

THE ROLE OF VIDEO IN THE CONNECTED CAR

Key topics we will discuss in this paper include:

- › Impact of video on the future of connected cars
- › Steps taken to ensure commercial viability
- › Mobile broadband design to meet the needs of these services

INTRODUCTION

Connected vehicles and associated services have emerged as a potentially significant revenue driver for the automotive industry. Growth in the market is going to be swift. According to Gartner, global connected car sales are expected to rise from 6.9 million units in 2015 to nearly 61 million units in 2020¹. This will mean an installed base of nearly 184 million new connected vehicles entering the market between 2015 and 2020.

And whilst nearly 70% of those new connections were tethered (used a passenger's separate mobile device for connectivity) in 2015, this situation will also change quickly. Just over 70% of connections will be embedded within new vehicles by 2020.

Other industry commentators also see rapid growth too. Strategy&² has projected that revenues from the sales of connected car service packages could rise from \$35.5 billion globally in 2015 to \$155.9 billion in 2022. The majority of sales and revenue will come initially from sales to owners buying premium brand vehicles, but by 2020 Strategy& expects the volume part of the market to account for three-quarters of all unit sales.

This growth will unleash tremendous creativity and innovation, with the introduction of many new services, and new business models. Cars' communications capability will enable:

- New in-car information and entertainment services
- Dramatically improved visibility into the performance, maintenance requirements and technical status of vehicles
- Better monitoring of drivers' health
- Digital transport systems, in which increasingly automated cars, roadside infrastructure and centralised management systems all communicate with each other to aid transport flows, and improve safety
- Improved car security solutions
- Better mobile network coverage (using the vehicle as a node to enable both vehicle-to-vehicle and vehicle-to-passenger communications – even where there is no traditional mobile network coverage)
- Enhanced situational awareness for autonomous vehicles. (Autonomous vehicles under development are currently limited to line of sight awareness).

Video imagery is being used by autonomous car prototypes to help the vehicle make sense of its environment (to work out where it and other road users are, and where they are going). But so far video has played a limited role in the connected car story. Whilst some video entertainment has been offered, early connected car services have focused on telematics and status information. This is going to change.

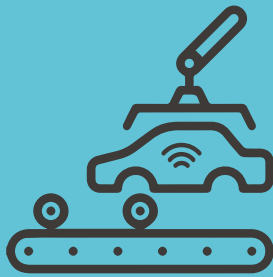
Several forces will combine to ensure that transmission of video – both to and from the car – becomes a major feature of connected cars:

- Video cameras are becoming mainstream technologies in cars. Cameras now available include reversing cameras; 360-degree vision systems (offered by combining the pictures from two or three cameras around the vehicle); blind spot monitoring cameras (in mirrors); split-view cameras which project right, left or central views on the dashboard; cameras to support lane positioning; and various high-end vehicles even include night view cameras. It is not uncommon for vehicles to have three or four in-built cameras. Chinese manufacturer BYD for instance markets sedans with four cameras to deliver 360-degree views around the car. At the high-end of the market, the Cadillac CT6 prestige sedan is equipped with seven cameras including the night vision option.
- Networks will rapidly improve (underpinned by the deployment of new generations of mobile technology) to make streamed video consumption much more reliable and enjoyable for passengers.
- Automotive manufacturers, entertainment and software companies have realised there is an untapped economic opportunity, and are moving to sell new video-rich services to passengers spending hours in their cars.
- Improved image recognition and video analysis technology will put video at the heart of connected and autonomous car security and safety systems.

