immobilized.

Tesla has utilized FOTA to deploy major updates to their ADAS ECUs, including support for Autopilot and Summon features and used OTA updates to improve the Model 3's braking distance by up to 20 feet. In 2019, Tesla released Version 10.0 of its software adding a range of new apps and features including ADAS visualization and Smart Summon as well as new infotainment apps.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	✓

SBD Insight & Predictions

Tesla regularly rolls out its OTA updates to its customers for both software and firmware, with hardware built into every model to allow all new vehicles to add the same functionality. Since 2018, Tesla has averaged 50-60 OTA updates each year, with 18 per year being updates of major features such as additional apps and ADAS functionality.

SBD predicts that over the coming years there will be more features and functions available to the customer with particular focus on autonomous and infotainment functionality.

OTA Capability Timeline

All ECUs		3G/Wi-Fi	4G/Wi-Fi									
ADAS		3G/Wi-Fi	4G/Wi-Fi									
Full IVI		3G/Wi-Fi	4G/Wi-Fi									
TCU		3G/Wi-Fi	4G/Wi-Fi									
IVI Apps		3G/Wi-Fi	4G/Wi-Fi									
	<= 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Future

OTA Fitment

Year	Make	Paired Device	Wi-Fi	3G/ 4G
2012+	Model S		✓	✓
2015+	Model X		✓	✓
2017+	Model 3		✓	✓

News & References

Headline/Reference	Year
Tesla software Version 10.0	2019
Tesla software update overview	



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Toyota first introduced OTA updates through its Entune App Suite solution allowing new content in the form of apps to the customers infotainment system by leveraging data from a connected smartphone. In 2017, Toyota released its Entune 3.0 system on the MY19 Camry offering OTA incremental map updates with no other OTA functionality having been announced for upcoming vehicles since. However Toyota's executive management has acknowledged the importance of OTA updates, with the feature mentioned as part of its strategy without specific plans being announced.

In 2019, Toyota, in cooperation with Toyota Tsusho and DENSO, announced an investment in Airbiquity to accelerate its development of OTA systems.

Use Cases

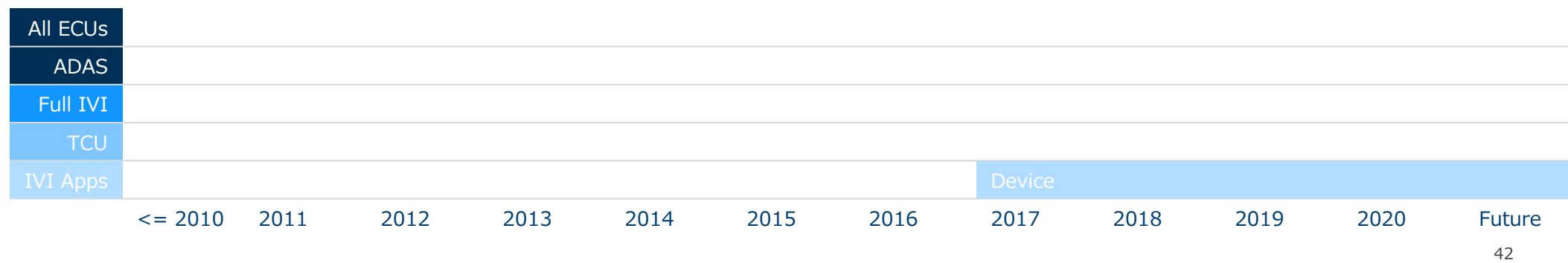
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
				✓			

SBD Insight & Predictions

With investments made in Airbiquity in 2019, and a significant mention on the importance of OTA updates in its future strategy, SBD believes Toyota will likely offer OTA updates in its next generation of infotainment system.

In order to remain competitive, we expect the Lexus brand to be the first to receive updates, alongside higher Toyota trims. In the future, Toyota will likely extend OTA updates to a majority of its infotainment & connectivity platforms. It is unclear if Toyota will extend updates to Level 2+ ADAS features in the near future.

OTA Capability Timeline



OTA Fitment

Year	Make	Paired Device	Wi-Fi	3G / 4G
2017+	Camry	✓		
2018+	C-HR	✓		
2018+	Corolla	✓		
2018+	Avalon	✓		
2018+	Sienna	✓		
2019+	RAV4	✓		
2019+	Prius	✓		

News & References

Headline/Reference	Year
Toyota invests in Airbiquity for OTA	2019
OTA part of Toyota's connected strategy	2019
CEO of Toyota Connected aims for OTA on all vehicles by 2020	2018
Entune 3.0 with OTA capability	2017



Global Brands	
Audi	
BMW	
FCA	
Ford	
GM	
Honda	
Hyundai	
Kia	
Jaguar Land-Rover	
Mazda	
Mercedes-Benz	
Mitsubishi	
Nissan	
Porsche	
Subaru	
Tesla	
Toyota	
Volkswagen	
Volvo	
Selected Chinese Brands	
NIO	
Roewe	
BYD	

Summary

Volkswagen currently does not have any OTA update capability but has made announcements on offering and testing these services. Volkswagen has publicly described its ideas around using OTA updates for product upsell opportunities, including testing the feature by offering product trials to consumers on a subscription or trial basis.

At CES 2017, VW showed a concept car with FaaS, allowing feature upgrades via OTA. Volkswagen has also announced that OTA updates will be included for future EV's, with its I.D. family of EV's planned to arrive in Europe in 2020 starting with the ID.3. In December 2019, the first ID.3 models were found to have software problems, which Volkswagen plans to resolve manually, and update the following batch of ID.3 in production through OTA updates.

Use Cases

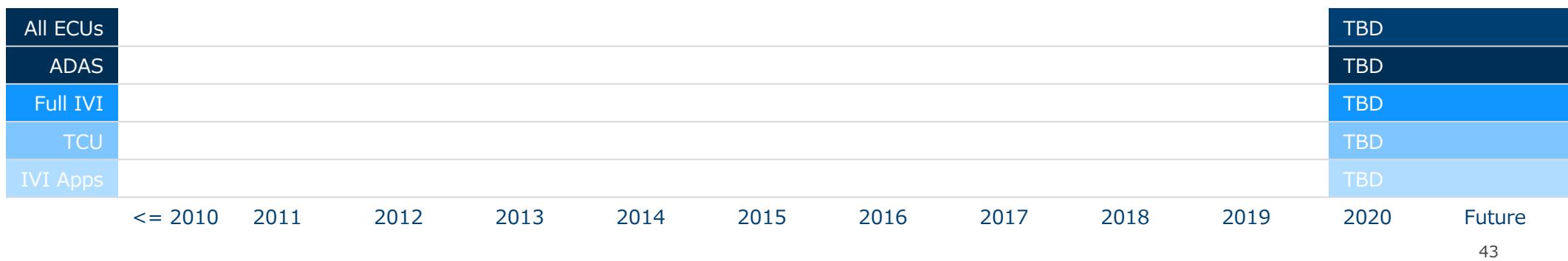
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
					✓		

SBD Insight & Predictions

Until the I.D. platform launches, Volkswagen will have minimal OTA update capabilities with its brands. We expect that Volkswagen will integrate Continental's OTA update capability with their next generation of connected services and infotainment in its main markets such as United States, Europe, and China within the next 2-3 years, whereas all I.D. vehicles will likely have the ability to update all ECUs upon launch later in 2020.

We also expect further cooperation amongst Volkswagen's brands (including Audi) as well as an expanded partnership with Ford.

OTA Capability Timeline



OTA Fitment (NAFTA)

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2019+	Golf/Polo			
	2019+	Jetta/Passat			
	2019+	Tiguan/Arteon			
	2019+	Beetle			
EV	2019+	e-Golf			
	2020 (EU)	ID.3			✓
Future		ID range			✓

News & References

Headline/Reference	Year
Continental to provide OTA for VW	2019
Concept with OTA shown in partnership with IOTA	2018
Volkswagen to offer new vehicle features enabled by OTA	2017

**Global Brands**

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

Volvo currently supports infotainment updates over the air. This allows Volvo to add or update navigation maps and embedded apps in the system. The updates can be applied by either using a tethered smartphone, a customer supplied data SIM card or by paying for a subscription to use data from the embedded SIM in the TCU. Volvo announced in mid-2016 that it will integrate technology that will allow its newer vehicles to seamlessly install safety updates and new functions.

Volvo has announced that it will launch Google Automotive Services in 2020, which SBD expects at minimum will include full infotainment software updates to be leveraged to keep the Android OS and attendant applications up to date. In addition, Polestar will likely support broader, full-vehicle updates.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓		

SBD Insight & Predictions

With Volvo's announcement to be one of the first OEMs introducing Android Automotive OS, OTA updates will become available in 2020 and expected to expand to more models on the same platform.

Furthermore, Volvo's Polestar electric vehicle platform will likely support Tesla-like updates to a majority of the vehicles components, including infotainment, connectivity, ADAS, powertrain, and cockpit components.

OTA Capability Timeline

All ECUs												4G
ADAS												4G
Full IVI						3G/Wi-Fi	4G/Wi-Fi					4G (GAS)
TCU						3G/Wi-Fi	4G/Wi-Fi					
IVI Apps						3G/Wi-Fi	4G/Wi-Fi					4G (GAS)
	<= 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Future

OTA Fitment

	Year	Make	Paired Device	Wi-Fi	3G / 4G
ICE	2015+	XC90		✓	✓
	2016+	S60		✓	✓
	2016+	S90		✓	✓
	2016+	V60		✓	✓
	2016+	XC60		✓	✓
	2016+	XC70		✓	✓
EV	2020+	Polestar		✓	✓

News & References

Headline/Reference	Year
OTA updates for apps on Sensus Connect system	2019
HERE to provide OTA map updates for Volvo cars	2017
Volvo, Lynk & Co cars to have OTA in 2017	2016



NIO



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

As one of the more advanced EV startups in the world, NIO attaches great importance to core technologies and develops its autonomous driving algorithms, foundational software, ADAS and other technologies in-house.

By leveraging OTA as a core enabler in all of its E/E platforms, NIO has iterated on its in-vehicle user interface and experience. It also integrates third-party content such as Baidu Maps and QQ Music.

Starting with the ES8, NIO has supported full vehicle OTA updates. In 2019, NIO successfully updated its ADAS and NIO OS 2.0.0 through FOTA.

Use Cases

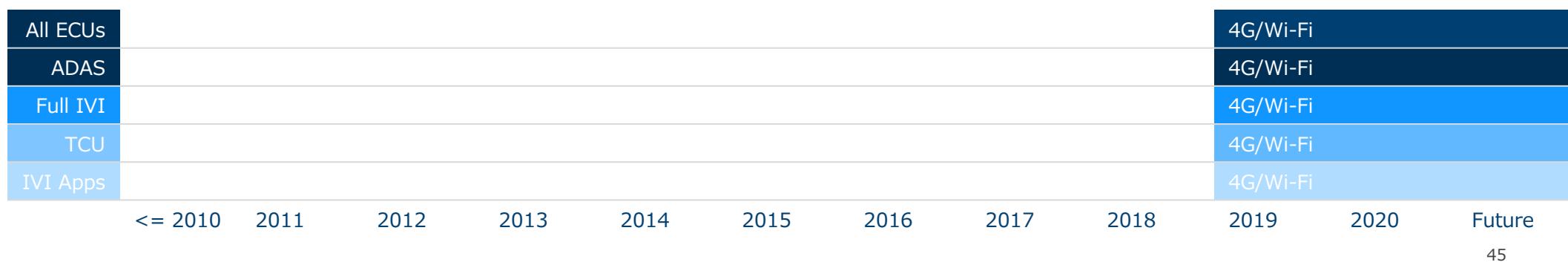
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	

SBD Insight & Predictions

Although outsourcing to Tier 1 suppliers may still be necessary in some cases, NIO is very cautious about core technology and independent R&D. It chooses to self-develop core electric systems (motor, electronic control, battery pack) and intelligent systems (intelligent gateway, intelligent cockpit, ADAS). Despite the price tag, the approach could pay long-term dividends as major volume OEMs try to catch up. NIO's full-vehicle integration of OTA as a result of self-development could be very helpful to stabilize itself.

Furthermore, without the liability of Tier 1 development, NIO can collect complete raw user data, and improve specific products and features based on its own requirements – much like Tesla.

OTA Capability Timeline



OTA Fitment

Year	Make	Paired Device	Wi-Fi	3G/ 4G
≥ 2018+	ES8		✓	✓
2019+	ES6		✓	✓

News & References

Headline/Reference	Year
NIO announces strategic collaboration with Mobileye on L4 ADAS	2019
NIO Power partners with State Grid on charging payment channel	2019
NIO recalls 4,803 ES8s for battery safety concerns	2019
NIO updates L2 ADAS and NIO OS 2.0.0 through FOTA.	2019
NIO officially launches ES6	2018



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe
BYD

Summary

In contrast with NIO who developed their OTA capability in-house, SAIC developed its Internet vehicle and OTA update solution with Alibaba. This joint venture is called Banma, an in-vehicle and offboard connected vehicle platform based on Alibaba's AliOS technology. Banma's platform has been used in many Roewe models and provides Roewe with most connected services including OTA through both embedded and tethered solutions.

As of early 2020, Roewe and Banma have rolled out two OTA updates, mainly focusing on infotainment refreshes and upgrades, including AliOS 2.0.

Use Cases

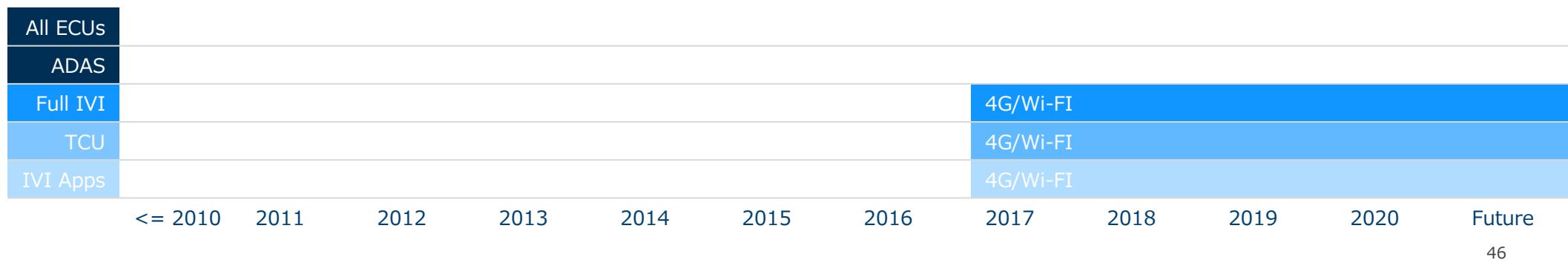
Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓		

SBD Insight & Predictions

Roewe's use of OTA updates on the AliOS/Banma infotainment system is one of the first production uses of OTA updates in the China market. The approach echoes what many global OEMs may receive when working with Google on Android Automotive solutions.

We expect SAIC to continue to develop an OTA capability to equip on its brands and trims outside of the Roewe brand. As one of the largest automakers in China, many other automakers may look to SAIC as a model for how to implement OTA updates on legacy platforms and in larger organizations.

OTA Capability Timeline



OTA Fitment

Year	Make	Paired Device	Wi-Fi	3G / 4G
2018+	ICE	RX3, 5, 8	✓	✓
2018+		ei6/i6	✓	✓
2019+		ei5	✓	✓
2019+		I5/I5GL	✓	✓
2019+		Marvel X	✓	✓
2019+		RX5 Max/eRX5/eRX8	✓	✓
2019+		950/e950	✓	✓

News & References

Headline/Reference	Year
Banma released 3.0, which will be available for all Roewe RX5.	2019
Roewe updates to Banma 2.0 through OTA.	2017



BYD



Global Brands

Audi
BMW
FCA
Ford
GM
Honda
Hyundai
Kia
Jaguar Land-Rover
Mazda
Mercedes-Benz
Mitsubishi
Nissan
Porsche
Subaru
Tesla
Toyota
Volkswagen
Volvo
Selected Chinese Brands
NIO
Roewe

Summary

BYD is a large, established OEM that owns its own intellectual property within the underlying core technologies such as the engine ECU, transmission TCU, electronic control system management, and on-board multimedia systems. Therefore, it has become one of the earliest to announce full-vehicle OTA on mass-produced vehicle, owing to its ability to iterate internally on its software platforms.

In 2018, BYD deployed a major full-vehicle OTA update which enabled various new functions and features, included karaoke, new voice commands, HVAC control updates, and door opening functionality.

Use Cases

Security	Recalls	Features	Maps	Apps	Bugs	Plant	ADAS
✓	✓	✓	✓	✓	✓	✓	✓

SBD Insight & Predictions

BYD is a valuable reference case study for larger OEMs looking to implement OTA updates on their own vehicles. While BYD has many models and platforms, it designed an original E/E platform on which it is now deploying several major OTA updates. This underscores the importance of designing for OTA from the ground up. Many OEMs try to adapt legacy E/E architectures to support OTA, but will not be able to achieve the level of granular software updates possible without re-designing completely with OTA in mind.

BYD is a technology leader in the Chinese market, and we expect its usage of OTA to cement BYD's perception as an innovative car brand.

OTA Capability Timeline

All ECUs	Data not available										4G/Wi-Fi
ADAS											4G/Wi-Fi
Full IVI											4G/Wi-Fi
TCU											4G/Wi-Fi
IVI Apps											4G/Wi-Fi

<= 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 Future

OTA Fitment

Year	Make	Paired Device	Wi-Fi	3G/ 4G
2018+	Qin Pro		✓	✓

News & References

Headline/Reference	Year
BYD has its first full-vehicle OTA on Qin Pro.	2018

OTA suppliers



Executive Summary <ul style="list-style-type: none">• OTA definitions• Primary report takeaways Pages 6-10	Introduction <ul style="list-style-type: none">• OTA timeline• OTA in automotive• Subscription strategy• EV vs. ICE differences Pages 11-15	Customer Experience <ul style="list-style-type: none">• Importance of customer experience• Touchpoints• OEM examples• Recommendations Pages 16-21	OEM Strategies & Case Studies <ul style="list-style-type: none">• OTA timeline• Connectivity methods• OTA use cases• Overview of OEMs Pages 22-47	OTA Suppliers <ul style="list-style-type: none">• Overview OTA suppliers Pages 48-83
Governance <ul style="list-style-type: none">• Importance of OTA governance• OTA release process• OTA governance for organization Pages 84-89	Technical Topics <ul style="list-style-type: none">• OTA solution architecture• OTA E/E architecture• Software sourcing trend• Cybersecurity Pages 90-102	Connectivity Strategy <ul style="list-style-type: none">• Types of connectivity• Connectivity challenges• OEM strategies• SBD view on OEM strategies Pages 103-108	Regulatory Activity <ul style="list-style-type: none">• UNECE WP.29• European Union• United States• Other major federal activity Pages 109-115	Industry Activity <ul style="list-style-type: none">• Uptane• Open Mobile Alliance• GENIVI• eSync Alliance• AUTOSAR• ISO/SAE Pages 116-124

Section introduction



EnGIS Technologies Company Overview

Global Suppliers

- Aeris
- Airbiquity
- Aptiv
- Aurora Labs
- Bosch
- Elektrobit (Continental)
- EnGIS Technologies
- Excellor
- Fujitsu
- Harman
- HERE
- Google
- Sibros
- Wind River

Business & Product Summary

EnGIS Technologies is a global automotive and information technology service provider based in South Korea. EnGIS has rapidly built connected navigation and ADAS services for global OEMs such as General Motors, BMW, Toyota, and others.

One of EnGIS's core products is EnAIR, its OTA software update platform, enabled through its partnership with LG Electronics. The initial OTA software launched was in 2014, and EnGIS has continued to iterate on the platform as software updates have become standard in the industry.

Company Information

HQ Location	Seoul, South Korea
Other Locations	Galway (Ireland)
# Employees	150 (estimated)
Ownership	Public (KOSDAQ)
CEO	Gregory Park
Founded	1998

Product Timeline

- EnGIS Technologies founded primarily as a GIS supplier with digital mapping specialties
- First OTA capabilities launched to production
- Launched first automotive navigation solution with Toyota
- EnAIR product formally launched

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WIND RIVER Wind River Platform Overview

Global Suppliers

- Aeris
- Airbiquity
- Aptiv
- Aurora Labs
- Bosch
- Elektrobit (Continental)
- EnGIS Technologies
- Excellor
- Fujitsu
- Harman
- HERE
- Google
- Sibros
- Wind River

Functional Components

- PLM Database
- Vehicle Identification
- Data Preparation
- Software Signing & Encryption
- Campaign Management
- Content Delivery Network (CDN)
- Master Device Client
- Secondary Device Client

Supported Standards & Protocols

- OTA
- M2M
- TLS 1.2
- CDL-Car
- Websocket
- Information not available
- UICP
- AUTOMOTIVE PLATFOR

SBD Insights & Forecast

Argo, like ATIS, was a full member of GENIVI and likely based many of their OTA platform components on the GENIVI Development Platform. Since acquisition in 2016, it is also likely Wind River has adapted a large portion of the software to adapt to its own business requirements while integrating with its various other automotive software platforms. Wind River has built out the platform to a fully-fledged, end-to-end software update platform with campaign management, software differential capabilities, PLM, and device client software. The announcement of Ford as a customer validates the progress that Wind River has made in building out the platform to be sufficient to meet automaker needs.

Positive developments aside, the divestiture to TPG Capital does raise some red flags – who will be the eventual owner of Wind River? What will their business interests entail? The partnership with Airbiquity is also somewhat concerning considering both Airbiquity and Wind River compete directly within the OTA space. The most likely explanation is to prove to both Airbiquity and Wind River's potential customers that they are willing to be "modular" in their approach and work with multiple OTA vendors to deliver disparate functionality.

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Questions answered:

- What is the background to each of the businesses and products profiled?
- Where are they based, how many employees do they have and how are they owned?
- What recent news has each company released in relation to their OTA offerings?
- Which companies are they partnered with and customers to?
- How have their products evolved over time?

Global Suppliers		Business & Product Summary		News & References	
Aeris		<p>Aeris is an IoT & M2M platform provider with multiple products in the device connectivity and connected vehicle space. Aeris' primary products focus on providing MVNO services to embedded devices, acting as the mobile carrier for many IoT products.</p> <p>Aeris' primary product in the connected vehicle space is the Aeris Mobility Platform which provides a broad range of connected vehicle services, including OTA updates. While AMP is not a purpose-built OTA platform, it does contain all of the necessary back office components and device integration touchpoints to enable an OTA update solution.</p> <p>Aeris partners with SoftBank for its business in Japan.</p>		Headline/Reference	Year
Airbiquity				Aeris chooses Google Cloud Platform for Fusion IoT	2019
Aptiv				SELIS partners with Aeris for launching connected eVehicles	2019
Aurora Labs				Mitsubishi Motors selects Aeris to power its Mitsubishi Connect platform	2018
Bosch				SoftBank, Aeris establish joint venture in Japan	2016
Elektrobit (Continental)				Softbank, Aeris to expand IoT business globally	2016
EnGIS Technologies					
Excelfore					
Fujitsu					
Harman					
HERE					
Google					
Sibros					
Wind River					
Chinese Suppliers		Company Information		Customers & Partners	
ABUP		HQ Location	Santa Clara, CA	SoftBank	SoftBank
Carota		Other Locations	Chicago, Tokyo, Noida (India), Hammersmith (UK)		SELIS
Red Stone		# Employees	250 – 500 (estimated)		<ul style="list-style-type: none"> Japan business development
		Ownership	Private		<ul style="list-style-type: none"> AMP customer
		CEO	Marc Jones		
		Founded	1992		
Product Timeline					
<ul style="list-style-type: none"> Aeris founded in Santa Clara, CA 					
<ul style="list-style-type: none"> Aeris selected by Honda to power connected vehicle device management 		2012			
<ul style="list-style-type: none"> Aeris Mobility Platform announced & OTA update capability introduced 					
<ul style="list-style-type: none"> Mitsubishi Motors announced as AMP customer 		2016			
<ul style="list-style-type: none"> Aeris chosen by SoftBank to expand IoT business globally 		2018			

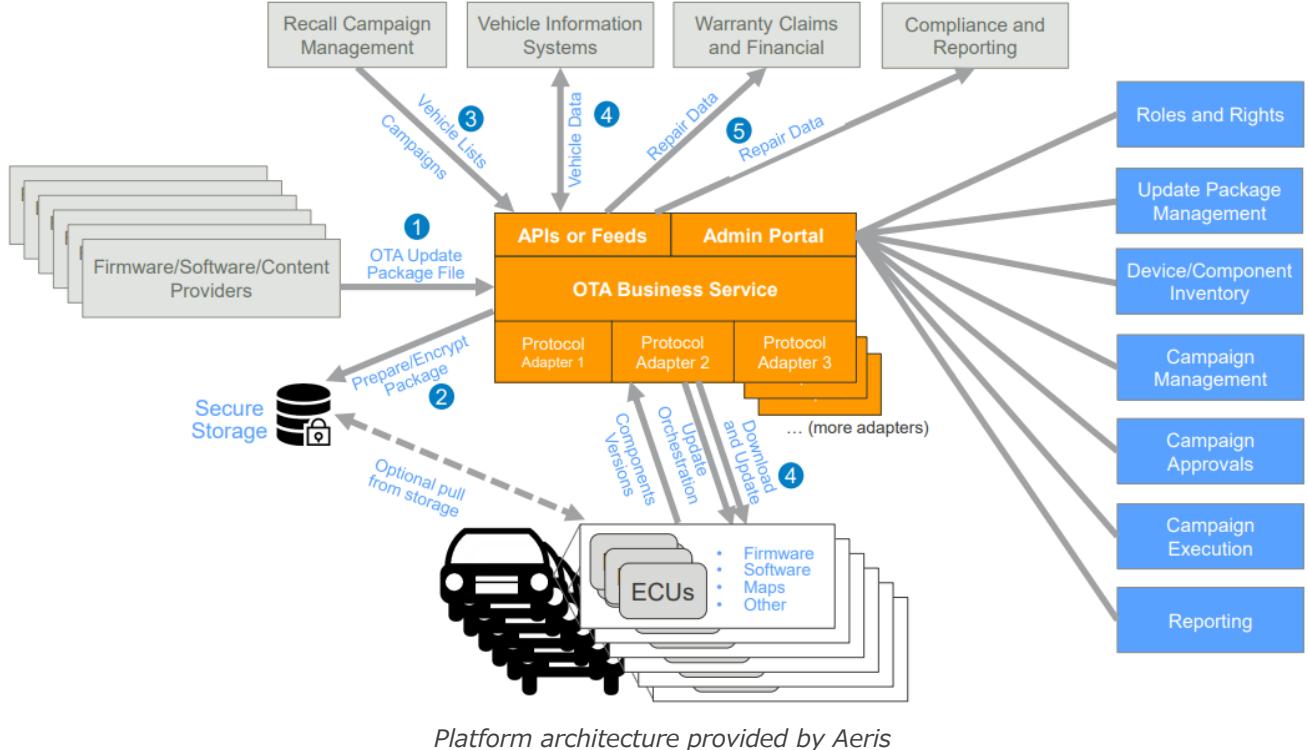
Global Suppliers		Functional Components
Aeris		PLM Database
Airbiquity		Vehicle Identification ✓
Aptiv		Delta Preparation
Aurora Labs		Software Signing & Encryption ✓
Bosch		Campaign Management
Elektrobit (Continental)		Content Delivery Network (CDN) ✓
EnGIS Technologies		Master Device Client ✓
Excelfore		Secondary Device Client
Fujitsu		
Harman		
HERE		
Google		
Sibros		
Wind River		
Chinese Suppliers		Supported Standards & Protocols
ABUP		HTTP ✓
Carota		MQTT ✓
Red Stone		TLS 1.2 ✓
		OMA-DM
		LWM2M
		Websocket
		Uptane
		AUTOSAR Adaptive Platform

SBD Insights & Forecast

Aeris is a non-traditional player in the automotive OTA space, bringing it in as a key element of their broader connected car & mobility solution, the Aeris Mobility Platform (AMP). While Aeris does not specialize in OTA, it is operationally supporting multiple OEM connected vehicle programs.

While Aeris will face strong headwinds competing against some industry stalwarts such as Harman and HERE, if it can leverage its production program to continue to build out a competitive, comprehensive platform with a strong product roadmap, it could stand to have a unique selling proposition in the wide-ranging capabilities of its platform, particularly through the integration of connectivity management with software update delivery.

We expect Aeris to remain a competitor in the space, but many OEMs might not even think of Aeris as an OTA platform provider due to a subdued marketing presence for the capability.



Platform architecture provided by Aeris

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

Airbiquity has a long history of connected vehicle software, starting with the aqLink product line which supported early connected vehicle programs in the late 1990s. In 2017, Airbiquity announced its entry into the OTA market with its Software and Data Management platform, later rebranded to OTAmatic.

The OTAmatic platform is an end-to-end OTA solution which provides the requisite components to manage and deliver software updates to vehicles as well as manage the data that is sent to & from the vehicle. Airbiquity collaborates extensively with the Tier 1 and SoC market, publicly exhibiting integrations with Wind River, NXP, and STMicroelectronics.

In 2019, Airbiquity announced a \$15M joint investment from Toyota, Toyota Tsusho, and DENSO to develop OTA software.

Company Information

HQ Location	Seattle, WA, USA
Other Locations	London, UK; Tokyo, JP; Frankfurt, DE; Detroit, MI
# Employees	50-150 (estimated)
Ownership	Private
CEO	Kamyar Moinzadeh

Founded 1992

Product Timeline

- Company founded as Airbiquity in Seattle, WA
- Deployed initial connected car software

1997

- First OTA update capability on smartphone projection infotainment apps

2008

- Entered smartphone project market with Choro platform on Ford vehicles

2009

- \$15M investment from Toyota, Toyota Tsusho, and DENSO

2017

- OTAmatic product introduced

2019

News & References

Headline/Reference	Year
Airbiquity announces \$15M investment from Toyota family	2019
Airbiquity, Wind River collaborate on vehicle-to-cloud OTA solutions	2019
Airbiquity joins forces with NXP Semiconductors	2019
Airbiquity joins JASPAR to advanced standardization of software	2018
Airbiquity joins Automotive Grade Linux	2018

Customers & Partners

	Toyota Toyota Tsusho DENSO	• Equity investors
	NXP	• SoC partner
	STMicro	• SoC partner
	Wind River	• In-vehicle software partner
	Arity	• Insurance data management partner

Global Suppliers	
Aeris	
Airbiquity	
Aptiv	
Aurora Labs	
Bosch	
Elektrobit (Continental)	
EnGIS Technologies	
Excelfore	
Fujitsu	
Harman	
HERE	
Google	
Sibros	
Wind River	
Chinese Suppliers	
ABUP	
Carota	
Red Stone	

Functional Components

PLM Database	
Vehicle Identification	✓
Delta Preparation	✓
Software Signing & Encryption	✓
Campaign Management	✓
Content Delivery Network (CDN)	✓
Master Device Client	✓
Secondary Device Client	

Supported Standards & Protocols

HTTP	✓
MQTT	✓
TLS 1.2	✓
OMA-DM	
LWM2M	
Websocket	

Uptane	✓
AUTOSAR Adaptive Platform	

SBD Insights & Forecast

While providing early OTA update capabilities to app platforms in the earliest infotainment app integration products in the late 2000s and early 2010s, Airbiquity shifted its business model to focus primarily on OTA in 2017. While borne primarily out of necessity given the overall industry trend with its other app and connected services businesses, the pivot to OTA has been executed as well as any other industry provider developing OTA, with a market-leading and feature rich campaign management portal.

The biggest indicator of Airbiquity's roadmap comes through the \$15M investment from Toyota and its subsidiaries. It is reasonable to assume that if Toyota has invested in Airbiquity's OTAmatic platform, that at least a portion of the platform's capability will be considered for production somewhere within Toyota's various brands and markets. The question then will become whether or not Airbiquity is acquired or otherwise act as a direct subsidiary for Toyota, or if it will continue its multi-OEM business model. One of Toyota's primary goals is to dictate its own technology direction, as evidenced by its many subsidiaries such as Toyota Connected, and in theory Airbiquity could be another part of that puzzle.

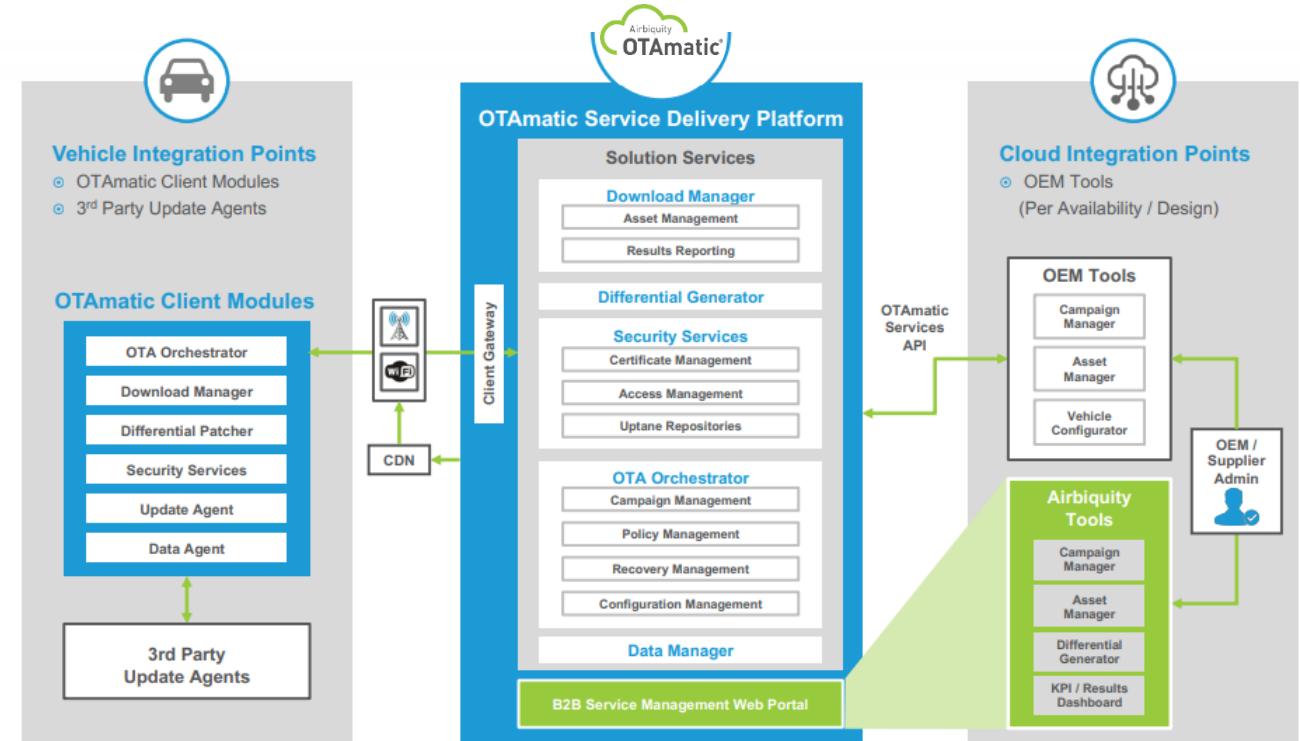


Image Source: Airbiquity

• A P T I V • Aptiv Company Overview



Global Suppliers

Aeris

Airbiquity

Aptiv

Aurora Labs

Bosch

Elektrobit
(Continental)

EnGIS Technologies

Excelfore

Fujitsu

Harman

HERE

Google

Sibros

Wind River

Chinese Suppliers

ABUP

Carota

Red Stone

Business & Product Summary

Aptiv (as Delphi) acquired its primary OTA capabilities through Movimento in 2017. Movimento was one of the first pioneers to develop automotive OTA update capabilities, focusing on delivering software in plants and ports for “just in time” updates prior to vehicles being shipped to dealerships.

Since the Aptiv acquisition, the OTA capability has been advertised through the Aptiv Connect solution, but the overall momentum in messaging has been relatively subdued as Aptiv has looked to build out messaging for its autonomous and connected vehicle platforms which each hook into the OTA capability.

The latest messaging from Aptiv regarding its OTA capabilities is through the Aptiv “Smart Vehicle Architecture”, announced at CES 2020, which aims to address OEM challenges in updating legacy E/E platforms. (*Note: These trends are discussed in more detail in SBD report 630 - E/E Architectures*)

Company Information

HQ Location	Dublin, Ireland
Tech Centers	15+ in United States, Poland, Mexico, Singapore, India, China, others
# Employees	149,000+
Ownership	Public
CEO	Kevin Clark
Founded	Aptiv – 2017 / Delphi - 1994

Product Timeline

- Delphi originally founded as Automotive Components Group

1994

2003

- Movimento founded in Plymouth, MI

News & References

Headline/Reference	Year
Aptiv to unveil open source electronic robocar architecture	2019
Aptiv announces Android Automotive OS with OTA	2018
Aptiv delivers OTA update capabilities through Aptiv Connect	2019
Delphi sees gold in over-air service	2017
Delphi acquires Movimento	2017

Customers & Partners

Delphi Technologies	Delphi Technologies	• Sister company
MOVIMENTO	Movimento	• Acquired by Aptiv/Delphi
	Hyundai	• Autonomous JV partner



Hyundai

Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client
Fujitsu	
Harman	
HERE	
Google	
Sibros	
Wind River	
Chinese Suppliers	
ABUP	
Carota	
Red Stone	

Supported Standards & Protocols

[HTTP](#)

[MQTT](#)

[TLS 1.2](#)

[OMA-DM](#)

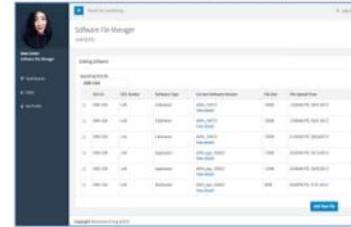
[LWM2M](#) Information not available

[Websocket](#)

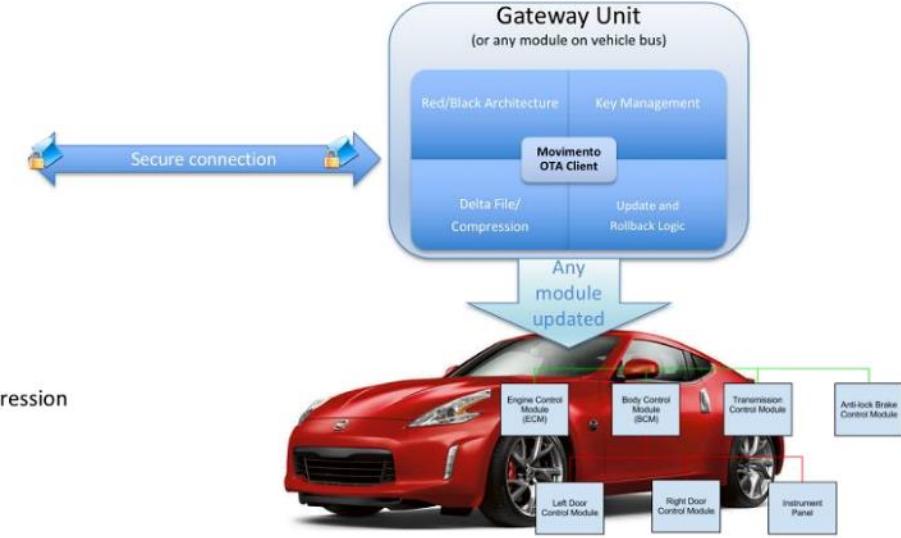
[Uptane](#)

[AUTOSAR Adaptive Platform](#)

Movimento Over-the-Air (OTA) Management System (MS)



- OEM campaign management
- Fleet Management
- Vehicle Management
- Delta file optimization and compression
- Security
- Reporting
- Data Analytics



Note: image from 2018

SBD Insights & Forecast

Aptiv has been diligently moving away from marketing standalone OTA services, and instead has rolled OTA capabilities into their various products, such as Aptiv Connect Platform and Smart Vehicle Architecture. We assume this is largely due to the overall commodification of the OTA market. Given that the prices OEMs are willing to pay for standalone OTA services are diminishing with the saturation of the market, Aptiv instead will look to embed the Movimento OTA platform capabilities into their broader connected services and E/E integration services.

While companies such as GM, FCA, and Volkswagen remain Aptiv's top customers, there is no evidence that any of these OEMs have chosen Aptiv's OTA platform for their own software update capabilities. While companies such as HERE and Harman dominate the market, Aptiv seems to be pivoting its differentiation focus into its AV, EV and connected vehicle intellectual property.

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

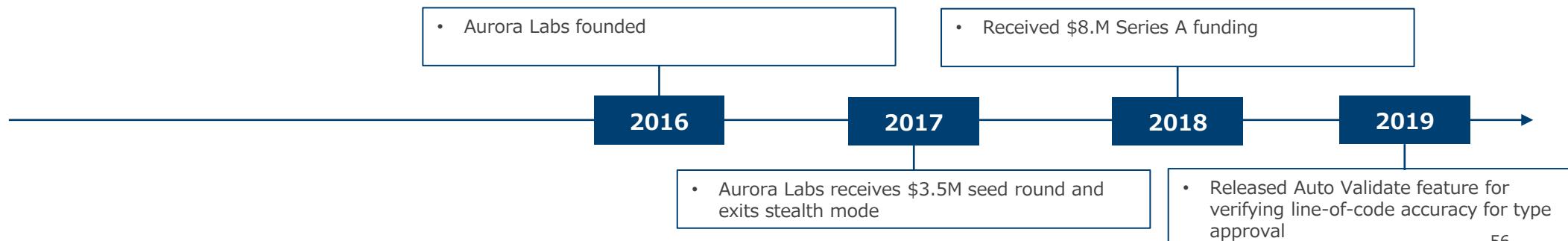
Business & Product Summary

Aurora Labs is one of the newer OTA platform providers in the space, entering the market in 2016 after a period of stealth development. Aurora Labs' platform focuses not just on the provision of OTA update capabilities, but also the ability digitally represent the vehicle's current configuration and verification of software for type approval.

Aurora Labs' key positioning is with its "self-healing" capabilities, which includes line-of-code level analysis and differentiation of software. The goal of the platform is to both monitor the health of software in vehicles as well as facilitate their triage and update. Many former Redbend (Harman) employees work on the Aurora Labs solution in Israel, likely building on automotive industry experience to iterate on the both the efficiency and concept of what role software updates can play in the automotive industry.

Company Information

HQ Location	Tel Aviv, Israel
Other Locations	Detroit, Munich, Macedonia
# Employees	25 – 50 (estimated)
Ownership	Private
CEO	Zohar Fox
Founded	2016

Product Timeline**News & References**

Headline/Reference	Year
Aurora Labs announces Auto Validate to decrease cost of type approval	2019
Aurora Labs raises \$8.4M Series A	2018
Aurora Labs opens German office	2019
Aurora Labs comes out of stealth mode	2017

Customers & Partners

Aurora Labs has not disclosed any public customers or partners, but has cooperated with UNECE, the Automated Vehicle Safety Consortium, and FISITA on a variety of industry regulations, standards, and collaborations.

Global Suppliers
Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River
Chinese Suppliers
ABUP
Carota
Red Stone

Functional Components

PLM Database	
Vehicle Identification	✓
Delta Preparation	✓
Software Signing & Encryption	✓
Campaign Management	✓
Content Delivery Network (CDN)	✓
Master Device Client	✓
Secondary Device Client	

Supported Standards & Protocols

HTTP	✓
MQTT	✓
TLS 1.2	✓
OMA-DM	
LWM2M	
WebSocket	

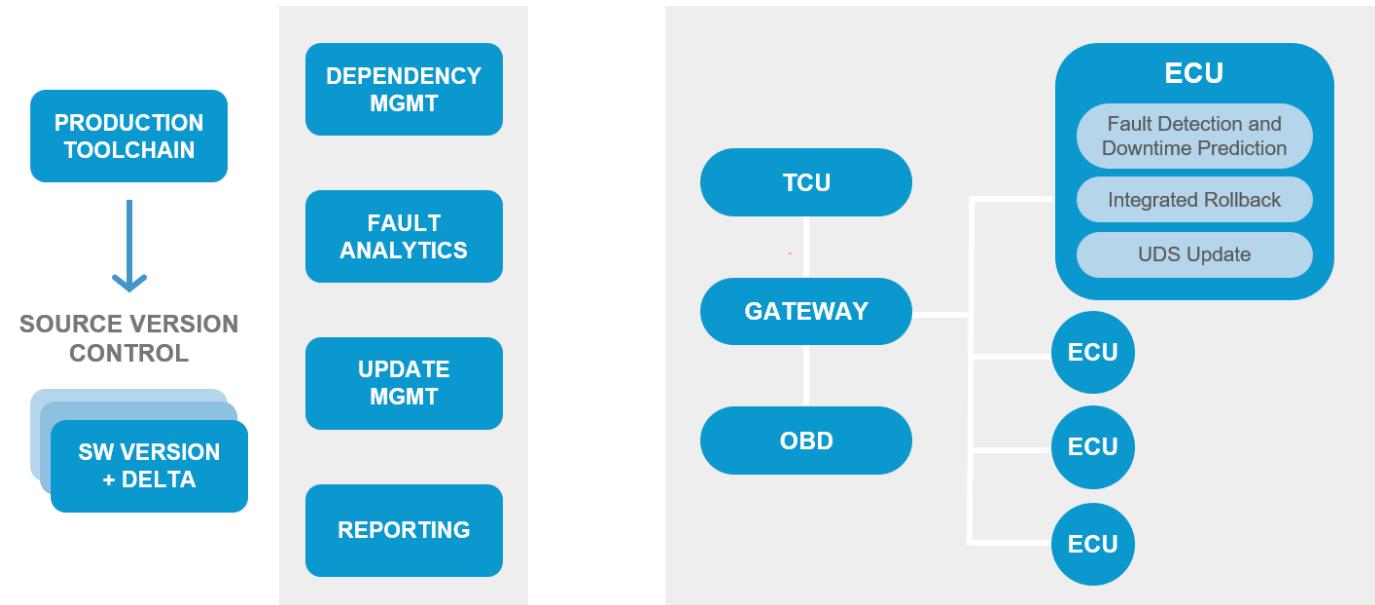
Uptane	✓
AUTOSAR Adaptive Platform	

SBD Insights & Forecast

Aurora Labs is one of the most aggressive start-ups in the OTA space, publicly positioning itself as a leader in both OTA product innovation as well as working with and aligning to emerging regulations and standards around OTA. The collective experience of Aurora Labs' key leaders further gives credibility to the long-term viability of the Self-Healing OTA product for the industry.

Given the recently opened office in Germany, our expectation is that Aurora Labs is engaged in some way with at least one of the German OEMs, either building a proof of concept or even integrating into a broader production technology ecosystem.

The line-of-code level accuracy for its software validation system is a boon for OEMs concerned about potential upcoming type approval regulations from the United Nations, and provides a higher level of audit accuracy than many other competing solutions. The primary issue Aurora Labs will face is general aversion by automotive OEMs towards putting too many "eggs" into a startup's basket, meaning it will likely need to align itself to a larger entity, or potentially even receive equity funding from an OEM, similar to Airbiquity.



Global Suppliers		Business & Product Summary		News & References	
Aeris		Bosch is one of the biggest, longest-running tier 1 suppliers to the automotive industry. In efforts to diversify its parts business, Bosch announced a new Connected Mobility Solutions division which focuses on building and delivering cloud-based applications and services for its customers.		Headline/Reference	Year
Airbiquity				Bosch IoT suite at NAIAS 2019	2019
Aptiv				Bosch establishes division for connected mobility services	2018
Aurora Labs				Bosch launches IoT software solutions on Huawei Cloud	2018
Bosch				Bosch says it is securely updating cars over the air	2017
Elektrobit (Continental)					
EnGIS Technologies					
Excelfore					
Fujitsu					
Harman					
HERE					
Google					
Sibros					
Wind River					
Chinese Suppliers		Company Information		Customers & Partners	
ABUP		HQ Location	Gerlingen, DE	escrypt	ESCRYPT
Carota		Other Locations	Global		• Cybersecurity subsidiary
Red Stone		# Employees	400,000	Bosch SoftTec GmbH	SoftTec
		Ownership	Private		• Software subsidiary
		CEO	Volkmar Denner		Huawei
		Founded	1886		• Cloud partner in China
		Product Timeline		<i>Not announced</i>	• 3+ OEMs
		<ul style="list-style-type: none"> Bosch founded in Stuttgart, Germany as a supplier of automotive parts 		<ul style="list-style-type: none"> Bosch SoftTec introduces FOTA Delta product 	
		<ul style="list-style-type: none"> Bosch SoftTec subsidiary founded as developer of connected services and MySpin 		<ul style="list-style-type: none"> Bosch Connected Mobility Services division established 	

Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client ✓
Fujitsu	
Harman	
HERE	
Google	
Sibros	
Wind River	
Chinese Suppliers	Supported Standards & Protocols
ABUP	HTTP ✓
Carota	MQTT ✓
Red Stone	TLS 1.2 ✓
	OMA-DM ✓
	LWM2M
	Websocket ✓
	Uptane ✓
	AUTOSAR Adaptive Platform

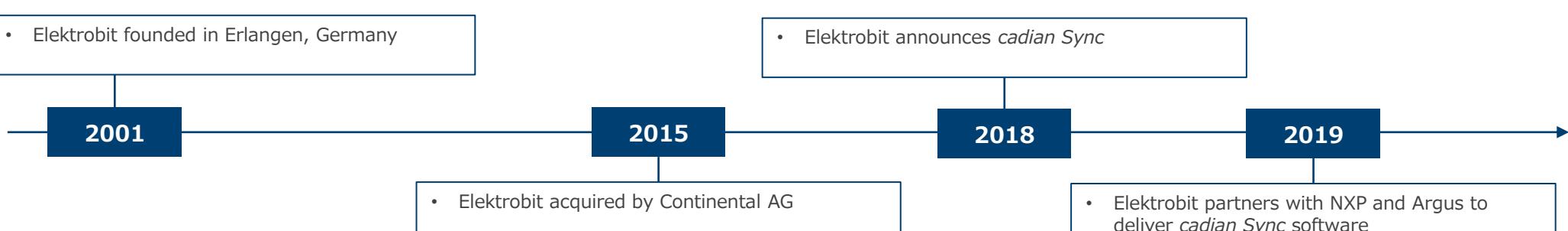


Image source: ATZ Magazine (January 2019)

SBD Insights & Forecast

As one of the largest and well-funded automotive suppliers in the world working with leading car brands from North America, Europe, and Asia, Bosch is well-positioned to deliver an automotive-grade OTA solution to OEMs. One of Bosch's key advantages is its experience working with OEMs – as a tier 1 supplier, it can leverage this experience to bridge the gap between traditional OEM platforms and modern technical and security requirements for connected and autonomous vehicles.

While Bosch has claimed some level of OTA capability for some time, in the grand scheme of the market, its formal offering is a late entrant and thus may not see the market penetration of competing solutions from companies like Harman, but Bosch is well-positioned to be a significant player in the OTA update ecosystem in the 2020s, particularly as OEMs update their E/E architectures to support more complex software update use cases.

Global Suppliers		Business & Product Summary		News & References	
Aeris		Elektrobit is a German automotive software company which has a variety of software intellectual properties, spanning HMI, infotainment, and connected services capabilities. Elektrobit was acquired by Continental in 2015 but has continued to operate as a separate brand.		Headline/Reference	Year
Airbiquity				Argus, Elektrobit, and NXP provide combined solution	2019
Aptiv				Elektrobit cadian Sync demo video	2018
Aurora Labs				Elektrobit announces cadian Sync OTA platform	2018
Bosch				Elektrobit technical paper on cadian Sync	2018
Elektrobit (Continental)		In 2018, Elektrobit introduced the <i>cadian sync</i> product line which offers over-the-air update capabilities as well as data analytics management. The platform offers an end-to-end suite of capabilities for OTA, competing with full stack providers such as HERE, Harman, and Airbiquity.			
EnGIS Technologies		With the backing of Continental, Elektrobit has become a major player in the OTA update space, augmenting its infotainment, HMI, and analytics products with a complete software-as-a-service offering for automotive OEMs.			
Company Information		Customers & Partners			
HQ Location	Erlangen, DE	 Continental	Continental	• Parent company	
Other Locations	Tel Aviv, Detroit, Stuttgart, Tokyo, 20+ others	 Argus	Argus	• Cybersecurity partner / co-subsidiary (Continental)	
# Employees	2,600+		NXP	• SoC partner	
Ownership	Public (Continental)		Audi	• e.solutions JV partner	
Mng. Director	Alexander Kocher				
Founded	1985				
Product Timeline					
<ul style="list-style-type: none"> Elektrobit founded in Erlangen, Germany 		<ul style="list-style-type: none"> Elektrobit announces <i>cadian Sync</i> 			
		<ul style="list-style-type: none"> Elektrobit acquired by Continental AG 			
		<ul style="list-style-type: none"> Elektrobit partners with NXP and Argus to deliver <i>cadian Sync</i> software 			

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Functional Components

PLM Database	
Vehicle Identification	✓
Delta Preparation	✓
Software Signing & Encryption	✓
Campaign Management	✓
Content Delivery Network (CDN)	✓
Master Device Client	✓
Secondary Device Client	✓

Supported Standards & Protocols

HTTP	✓
MQTT	✓
TLS 1.2	✓
OMA-DM	
LWM2M	Information not available
Websocket	✓
Uptane	✓
AUTOSAR Adaptive Platform	✓

SBD Insights & Forecast

Elektrobit (and its parent entity, Continental) represents a significant force within the connected and autonomous vehicle areas of development. While EB's intellectual property spans across a variety of domains, the partnership between itself and Continental's tier 1 entities position *cadian Sync* as a top-tier option for automotive OEMs building out their OTA solutions. EB's and Continental's involvement in automotive industry organizations such as AUTOSAR mean that they are positioning themselves right within the key enablers for next-generation E/E architectures, further ensuring that *cadian Sync* will be continuously evolved to address emerging technical requirements and standards within the vehicle and outside.

A major headwind facing *cadian Sync* is the relative newness of the solution. While supported by industry-leading engineering organizations, other solutions have been able to gain a much larger market foothold due to relative product maturity. If Elektrobit is able to continue to develop *cadian Sync* to adopt industry standards such as Uptane, AUTOSAR Adaptive, and others, as well as find novel ways to integrate it with other Elektrobit and Continental products, *cadian Sync* is likely to be a leading contender for next-generation OTA sourcing activities.