1 - September 2016: <http://www.gartner.com/newsroom/id/3460018>

2 - September 2016: <http://www.strategyand.pwc.com/reports/connected-car-2016-study>

KEY DATA



**61
MILLION**

Global connected car sales are expected to rise from 6.9 million units in 2015 to nearly 61 million units in 2020



**141
BILLION**

A report from Allied Market Research suggests that the global connected car market may generate revenues of \$141 billion in total by 2020



**1.8
BILLION**

LeEco plans to invest \$1.8 billion in a car plant in China

VIDEO WILL PERFORM SEVERAL MAJOR TASKS IN THE FUTURE CONNECTED CAR

PART 1

Video transmission to and from cars will enable a range of innovative services for customers:

- Video-rich in-car entertainment
- Video-enabled safety features
- Video-supported security services.

› Video At the Heart of In Car Entertainment

Streamed video entertainment services for passengers will become increasingly popular and sophisticated, and there are many examples of organisations already moving to exploit the opportunity this presents. Chinese media streaming company LeEco³ has unveiled an approach which sums up the role cars will play in the future of entertainment consumption. LeEco announced an ecosystem consisting of platform, content and applications that will all run on its Le Cloud video delivery network and that will be accessible from a range of devices including phones, TVs, and smart bikes. The content and applications have also been included in LeEco's new concept car, called the LeSee Pro. LeEco promises the ability to "cast content from your phone to your car with a simple swipe"⁴. LeEco's entertainment lounge in future vehicles will provide its full portfolio of content (including music, full-length HD movies, TV programmes and sports) on any of five in-car screens (and not necessarily the same content on each screen). The LeSee Pro remains a concept vehicle at this stage but the company harbours commercial ambitions. It plans to invest \$1.8 billion in a car plant in China, and has announced projects to work with Aston Martin, BAIC Motor, Yidao Yongche and Faraday Future. It is expected to show its first production car in 2017.

LeEco is not the only car company showing off its entertainment plans. Volvo for instance unveiled Concept 26,⁵ another concept car that it named to reflect the average 26 minutes spent commuting daily that "could be spent doing something more meaningful". The solution presented in Concept 26 continuously receives streamed entertainment – even through network not-spots – by analysing the planned or likely route, and speeding up content delivery to provide a buffer when passing through areas with connectivity.

"Imagine a highway full of autonomous cars with their occupants sitting back watching their favourite TV shows in high definition. This new way of commuting will demand new technology, and a much broader bandwidth to ensure a smooth and enjoyable experience."

- **Anders Tylman**, General Manager Volvo Monitoring & Concept Centre at Volvo Car Group⁶

AT&T and Uber meanwhile have been testing demand for in car entertainment since October 2015 by streaming live college football games to Samsung tablets mounted in headrests in specially adapted cars. The service has been available in several US cities, using AT&T's LTE network to deliver the content. The partnership has been expanded and in September 2016 they announced a marketing initiative to promote the launch of AT&T's new DirecTV Now service, offering free rides with selected cars getting free live streaming of matches⁷.

"Video will play an important role for in-car entertainment. People will want to be able to stream video, and do anything they are now doing on their mobile phones, whilst in their cars and in autonomous driving scenarios there will be many more viewing opportunities for drivers."

- **Lars Schultheiss**, Vice President Product Marketing and Sales, Continental Automotive

3 - <http://www.leeco.com/news/leeco-ecosystem-us-launch/>

4 - <http://lesee.leeco.com/en/>

5 - <https://www.media.volvocars.com/global/en-gb/media/pressreleases/169396/volvo-cars-unveils-concept-26-delivering-the-luxury-of-time>

6 - <https://www.media.volvocars.com/global/en-gb/media/pressreleases/172080/volvo-cars-and-ericsson-developing-intelligent-media-streaming-for-self-driving-cars>

7 - <https://newsroom.uber.com/att-college-football/>

VIDEO WILL PERFORM SEVERAL MAJOR TASKS IN THE FUTURE CONNECTED CAR

PART 2



The automotive industry has rapidly embraced the use of virtual reality to show off its cars. So far this focuses on provision of static augmented reality (AR) suites where customers can take the new vehicles for virtual test runs. But it may also be soon – given wider moves to innovate with in-car entertainment – that automotive manufacturers start offering virtual reality (VR) entertainment inside the car too. It is a concept they have been considering for some time. Chevrolet⁸ has worked with Future Lab to use virtual reality technology to turn rear passenger windows into interactive displays. Audi has been using virtual reality to simulate environments for drivers driving around test tracks. Honda's engineers have been experimenting with delivery of virtual reality content to passengers with Oculus Rift Dream Drive, which integrates the movements of the car with VR simulations to create a more interesting consumer experience.