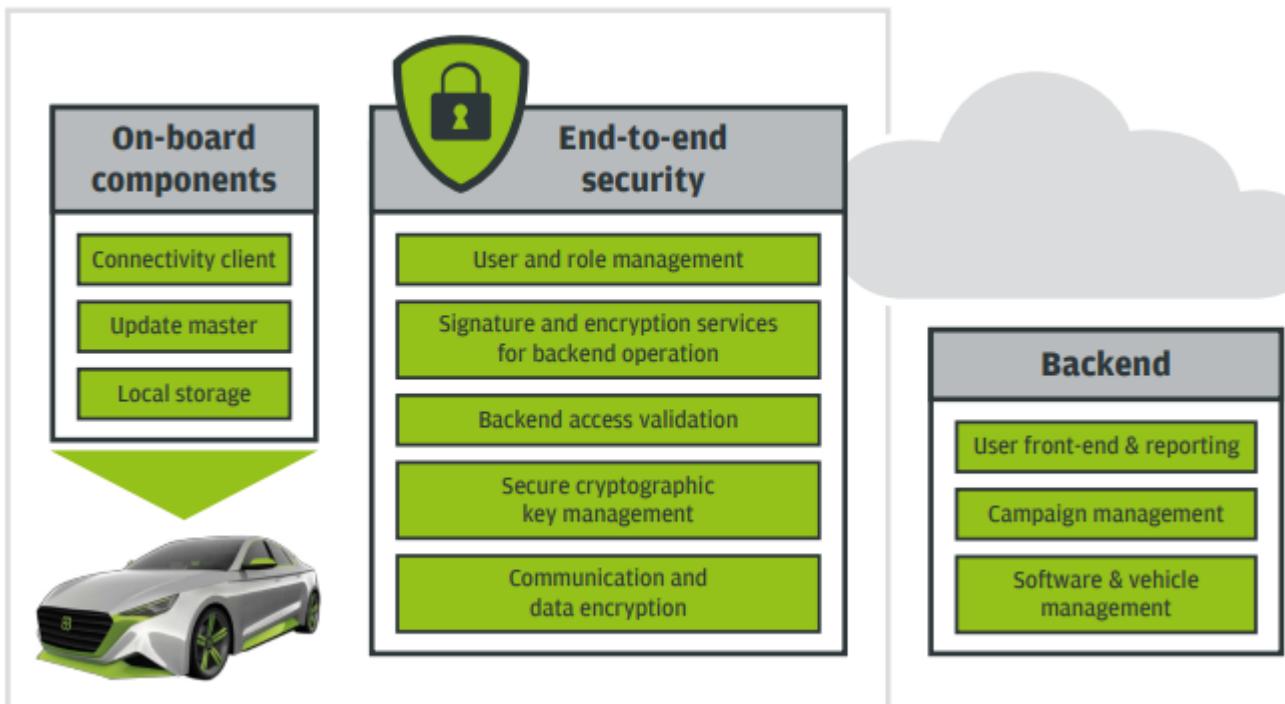
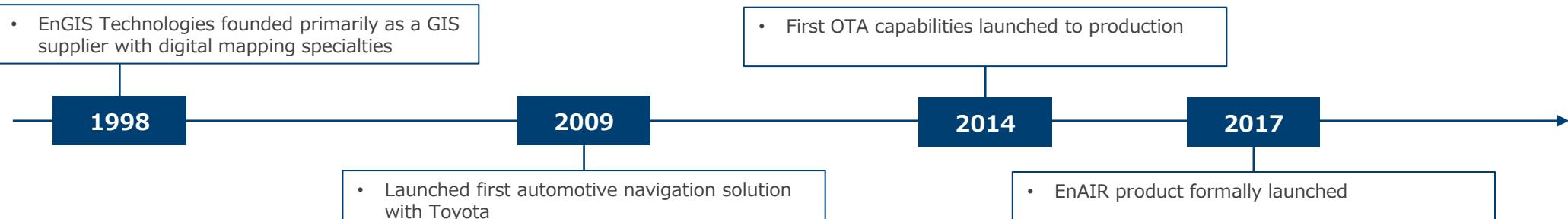


Image Source: Elektrobit

Global Suppliers		Business & Product Summary	News & References								
Aeris		EnGIS Technologies is a global automotive and information technology service provider based in South Korea. EnGIS has traditionally built connected navigation and ADAS services for global OEMs such as General Motors, BMW, Toyota, and others.									
Airbiquity											
Aptiv											
Aurora Labs											
Bosch											
Elektrobit (Continental)											
EnGIS Technologies		<p>One of EnGIS's core products is EnAIR, its OTA software update platform, enabled through its partnership with LG Electronics. The initial OTA software launched was in 2014, and EnGIS has continued to iterate on the platform as software updates have become standard in the industry.</p> <p>EnAIR is largely based on the OMA-DM standards which have been used for software updates in other industries, in particular telecommunications. EnGIS promotes their image differential (delta) software and OEM protocol flexibility as being key differentiators. EnGIS is also one of the first OTA service providers to support production vehicles and anticipates more than 5 million supported devices in the next six years.</p>	<table border="1"> <thead> <tr> <th>Headline/Reference</th> <th>Year</th> </tr> </thead> <tbody> <tr> <td>EnGIS and KT sign MOU to develop IVI and OTA services (Korean)</td> <td>2018</td> </tr> <tr> <td>EnGIS signs 430M KRW contract to develop OTA solutions in Japan</td> <td>2017</td> </tr> <tr> <td>Airbiquity integrates EnGIS Technology into [OTAmatic]</td> <td>2016</td> </tr> </tbody> </table>	Headline/Reference	Year	EnGIS and KT sign MOU to develop IVI and OTA services (Korean)	2018	EnGIS signs 430M KRW contract to develop OTA solutions in Japan	2017	Airbiquity integrates EnGIS Technology into [OTAmatic]	2016
Headline/Reference	Year										
EnGIS and KT sign MOU to develop IVI and OTA services (Korean)	2018										
EnGIS signs 430M KRW contract to develop OTA solutions in Japan	2017										
Airbiquity integrates EnGIS Technology into [OTAmatic]	2016										
Excelfore											
Fujitsu											
Harman											
HERE											
Google											
Sibros											
Wind River											
Chinese Suppliers		Customers & Partners									
ABUP		 LG Electronics	• Tier 1 partner								
Carota		 Airbiquity	• OTA solution partner								
Red Stone		 2+ Asian OEMs	• Platform customer								
Product Timeline											
<ul style="list-style-type: none"> EnGIS Technologies founded primarily as a GIS supplier with digital mapping specialties 		<ul style="list-style-type: none"> First OTA capabilities launched to production 									
 <p>The timeline diagram illustrates the evolution of EnGIS Technologies. It starts in 1998 with the company's founding as a GIS supplier. In 2009, they launched their first automotive navigation solution with Toyota. In 2014, they introduced their first OTA capabilities. Finally, in 2017, the EnAIR product was formally launched.</p>		<ul style="list-style-type: none"> Launched first automotive navigation solution with Toyota 									

Functional Components	
Global Suppliers	Aeris
	Airbiquity
	Aptiv
	Aurora Labs
	Bosch
	Elektrobit (Continental)
EnGIS Technologies	Excelfore
	Fujitsu
	Harman
	HERE
	Google
	Sibros
	Wind River
Supported Standards & Protocols	
Chinese Suppliers	HTTP
	MQTT
	TLS 1.2
	OMA-DM
	LWM2M
	Websocket
	Uptane
	AUTOSAR Adaptive Platform
SBD Insights & Forecast	
<p>With support from LG, EnGIS has developed an extremely capable OTA platform engineered on well-established patterns and standards. Accordingly, OEMs which use platforms which are engineered for resiliency and fault tolerance would be prime users of the EnAIR platform. EnAIR leverages standards published by Open Mobile Alliance to pattern its interface with the vehicle, further giving OEMs the ability to modularly develop certain components in-house or to put together multi-vendor solutions.</p> <p>The major drawback of this approach is that some other newer platforms align to emerging standards and frameworks (such as LWM2M and Uptane), and these are more likely to meet emerging OEM OTA requirements. EnGIS will need to consider tactically which emerging industry standards it would like to implement and/or support in order to ensure it maintains its business with global OEMs.</p>	

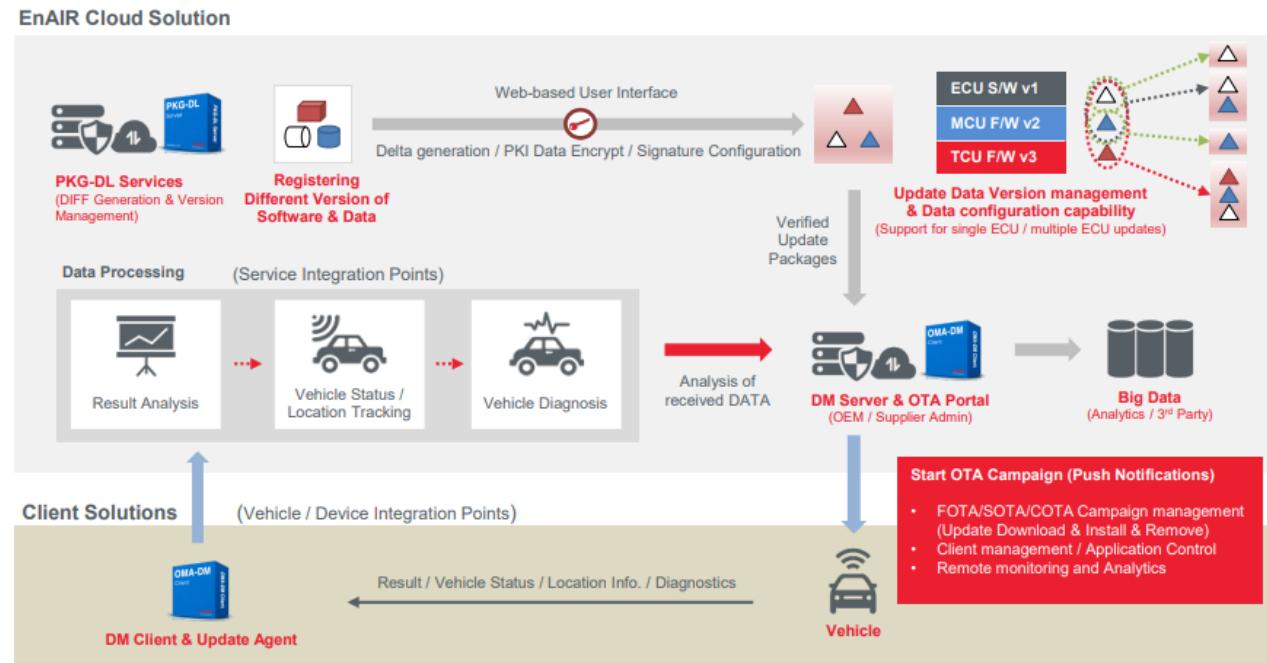


Image Source: EnGIS Technologies

Global Suppliers		Business & Product Summary	News & References
Aeris		Excelfore is a Silicon Valley-based automotive engineering firm which specializes in the development of OTA technology as well as in-vehicle networking software. It was founded in 2008, with its first product launched in 2011, focusing primarily on the in-vehicle networking and diagnostics capabilities.	Headline/Reference Year
Airbiquity			Excelfore collaborates with Microsoft on Automotive OTA 2019
Aptiv			Baidu selects Excelfore platform for Apollo project 2019
Aurora Labs			FAW deploys the Excelfore eSync platform 2019
Bosch			Excelfore receives investments from Molex and HELLA 2018
Elektrobit (Continental)			eSync Alliance will drive industry-wide secure automotive OTA 2017
EnGIS Technologies			
Excelfore			
Fujitsu			
Harman			
HERE			
Google			
Sibros			
Wind River			
Chinese Suppliers		Customers & Partners	
ABUP		Molex	• Investor / eSync Alliance member
Carota		Alpine	• Investor / eSync Alliance member
Red Stone		Hella	• Investor / eSync Alliance member
		Microsoft	• Cloud platform partner
		FAW	• Customer
Product Timeline			
<ul style="list-style-type: none"> Excelfore founded in California by Shrinath Acharya, Shrikant Acharya, and John Crosbie 		<ul style="list-style-type: none"> Excelfore partners with Microsoft to launch eSync platform in cloud 	
<p>The timeline diagram shows a horizontal axis with five blue rectangular boxes representing years: 2008, 2011, 2017, 2018, and 2019. Above each year box is a list of events. Below the 2011 box is a box containing the event: "Excelfore launches its first technology products (non-OTA)". Below the 2017 box is a box containing the event: "Series B financing from Hella and Molex".</p>		<ul style="list-style-type: none"> Excelfore partners with Microsoft to launch eSync platform in cloud 	

Global Suppliers

Functional Components	
PLM Database	
Vehicle Identification	✓
Delta Preparation	✓
Software Signing & Encryption	✓
Campaign Management	✓
Content Delivery Network (CDN)	✓
Master Device Client	✓
Secondary Device Client	✓

EnGIS Technologies

Supported Standards & Protocols

HTTP	✓
MQTT	✓
TLS 1.2	✓
OMA-DM	
LWM2M	
Websocket	

Chinese Suppliers

Uptane
AUTOSAR Adaptive Platform

SBD Insights & Forecast

Excelfore has parlayed its agile development shop and extensive in-vehicle engineering experience to build out an OTA platform that is particularly well-suited for EVs and modern E/E vehicle platforms. Its early successes in China and California, along with its partnership with Microsoft, portend that Excelfore will continue to be a strong provider in the OTA space. Excelfore has also attempted to diversify its offering by integrating its data exchange platform (eDatX) and analytics platform (eLearn) with OTA to build a value-chain based solution that avoids some of the issues associated with commoditization of the OTA market.

While covered separately, Excelfore should be applauded for its efforts to build an industry consortium through the eSync Alliance, an effort which would tangibly benefit automotive OEMs by mitigating supplier risk for suppliers which leverage the eSync specification. However, due to a number of factors, there have been few additional members added since its inception in 2017, and no public OEM members. While it is possible that eSync may still expand, without OEM momentum, the eSync Alliance will struggle to gain momentum.

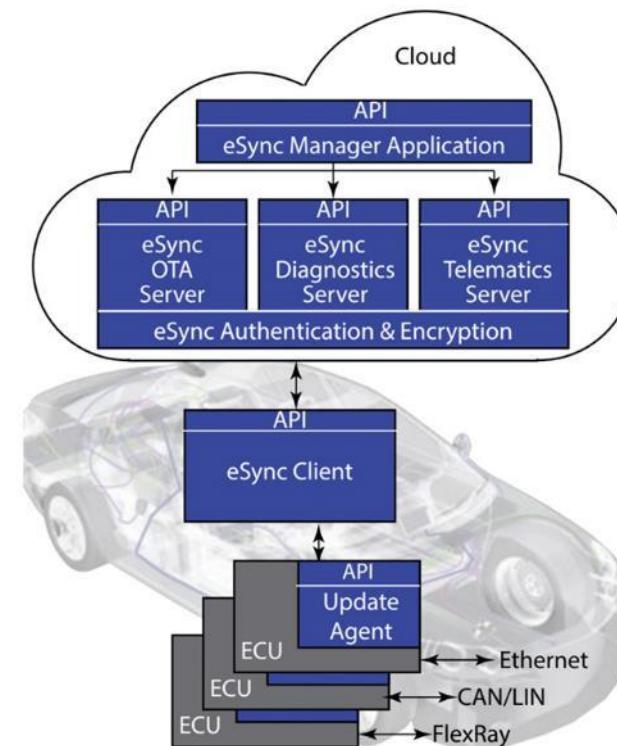


Image Source: Excelfore

Global Suppliers**Business & Product Summary**

Fujitsu is a Japanese information technology and software development firm with an extensive history of supporting automotive companies with information technology software platforms and engineering.

One of Fujitsu's core development areas in the connected, autonomous, shared, and electric (CASE) area of automotive is its OTA update platform. The solution comprises of three key capabilities: delta/differential software update generation, campaign/configuration manager, and a security manager. This platform was inspired by Fujitsu's support to software update capabilities in other industries, in particular mobile devices.

While Fujitsu has many customers outside of Japan, its primary automotive customers are Japanese OEMs, in particular Toyota, Suzuki, Mazda, and others.

Company Information

HQ Location	Tokyo, Japan
Other Locations	100+
# Employees	140,365 (2018)
Ownership	Public (Furukawa Group)
President	Takahito Tokita
Founded	1935

Product Timeline

- Fujitsu founded as Fuji Telecommunications Equipment Manufacturing

1935

- Fujitsu targets OTA platform marketing to automotive customers

2017

2018

- Fujitsu announces collaboration with VMWare on OTA platform

News & References

Headline/Reference	Year
(Blog) OTA updates will do much more than just update software	2019
Video on Fujitsu OTA reprogramming platform	2018
Fujitsu presentation on OTA update platform	2018
Fujitsu and VMWare expand strategic collaboration on IoT solutions	2017

Customers & Partners

VMWare

- OTA partner

Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client ✓
Fujitsu	Supported Standards & Protocols
Harman	HTTP ✓
HERE	MQTT
Google	TLS 1.2 ✓
Sibros	OMA-DM
Wind River	LWM2M
	Websocket
Chinese Suppliers	
ABUP	Uptane
Carota	AUTOSAR Adaptive Platform
Red Stone	

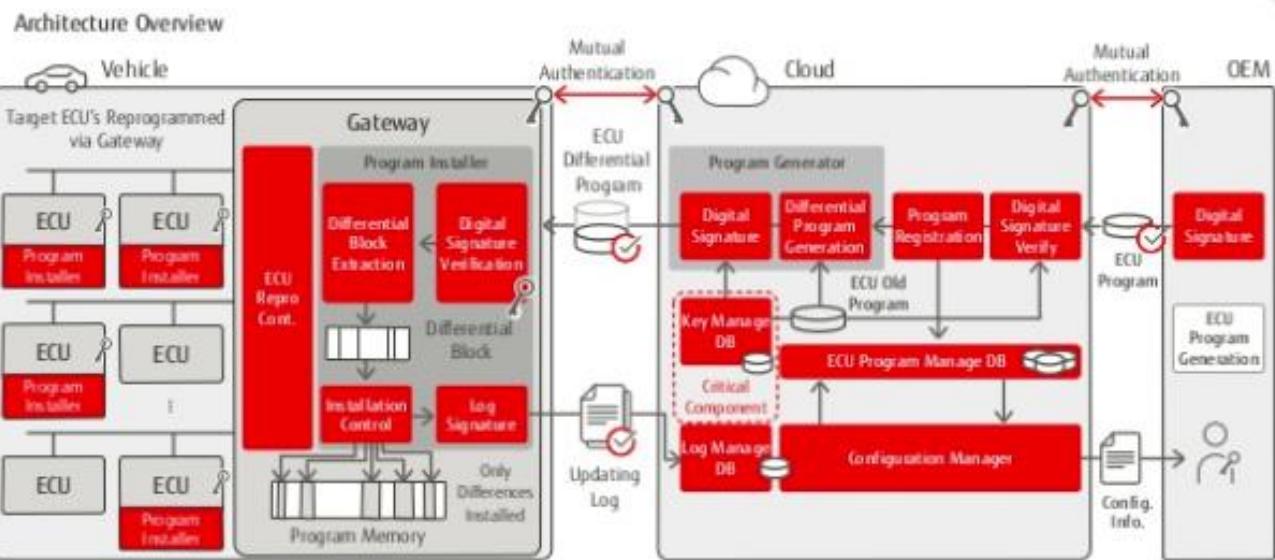


Image Source: Fujitsu

SBD Insights & Forecast

In the grand scheme of OTA, Fujitsu's product offering for automotive is a relatively late addition to the competitive mix. The platform is well-architected with all the necessary components to safely and securely deliver software updates to vehicles. Given Fujitsu's credibility in developing software for the automotive industry, we expect that the platform is sufficiently engineered to support production, volume OEMs.

We expect that Fujitsu's primary OTA customers are or will be based in Japan, however there is no public evidence of any direct development effort between an OEM and Fujitsu for OTA. Fujitsu will need to pay close attention to some of the development occurring within the EV and OTA startup space to ensure alignment of its platform capabilities to emerging industry capabilities. This will allow their volume customers to rapidly adopt new, innovative technologies into mass-market vehicle platforms while gaining the benefit of working with a well-established supplier like Fujitsu.

Global Suppliers

Business & Product Summary

Harman, a global automotive tier 1, is the industry leader for automotive OTA in terms of production programs supported and production volume. Through its acquisition of Redbend, Harman was a first mover in the automotive OTA space and has grown its customer base aggressively with the rapid adoption of OTA by global OEMs.

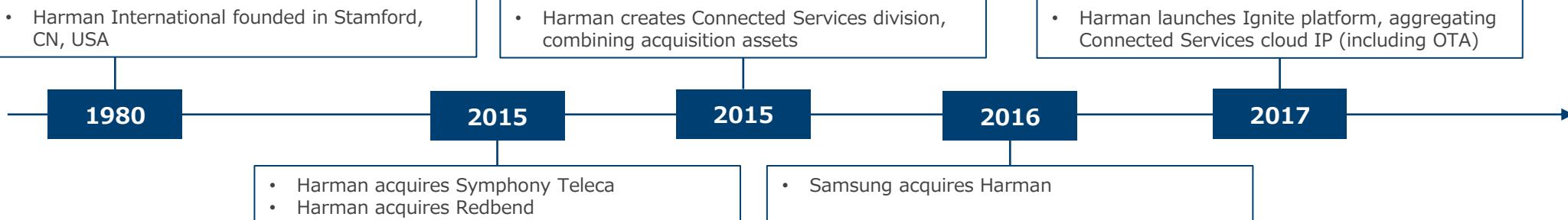
The Harman OTA platform is integrated with its Ignite solution, paired alongside services such as diagnostics analytics, media integration, map aggregation, and other connected services which serve to augment Harman's tier 1 supplier business. The OTA solution itself is based on the original Redbend solution which was originally built for the telecommunications sector.

Because of its large market share, the platform itself is proven in automotive use cases, but now risks disruption from other tier 1s as well as innovative startups.

Company Information

HQ Location	Stamford, CN (USA) / (Parent: Samsung, Seoul, South Korea)
Other Locations	Novi, MI (automotive/Ignite); Tel Aviv, Israel (OTA); + more
# Employees	25,000+
Ownership	Public (Samsung)
CEO	Dinesh C. Paliwal
Founded	1953 (Harman Kardon) / 1980 (Harman International)

Product Timeline



News & References

Headline/Reference	Year
HARMAN OTA service expands to include HD map updates	2019
Great Wall Motors chooses HARMAN to deliver OTA technology	2018
17 OEMs have deployed 25M vehicles with HARMAN OTA	2017
HARMAN introduces HARMAN Ignite	2017
HARMAN completes acquisition of Redbend	2015

Customers & Partners

SAMSUNG	Samsung	• Parent company
redbend	Redbend	• Acquisition/OTA specialist
ST symphony teleca	Symphony Teleca	• Acquisition/integration specialist
NXP	NXP	• SoC partner
	24+ OEM brands	• OTA platform customers

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota

Red Stone

Functional Components

PLM Database
Vehicle Identification
Delta Preparation
Software Signing & Encryption
Campaign Management
Content Delivery Network (CDN)
Master Device Client
Secondary Device Client

Supported Standards & Protocols

HTTP
MQTT
TLS 1.2
OMA-DM
LWM2M
Websocket

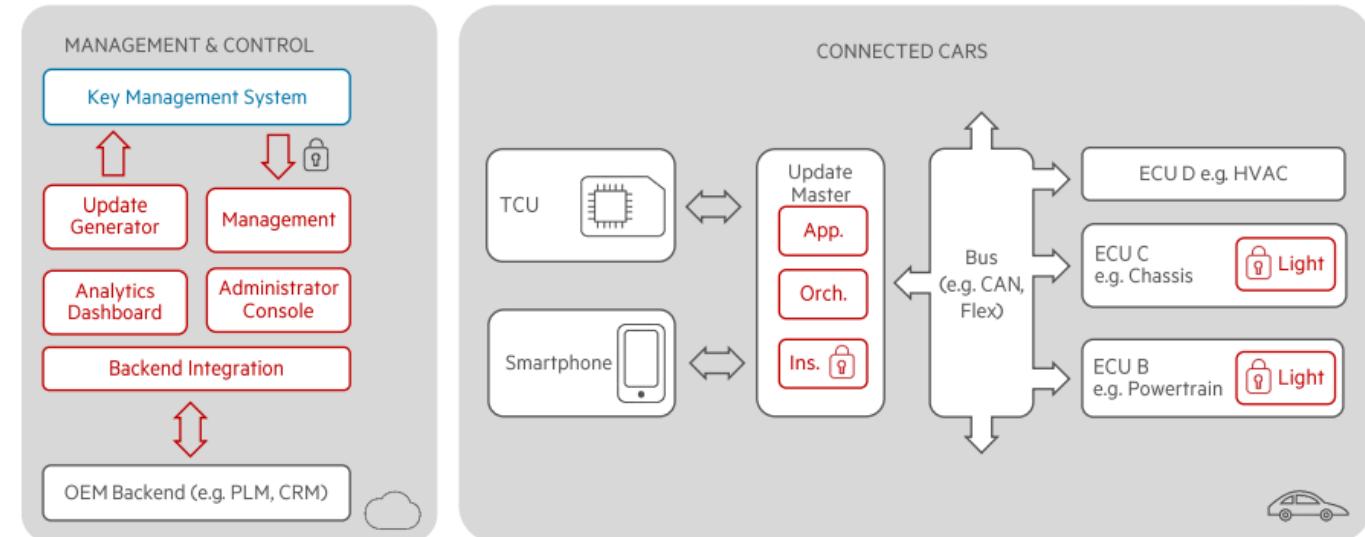


Image Source: Harman

SBD Insights & Forecast

Given Harman's proliferation as a leading OTA supplier, they will have both the relationships and the revenue to ensure they remain an outsized player in the OTA ecosystem, leveraging its battle-tested platform and deep industry knowledge to support OEMs. With the deployment velocity Harman has experienced, it is likely that product roadmap development has slowed while meeting OEM project obligations, and we are keen to see public statements about the further iterations Harman has made or is making to the platform.

Additionally, many of Harman's competitors have started introducing innovative integrations with their OTA services such as data management, analytics, diagnostics, and compliance auditing tools. In order to maintain its market leader position, Harman will need to figure how to balance its delivery commitments and OEM partnerships with building out new features and services to meet emerging OEM and regulatory needs.

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

HERE is a global mapping and location-based services company based in Amsterdam, with major engineering centers in Berlin and Chicago. Formerly part of Nokia, HERE has been a mainstay in the automotive industry through its in-vehicle mapping and navigation services and has continued to iterate on these by adding location-based services as well as data management platforms.

HERE acquired the German OTA platform startup Advanced Telematic Systems (ATS) GmbH in early 2018 in order to capitalize on both the OTA technology as well as integrate it into its other platform services, such as map updates. HERE brands its OTA product as OTA Connect which is offered as a key element of its broader location-based services and data platform. The initial ATS team was the sole contributor to the GENIVI RVI SOTA project, and its newer iteration – Aktualizr – is still available within the GENIVI Development Platform (GDP). OTA Connect and Aktualizr are also part of Automotive Grade Linux. HERE is a major contributor to the Uptane security standard.

Company Information

HQ Location	Amsterdam, Netherlands
Other Locations	Chicago, Berlin, Mumbai
# Employees	9000+
Ownership	Private (BMW, Audi, Daimler, Mitsubishi Corp., NTT, Intel)
CEO	Edzard Overbeek
Founded	1985

Product Timeline

- HERE founded as Karlin & Collins Inc. (eventually Navteq) in the United States

1985

2013

2016

2017

2018

- ATS founded in Berlin, Germany

- HERE announces acquisition of ATS (closed in January 2018)

News & References

Headline/Reference	Year
HERE Technologies joins the Uptane Alliance	2019
HERE launches OTA technology for connected and self-driving vehicles	2018
HERE completes acquisition of ATS	2018
HERE powers over-the-air map updates for Volvo cars	2017

Customers & Partners

BMW

- Shareholder



Audi

- Shareholder

DAIMLER

Daimler

- Shareholder



ATS

- HERE acquisition



Volvo

- Map OTA customer

Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client ✓
Supported Standards & Protocols	
HERE	<u>HTTP</u> ✓
	<u>MQTT</u> ✓
	<u>TLS 1.2</u> ✓
Google	<u>OMA-DM</u>
Sibros	<u>LWM2M</u>
Wind River	<u>Websocket</u>
Chinese Suppliers	
ABUP	<u>Uptane</u> ✓
Carota	<u>AUTOSAR Adaptive Platform</u>
Red Stone	

SBD Insights & Forecast

HERE's OTA business unit has a lot of important tailwinds that position it as a top-tier leader in the field, including its experience in automotive, market-leading autonomous and mapping products, an automotive-centric ownership group, and an extensive OEM sales support organization. These all portend that HERE will continue to be a major competitor within the OTA space, particularly in the next round of supplier sourcing for OTA technology. Furthermore, its involvement with the Uptane Alliance positions OTA Connect as a leading security-oriented platform.

However, as the OTA market has commoditized and OEMs move through sourcing cycles, HERE will likely leverage its position as a leader in location-based services to augment its IoT and related markets to bring OTA software updates to these verticals as well. In addition, OTA Connect will be fully integrated as a tool within HERE's broader data platform as a tool for OEMs (and other industries) to manage diagnostics & data process configurations.

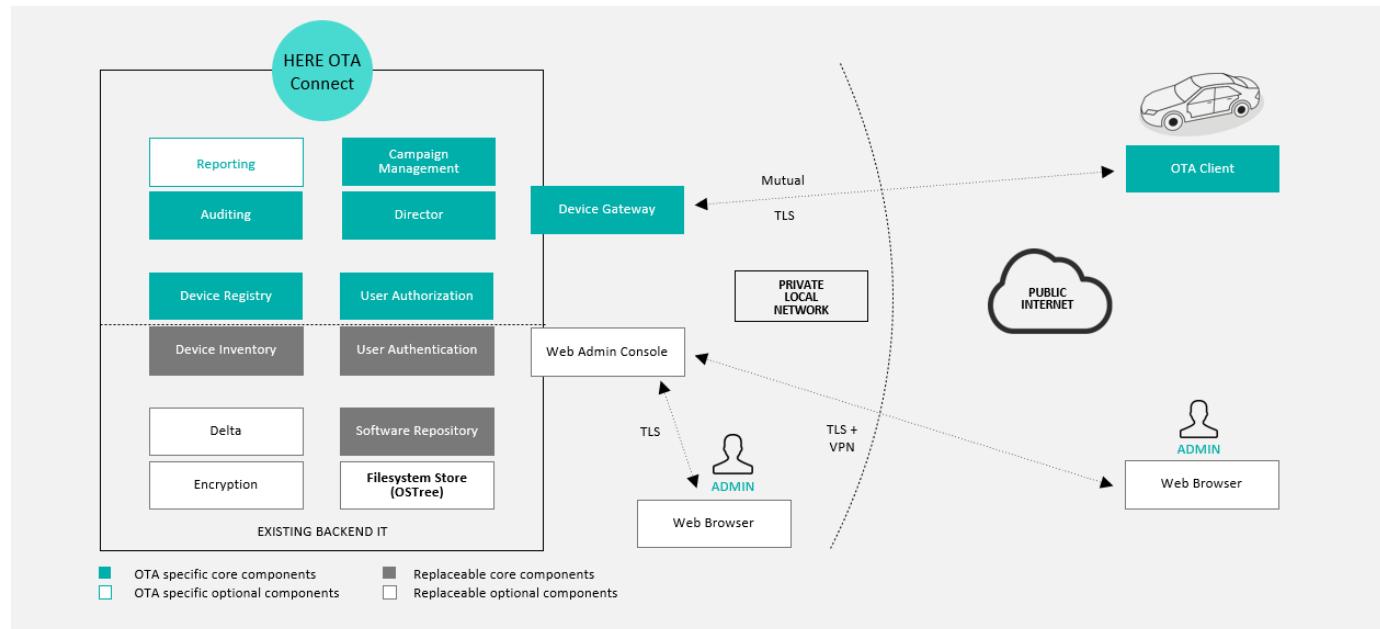


Image Source: HERE



Google Company Overview



Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

Although not a traditional OTA company, Google has OTA update capabilities as evidenced through its OEM smartphone businesses. Through its development activities with Android Automotive and Google Automotive Services, Google can also offer OTA update capabilities for OEMs who leverage the Android Automotive platform for their infotainment platform.

Google publicly stated they will offer OTA update services to OEMs in an interview with *The Verge* during CES 2019: *"Just like on phones, we have our own over-the-air update service that deploys updates through Google's global data center network."*

It is unclear if Google is offering OTA updates for full vehicles or just the infotainment platform, but we can assume that software updates will be a major requirement for all Android Automotive platforms, and Google will at minimum support OTA updates for apps enabled through the Play Store.

Company Information

HQ Location	Mountain View, CA
Other Locations	100+
# Employees	114,096 (Q3 2019)
Ownership	Public/Subsidiary (Alphabet Inc.)
CEO	Sundar Pichai
Founded	1998

Product Timeline



News & References

Headline/Reference	Year
Everything we know about Android Automotive in the Polestar 2	2019
Interview: How Google will power the car of the near future	2019

Customers & Partners

	General Motors	• Android Automotive customer
	Renault-Nissan-Mitsubishi	• Android Automotive customer
	Volvo	• Android Automotive customer

Note: Android Automotive customer does **not** imply that OEM is using Google for OTA



Google Platform Overview



Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption Information not available
Bosch	Campaign Management
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client
Fujitsu	
Harman	
HERE	
Google	Supported Standards & Protocols
Sibros	HTTP
Wind River	MQTT ✓
	TLS 1.2 ✓
	OMA-DM
	LWM2M Information not available
	websocket ✓
	Uptane ✓
	AUTOSAR Adaptive Platform
Chinese Suppliers	SBD Insights & Forecast
ABUP	Google is a relative unknown as far as its OTA capabilities go, reserving most of this information only for the customers that choose to adopt Android Automotive. We don't believe that many (if any) OEMs will choose to leverage Google's OTA platform given the wide-ranging needs that OEMs have for their OTA programs, including extensive support for type approval, compliance, autonomous driving functions, and other automotive-centric functions that may not be present in Google's platform.
Carota	We also expect that OEMs will want to manage the software update deliveries from the various suppliers directly, managing their own CDN – this further entrenches the notion that most OEMs will likely choose an independent OTA provider in lieu of piggybacking on Google's OTA services.
Red Stone	

For a more detailed view of Android Automotive, Google Automotive Services, and the emerging infotainment ecosystem battleground, please refer to the upcoming SBD special report:

Automotive Operating Systems and Connected Infotainment Platforms (2020)

Global Suppliers
Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River
Chinese Suppliers
ABUP
Carota
Red Stone

Business & Product Summary

Sibros is a young automotive platform startup based in San Jose CA which was founded in 2018 by Hemant and Mayank Sikaria. Hemant previously worked for Tesla as a lead engineer for its OTA update capability.

Sibros' Deep Updater product was introduced in 2019, focusing largely on the client software as well as building an easy-to-use, iterative campaign management toolset. Based on its initial software development efforts, Sibros has raised around \$20M in venture capital in its Seed and Series A rounds.

Sibros primary development focus has been to partner with primarily other startups – particularly EV startups – to help bolster the platform capability in a relatively low-risk environment. Sibros also provides OTA capabilities to bikes, scooters, trucks, and IoT devices.

Company Information

HQ Location	San Jose, CA
Other Locations	N/A
# Employees	25 – 50 (estimated)
Ownership	Private (startup)
CEO	Hemant Sikaria
Founded	2018

Product Timeline

News & References

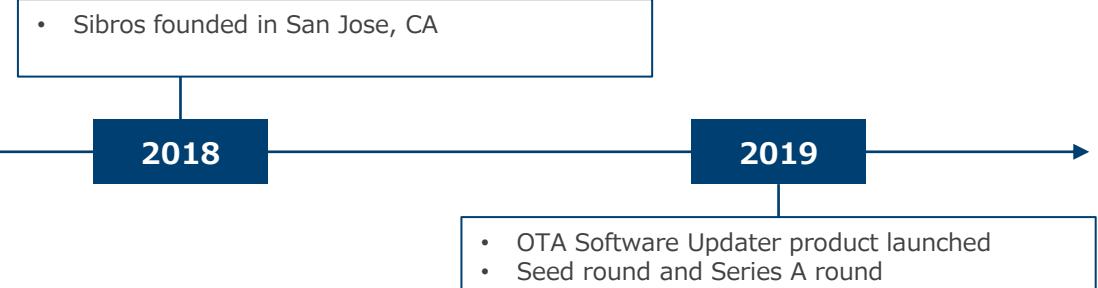
Headline/Reference	Year
Sibros raises \$3.5M from Nexus Venture Partners and Moneta Ventures	2019
Former Tesla executive joins Sibros as advisor	2019
Peter Savagian joins as Sibros advisor	2019

Customers & Partners



2+ EV startups

- OTA customers



Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client
Supported Standards & Protocols	
	HTTP ✓
	MQTT ✓
	TLS 1.2 ✓
	OMA-DM
	LWM2M
	websocket
	Uptane ✓
	AUTOSAR Adaptive Platform ✓
SBD Insights & Forecast	

Given the young age of Sibros, the platform itself is likely in a formative state while the development team builds out the product roadmap in accordance with its initial EV customers. Some early focus areas for development include the campaign management toolset as well as building in Uptane compliance as part of its cybersecurity framework.

Overall, we think Sibros will struggle to win new OEM business in the current round of sourcing – at least, with the large, international volume OEMs. If Sibros can grow alongside its EV customers and parlay its Series A financing into a global, scaled platform, it will be in a strong position to enhance its OTA platform to meet broader industry requirements. Sibros must also focus on integrating its OTA capabilities into value-add services such as data management and analytics in order to provide differentiating services to OEMs.

Vehicle Command Center

The Sibros Vehicle Command Center is the **only solution** on the market that works with **existing vehicle hardware**.



Holistic Security Solution

All vehicle-to-cloud communication can now happen through a single bi-directional data pipe compliant with Uptane, the industry leading security framework.



Deep Updates & Deep Logging

Secure updates to all downstream components and sensors, as well as secure data collection (periodic and event triggered).



360° Data on Vehicle Lifecycle

Real-time insight into every vehicle's data from day 0 to end-of-life including: manufacturing (assembly & end-of-line), service, and GDPR compliant data collection.



Enabling the Connected Vehicle Ecosystem

Abstraction of vehicle in the cloud allows new applications (in-house or third-party) to be developed without requiring knowledge of vehicle hardware.

Component architecture not available

Image source: Sibros

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)

EnGIS Technologies

Excelfore
Fujitsu
Harman
HERE
Google
Sibros

Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

Wind River is a traditional embedded software development firm, previously a wholly owned subsidiary of Intel. Intel divested Wind River in 2018 to TPG Capital.

Wind River acquired Arynga, an OTA platform startup, in 2016 in order to enter the OTA market. The OTA services were rebranded as Edge Sync and subsequently marketed to automotive OEMs.

Since acquisition and rebranding, Wind River has positioned Edge Sync alongside its embedded software offerings such as its VxWorks RTOS, Drive (Adaptive AUTOSAR software services), and Chassis (software framework). This gives Wind River a particularly relevant software stack for OEMs which intend to develop their own infotainment stack rather than relying on brought-in platforms such as Android Automotive.

Wind River has announced Ford as an OTA customer.

Company Information

HQ Location	Alameda, CA, USA
Other Locations	100+ (Major: Kanata [Canada], Beijing, Kista [Sweden])
# Employees	1,000 – 1,500 (estimated)
Ownership	Private (TPG Capital)
CEO	Jim Douglas
Founded	1998

Product Timeline

- Wind River Systems founded in Silicon Valley, CA

1981

2009

2016

2018

- Wind River acquired by Intel for \$884M USD

- Intel divests Wind River to TPG Capital
- Wind River announces Ford as OTA customer

News & References

Headline/Reference	Year
Wind River and Airbiquity team on vehicle-to-cloud OTA solutions	2019
Wind River advances automotive OTA technology with differential system	2018
Ford selects Wind River over-the-air update technology	2018
Wind River acquires Arynga	2016

Customers & Partners

Ford

- OTA customer



Airbiquity

- OTA partner



TPG Capital

- Parent company



Arynga

- Acquired by Wind River for OTA

Wind River Platform Overview

Global Suppliers	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client ✓
Supported Standards & Protocols	
Fujitsu	HTTP
Harman	MQTT
HERE	TLS 1.2
Google	OMA-DM
Sibros	LWM2M
Wind River	Information not available
Chinese Suppliers	
ABUP	Websocket
Carota	Uptane
Red Stone	AUTOSAR Adaptive Platform ✓

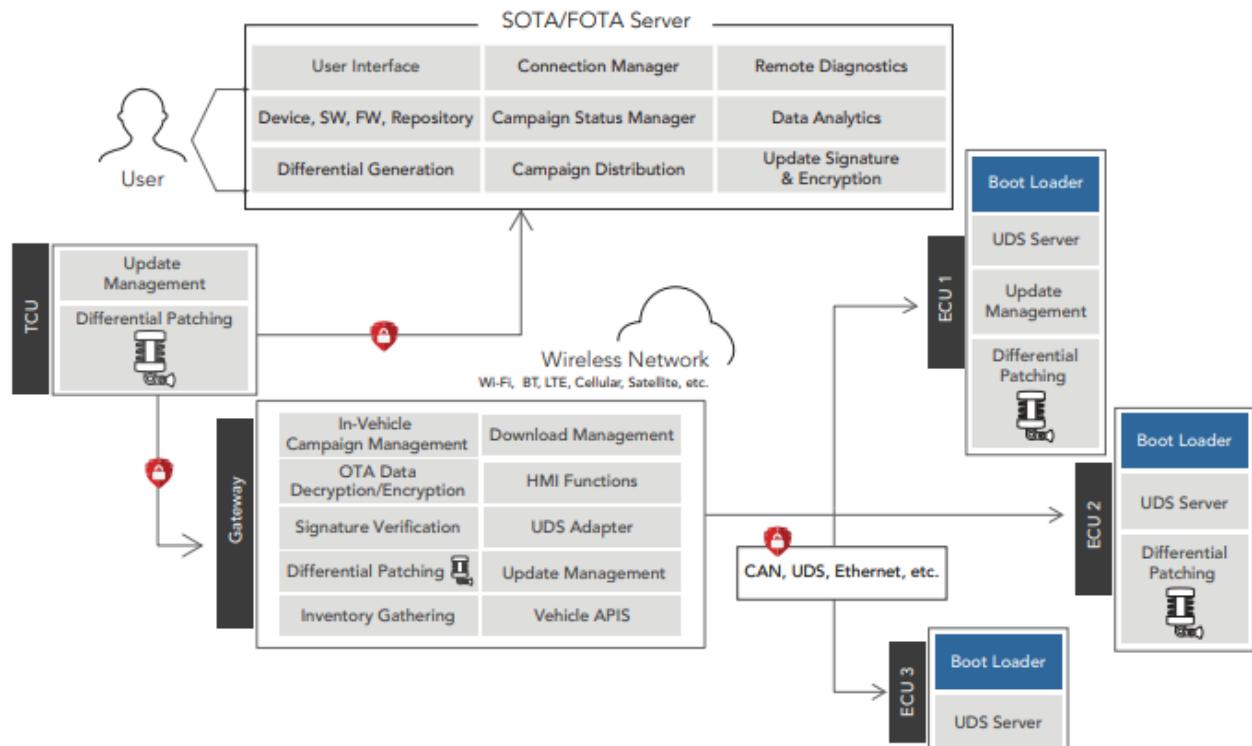


Image Source: Wind River

SBD Insights & Forecast

Arynga, like ATS, was a full member of GENIVI and likely based many of their OTA platform components on the GENIVI Development Platform. Since acquisition in 2016, it is also likely Wind River has adapted a large portion of the software to adapt to its own business requirements while integrating with its various other automotive software platforms. Wind River has built out the platform to a fully-fledged, end-to-end software update platform with campaign management, software differential capabilities, PKI, and device client software. The announcement of Ford as a customer validates the progress that Wind River has made in building out the platform to be sufficient to meet automaker needs.

Positive developments aside, the divestiture to TPG Capital does raise some red flags – who will be the eventual owner of Wind River? What will their business interests entail? The partnership with Airbiquity is also somewhat confusing considering both Airbiquity and Wind River compete directly within the OTA space. The most likely explanation is to prove to both Airbiquity's and Wind River's potential customers that they are willing to be "modular" in their approach and work with multiple OTA vendors to deliver disparate functionality.

Global Suppliers
Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers
ABUP
Carota
Red Stone

Business & Product Summary

ABUP is a leading IoT and IoV (Internet of Vehicles) OTA upgrade solution supplier in China.

ABUP provides an ECU OTA integration service directly to automotive OEMs as well as an end-to-end OTA platform. This includes a cloud OTA management platform, secure wireless pipeline connection, and the construction of automotive product-end upgrade capabilities.

ABUP has developed a wide range of partnerships with OEMs and suppliers in China and provides many chipmaker module manufacturers with professional OTA services.

In addition to automotive, ABUP has ported its OTA solution for bike-sharing programs, updating hundreds of thousands of devices concurrently.

Company Information

HQ Location	Shanghai, China
Other Locations	China (Beijing, Hefei, Chongqing and Shenzhen)
# Employees	60+
Ownership	Private
CEO	Rui Ya'nan
Founded	2017

Product Timeline

- IoV and IoT Divisions were founded for FOTA service in automotive and IoT industries

- ABUP established officially
- Products across automotive electronics, smart home and etc.
- BYD models equipped with ABUP full-vehicle OTA solution launched
- Partnerships with JAC and GM on OTA system construction and service

2015

2016

2017

2018

- Established partnership with BYD
- Developed partnerships with intelligent hardware vendors

- Partnership with Great Wall
- Offers consulting service to OEMs

News & References

Headline/Reference	Year
ABUP participated in the Automotive Information Security Standards Working Group Meeting as a representative member of the OTA field	2019
ABUP becomes the first FOTA service provider passing the certification test of China Telecom IoT open platform	2018
ABUP announces ABUP Brand, Automotive OTA upgrade solution, and IoT OTA solution.	2017

Customers & Partners



BYD

- OEM mainly focusing on NEV



JAC

- OEM customer



General Motor

- OEM customer



Great Wall

- OEM customer



MAXIEYE

- ADAS system and solution technology supplier

ABUP ABUP Platform Overview



Global Suppliers

	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client
	Supported Standards & Protocols
HTTP	✓
MQTT	
TLS 1.2	✓
OMA-DM	✓
LWM2M	
WebSocket	

Chinese Suppliers

ABUP
[AUTOSAR Adaptive Platform](#)

Carota

Red Stone

Functional Components

PLM Database
Vehicle Identification ✓
Delta Preparation ✓
Software Signing & Encryption ✓
Campaign Management ✓
Content Delivery Network (CDN) ✓
Master Device Client ✓
Secondary Device Client

Supported Standards & Protocols

HTTP	✓
MQTT	
TLS 1.2	✓
OMA-DM	✓
LWM2M	
WebSocket	

Docking with other platforms



UA: Update Agent

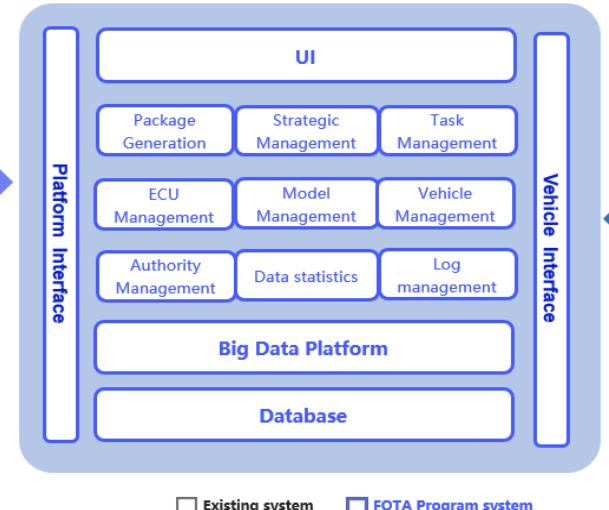
UC: Update Controller

UP: Update Protocol

UI: User Interface

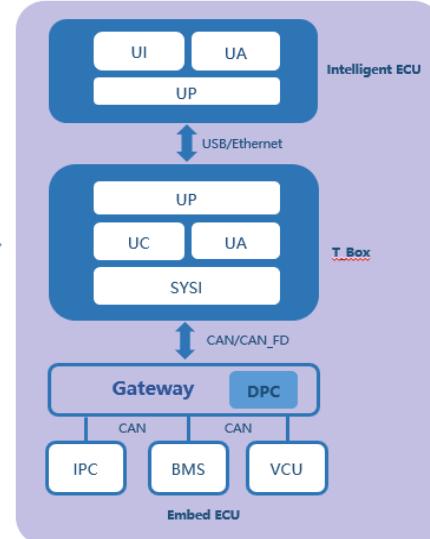
DPC: Diagnostic Programming Controller

OTA Management Platform



Existing system FOTA Program system

Vehicle Update programs



SBD Insights & Forecast

ABUP has emerged as an industry leader in the Chinese OTA market, with multiple OEM customers supporting the initial rollout of the OTA system within the last three years. Through ABUP's public documentation and presentation, they have clearly demonstrated proficiency in the space, providing the full range of functions required for OEMs to deploy OTA updates.

In the future, we expect ABUP to collaborate with additional OEMs in the China market, adapting its product to the demands of its customers as their OTA programs mature.

One key differentiator of ABUP is its consulting offering to OEMs, providing hands-on support to OEMs building out their initial OTA program and sustaining it over time.

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

Carota provides full vehicle OTA solutions and network security services. It is a joint venture from MediaTek, Trend Micro, SingTel Innov8, CDIB, CID venture and ARM China mentor fund. Its OTA services has covered more than 300 million intelligent devices in over 20 countries and regions across US, Germany, China, Taiwan, India, Russia and Southeast Asia.

Since establishment, OTA has become its core business. The company has developed advantages in self-developed upgrading architectures, high compression efficiency, and protection mechanisms for different working conditions. Cryptographic digital signatures, encrypted channels, secure boot. Additional solutions such as connecting with a third-party PKI are also available.

Company Information

HQ Location	Shanghai (China)
Other Locations	Sunnyvale (CA, USA), Taipei (Taiwan), India, Russia, Southeast Asia
# Employees	Around 80 by 2018 Sep
Ownership	Joint Venture
CEO	Paul Wu
Founded	2011

Product Timeline



News & References

Headline/Reference	Year
Carota cooperates with Jingwei Hirain on full-vehicle OTA	2019
Carota showcases its latest OTA update demo at Shanghai	2018
Dongfeng fxauto T5 equipped with Carota OTA	2018

Customers & Partners

	Dongfeng Auto	<ul style="list-style-type: none"> OEM customer
	Weltmeister	<ul style="list-style-type: none"> Chinese start-up OEM
	Geely Auto	<ul style="list-style-type: none"> OEM customer
	Jingwei Hirain	<ul style="list-style-type: none"> Tier 1 supplier

Global Suppliers

	Functional Components
Aeris	PLM Database
Airbiquity	Vehicle Identification ✓
Aptiv	Delta Preparation ✓
Aurora Labs	Software Signing & Encryption ✓
Bosch	Campaign Management ✓
Elektrobit (Continental)	Content Delivery Network (CDN) ✓
EnGIS Technologies	Master Device Client ✓
Excelfore	Secondary Device Client ✓

Supported Standards & Protocols

HTTP	✓
MQTT	
TLS 1.2	✓
OMA-DM	
LWM2M	
Websocket	

Chinese Suppliers

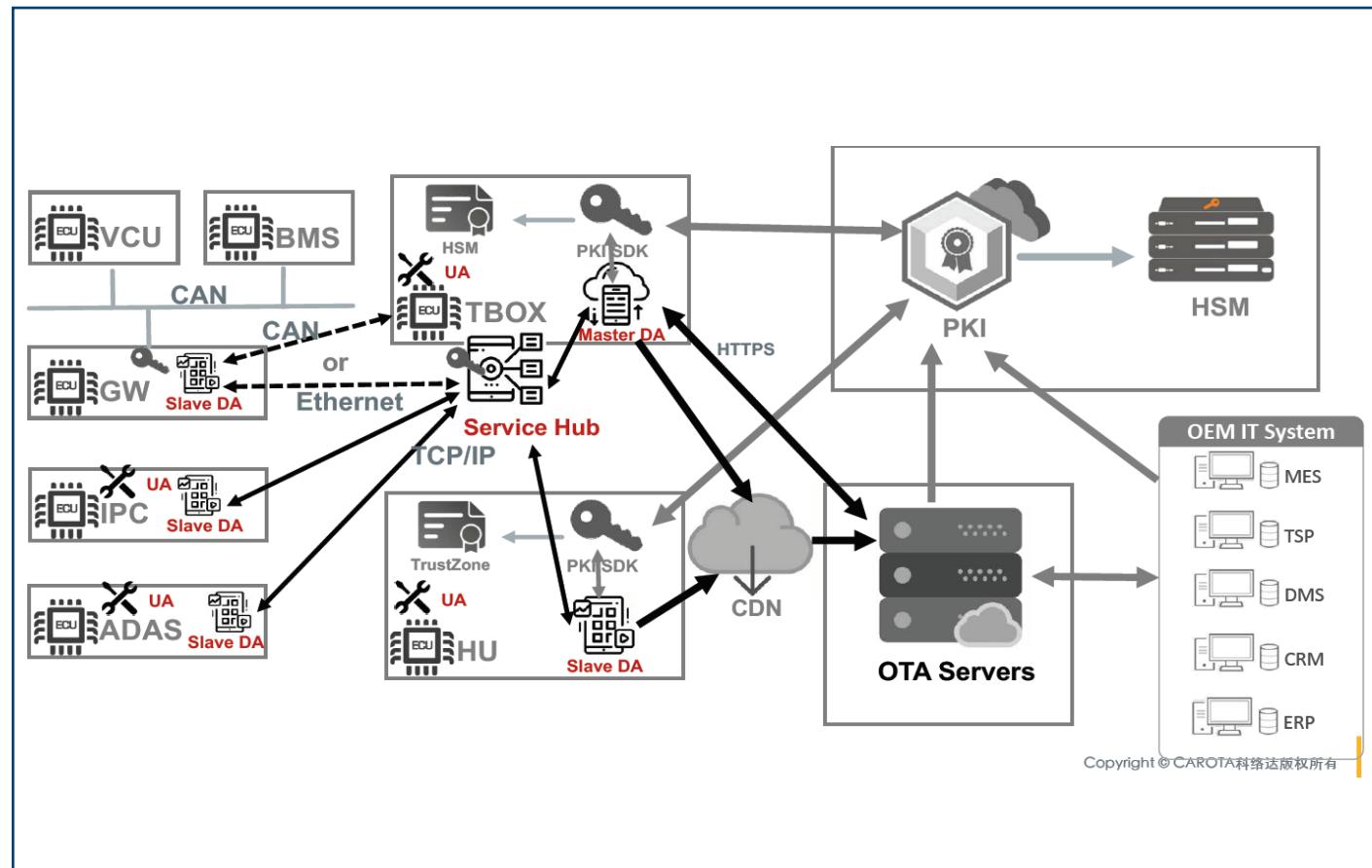
ABUP
Carota

Red Stone

SBD Insights & Forecast

Carota has engaged with many OEMs, including Geely, Volvo, Zotye, Hozon, Weltmeister, and Dongfeng. While there is not much public information on the platform and its maturity, we would expect at least some level of maturity given the technology has launched on at least one production program (Dongfeng). However, we believe many of these OEM engagements are on partial or smaller programs, not on entire fleets or brands.

Based on available information, the solution itself seems to provide the “bar bones” tools necessary to support over the air updates, and these tools will be enhanced as OEM programs and their attendant requirements mature.



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Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Business & Product Summary

Red Stone's primary businesses are in auto OTA, IoT, and smartphone OTA. As one of the largest OTA service providers in China, Red Stone claims to occupy more than 60% of DM/FOTA market share in China as of October 2018. Globally, it provides OTA update services for 670 million intelligent terminals and IoT devices covering 226 countries and regions. Red Stone claimed itself as the only automotive OTA upgrade company in China that has both equipment upgrade capability and in-depth development of in-vehicle systems.

According to Red Stone, it has cooperated with Chery, BYD, BAIC, Dongfeng, Great Wall and other OEMs, with 1.26 million vehicles using Redstone OTA platform. Red Stone also claims that at least 2,200 vehicles are added to its platform every day.