Taking these ideas a step further was Lockheed Martin's spring 2016 project, developed with VR specialist Framestore and McCann. The companies turned the windows of a school bus into screens showing the surface of Mars, so the children felt they were driving across the surface of the red planet. The companies created what they described as "Group VR" technology, using the bus as the VR headset. The bus integrated a virtual 3D map of Mars, custom screen technology, GPS, 3-axis accelerometer, magnetometer, and a laser surface velocimeter. When the bus moved, the Mars surface shown on the bus windows moved. When the bus turned in real-life, it appeared to turn on Mars too. This project demonstrated a type of application that could in future use streamed cloud-rendered images.

8 - http://media.gm.com/media/intl/en/chevrolet/news.detail.html/content/Pages/news/intl/en/2012/chevrolet/02_15_ChevroletKicksBackseatBoredomToTheCurb.html

VIDEO WILL PERFORM SEVERAL MAJOR TASKS IN THE FUTURE CONNECTED CAR

PART 3

› Video Improving Safety

Video will play a more important role than simply entertaining people. Video will also be used to improve safety for drivers and for other road users. In this context, it will be used in systems that don't need connectivity and in systems requiring mobile connectivity:

› AR systems not needing connectivity:

Augmented reality systems that enable people to see through their cars (for instance to see through the bonnet, or to see what is happening in the immediate vicinity at the rear of the vehicle); or augmented reality displays that superimpose simple road information (such as speed limits) onto a driver's screen or heads up display (HUD), have been in development for some time. There have been a number of trials and demonstrations of these sorts of augmented reality applications. For instance, BMW demonstrated MINI Augmented Vision at the Auto Shanghai 2015 car show, a solution which enables drivers with augmented reality glasses to see through their vehicles and eliminate blind spots. (The glasses reflect what is being seen by cameras on the exterior of the vehicle.) Continental has been demonstrating HUDs for a couple of years now.

› AR systems needing connectivity:

Augmented reality displays that enable people to see through other cars (also known as see-through services) and to see what is happening around corners (also known as bird's eye view services) will extend the in-car augmented reality solution to the wider area. These features of future connected cars will effectively enable a driver to see what is happening when their immediate view is restricted by another vehicle such as a truck or lorry, or by buildings and signs. The cars in front would broadcast what they can see, with their views imposed on following drivers' HUDs. This type of service is not ready for commercialisation at this stage because the networking requirements are onerous. LTE technology needs to evolve to support the required vehicle-to-vehicle transmission methods. Networks need to deliver the imagery at high data rates, for fast moving vehicles, with very little latency.

Huawei is involved in various trials of experimental vehicle-to-everything (V2X) services in China. At its trial in Hangzhou it has been working alongside China Mobile, SAIC Motor and Xihu Electronics Group to test six cellular-V2X (C-V2X) scenarios along a 3.2km road equipped with 34 base stations, including see-through services (actual screen shots shown below).



The trials proved the see-through technology can work.

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PART 4

➤ As an interim step towards delivering see-through services involving full video streaming, automotive companies are developing augmented reality technologies which project useful information onto heads up displays – and not just for cars. In January 2016 BMW revealed a development concept for a HUD within a motorcycle helmet. The BMW Motorrad helmet was fitted with a heads-up display function that projects data directly into the rider's field of vision. Initially, display options for the helmet provide data about tyre pressure, fuel level, travel speed, speed limits and road signs. BMW envisages future versions (using V2V technologies) that can display information in real time - for instance about problems up ahead. The company also envisages the display showing content related to navigation and route choice, and even – via forward and rear facing cameras - recording journeys, and acting as a digital rear view mirror. At the time of the presentation BMW stated it expected the technology – which is designed to be retrofitted to existing helmets - would take a few years to bring to commercial production.