Company Information

HQ Location	Beijing (China)
Other Locations	Shanghai, Shenzhen (China) and San Diego (CA, USA)
# Employees	50-150
Ownership	Public
CEO	Han Liguang
Founded	2011

Product Timeline



News & References

Headline/Reference	Year
Redstone IoV OTA Enablement Platform released	2018
Redstone Sunshine OTA boosts Samsung Galaxy P30	2018/2017
Redstone Sunshine signed cooperation with ARM	2018/2017
Redstone Sunshine Launches FOTA IOT Service Platform	2017
Redstone Sunshine released the car network security FOTA solution	2016

Customers & Partners

	BYD	• OEM customer
	Dongfeng	• OEM customer
	BAIC	• OEM customer
	Chery	• OEM customer
	China Mobile	• MNO partner

Global Suppliers

Aeris
Airbiquity
Aptiv
Aurora Labs
Bosch
Elektrobit (Continental)
EnGIS Technologies
Excelfore
Fujitsu
Harman
HERE
Google
Sibros
Wind River

Chinese Suppliers

ABUP
Carota
Red Stone

Functional Components

PLM Database
Vehicle Identification
Delta Preparation
Software Signing & Encryption
Campaign Management
Content Delivery Network (CDN)
Master Device Client
Secondary Device Client

Supported Standards & Protocols

HTTP
MQTT
TLS 1.2
OMA-DM
LWM2M
Websocket

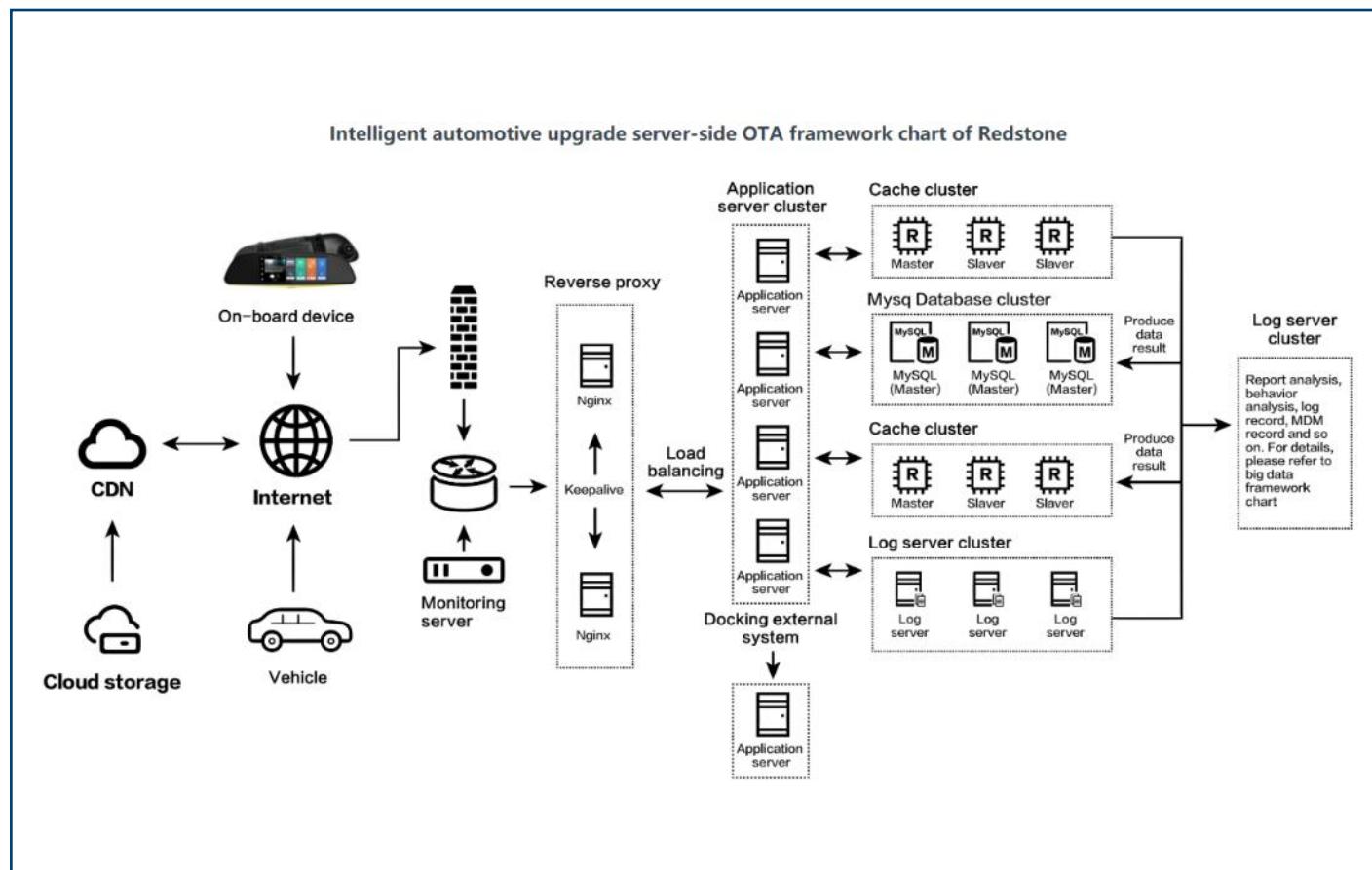
Uptane

[AUTOSAR Adaptive Platform](#)

SBD Insights & Forecast

Given that Red Stone has launched multiple OEM OTA programs, including with Dongfeng, Chery, and BYD, they have significant credibility amongst their competitors as additional OEMs consider which OTA providers to work within in the market. However, the back-end services available on the platform still seem to lag behind those available from some of the global market leaders such as Harman, which is to be expected given the relatively young age of Red Stone.

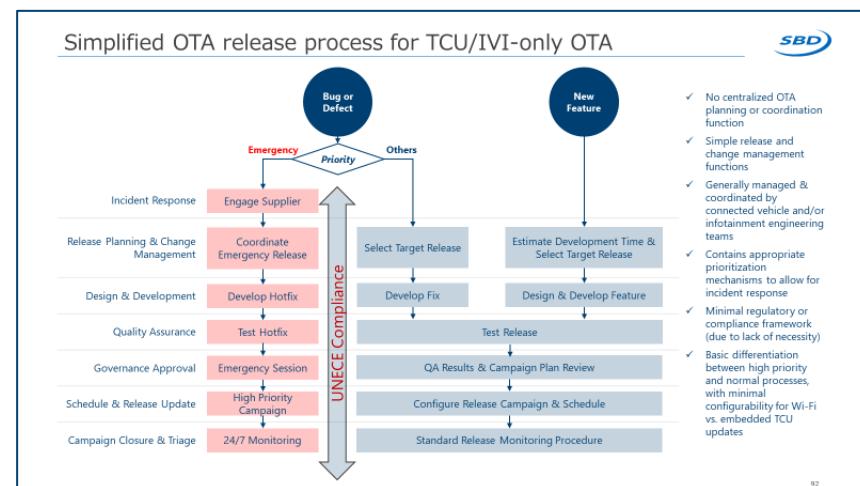
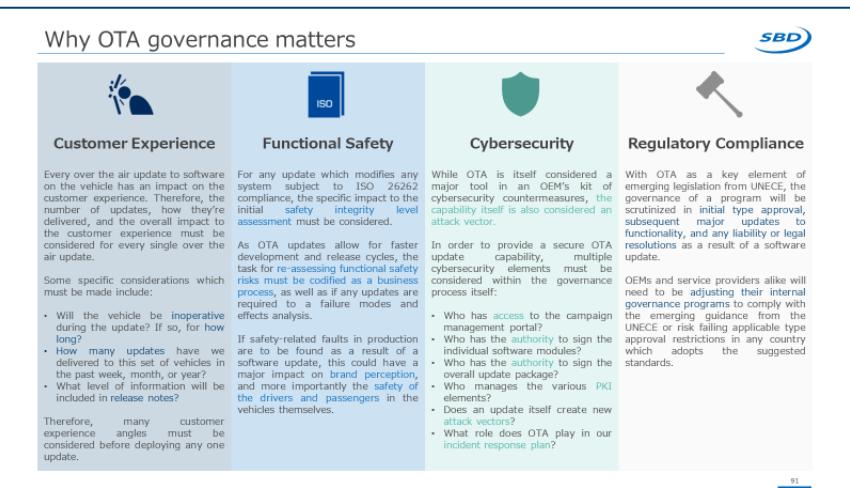
Red Stone will look to continue its growth domestically within the China market with primarily domestic OEMs.



Executive Summary	Introduction	Customer Experience	OEM Strategies & Case Studies	OTA Suppliers
<ul style="list-style-type: none">• OTA definitions• Primary report takeaways	<ul style="list-style-type: none">• OTA timeline• OTA in automotive• Subscription strategy• EV vs. ICE differences	<ul style="list-style-type: none">• Importance of customer experience• Touchpoints• OEM examples• Recommendations	<ul style="list-style-type: none">• OTA timeline• Connectivity methods• OTA use cases• Overview of OEMs	<ul style="list-style-type: none">• Overview OTA suppliers
Pages 6-10	Pages 11-15	Pages 16-21	Pages 22-47	Pages 48-83

Governance	Technical Topics	Connectivity Strategy	Regulatory Activity	Industry Activity
<ul style="list-style-type: none">• Importance of OTA governance• OTA release process• OTA governance for organization	<ul style="list-style-type: none">• OTA solution architecture• OTA E/E architecture• Software sourcing trend• Cybersecurity	<ul style="list-style-type: none">• Types of connectivity• Connectivity challenges• OEM strategies• SBD view on OEM strategies	<ul style="list-style-type: none">• UNECE WP.29• European Union• United States• Other major federal activity	<ul style="list-style-type: none">• Uptane• Open Mobile Alliance• GENIVI• eSync Alliance• AUTOSAR• ISO/SAE
Pages 84-89	Pages 90-102	Pages 103-108	Pages 109-115	Pages 116-124

Section introduction



Questions answered:

- Why OTA governance matters?
- What does a simplified OTA release process for TCU/IVI-only OTA look like?
- What does a simplified OTA release process for ADAS+ OTA look like?
- What type of OTA governance structure would suit your organization?

Why OTA governance matters



Customer Experience

Every over the air update to software on the vehicle has an impact on the customer experience. Therefore, the number of updates, how they're delivered, and the overall impact to the customer experience must be considered for every single over the air update.

Some specific considerations which must be made include:

- Will the vehicle be **inoperative** during the update? If so, for **how long?**
- **How many updates** have we delivered to this set of vehicles in the past week, month, or year?
- What level of information will be included in **release notes?**

Therefore, many customer experience angles must be considered before deploying any one update.



Functional Safety

For any update which modifies any system subject to ISO 26262 compliance, the specific impact to the initial **safety integrity level assessment** must be considered.

As OTA updates allow for faster development and release cycles, the task for **re-assessing functional safety risks must be codified as a business process**, as well as if any updates are required to a failure modes and effects analysis.

If safety-related faults in production are to be found as a result of a software update, this could have a major impact on **brand perception**, and more importantly the **safety of the drivers and passengers** in the vehicles themselves.



Cybersecurity

While OTA is itself considered a major tool in an OEM's kit of cybersecurity countermeasures, **the capability itself is also considered an attack vector**.

In order to provide a secure OTA update capability, multiple cybersecurity elements must be considered within the governance process itself:

- Who has **access** to the campaign management portal?
- Who has the **authority** to sign the individual software modules?
- Who has the **authority** to sign the overall update package?
- Who manages the various **PKI** elements?
- Does an update itself create new **attack vectors**?
- What role does OTA play in our **incident response plan**?

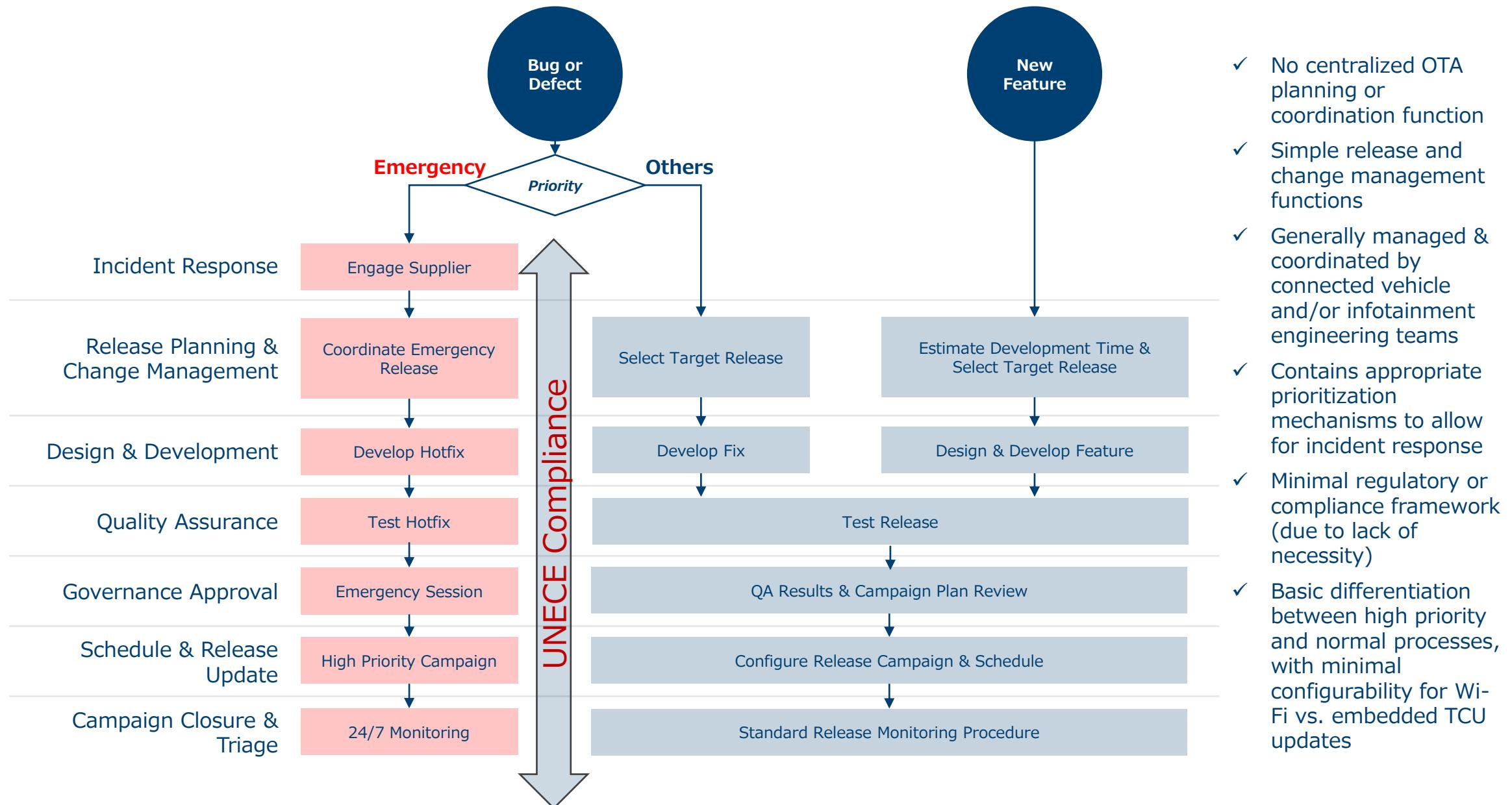


Regulatory Compliance

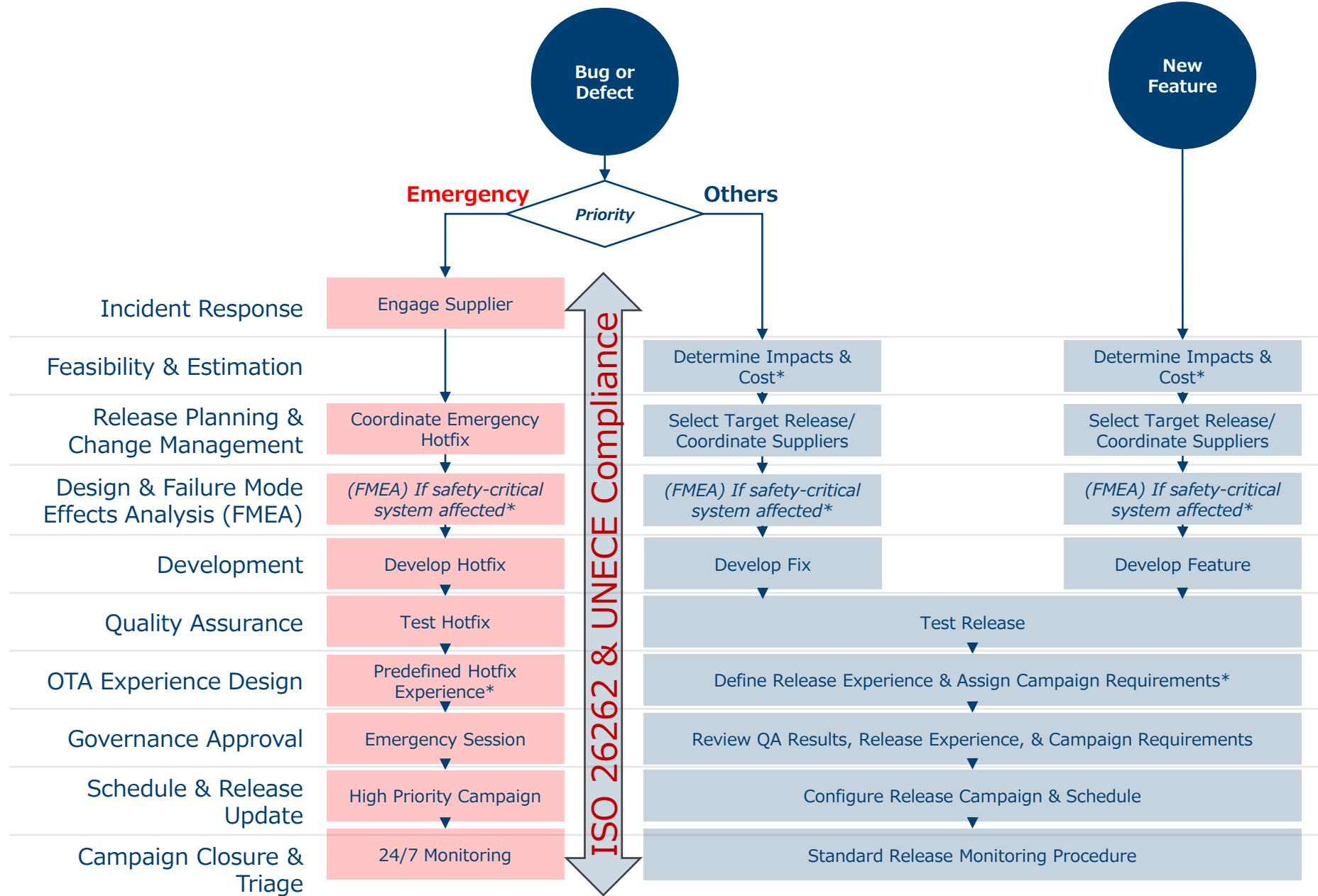
With OTA as a key element of emerging legislation from UNECE, the governance of a program will be scrutinized in **initial type approval, subsequent major updates to functionality, and any liability or legal resolutions** as a result of a software update.

OEMs and service providers alike will need to be **adjusting their internal governance programs** to comply with the emerging guidance from the UNECE or risk failing applicable type approval restrictions in any country which adopts the suggested standards.

Simplified OTA release process for TCU/IVI-only OTA



Simplified OTA release process for ADAS+ OTA



- ✓ Requires additional QA to ensure adherence to functional safety standards
- ✓ Process can depend on type of in-vehicle electrical architecture, i.e. the level of abstraction between hardware/sensors and software
- ✓ Requires coordinated, dedicated resources to manage the OTA process, including at least one individual who is responsible for ensuring OTA releases are not too frequent or intrusive unless absolutely necessary
- ✓ Requires additional due diligence to ensure accurate impact analysis and cost estimation up front due to broader architectural impacts, particularly with new features

Right-sizing the OTA governance for your organization



Not every OTA program will require the same types of processes, number of dedicated resources, or release planning functions. However, as small-scale OTA programs handling only a few updates per year grow, certain new requirements will emerge. Below we have outlined some of our recommended enhancements to OTA governance programs as they mature.

Baseline (All Programs or Hotfix Only)



Governance Committee

The governance committee is responsible for ensuring all aspects of the OTA program operate in accordance with the company's intended use of the technology. The committee acts as the voice of the executive in all matters related to decision-making for costs, impacts, priorities, and releases, and comprises of stakeholders across different organizations.

Any program with OTA update capabilities should have a governance committee with oversight over usage of the service in order to avoid any miscommunication between management, product, and engineering organizations.



Change & Release Management

The change and release management function tracks, manages, and escalates all elements of the process from when an issue is discovered to the release of the fix as well as from when a feature is conceived to when it is launched into production.

The core mandate of the change & release management function is to ensure the overall flow of software into production is done in a coordinated manner, avoiding certain risks such as poor communication between teams and providing a single management entity that works across the different groups in the OTA process.



Compliance Auditor

The compliance auditor ensures the OTA program maintains compliance with all applicable regulations, such as type approval or cybersecurity.

This function is primarily necessary for the upcoming UNECE type approval recommendations but may also provide compliance audit functions for related standards such as ISO 26262 (functional safety), ISO/SAE 21434 (cybersecurity), ISO 27001 (IT security), and others.

+ Releases



Issue Prioritization Framework

Once the OTA capability becomes more frequently used by various teams, it will not be possible to manage each individual software change as a single update. Instead, prioritization must be used to ensure that higher priority issues are resolved first.

This prioritization also will come along the packaging of releases to ensure that vehicle owners don't have to deal with constant updates. Instead, they will receive updates on a predictable schedule (e.g. once per month) except for in emergency circumstances.

+ Features



Product Owner

Broadly speaking, a product owner is a stakeholder who is accountable for the delivery of a specific product or service to a customer. In the context of OTA, an "OTA Product Owner" would be the stakeholder whose day-to-day mandate is to ensure the capability is delivering on its promises to the business.

The OTA product owner would work with (or within) the change and release management function to coordinate releases, while further peering with other organizations such as marketing, revenue management, and others to ensure new features or releases are properly evangelized.



User Experience Design

As releases become bigger and/or more frequent, it becomes of utmost importance to ensure the end customer sees a net benefit from the technology. If the experience is annoying, is prone to failure, or not friendly overall, using OTA to deploy new features could even result in a net negative to the brand's perception.

The OTA user experience design function would be accountable for scoping, designing, and leveraging the appropriate user channels and engineering design decisions to ensure each release is done in a user-friendly way.

Greater Maturity

Technical topics



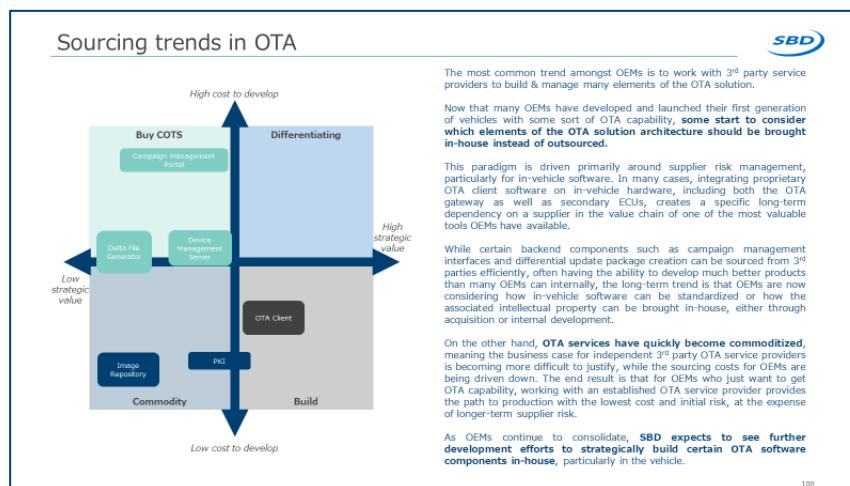
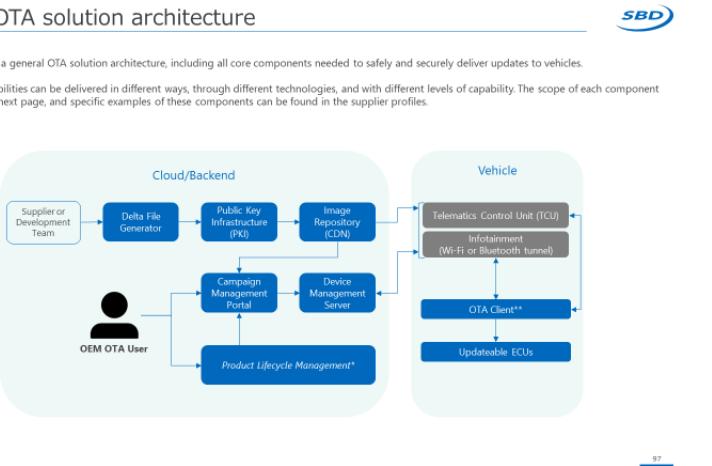
<h3>Executive Summary</h3> <ul style="list-style-type: none">• OTA definitions• Primary report takeaways <p>Pages 6-10</p>	<h3>Introduction</h3> <ul style="list-style-type: none">• OTA timeline• OTA in automotive• Subscription strategy• EV vs. ICE differences <p>Pages 11-15</p>	<h3>Customer Experience</h3> <ul style="list-style-type: none">• Importance of customer experience• Touchpoints• OEM examples• Recommendations <p>Pages 16-21</p>	<h3>OEM Strategies & Case Studies</h3> <ul style="list-style-type: none">• OTA timeline• Connectivity methods• OTA use cases• Overview of OEMs <p>Pages 22-47</p>	<h3>OTA Suppliers</h3> <ul style="list-style-type: none">• Overview OTA suppliers <p>Pages 48-83</p>
<h3>Governance</h3> <ul style="list-style-type: none">• Importance of OTA governance• OTA release process• OTA governance for organization <p>Pages 84-89</p>	<h3>Technical Topics</h3> <ul style="list-style-type: none">• OTA solution architecture• OTA E/E architecture• Software sourcing trend• Cybersecurity <p>Pages 90-102</p>	<h3>Connectivity Strategy</h3> <ul style="list-style-type: none">• Types of connectivity• Connectivity challenges• OEM strategies• SBD view on OEM strategies <p>Pages 103-108</p>	<h3>Regulatory Activity</h3> <ul style="list-style-type: none">• UNECE WP.29• European Union• United States• Other major federal activity <p>Pages 109-115</p>	<h3>Industry Activity</h3> <ul style="list-style-type: none">• Uptane• Open Mobile Alliance• GENIVI• eSync Alliance• AUTOSAR• ISO/SAE <p>Pages 116-124</p>

Section introduction

General OTA solution architecture

This chart describes a general OTA solution architecture, including all core components needed to safely and securely deliver updates to vehicles.

Many of these capabilities can be delivered in different ways, through different technologies, and with different levels of capability. The scope of each component is described on the next page, and specific examples of these components can be found in the supplier profiles.



Questions answered:

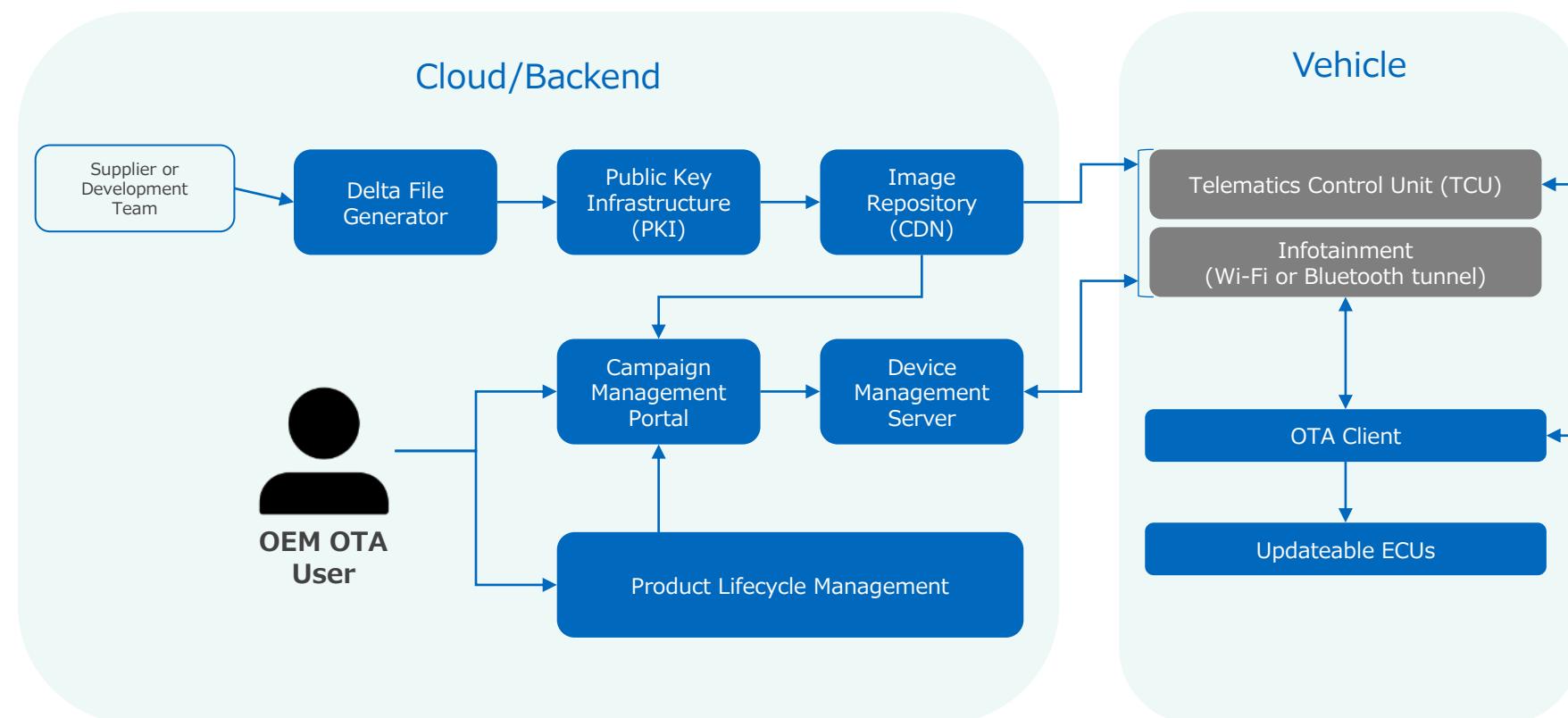
- What does a general OTA solution architecture look like?
- How can OTA components be defined?
- What are the latest sourcing trends in OTA?
- What does a lifecycle look like for an OTA update?
- What types of attacks are OTA updates exposed to & what can be done to prevent them?
- How do the latest cybersecurity trends affect OTA updates?

General OTA solution architecture



This chart describes a general OTA solution architecture, including all core components needed to safely and securely deliver updates to vehicles.

Many of these capabilities can be delivered in different ways, through different technologies, and with different levels of capability. The scope of each component is described on the next page, and specific examples of these components can be found in the supplier profiles.



Component descriptions



	Component	Function	COTS Examples
Backend	Delta File Generator	Reduce the footprint of a software package by generating a secondary file which contains only the differences between the current software and an older version of the software	<ul style="list-style-type: none"> bsdiff (FOSS) xdelta (FOSS) open-vcdiff (FOSS)
	Public Key Infrastructure	Store, manage, and coordinate all roles, policies and procedures required for the digital certificates used within the OTA solution	<ul style="list-style-type: none"> OpenXPKI (FOSS) Dogtag PKI (FOSS) Enterprise PKI (Proprietary)
	Image Repository (CDN)	Store all final images on a collection of file servers which are accessible by the vehicle in all markets where OTA is enabled, often leveraging a CDN	<ul style="list-style-type: none"> Amazon CloudFront (Proprietary) Azure CDN (Proprietary) Key CDN (FOSS)
	Campaign Management Portal	A purpose-built web portal which allows OEM users and developers to upload and sign images as well as configure, approve, and manage campaign workflows	<ul style="list-style-type: none"> See <i>Supplier Solutions section (all proprietary)</i>
	Device Management Server	Defines and manages the metadata associated with each OTA-enabled vehicle. Provides metadata to vehicle upon request and tracks current software levels on vehicle	<ul style="list-style-type: none"> Leshan (FOSS – LWM2M) Telit IoT Platform Many COTS Campaign Management Portals support DM functions as well
Vehicle	OTA Client	Software running on a vehicle device that acts as the client to both the Device Management Server and Image Repository. Orchestrates OTA workflow through metadata verification, image download, and installation	<ul style="list-style-type: none"> Often integrated w/ TCU or IVI Often provided as pair with device management server or campaign management portal
	Updateable ECUs (Secondary OTA Client)	Secondary OTA client software running on updateable ECUs which receive instructions and images from the primary OTA client. If using UDS or other existing diagnostic protocol(s), may not be required	<ul style="list-style-type: none"> Aktualizr (FOSS)

OTA & E/E architecture

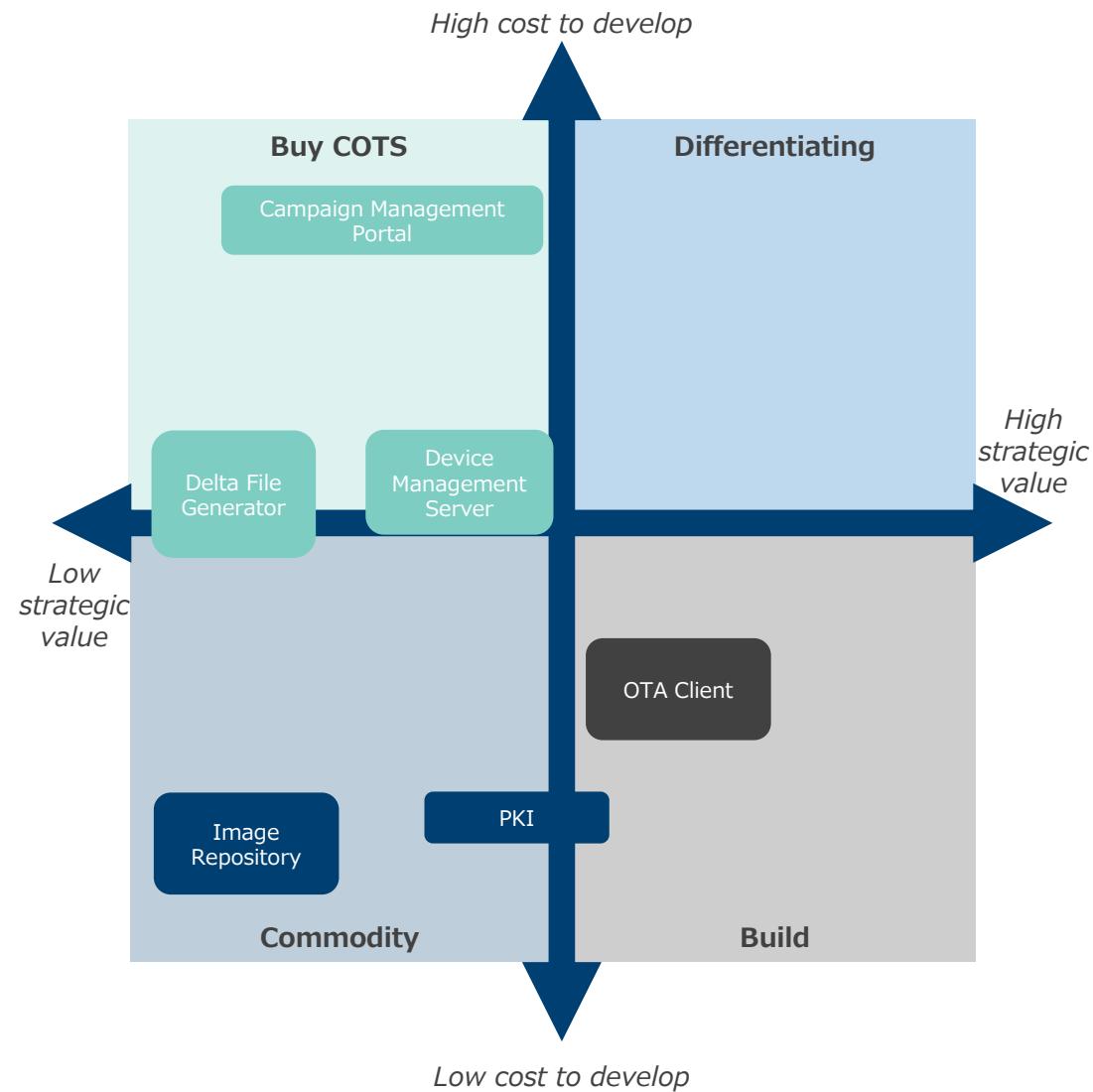


A core enabler of OTA is the design of the vehicle's in-vehicle electrical architecture. Below we have identified key recommended technical requirements for the vehicle architecture to enable the different levels of OTA.

For a comprehensive evaluation and forecast of the future of in-vehicle E/E architecture and networks, please refer to SBD report 630:
Evolution and Technology Drivers for Next-Generation E/E Architectures

Requirement:	Level of OTA:	Infotainment Apps	Connectivity Module (4G or Wi-Fi)	Infotainment (All software)	ADAS ECUs	All ECUs	Electric Vehicles	Explanation
Requirement:	App Framework	✓						App framework allows for sandboxed applications to be updated in the IVI
	Customer Registration	✓	✓	✓	✓	✓	✓	Customer registration is required in order to gain consent to perform software updates
	Device Management System	✓	✓	✓	✓	✓	✓	The DM server is required to manage the metadata associated with software, firmware, and app versions
	Content Delivery Network (CDN)	✓	✓	✓	✓	✓	✓	The CDN is required to host and deliver large files efficiently in different served markets/regions
	Software Signing	✓	✓	✓	✓	✓	✓	All apps and firmware must be appropriately signed in accordance with the cybersecurity design of the system
	OTA Encryption (PKI)	✓	✓	✓	✓	✓	✓	All transmissions, including both metadata and files themselves, must be encrypted between vehicle and cloud
	OTA Gateway		✓	✓	✓	✓	✓	The in-vehicle OTA gateway is necessary to act as the orchestrator between the cloud and the vehicle ECUs. It hosts the primary OTA client
	Intrusion Detection/Prevention			✓	✓	✓	✓	Some level of IDPS is necessary to detect behavior which exploits update functionality
	Advanced Battery Management			✓	✓	✓	✓	Enhanced battery management, particularly in ICE vehicles, is required to ensure there is no loss of power during the update process
	Non-CAN Integration			✓	✓	✓	✓	Modern vehicles have many different types of networks, requiring the OTA system to efficiently integrate across disparate network types
	Multiple Functional Safety Domains			✓	✓	✓	✓	Functional safety domains allow software updates to be logically orchestrated to prevent unexpected failure modes

Sourcing trends in OTA



The most common trend amongst OEMs is to work with 3rd party service providers to build & manage many elements of the OTA solution.

Now that many OEMs have developed and launched their first generation of vehicles with some sort of OTA capability, **some start to consider which elements of the OTA solution architecture should be brought in-house instead of outsourced.**

This paradigm is driven primarily around supplier risk management, particularly for in-vehicle software. In many cases, integrating proprietary OTA client software on in-vehicle hardware, including both the OTA gateway as well as secondary ECUs, creates a specific long-term dependency on a supplier in the value chain of one of the most valuable tools OEMs have available.

While certain backend components such as campaign management interfaces and differential update package creation can be sourced from 3rd parties efficiently, often having the ability to develop much better products than many OEMs can internally, the long-term trend is that OEMs are now considering how in-vehicle software can be standardized or how the associated intellectual property can be brought in-house, either through acquisition or internal development.

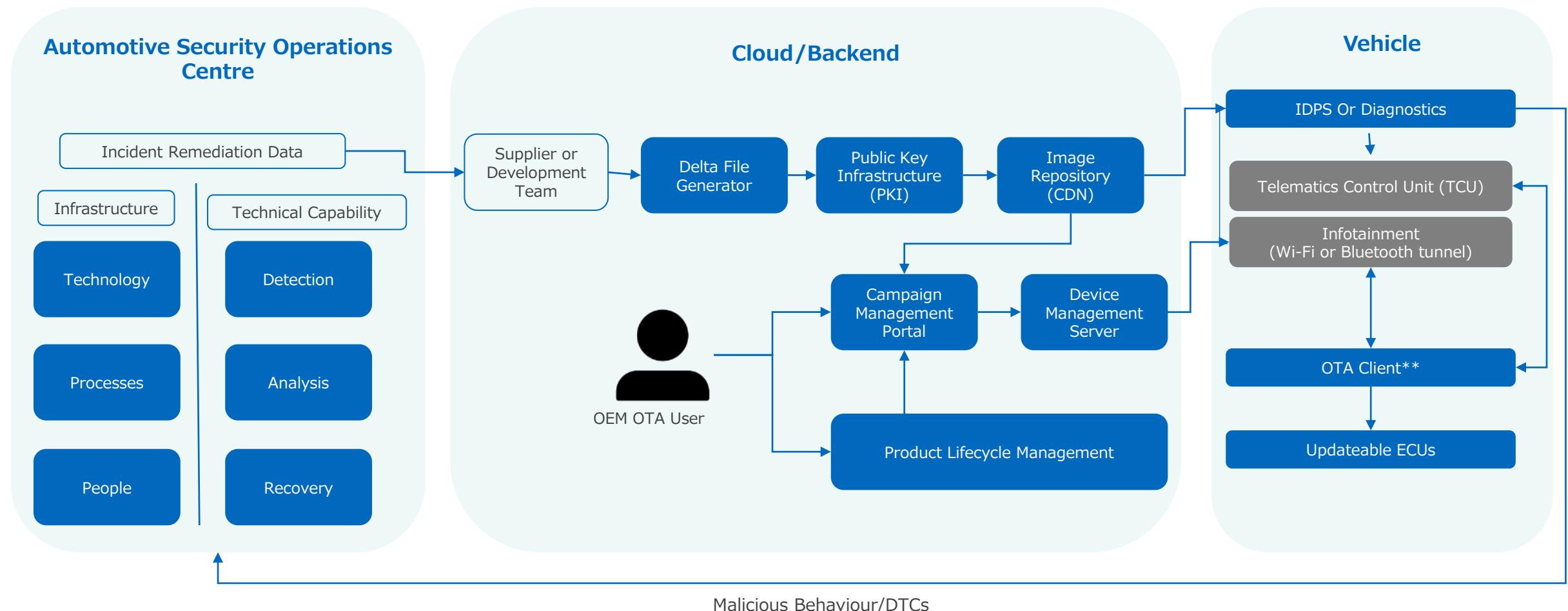
On the other hand, **OTA services have quickly become commoditized**, meaning the business case for independent 3rd party OTA service providers is becoming more difficult to justify, while the sourcing costs for OEMs are being driven down. The end result is that for OEMs who just want to get OTA capability, working with an established OTA service provider provides the path to production with the lowest cost and initial risk, at the expense of longer-term supplier risk.

As OEMs continue to consolidate, **SBD expects to see further development efforts to strategically build certain OTA software components in-house**, particularly in the vehicle.

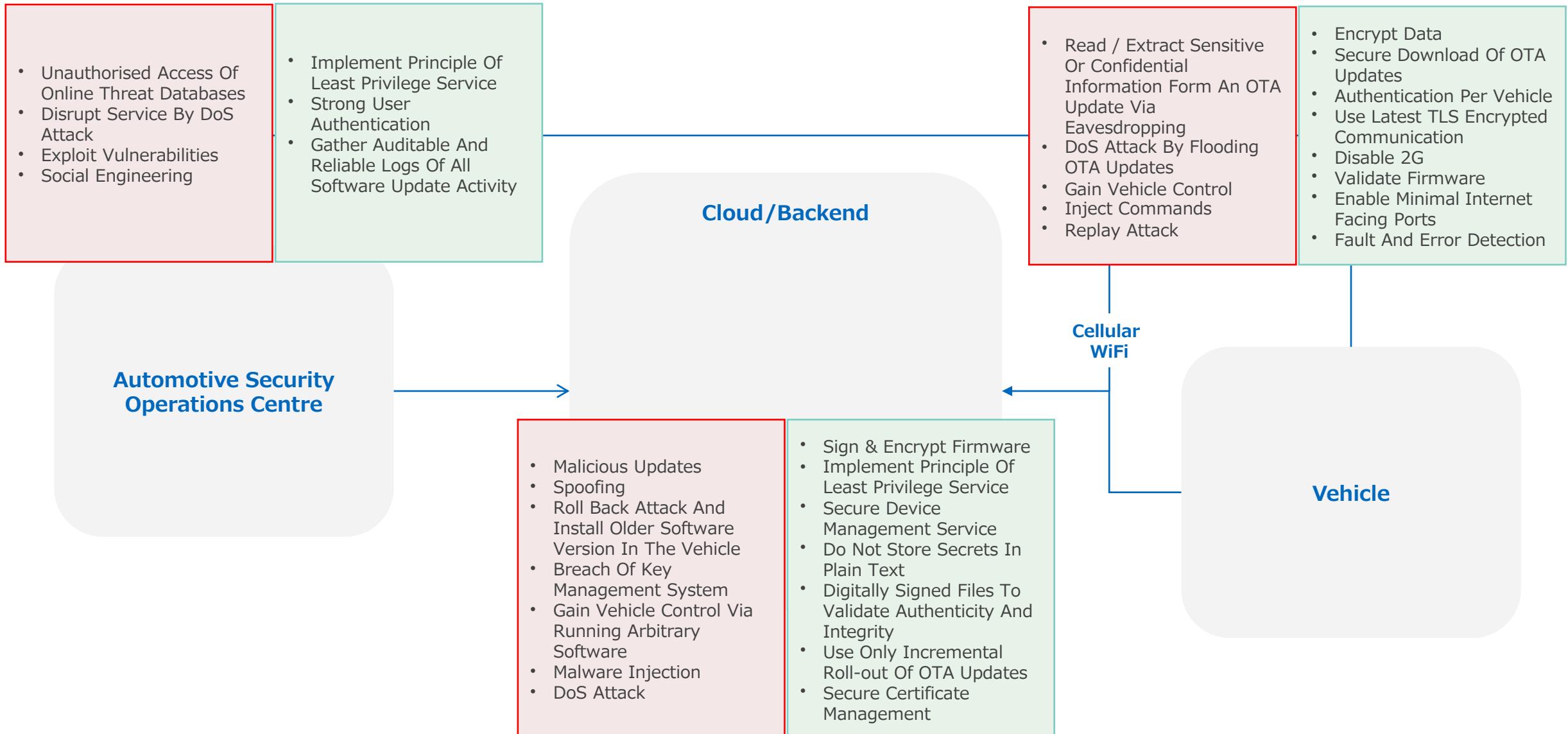
OTA cybersecurity lifecycle



The diagram below shows the complete lifecycle of the Over-The-Air (OTA) updates for vehicles, including an Automotive Security Operations Centre (ASOC) and IDPS or Diagnostics for reporting incidents and perform further analysis.



High-level attacks & countermeasures overview



Future OTA E/E architecture considerations



Current E/E	Future E/E
<p>Most of the E/E architectures today follow an <i>ECU/Function Centric approach</i> that utilize a Distributed or Central Gateway for in-vehicle network communication</p>	<p>The two major mainstream factors that drive the evolution of automotive OTA are the following:</p> <p>1. Service Oriented E/E Architecture (SOA): One of the key enablers of such architecture is FOTA. In this regard gateways, with their central positioning on the network, are increasingly taking up the role of Onboard FOTA manager.</p> <p>The cost/weight/flexibility benefits, together with the need of high-performance computing platforms, are accelerating ECU consolidation. This gives rise to Domain Controllers (DC), with each DC expected to function as a local multi-protocol gateway, and also serve as the main domain node on the Ethernet based backbone network.</p> <p>An extension of DC based architecture with fused domain would make Connected Gateways a more attractive and viable option.</p> <p>SOA also requires flexible/adaptable hardware agnostic software platforms on gateways that could manage time sensitive service oriented communication routing. This largely drives the introduction of new CPU architectures and the Adaptive AUTOSAR platform.</p> <p>2. Cyber Security: With increased connectivity and domain consolidation of computing platforms to enable functions of mixed safety and security criticality, the need for hardware security elements (e.g. TPM, HSM etc.) on Gateways are also on the rise, to ensure secure execution environments. GWs, with their full visibility of the in-vehicle network communication, are naturally expected to take the role of an onboard trust anchor. Being centrally placed allows them to host more advanced cyber controls, such as IDPS (Intrusion Detection and Prevention Systems) and key manager for message encryption/authentication etc.</p>
<p>SBD's research into the current ASIL level ratings for OTA suggests that most OTA implementations are rated at either QM or ASIL B</p>	<p>The combination of the FOTA and Gateway for safety critical vehicle functions in a highly consolidated domain controller architecture poses a new challenge in ISO 26262 certification while solving many issues from legacy architectures.</p> <p>Future OTA requirements on Gateways are likely to change from QM/B to ASIL C/D. Even though actual ASIL levels must be determined on a case-by-case basis by OEMs it is recommended that the Onboard FOTA manager service implemented on a gateway assume the highest level of ASIL level by default.</p>

Security products for protecting OTA lifecycle

While analysis of OTA products is given earlier in this report, the table below outlines a list of security products that can be used to protect the whole OTA lifecycle, including SOCs and IDPS.

Company Name	Products For Protecting OTA Lifecycle	Links
Argus	<ul style="list-style-type: none"> • IDPS • Diagnostic Authenticator • ASOC • Argus Differential OTA Update 	Website
Arilou	<ul style="list-style-type: none"> • IDPS – Maintenance With Secure Updates • SIEM/SOC Backend Solution – Secure Firmware Updates 	Website
Apollo (Baidu)	<ul style="list-style-type: none"> • Cyber Security 4S • Non-recall Repair, Bug Fixes and OTA Updates • IDPS 	Website
Cymotive	<ul style="list-style-type: none"> • CIDS – Cymotive Intrusion Detection System 	Website
Enigmatos	<ul style="list-style-type: none"> • CAN Parasite Detector (CPD) – Analysis and Policy Update, SOC 	Website
ESCRYPT	<ul style="list-style-type: none"> • Secure OTA Management • CycurKEYS • CycurTLS 	Website
Gemalto	<ul style="list-style-type: none"> • Cinterion – Secure OTA Management of Security Credentials 	Website
Harman (Samsung)	<ul style="list-style-type: none"> • Harman Shield – IDPS • SOC 	Website
Movimento	<ul style="list-style-type: none"> • Secure OTA Management System 	Website
Panasonic	<ul style="list-style-type: none"> • IDPS 	Website
Penta Security Systems	<ul style="list-style-type: none"> • AutoCrypt KMS – Key Management System 	Website
Trillium	<ul style="list-style-type: none"> • vSEC – IDPS • Trusted V2C Data Transport 	Website

SBD publishes a comprehensive guide to the automotive cybersecurity landscape once per quarter.

SBD's Cyber Guide contains overviews of every major automotive cybersecurity supplier as well as major news, events, trends, and data.

In addition, our team of world-class automotive cybersecurity analysts and penetration tests work with automakers and suppliers around the globe to strategize, plan, design, and penetration test both OTA and connected & autonomous vehicle platforms, both in the vehicle and in the cloud.

For more information on the Cyber Guide or our cybersecurity practice, please consult your SBD sales representative.

Cybersecurity focus: UNECE WP.29 CS/OTA



UNECE WP.29 is developing UN Regulation on Vehicle Cyber Security, on measures ensuring cybersecurity and data protection of connected vehicles and vehicles with automated driving technologies (ADT).

For the development of this regulation, a [UNECE task force on Cyber Security and \(OTA\) software updates \(CS/OTA\)](#) is created. The UNECE World Forum for Harmonisation of Vehicle Regulations (WP.29) is a unique worldwide regulatory forum within the institutional framework of the UNECE Inland Transport Committee.

The main highlights from this draft regulation are the following:

Vehicle OEMs shall have a Cyber Security Management System (CSMS) in place, in compliance with this Regulation. CSMS shall consider the development, production and post-production phase of vehicle lifecycle.

Contracting parties shall appoint an Approval Authority to perform the assessment of the OEM and issue a Certificate of Compliance for CSMS.

The Certificate of Compliance for CSMS shall remain valid for a maximum of three years from the date of deliverance of the certificate unless it is withdrawn.

Within the draft regulation, a set of requirements for the Certificate of Compliance for CSMS are outlined.

SBD believes that such regulation that will require independent audits before a new vehicle can gain type approval and this will have major impact to OEMs.

UNECE WP.29 is developing UN Regulation on Software Updates, on measures on how to provide secure OTA software updates.

The main highlights from this draft regulation are the following:

Vehicle OEMs shall have a Certificate of Compliance for Software Update Management System (SUMS) as outlined on the Regulation.

"Software Update Management System (SUMS)" means a systematic approach defining organizational processes and procedures to comply with the requirements for delivery of software updates according to this Regulation.

The Certificate of Compliance for SUMS shall remain valid for a maximum of three years from the date of deliverance of the certificate unless it is withdrawn.

Within the draft regulation, a set of requirements and processes for SUMS are outlined.

During the assessment for the Certification of Compliance for SUMS, OEMs shall demonstrate processes related to the integrity and validation of data as well as full documentation for all software updates.

In addition, the authenticity and integrity of software updates shall be protected to reasonably prevent their compromise and reasonably prevent invalid updates.

SBD believes that such regulation that will require independent audits before a new vehicle can gain type approval and this will have major impact to OEMs.

Automotive Industry Guidelines for Secure Over-the-Air (OTA) Updates is published by the FASTR Connectivity and Cloud Work Group.

This document is intended to provide those evaluating OTA potential solutions with a comprehensive and objective standard by which to analyse SOTA software update systems.

The document recommends, among others, that:

- SOTA software update systems should be resistant to any attack which does not physically modify the vehicle. Attacks which require physical modification of any part of the vehicle are considered out of scope
- High-level guidelines should be followed to defend against the identified attacks
- Compliant SOTA systems should use recommended cryptographic algorithms
- Compliant SOTA software update systems should have a detailed Key Management Plan (KMP)

The document also includes a SOTA Software Update Guidelines checklist that can be used to evaluate the compliance of such systems.

FASTR's assets have now been rolled into the GENIVI organization, and the guidelines are accessible via the GENIVI Alliance.

Cybersecurity focus - Uptane



Introduction

Uptane is an open and secure software update framework which protects software delivered OTA to ground vehicles. Uptane provides procedures for OEMs and suppliers to securely design and implement this framework to protect connected units on automobiles. The framework can prevent malicious attacks such as compromising servers and networks used to sign and deliver updates. Multiple different free open source and closed source implementations are available.