➤ Finally in the safety context, video will also be used to support detailed hazard mapping services. In a world of automated vehicles, cars will need to be able identify potholes, road debris etc. Doing this will require high definition camera/video image analysis (and communication to centralized mapping applications to share the findings).



BMW's Motorrad helmet is fitted with a heads-up display function.
Images from BMW's press office (www.press.bmwgroup.com)

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PART 5

► Video Will Underpin Security In Connected Cars

Most current in-car surveillance systems come equipped with a built-in DVR (digital video recorder) or storage card. For instance, the Cadillac CT6 includes seven cameras, four of which are hidden surveillance cameras fitted in the front grille, door-mounted rear view mirrors and the lid of the trunk. As well as filming journeys and offering a 360-degree display, they also record video when an alarmed car is tampered with, or record an incident. The Cadillac records evidence on an SD card in the trunk.

However, work is underway to bring cloud-based systems to market, removing the possibility for destruction of evidence, or loss of evidence if a vehicle is stolen. The solutions being introduced – which feature significant use of camera images and video – use both tethered and integrated LTE connections.





Caruma⁹, for instance, is developing a solution that can be installed by consumers, and which – amongst other things – will provide HD recordings of video and audio inside and outside the car. Activated by motion or glass breakage, it stores data in the cloud and notifies a user's smartphone. It uses an LTE connection within the device. A similar solution is already available from LyfeLens¹⁰ which offers notifications and video to devices within WiFi range, or for those taking out a subscription, via LTE.

Cloud surveillance specialist ThroughTek, meanwhile, has announced¹¹ its first automotive customer for a built-in video surveillance solution for cars.

Its unnamed Chinese client will introduce the service for drivers of one of its makes of cars. The service, which is integrated with a built-in camera inside the vehicle, enables owners to remotely monitor their cars using a live streaming application, to video record events for playback, share streams of captured video or stills with other identified devices, and receive over-the-air updates. Alerts are issued when the vehicle recognises an event such as a window breakage.

Future versions of these technologies are highly likely to include use of biometric evidence too. Several automotive manufacturers have been looking at facial recognition systems as a means of identifying and authorising drivers, so that the owner can be alerted not just if the car starts, but if it is started by an unknown person. They are also exploring tailoring the in-car experience and even the car's performance capabilities, according to who is known to be sitting behind the steering wheel.

THE TRIALS PROVED THE SEE-THROUGH TECHNOLOGY CAN WORK.

COMPANY	DESCRIPTION
	Announced a research project named Ford Mobii with Intel ¹² , to explore use of facial recognition for security (comparing the would-be driver with images of known authorised drivers), alongside motion recognition for control of internal systems, and live streaming video of the vehicles' interior to the owner, wherever they are.
	Reported to be planning the introduction of facial recognition to alert users when they start to fall asleep, or when they are not paying sufficient attention ¹³ . The company linked as the supplier of the facial recognition technology has stated ¹⁴ that it is working on development projects with 14 automotive companies, as well as an automotive camera manufacturer.
	Is introducing facial recognition to ensure that Uber drivers match those in its database ¹⁵ . Uses Microsoft Cognitive Services to undertake infrequent real-time ID checks, with the aim of improving passenger safety and protect drivers from fraud. The system currently uses mobile phones, but it is not hard to imagine in-built cameras will be used in future vehicles.
	Actively working on testing infra-red face scans of people, combined with information such as their weight, to identify authorized drivers, and to notify authorised drivers when there is an anomaly. The owner would then be able to check the would-be driver, and authorise, or disable the car remotely and contact the police ¹⁶ . It reports the system is not ready for live deployment, and needs testing against attempts to spoof it (e.g. by using masks or photos).

9 - [https://www.indiegogo.com/projects/the-world-s-first-connected-car-camera#/,](https://www.indiegogo.com/projects/the-world-s-first-connected-car-camera#/) <https://caruma.tech/>

10 - <http://www.lyfelens.com/>

11 - http://www.throughtek.com/news_pressroom_2016_ThroughTek_connected_car_0908.html

12 - <http://blogs.intel.com/iot/2014/06/25/mobii-takes-internet-things-road-easier-safer-driving/>

13 - <http://www.foxnews.com/leisure/2014/09/02/gm-reportedly-ready-to-introduce-facial-recognition-tech-in-cars/>

14 - <https://www.seeingmachines.com/wp-content/uploads/2016/10/FY-2016-London-October-final-without-medical.compressed-1.pdf>

15 - <https://newsroom.uber.com/securityselfies/>

16 - http://www.volkswagenag.com/content/vwcorp/content/en/innovation/communication_and_networking/Biometric.html

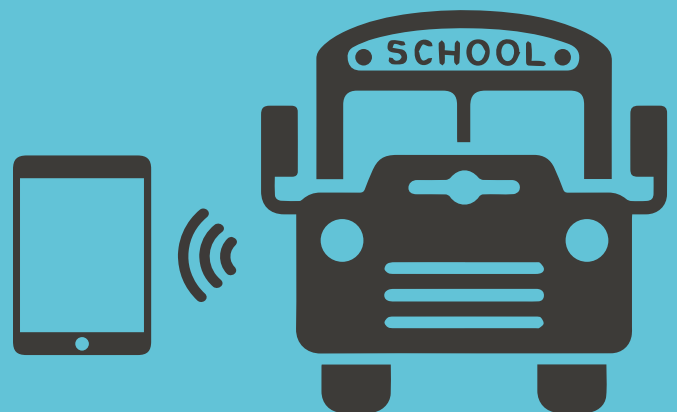
PROGRESS IS BEING MADE TOWARDS DELIVERING THESE SERVICES

As the examples above illustrate, although video-based safety services offering see-through and bird's eye view capabilities are some way away from being ready for deployment, progress is being made towards commercialising many of the other video-centric services.

Huawei's Smart Vehicle Solution is a market-ready solution that demonstrates how far many of the video rich connected vehicle applications have progressed. Delivered using an AR510 IoT gateway with GPS positioning and high speed Internet using a pair of 4G SIM cards, the Smart Vehicle Solution is available for public transport systems (including buses, taxis and heavy goods vehicles).

It offers a variety of safety and security services such as in-vehicle video surveillance, passenger tracking, emergency services communication, and real-time vehicle health data analysis, and even allows for delivery of multimedia services for the passengers' entertainment.

In the context of a school bus, the system can provide real-time HD images of the inside and outside the bus to both parents and schools (for instance so the driver or the pupils can be monitored). It can also provide up to 60 concurrent users with access to the Internet, HD teaching videos and learning materials via WiFi.



In addition to this specific service, Huawei has announced¹⁷ a partnership with Shanghai General Motors to promote the development of connected cars. Huawei's telematics solution incorporating LTE connectivity, location-based services, emergency assistance and automatic phone tracking will be pre-installed in some GM models.

In addition to developing devices and services, Huawei has taken a leading role in developing the critical network infrastructure that is needed to underpin connected car services. More detail on its work in this area is available in a separate paper entitled Communications networks for connected cars.

Huawei has additionally signed an agreement with Audi for the development of an LTE module tailored for Asia-Pacific markets. Audi will use the module (which supports the TDD-LTE (Time Division Duplexing) wireless standard, and the FDD-LTE (Frequency Division Duplexing) standard in China, Japan and Korea.