Potential Attacks

Several potential attacks with respect to OTA update were identified. These attacks could be summarized in the following:

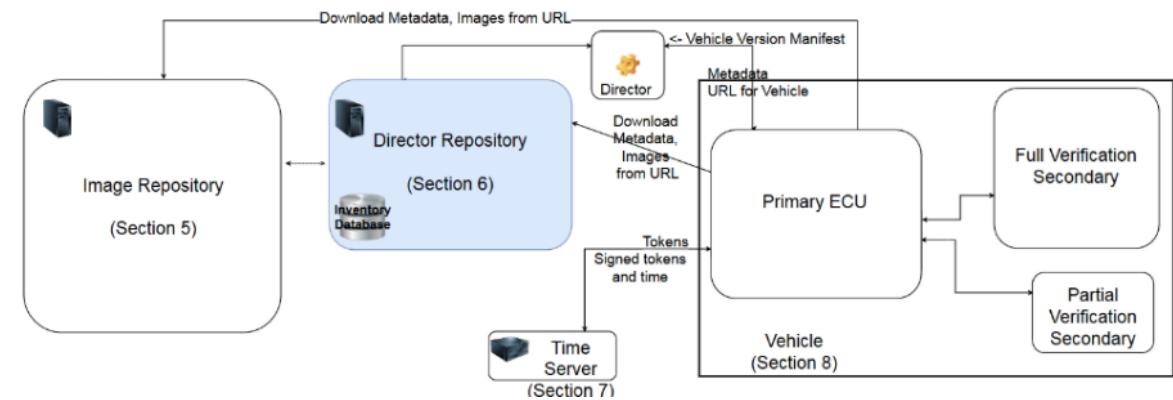
1. Read the contents of updates to discover confidential information, reverse-engineer firmware, or compare two firmware images to identify security fixes and hence determine the fixed security vulnerability
2. Deny installation of updates to prevent vehicle from fixing software problems
3. Cause one or more ECUs in the vehicle to fail, denying use of the vehicle or of certain functions
4. Control ECUs within the vehicle, and possibly the vehicle itself

Assumptions

The following preconditions are required for Uptane:

1. Vehicles have the ability to establish connectivity to required backend services via Cellular, WiFi, etc
2. ECUs are connected to the communication channel either directly or indirectly via network gateway
3. ECUs are programmable and able to be updated
4. ECUs must be able to perform a public key cryptography operation
5. State-of-the-art secure servers such as Director and Image repository servers are in place.

This diagram below is part of the Uptane Implementation Specification, shows the key integrations and components of an Uptane-compliant system.



SBD Recommendation

The OTA software update process can adopt the Uptane specification. Uptane uses four design features to solve specific security weaknesses commonly found in OTA solutions. These features are:

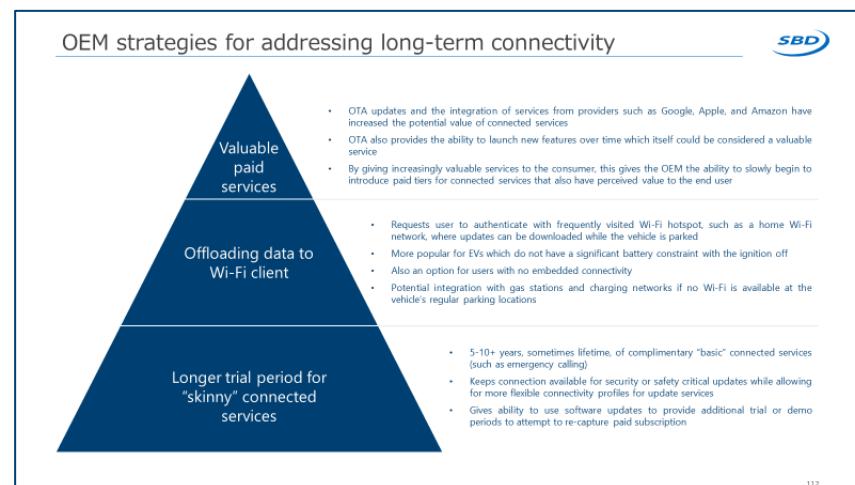
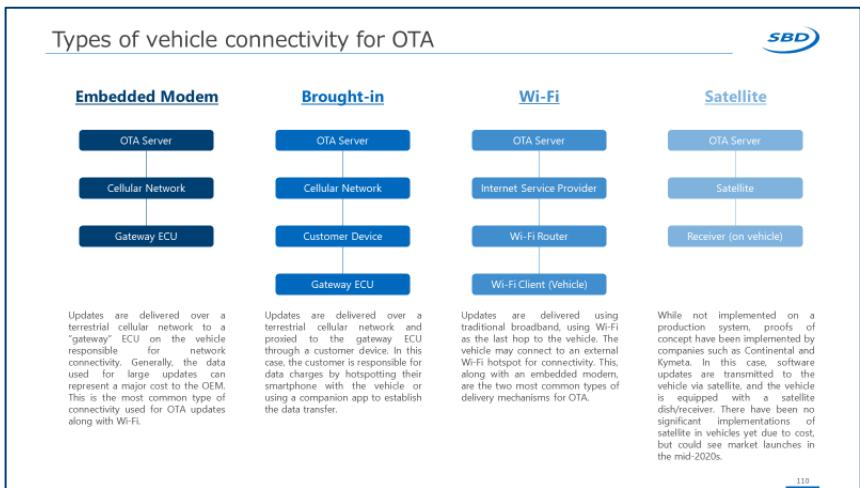
- leverage additional storage to recover from endless data attacks,
- broadcast metadata to prevent mixed-bundles attacks,
- utilize a vehicle version manifest to detect partial bundle installation attacks and
- use a time server to limit freeze attacks.

Connectivity strategy



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Section introduction



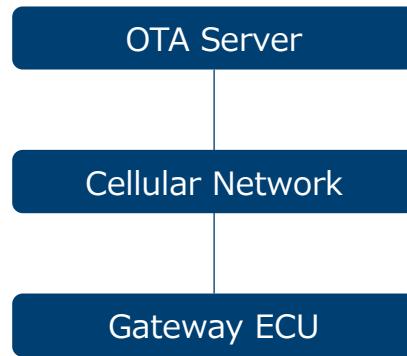
Questions answered:

- What types of vehicle connectivity are there for OTA?
- What are the challenges associated with vehicle connectivity?
- What strategies are OEMs pursuing for long-term connectivity?
- How will OEMs adapt their connectivity for OTA?

Types of vehicle connectivity for OTA

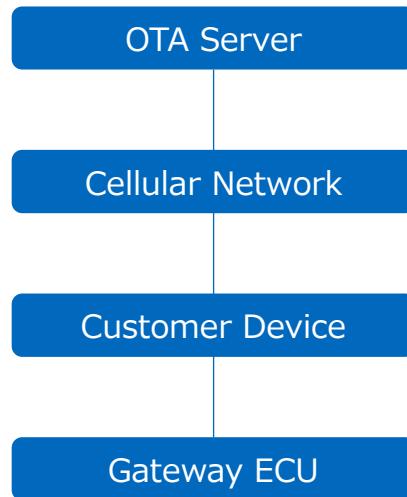


Embedded Modem



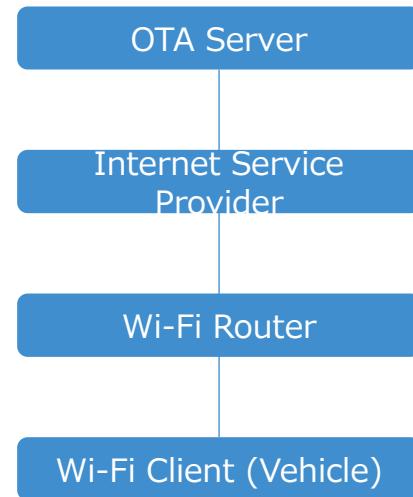
Updates are delivered over a terrestrial cellular network to a "gateway" ECU on the vehicle responsible for network connectivity. Generally, the data used for large updates can represent a major cost to the OEM. This is the most common type of connectivity used for OTA updates along with Wi-Fi.

Brought-in



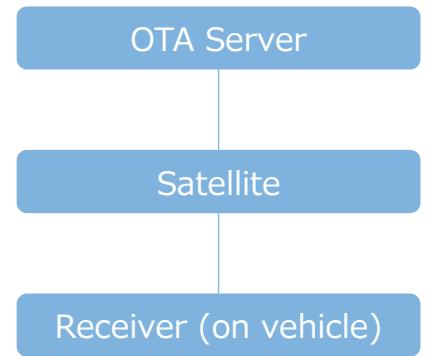
Updates are delivered over a terrestrial cellular network and proxied to the gateway ECU through a customer device. In this case, the customer is responsible for data charges by hotspotting their smartphone with the vehicle or using a companion app to establish the data transfer.

Wi-Fi



Updates are delivered using traditional broadband, using Wi-Fi as the last hop to the vehicle. The vehicle may connect to an external Wi-Fi hotspot for connectivity. This, along with an embedded modem, are the two most common types of delivery mechanisms for OTA.

Satellite



While not implemented on a production system, proofs of concept have been implemented by companies such as Continental and Kymeta. In this case, software updates are transmitted to the vehicle via satellite, and the vehicle is equipped with a satellite dish/receiver. There have been no significant implementations of satellite in vehicles yet due to cost, but could see market launches in the mid-2020s.



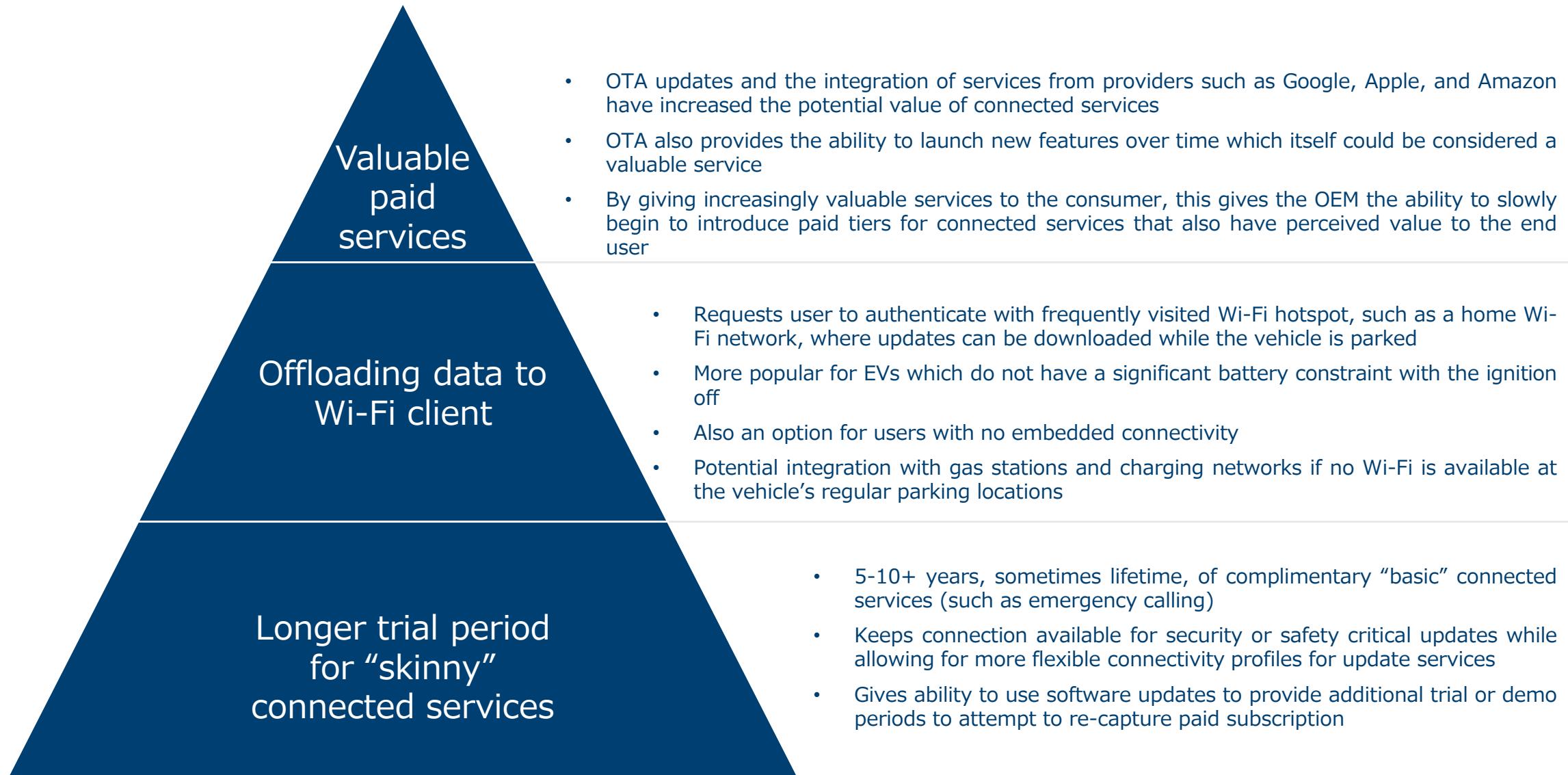
Cost

Offset

Keeping the light on

- When software updates are delivered via embedded connectivity, the OEM must pay for the data used to deliver the update via the cellular network, often costing a few cents per megabyte.
- Some software updates, particularly those with map or content updates, are particularly large – running from 500 MB to 2 or more GB.
- This can result in sizeable expenses to OEM connectivity programs, with single updates costing **\$5 or more per vehicle**.
- The existing paradigm is to subsidize embedded connectivity programs through aftersales programs, primarily subscriptions for connected services packages.
- This strategy has largely failed due to low willingness to pay by consumers for connected services, further compounded by high price tags and low consumer awareness.
- While some OEMs have iterated on their subscription strategy through better dealer training, longer free trial periods, more diverse subscription offerings, and enhanced branding, most have continued to struggle to get consumers to subsidize connected services and the associated data costs.
- Some OEM programs convert **less than 20%** of trial users to paid users, leaving a large gap.
- Beyond this, OEMs must also consider the cost of keeping a connection active without additional revenue – in some cases, suspending connectivity to a telematics control unit (TCU) in the absence of an active subscription.
- OEMs may also be subject to a fee for keeping the account active, even if it is not actively using data.
- This creates a gap between modern operational assumptions around OTA software updates (that a majority of vehicles will be able to receive the update) and reality.

OEM strategies for addressing long-term connectivity



Our view on how OEMs will adapt their connectivity for OTA



Vehicle Lifecycle
Development → Sales → Aftersales

Connectivity Management	Prioritizing types of connectivity for different updates	<ul style="list-style-type: none"> Not every update will have the same level of priority – for example, security updates should have a higher priority than other types of updates If the owner has connected the vehicle to a Wi-Fi hotspot, the OTA client can wait to download most updates until it is connected to the Wi-Fi hotspot by developing and configuring a connection type priority mechanism which smartly decides when and how to download an update
Type Approval	Ensuring regulatory compliance	<ul style="list-style-type: none"> If software updates are both subject to enhanced type approval regulations while at the same time may be mandated on certain types of autonomous vehicles, OEMs will need to build an extremely configurable system which can adapt to different trim levels, markets, and hardware Integrating multiple types of connectivity (embedded, Wi-Fi, Bluetooth, etc.) allows the OEM to choose which types of connectivity work best on its different trim levels and hardware, ensuring a safe, complaint operating environment
Dealership Training	Teaching and incentivizing trial activation	<ul style="list-style-type: none"> Many connected services programs already struggle due to poor dealership engagement and training OTA software updates, being one of many threats to dealerships, may be a <i>disincentive</i> for dealers to promote connectivity Therefore, comprehensive incentivization and training programs are necessary to ensure dealerships help activate connectivity trials OEMs should also start to consider other means to engage with its consumer on connected services beyond the dealership
Extended Skinny Trial	Keeping modem on for longer periods of time	<ul style="list-style-type: none"> Providing 5 to 10 years, and sometimes even lifetime, basic services for free will better incentivize customers to activate connectivity packages This ensures the OEM can leverage the embedded connection to delivery high priority or high value updates, such as cybersecurity fixes or feature updates to drive premium subscription revenue It also allows OEMs to better enable “features as a service” (FaaS) business models where features are sold individually
Premium Services	Locking some OTA and services behind	<ul style="list-style-type: none"> With more extensible hardware platforms enabling software-defined functionality in the vehicle, OEMs can now build new, valuable services using only software updates after the vehicle is launched Some OEMs, such as Tesla and BMW, have already started doing this – charging separately for high-value services which require many updates, while only allowing OTA updates via the embedded modem when the customer is subscribed to a premium connectivity package
Feature Dependencies	Requiring software updates to enable features	<ul style="list-style-type: none"> Many software-defined features will have multiple dependencies throughout the vehicle platform Because of this, most new functionality will require software updates to perform safely and correctly If consumers are made aware of new features but cannot use them because they have not updated, this could drive more users to ensure their updates are enabled, both through Wi-Fi and embedded connectivity channels

Regulatory activity



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Section introduction

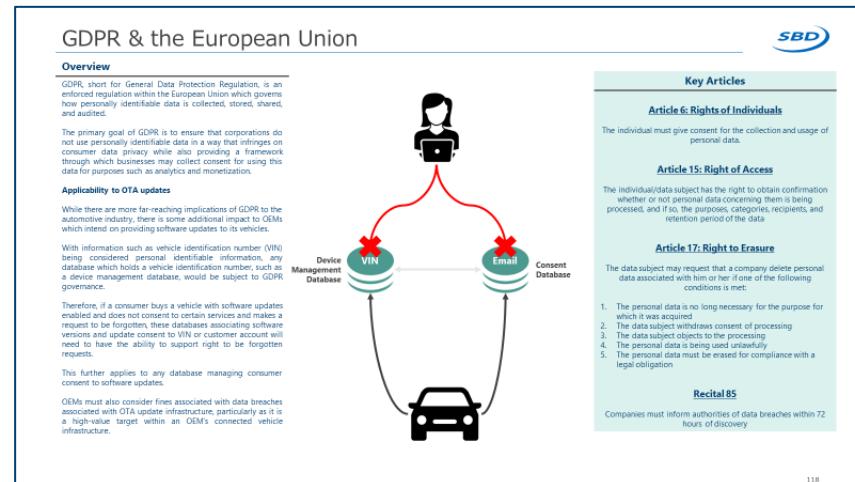


UNECE WP.29 CS/OTA

Overview	
<p>The United Nations Economic Commission for Europe is one of the five major regional commissions of the United Nations. Its core mandate is to create a forum for the harmonization of regulations between member countries with collaboration of private industry members.</p> <p>WP.29 is the shorthand for UNECE's "Working Party on Automated/Autonomous and Connected Vehicles" whose core mandate is to harmonize regulations on connected and autonomous vehicles.</p> <p>The CS/OTA task force, discussed here, is the sub-group within WP.29 focused on developing harmonized regulations on vehicle cybersecurity and software updates. The group has been meeting regularly since November 2016, and as of the publication of this report, is on its 17th such meeting.</p> <p>The group is continuing to iterate on a working document which contains all general specifications for software update capabilities which will be applied to any vehicle sold within a country which adopts the technical standards defined therein and adopted by the UN.</p> <p>A key point of discussion is how much of a change is considered a software update, and to what extent these changes would require a modified type approval. Due to the requirements of type approval, this distinction is of extreme importance to any OEMs with significant volumes in Europe where they manage software updates. In particular, as the type approval process may add delays to the OEM's ability to deploy software updates to vehicles.</p> <p>To address software versioning issues, the concept of an "RKSWIN" (Regulation X Software Identification Number) is being developed. Its intent is to provide a "dedicated identifier, defined by the vehicle manufacturer, which identifies the vehicle and its unique software of the Electronic Control System contributing to the Regulation Number X type approval relevant characteristics of the vehicle." Or, more simply, a unique identifier for the vehicle's software update scheme which will be used to manage the overall type approval process.</p> <p>Finally, the draft regulation also specifies the need for an approval authority to carry out issuance of compliance certificates for software update management systems.</p> <p><small>*Japan in particular has been a proponent for rapid discussion and adoption of regulations</small></p>	
Key Participating Countries	Impacts to OEMs
Japan*	Type Approval
Germany	Audit
United States	Versioning
South Korea	Certificate of Compliance
Timing	Impacts to OTA Service Providers
	Audit Capability
	Certificate of Compliance

*Japan in particular has been a proponent for rapid discussion and adoption of regulations

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Questions answered:

- What regulatory activity relating to OTA is taking place in China, Europe, the US and other major geographies?
- What are the potential effects of these regulations on OEMs?
- How might OTA service providers be affected also?

Overview

The United Nations Economic Commission for Europe is one of the five major regional commissions of the United Nations. Its core mandate is to create a forum for the harmonization of regulations between member countries with collaboration of private industry members.

WP.29 is the shorthand for UNECE's "**World Forum for Harmonization of Vehicle Regulations**" whose core mandate is to harmonize regulations for the importation and sale of vehicles.

The CS/OTA task force, discussed here, is the sub-group within WP.29 focused on developing harmonized regulations on vehicle cybersecurity and software updates. The group has been meeting regularly since December 2016, and as of the publication of this report, is on its 17th such meeting.

The group is continuing to iterate on a working document which contains all general specifications for software update capabilities which would be applied to any vehicle sold within a country which adopts the technical standards defined through the activity.

A key point being considered is **how much of a change is considered a software update, and to what extent these changes would require a modified type approval**. Due to the requirements of type approval, this distinction is of extreme importance to any OEMs with significant volume in European markets which also leverages software updates, in particular as the type approval process may add delays to the OEMs ability to deploy software updates to vehicles.

To address software versioning issues, **the concept of an "RXSWIN" (Regulation X Software Identification Number) is being developed**. Its intent is to provide a "dedicated identifier, defined by the vehicle manufacturer, representing information about the type approval relevant software of the Electronic Control System contributing to the Regulation Number X type approval relevant characteristics of the vehicle." Or, more simply, the RXSWIN is the easily available software versioning scheme which will be used to manage the overall type approval process.

Finally, the draft regulation also specifies the need for an approval authority to carry out issuance of compliance certificates for software update management systems.

Key Participating Countries



Japan*



Germany



United States



South Korea

Timing

The draft regulation's most recent revision was issued in mid-November 2019, with an extensive test phase conducted with confidential manufacturers in Q3 and Q4.

The working group is expected to submit a resolution document to submit to the Working Party on Autonomous Vehicles and Connected Vehicles (GRVA) in February.

While the GRVA will consider the proposal in its fifth session in February, it is unknown at this point if it will adopt the regulations or request further development.

Impacts to OEMs

Type Approval

- For certain types of functional software updates, OEMs will need to go through a modified type approval process prior to issuing the software update
- This will add overhead to any existing software update processes as well as downstream impacts discussed below

Audit

- An important element of the regulation is being able to determine what types of functional changes constitute major versioning changes
- In order to ensure OEMs don't "cheat" the regulation, an auditing process will be required to ensure the software in the vehicle matches any software versioning testaments
- Some OTA service providers, such as Aurora Labs, have already begun building this type of auditing control into their software platforms

Versioning

- The RXSWIN definition attempts to provide a common definition for how software is versioned and where this software version information is made available (e.g. OBD-II port)
- While the regulation is not final, the wording suggests that the key point will be what types of individual ECU software updates constitute whole-vehicle software platform updates

Certificate of Compliance

- The regulation further mandates that OEMs must uphold a Certificate of Compliance for their software update management system
- This means that software update governance processes become of utmost importance as they will be subject to compliance regulations

Impacts to OTA Service Providers

Audit Capability

- Service providers will need to support the appropriate level of detail in data required by auditors

Certificate of Compliance

- Service providers must be able to adapt both system requirements and support processes to OEM requirements to acquire a Certificate of Compliance

Resources for UNECE WP.29 CS/OTA



Document Name	Description	Issuer	Date
Overview of Test Phase	<ul style="list-style-type: none">Detailed overview of regulatory test phase in Q2 & Q3 2019 supported by manufacturers and service providers as well as the International Standards Organization (ISO) and SAE InternationalSupported by France, Germany, Japan, Netherlands, Republic of Korea (South Korea), United Kingdom, and SpainParties included determined, generally, that the initial assessment is positive and the general concept works as intended	CS/OTA Working Party	November 29, 2019
RXSWIN Definition	<ul style="list-style-type: none">Draft proposal to amend existing UN regulations with modified wording to address requirements for providing RXSWIN in type approval processes	CS/OTA Working Party	November 29, 2019
Proposal for new UN regulation on OTA updates	<ul style="list-style-type: none">Draft text of the formal UN regulation which would apply to any manufacturer selling vehicles in any member nation which adopts the regulation text	CS/OTA Working Party	December 2, 2019
GRVA Homepage	<ul style="list-style-type: none">Homepage of the Working Party on Automated/Autonomous and Connected Vehicles (GRVA), including references and links to all relevant working sub-groups (CS/OTA, ADAS, etc.)	World Forum for the Harmonization of Vehicle Regulations	N/A
CS/OTA Wiki	<ul style="list-style-type: none">Meeting minutes and supporting documents for all 17+ meetings of the CS/OTA task force	CS/OTA Working Party	N/A

GDPR & the European Union



Overview

GDPR, short for General Data Protection Regulation, is an enforced regulation within the European Union which governs how personally identifiable data is collected, stored, shared, and audited.

The primary goal of GDPR is to ensure that corporations do not use personally identifiable data in a way that infringes on consumer data privacy while also providing a framework through which businesses may collect consent for using this data for purposes such as analytics and monetization.

Applicability to OTA updates

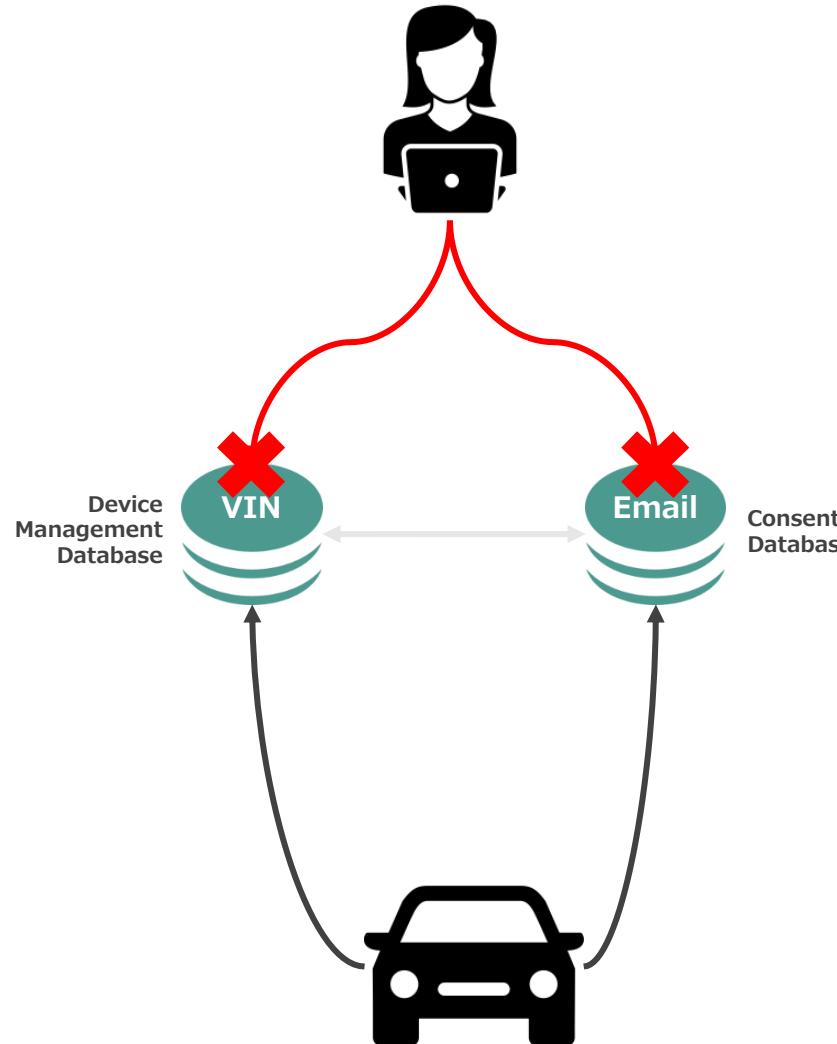
While there are more far-reaching implications of GDPR to the automotive industry, there is some additional impact to OEMs which intend on providing software updates to its vehicles.

With information such as vehicle identification number (VIN) being considered personal identifiable information, any database which holds a vehicle identification number, such as a device management database, would be subject to GDPR governance.

Therefore, if a consumer buys a vehicle with software updates enabled and does not consent to certain services and makes a request to be forgotten, these databases associating software versions and update consent to VIN or customer account will need to have the ability to support right to be forgotten requests.

This further applies to any database managing consumer consent to software updates.

OEMs must also consider fines associated with data breaches associated with OTA update infrastructure, particularly as it is a high-value target within an OEM's connected vehicle infrastructure.



Key Articles

Article 6: Rights of Individuals

The individual must give consent for the collection and usage of personal data.

Article 15: Right of Access

The individual/data subject has the right to obtain confirmation whether or not personal data concerning them is being processed, and if so, the purposes, categories, recipients, and retention period of the data

Article 17: Right to Erasure

The data subject may request that a company delete personal data associated with him or her if one of the following conditions is met:

1. The personal data is no longer necessary for the purpose for which it was acquired
2. The data subject withdraws consent of processing
3. The data subject objects to the processing
4. The personal data is being used unlawfully
5. The personal data must be erased for compliance with a legal obligation

Recital 85

Companies must inform authorities of data breaches within 72 hours of discovery

United States regulatory activity



Regulation	Agency	Description	OTA Impact
<u>Federal Motor Vehicle Safety Standards (FMVSS) No. 150 (V2V) & UNECE WP.29</u>	National Highway Traffic Safety Administration (NHTSA)	<p>FMVSS is the set of U.S. standards that reflects the overall guidance of the United Nations World Forum for Harmonization of Vehicle Regulations (WP.29); however, there are many customizations which differ from the general guidance issued by WP.29.</p> <p>The overall direction of rulemaking is generally dependent on the political climate of the executive administration, and since 2016, NHTSA has slowed its adoption of new regulatory standards. However, this should not be taken to assume that new standards will not be adopted – automotive companies should continue to monitor the departments activities along with UNECE WP.29.</p>	<p>Standard No. 150, regarding V2X communications was formally proposed as a standard in 2017 and states that OTA updates would be required on vehicles equipped with V2X systems. However, this regulation has not been advanced beyond proposal since 2017 due to advancements in the 5G space and lobbying from telecom operators.</p> <p>FMVSS should be monitored for further updates as a result of UNECE WP.29 activity on cybersecurity and over the air updates (CS/OTA).</p>
<u>Automated Vehicles Policy</u>	National Highway Traffic Safety Administration (NHTSA)	<p>NHTSA published its initial guidance on autonomous driving policies in 2016, and has released subsequent updates in 2017 and 2018. To date, these documents have posited voluntary guidance to OEMs developing autonomous driving capabilities, and the current deregulatory ethos of NHTSA will likely mean that this guidance will remain voluntary for the foreseeable future.</p> <p>The only proposed rulemaking (ANPRM) from 2019 focuses on safe integration of autonomous driving for commercial vehicles, but so far has not addressed passenger vehicles.</p>	<p>The original proposed guidance in 2016 suggested that OTA updates should be a core function of autonomous vehicles, and that future regulation could potentially mandate the capability in autonomous vehicles. The latest version of the Automated Vehicles Policy, AV 3.0, published in December 2018, references standardization activity by ITU vis-à-vis ITU-T X.1373 (<i>Recommendation Secure Software Update Capability for Intelligence Transportation System Communication Devices</i>) but does not mandate it.</p>
<u>Safety Recall Compendium</u>	National Highway Traffic Safety Administration (NHTSA)	<p>NHTSA governs all regulations related to how safety recalls are triaged, communicated, and performed. While to date there has been no specific regulation regarding using OTA to perform safety recalls, it is possible that these regulations could change, depending on dealership, OEM, and lobby action.</p>	<p>NHTSA could foreseeably adjust the recall policy to ensure that OEMs don't "shortcut" the existing recall process using software updates, including ensuring owners are fully informed of the risks of failing to accept the update.</p>
<u>Dealer Protection Laws</u>	State-Level	<p>Many states have specific, varied policies protecting dealerships from various competitive forces, including direct sales by the manufacturer. Many dealerships face threats to revenue from software updates through aftersales maintenance and repair, and the direct selling trend cuts out the dealership from the consumer relationship.</p>	<p>Traditionally, dealerships have been the only way for vehicle owners to update the software on their vehicle, resulting in additive revenue for the dealership. Some states could see additional regulation targeting the ability of OEMs to update software without the involvement of a dealership despite having no real competitive basis.</p>

Other notable regulatory activity



Country	Regulation	Agency	Description	OTA Impact
Canada	<u>Canada Anti-Spam Legislation</u>	Chamber of Commerce	Canada's Anti-Spam Legislation (CASL) governs how companies can send electronic messages and software updates to users. Within the context of software updates specifically, an update cannot be installed on a device without the express consent of the owner or authorized user.	The basic impact is that all OEMs must have a system that not only captures customer consent before any software update is made, but that is also auditable by authorities in the event of an inquiry or litigation. If you are an OEM designing an OTA update experience for the Canadian market, SBD Automotive can help audit your solution to ensure you have the necessary components and workflows to capture appropriate consent.
United Kingdom	<u>Automated and Electric Vehicles Act 2018</u>	Parliament	Enacted in 2018, this act creates rules for automakers selling any electric and/or autonomous vehicles in the UK. Specific scope areas including defining insurance liability for autonomous vehicles, charging mandates for electric vehicles, and other various elements related to electric and autonomous vehicles.	Part 1 (Automated Vehicles) Section 4 addresses a scenario where there is an accident resulting from unauthorized software alterations or failure to update software. The key tenet is protection of the vehicle manufacturer in the event that an accident occurs when the manufacturer had released a software update to remedy the cause and reasonably notified the consumer prior to the accident, but the consumer had not accepted or installed the update.
Japan	<u>UNECE WP.29</u>	Japan Automobile Standards Internationalization Center (JASIC)	JASIC has been a key driver of updates and adoption of the UNECE WP.29 standards for cybersecurity and over the air updates. While these standards are not yet reflected in regulation in Japan (considering UNECE has not adopted the standards yet), Japan has consistently been one of the first countries to enact the UNECE standards domestically after adoption.	OEMs with significant vehicle sales volume in Japan developing OTA update capability should ensure that they are planning their system in accordance with the draft rulemaking within WP.29 CS/OTA.
China	<u>GuoBaio (国标)</u>	Standardization Administration of China (SAC)	GuoBaio (or GB) standards are all national standards ratified by the Chinese government. This includes automotive as well as many other industries.	There have been no specific standards regarding OTA updates mandated by SAC, however, the administration should be monitored for further development.

Industry activity



Executive Summary <ul style="list-style-type: none">• OTA definitions• Primary report takeaways Pages 6-10	Introduction <ul style="list-style-type: none">• OTA timeline• OTA in automotive• Subscription strategy• EV vs. ICE differences Pages 11-15	Customer Experience <ul style="list-style-type: none">• Importance of customer experience• Touchpoints• OEM examples• Recommendations Pages 16-21	OEM Strategies & Case Studies <ul style="list-style-type: none">• OTA timeline• Connectivity methods• OTA use cases• Overview of OEMs Pages 22-47	OTA Suppliers <ul style="list-style-type: none">• Overview OTA suppliers Pages 48-83
Governance <ul style="list-style-type: none">• Importance of OTA governance• OTA release process• OTA governance for organization Pages 84-89	Technical Topics <ul style="list-style-type: none">• OTA solution architecture• OTA E/E architecture• Software sourcing trend• Cybersecurity Pages 90-102	Connectivity Strategy <ul style="list-style-type: none">• Types of connectivity• Connectivity challenges• OEM strategies• SBD view on OEM strategies Pages 103-108	Regulatory Activity <ul style="list-style-type: none">• UNECE WP.29• European Union• United States• Other major federal activity Pages 109-115	Industry Activity <ul style="list-style-type: none">• Uptane• Open Mobile Alliance• GENIVI• eSync Alliance• AUTOSAR• ISO/SAE Pages 116-124

Section introduction



GENIVI

Overview

One of the more successful projects within GENIVI, Remote Vehicle Interaction (RVI), is an open-source reference implementation of client-server based technologies which manage communications between a vehicle and the cloud. One of the three major sub-projects within RVI was the SOTA (software over the air) project, which saw heavy development in 2016 and 2017. Development of the RVI SOTA project was largely driven by Advanced Telematic Systems (ATS), a German OTA startup which was acquired by HERE Technologies in January 2018.

In 2018, the SOTA client was rebadged to Aktilia after it was redeveloped in C++ (from Rust). Since the HERE acquisition, ATS has relinquished most of the development, leaving the project largely in maintenance while ATS likely has adopted the platform to HERE's broader IoT requirements. While much of the RVI SOTA documentation is still available on the ATS GitHub, no updates have been made to the stable source for the client or server since 2017.

As GENIVI adapts to the evolving infotainment landscape, their focus will shift towards core automotive collaboration areas, including integration with Android Automotive, multi-QS infotainment domains, distributed HMI, hypervisor APIs, and data sharing protocols/patterns between the vehicle and the cloud. With little activity on the RVI SOTA project in two years, GENIVI has set its sights on the next-generation problems for IVI while the work product of the RVI SOTA project remains a viable starting point for any OEM or provider looking to build an OTA capability.

Associated Entities

Advanced Telematic Systems (acquired by HERE)



Resources

[Aktualis Wiki](#)

[RVI SOTA Client Wiki](#)

[RVI SOTA Server Wiki \(ATS\)](#)

[RVI SOTA Server Source \(Stable\)](#)

[RVI SOTA Client Source \(Stable\)](#)

[RVI SOTA Architecture](#)

SBD Analysis

The RVI SOTA project proved to be a valuable exercise, primarily for ATS, which was able to demonstrate a number of major elements within its platform within the context of the GENIVI ecosystem. It is currently unclear if other OEMs, Tier 1 suppliers, or service providers have adapted the RVI SOTA project for their OTA solution, but it is clear that the project itself has entered dormancy as there have been no updates to RVI SOTA or Aktualis since 2018.

For any company wanting to develop its own OTA capability, the RVI SOTA project could prove to be a useful starting point to understand what work has been done, including hands-on experience with the software architecture. However, with the lack of active development, it could be more cost-effective to leverage existing industry standards for non-differentiating elements of the solution (i.e. LVMM2, esync, etc) while focusing development efforts on other areas of the OTA solution.

Given that OTA capabilities have become largely commoditized, SBD doesn't expect many new entrants to the space dedicated on OTA update services, and thus does not expect the project to come out of dormancy in the near future, barring unforeseen circumstances.

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Questions answered:

- What are the latest OTA developments initiated by industry associations?
- What has been the significance of them?
- Which companies are publicly sponsoring, participating, or using collaborative publications or platforms?
- Will the organization succeed in its mission statement based on current activity and momentum?
- How can I start participating in or joining these industry organizations?

Uptane

Overview

Uptane is an open-source design for a secure over-the-air update system, specifically engineered for vehicles. The project was initially conceived around 2015 in a joint research initiative between the University of Michigan Transportation Research Institute, New York University, and the United States Department of Homeland Security. The first public presentation of Uptane was at escor 2016, and since then, the project has gained traction within the industry, with multiple OTA service providers and OEMs both research and adopting the design within their OTA scope.

The Uptane Alliance was formed in 2018, and as of July 2019, has managed the first full release of the Uptane Standard for Design and Implementation (IEEE-ISTO 6100). All deliverables from Uptane are freely available on their website, linked as a resource. The alliance is comprised of well-known industry stakeholders such as Toyota, Automotive Grade Linux, Harman, HERE, and LG (plus many more), is chartered with managing the continuing update of the standard to accommodate for emerging industry requirements or enhancements.

The primary deliverable from Uptane is a reference design and set of requirements for how images should be cryptographically managed in an OTA update solution, including prescription of certain components and artifacts (e.g., Root, Director Repository, Snapshot, etc) with the overall concept providing a reference implementation for the secure management of software and vehicle metadata as well as the software images themselves.

Associated Entities

NYU

Board of Directors

UMTRI

Board of Directors

United States Department of Homeland Security

Sponsor

Lear Corporation

Board of Directors

HERE Technologies

Southwest Research Institute

General Telecom Systems

Secure Embedded Systems

General Motors

Datalogic



Resources

[Uptane Website](#)

[Uptane Design Overview](#)

[Uptane Alliance Governance and Members](#)

[IEEE-ISTO 6100.1.0 \(Uptane Standard\)](#)

[Protocols, Operations, Usage, and Formats Guide](#)

[Uptane Reference Implementation and Demo Code](#)

[Presentation on Uptane from SAE 2018](#)

[IEEE Website on Uptane Alliance](#)

SBD Analysis

Uptane is one of the healthiest industry standardization activities within the OTA space, spurred on primarily by public institution and governmental support as well as emerging relevance to automaker needs.

The formation of the Uptane Alliance provided a needed forum through which industry stakeholders can partake in the platform, and while some major OEMs (Toyota, General Motors) are currently publicly involved, SBD expects that additional OEMs will join the Uptane Alliance as it becomes a more common reference implementation for third-party OTA platforms, or even in-house solutions developed by OEMs themselves.

While major OTA service providers such as HERE, Carota and Airbiquity have been early adopters of Uptane, SBD further expects other major industry platform providers to engineer their solutions to become Uptane compliant. While Harman owns a large percentage of the industry volume, we would further expect Harman to address emerging OEM requirements for Uptane compliance as they manage their product cybersecurity roadmap.

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UMTRI	Board of Directors
United States Department of Homeland Security	Sponsor
Lear Corporation	Board of Directors
HERE Technologies Southwest Research Institute General Telecom Systems Renesas Secure Embedded Systems General Motors Datadog	Members of Industry Advisory Group



Resources

- [Uptane Website](#)
- [Uptane Design Overview](#)
- [Uptane Alliance Governance and Members](#)
- [IEEE-ISTO 6100.1.0.0 \(Uptane Standard\)](#)
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Open Mobile Alliance



Overview

The Open Mobile Alliance (OMA) is an industry consortium, primarily focusing on the mobile networking and telecommunications space, which manages and publishes a number of standards. OMA is the author of the Open Mobile Alliance Device Management (OMA-DM) protocol, which was the basis for many first-generation OTA update systems, including Redbend's solution support both mobile and automotive industries. While OMA-DM is a suitable protocol standard for defining devices and managing the associated software metadata, it isn't necessarily optimized for representing vehicle software or optimized for IoT implementations, and some of these limitations were exploited at demonstrated at conferences such as Black Hat.

To address this gap, OMA introduced the Lightweight Machine to Machine (LWM2M) standard in recent years to develop an industry standard which is better suited for embedded/IoT applications, including additional security mechanisms built into the protocol itself. While the standard itself has gained significant traction in the IoT space, few automotive OTA programs have adopted the standard as it migrates from legacy platforms or integrates with service providers which have proprietary standards instead. Some of the primary companies involved in LWM2M development include ARM, Ericsson, Gemalto, and Nokia. While some programs and platform providers may migrate to LWM2M, the more likely outcome is that OEMs will begin to drive some of the decision-making around protocols as OEMs consider the value of internal development of certain OTA software components such as the in-vehicle client and its attendant protocols.

Associated Entities

ARM	Board of Directors
Ericsson	Board of Directors
Gemalto	Sponsor
Nokia	Board of Directors



Resources

- [Open Mobile Alliance SpecWorks Homepage](#)
- [LWM2M Root Directory](#)
- [Overview of LWM2M](#)
- [LWM2M Technical Specification](#)
- [OMA Device Management Root Directory](#)
- [OMA-DM Protocol Specification](#)

SBD Analysis

When the concept of over the air updates was first introduced to the automotive industry in the early 2010s, OMA-DM was the most established, widely available standard on which the device management framework for the vehicle could be based. This proved to be the fastest path to production for the technology, finding prevalence in implementations by Tesla, Redbend, and others.

As the industry has accepted that OTA updates will be a technology shared by all in automotive, most have taken the viewpoint that something more purpose-built will be needed to truly scale the automotive OTA use case in a way that meets cybersecurity, efficiency, and structural requirements. Therefore, LWM2M has supplanted OMA-DM as the most applicable standard to automotive OTA from the Open Mobile Alliance.

While the industry has not yet seen a large uptick in the number of OTA deployments which leverage LWM2M, it will likely play a big role for automakers looking to mitigate supplier risk by leveraging open standards for certain elements of their OTA solution – in particular, vehicle software and the attendant cloud protocol(s).

Overview

One of the more successful projects within GENIVI, Remote Vehicle Interaction (RVI), is an open source reference implementation of client-server based technologies which manage communications between a vehicle and the cloud. One of the three major sub-projects within RVI was the SOTA (software over the air) project, which saw heavy development in 2016 and 2017. Development of the RVI SOTA project was largely driven by Advanced Telematic Systems (ATS), a German OTA startup which was acquired by HERE Technologies in January 2018.

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As GENIVI adapts to the evolving infotainment landscape, their focus will shift towards core automotive collaboration areas, including integration with Android Automotive, multi-OS infotainment domains, distributed HMI, hypervisor APIs, and data sharing protocols/patterns between the vehicle and the cloud. With little activity on the RVI SOTA project in two years, GENIVI has set its sights on the next-generation problems for IVI while the work product of the RVI SOTA project remains a viable starting point for any OEM or provider looking to build an OTA capability.

Associated Entities

Advanced Telematic Systems (acquired by HERE)	Primary Developer (RVI SOTA)
BMW	GENIVI Sponsor
Jaguar Land Rover	GENIVI Sponsor



Resources

- [Aktualizr Wiki](#)
- [RVI SOTA Client Wiki](#)
- [RVI SOTA Server Wiki \(ATS\)](#)
- [RVI SOTA Server Source \(Stable\)](#)
- [RVI SOTA Client Source \(Stable\)](#)
- [RVI SOTA Architecture](#)

SBD Analysis

The RVI SOTA project proved to be a valuable exercise, primarily for ATS, which was able to build a number of major elements within its platform within the context of the GENIVI Development Platform. It is currently unclear which (if any) other OEMs or service providers have adapted the RVI SOTA project for their OTA solution, but it is clear that the project itself has entered dormancy as there have been no updates to RVI SOTA or Aktualizr since 2018.

For any company wanting to develop its own OTA capability, the RVI SOTA project could prove to be a useful starting point to understand what work has been done, including hands-on experience with a reference architecture. However, with the lack of active development, it could be more conducive to leverage other industry standards for non-differentiating elements of the solution (i.e. LWM2M, eSync, etc) while focusing development efforts on other areas of the OTA solution.

Given that OTA capabilities have become largely commoditized, SBD doesn't expect many new entrants to the space dedicated on OTA update services, and thus does not expect the project to come out of dormancy in the near future, barring unforeseen circumstances.

Overview

The eSync Alliance was started in 2017 by OTA startup Excelfore along with its investors, Molex and Alpine. The stated objective of the eSync Alliance is to create a collaborative space for automotive companies to develop standard specifications for OTA update protocols, patterns, and components. In addition to Molex and Alpine, Hella, Mobica, and ZF have joined the alliance since its inception.

Similar to GENIVI, companies or solution providers may implement the eSync specification and apply for compliance once the solution meets the requirements stated in the eSync Alliance technical specification. Any solution that implements the eSync specification should be interoperable with other companies which implement the specification as written. This could include OTA platform providers, tier 1 suppliers, system integrators, and even OEMs themselves.

The advantage to OEMs for joining an initiative such as eSync is that if there are sufficient partners involved it lowers the overall supplier risk of the OTA program by ensuring that all providers in the OTA value chain are interchangeable. For suppliers, the advantage would be that OEMs may be more likely to work with a company with an eSync compliant solution over a one that implements a proprietary protocol or pattern so that they have both modularity and protection from supplier risk, particularly from all-in-one SaaS providers who deploy proprietary software in the vehicle.

Associated Entities

Excelfore	Primary Developer and Founder
Alpine	Founder (Supplier)
Hella	Member (Supplier)
Molex	Founder (Supplier)
ZF	Member (Supplier)
Mobica	Member (System Integrator)



Resources

- [eSync Alliance Homepage](#)
- [eSync Alliance Specification Synopsis \(v1.0\)](#)
- [eSync Membership Information](#)
- [News: eSync Alliance joins CVTA](#)

SBD Analysis

Initiatives such as the eSync Alliance are invaluable to automakers who are planning on implementing OTA updates. If multiple OEMs, platform providers, and suppliers all join in and are active within alliances such as eSync, it reduces both the supplier risk and cost profile of OTA for OEMs. An alliance is an ideal mechanism for collaboratively specifying how non-differentiating technologies such as OTA updates can be implemented.

The biggest challenge to the eSync Alliance is the lack of participation both from OEMs as well as other OTA platform providers. As it stands, unless an OEM intends to build its own OTA platform, there is minimal upside to joining the eSync Alliance as Excelfore is the only solution provider which is compliant with the eSync technical specification.

If OEMs, or even more relevant – their tier 1 suppliers, join and develop in accordance with the eSync technical specification, OEMs can start to realize the value of this type of collaboration. Until then, however, eSync will struggle to gain traction amongst the stakeholders that it requires for more broad adoption. If OEMs do join, we would expect to see Excelfore's current customers, such as FAW, be the first to make the jump. The only OTA solution providers we would expect to develop an eSync compliant solution are either startups or tier 1s beholden to OEM requirements.

Overview

AUTOSAR is an extremely popular automotive industry alliance headquartered in Germany which primarily develops standards and specifications for the portability of software between automotive components in vehicle networks/architectures. AUTOSAR was founded in 2002 and has enjoyed continual growth amongst OEMs and suppliers.

The AUTOSAR Adaptive platform implements a pattern of services and APIs intended to allow ECUs which implement it to more dynamically serve modern in-vehicle technical requirements and patterns, including over the air updates, service-oriented architectures, and API-driven communications. The platform specifies the various functions required in a component, including user applications, communication management, and most relevant to this report: update and configuration management.

The requirements specification for the Adaptive Platform Update and Configuration Management functionality was initially released in October of 2017, and most recently updated in November 2019. The advantage of implementing the AUTOSAR Adaptive platform is that both OEMs and suppliers developing software for AUTOSAR Adaptive ECUs may develop software independently of each other, and if their software follows the Adaptive requirements specification, should be interoperable without the need to define custom or proprietary interfaces, communication patterns, and component architectures.

Associated Entities

BMW, Bosch, Continental, Ford, Daimler, PSA, GM, Toyota, Volkswagen	Core AUTOSAR Partners
Nissan, Renault, Volvo, Hyundai, Tata, Honda, Great Wall Motors	OEM Premium Partners
Autoliv, Ossystem, Hella, dSPACE, DENSO, JTEKT, Lear Corp., Delphi, Panasonic, ZF, NEC, ThyssenKrupp, CNH Industrial, Valeo	Tier 1 Premium Partners
Mentor Graphics, Elektrobit, Intel, Mathworks, KPIT, eSol, Vector, SCSK, Luxoft, Nvidia	Software Premium Partners
Altran, ETRI, Deloitte, Green Hills, Tata Elxsi, LG Electronics, ETAS, Dassault Systemes, Fraunhofer	Tools & Services Premium Partners
Infineon, Renesas, STMicro, NXP	Semiconductor Premium Partners



Resources

- [Adaptive Platform Homepage](#)
- [Adaptive Platform Current Release](#)
- [AUTOSAR Introduction](#)
- [Update and Configuration Management Requirements Specification](#)
- [Adaptive Platform Working Groups](#)

SBD Analysis

AUTOSAR is one of the most important & influential automotive alliances. With its Adaptive Platform specifying certain requirements about how ECUs should manage software updates, we expect many tier 1 and tier 2 suppliers to implement Adaptive Platform-compliant hardware and software components for OEMs. Likewise, we expect OEMs to begin to specify Adaptive Platform compliance to suppliers.

For the most part, the Adaptive Platform requirements only affect the functionality of in-vehicle software. For OTA platform providers, this means ensuring any OTA client software developed is in accordance with the Update and Configuration Management Requirements Specification. We recommend that any independent OTA supplier investigating AUTOSAR Adaptive Platform to consult with and/or pre-integrate your OTA client software on a tier 1's platform which is implementing the broader platform to gain experience with it.

For OEMs, Adaptive Platform provides an excellent means to ensure that the OTA update software being integrated on the in-vehicle ECU platforms meets certain minimum functional requirements while also lowering associated supplier lock-in and risk.

Overview

The International Standards Organization (ISO) is developing *ISO/AWI 24089: Road vehicles – Software update engineering*. The project was approved in March 2019 and is currently in the *20.00 – Preparatory* stage of development, which means that the project is registered in the technical & steering committee (TC/SC) work programs. ISO / TC 22 / SC 32 *Electrical and electronic components and general system aspects* is responsible for the development of ISO/AWI 24089. The secretariat of the TC is the Japanese Industrial Standards Committee (JISC).

ISO has published little information on the activities of the working group (WG12). However, we can look at other industry organizations for clues as to how the standards will develop. In particular, the works of JasPar, UNECE WP.29, SAE J3061 (Cybersecurity) and SAE J2534 (Diagnostics and Reprogramming) may serve as input into the WG's development activities.

Associated Entities

Japanese Industrial Standards Committee (JISC)	Secretariat
Ayumi Ikedia	Committee Manager (TC 22/SC 32)
Andrew Dryden	Technical Program Manager
Fabiola Caragol	Editorial Program Manager
ZF	Member (Supplier)
Mobica	Member (System Integrator)



Resources

- [ISO/AWI 24089 Homepage](#)
- [ISO/TC 22/SC 32 Homepage](#)
- [ISO/TC 22/SC 32/WG 12 “Software update” Workspace](#)

SBD Analysis

While still in the early phases, these standards will be incredibly important to how OTA update capabilities are built once published. Many OEMs will require ISO compliance in order to align themselves with a tested, thorough scheme which is broadly accepted by governments, manufacturers, and suppliers.

We suggest interested parties regularly check the ISO/AWI 24089 homepage for updates as well as any new public information in the WG12 workspace, both linked under Resources on the left. Given that many countries are members of ISO, regulatory bodies and their representatives will be paying attention to the work of ISO in this space – similar to UNECE WP.29's type approval recommendations.

Overview

JasPar is a consortium of Japanese OEMs and suppliers which collaborates to develop technical standards for its member companies. All Japanese OEMs are members, while Toyota, Nissan and Honda (in addition to DENSO and Toyota Tsusho) round out the 5-member board. In addition to OTA, JasPar has working groups dedicated to functional safety, ADAS vehicle control, AUTOSAR, connectivity, in-vehicle high speed networks, and many other technical automotive topics.

The OTA working group is a sub-group of the cybersecurity working group. The WG has published multiple documents on OTA, including an OTA Software Update System Requirements Definition, Data Requirements Definition, HMI Requirements Definition, Vehicle Systems Requirements Definition, In-Car Rewrite Requirements Definition, In-Vehicle Communication Specification, Update Process Requirements Document, and glossary of terms. All OTA documents are available in Japanese only and only to members.

Associated Entities

Toyota, Nissan, Honda R&D, DENSO, Toyota Tsusho	Board members
Mazda, Subaru, Suzuki, Isuzu	OEM Members
Marelli, Tokai Rika, Bosch, Infineon, DENSO TEN, SEI, AISIN AW, 20+ others	Supplier Members
Hitachi, Toshiba, ETAS, KPIT, IBM, Fujitsu, PwC, NTTDATA	Integrator Members
Airbiquity, Fujitsu	OTA Members
Renesas, NXP	Semiconductor Members



Resources

- [JasPar Homepage \(English\)](#)
- [Working Group Overview \(English\)](#)
- [Working Group Deliverables \(Japanese\)](#)
- [JasPar Members \(English\)](#)

SBD Analysis

JasPar is incredibly influential and relevant for all Japanese OEMs implementing automotive solutions and components. The organization serves as an efficient collaboration space for OEMs to share financial, technical, and consultative resources in order to build non-differentiating technologies such as OTA at a lower overall cost.

Furthermore, JasPar serves as a standards body for automotive suppliers building components or solutions for Japanese OEMs. Many Japanese OEMs leverage JasPar's standards in their technical requirements/specifications such that the suppliers must implement their solution in accordance with the JasPar standard, meaning that many simply implement the published standard ahead of time to make the procurement and development process easier across their OEM customers.

We expect JasPar to continue to iterate on their OTA WG output as the technology evolves, and the output strongly suggests that all Japanese OEMs are now considering how best to implement OTA on their various vehicle platforms.