17 - <http://webcache.googleusercontent.com/search?q=cache:pqkoS-Xq21gJ:pr.huawei.com/en/news/hw-445112-shanghaigm.htm+&cd=1&hl=en&ct=clnk&gl=uk#.WBNJbyOrLGI>

ENHANCED MOBILE BROADBAND IS BEING DESIGNED TO MEET THE NEEDS OF THESE SERVICES

The variety of video rich communications services being considered for connected cars has the potential to generate an enormous amount of network traffic, and will require communications with very low latency and very high reliability – especially for safety-orientated services. Analysis by 5G-PPP suggests that depending upon the balance of pre-processing to transmission of raw data, video-based see-through and bird's eye view services could require anywhere between 1Mbit/s and 10–20Mbit/s of average throughput¹⁸. Huawei analysis suggests 2Mbit/s per stream could be needed both upstream and downstream to support LTE-V see-through services streaming at 1080p.

“Augmented reality is an area where video will be very important... You have to distinguish between enriched map data pre-produced from camera information, and data coming direct from a video stream... Using pre-processed data lowers the cost and the data set can be enhanced - for instance by highlighting [features or risks] ... In contrast, raw data needs interpretation and georeferencing before it can be used... but using raw data could deliver an advantage in terms of the resolution of the picture. The issue of how much reality you blend with the augmented information is – at the moment – still very much a question to be researched.”

- **Lars Schultheiss**, Vice President Product Marketing and Sales, Continental Automotive

Enhanced mobile broadband is being designed to meet the stringent service needs of in-car video services. The 3GPP has been developing mobile communications standards so that LTE-A Pro and 5G networks will be able to support vehicle-to-vehicle communications, even where there are no cell towers, and to support very large numbers of connections, requiring very high throughput, even when cars are moving at high speeds. Huawei is at the heart of 3GPP activity, and the forefront of LTE-A Pro and 5G development and deployment. It is working to support the development of connected cars and automated vehicles with fit for purpose network technologies, as a recent quote from the company's CEO of Consumer Business Group shows.

“Vehicles are becoming the next mobile smart device after smartphones. Huawei is focused on creating the network communication capacity that can realize the interconnection of all things.”

- **Richard Yu**, Chief Executive Officer of Huawei's Consumer Business Group



KEY TAKEAWAYS



01 The connected car market, although very young, is about to exhibit very rapid growth. High speed connectivity for vehicles will enable a range of new services, and importantly will enable automotive manufacturers, mobile network operators, software companies and entertainment providers to open up valuable new revenue streams.



03 Automotive manufacturers are planning to position their vehicles as hubs for information and entertainment whilst passengers are being transported. As Alibaba Group's Daniel Zhang's recent statement illustrates, many other types of company also see connected cars as a platform on which they can build new businesses.



04 Operators need to deploy the infrastructure that will facilitate these services, so there are no 'not-spots', otherwise user experience will be reduced. New mobile networks based on LTE-A, LTE-A Pro (including new LTE-V standards) and 5G will enable mobile operators to not only meet the network requirements of connected cars, but also to support automotive manufacturers and OTT service providers to make most of the economic opportunity offered by connected vehicles.



06 The vast volumes of video content being both generated by and consumed by people in their connected cars have the potential to place tremendous pressure on mobile infrastructure.



02 Video is not a major feature of early connected car services, but this is going to change. Video will at the heart of in-car entertainment offerings, and will underpin automotive safety, and security services.

“We believe cars will be the next wave of access point to the Internet...working together with SAIC, Alibaba will transform the car from a mode of transportation into a new platform for smart living...We hope to truly elevate the experience of driving and allow consumers a new lifestyle to be enjoyed via their vehicles.”

- Daniel Zhang, Chief Executive Office at Alibaba Group¹⁹



05 Huawei is already a leader in the emerging connected cars market. It not only provides the network infrastructures, but is also actively involved in service development trials, and in the provision of networking modules that will link the cars of the future to the outside world, and bring the outside world in to passengers.



07 Video transmitted by and downloaded to connected cars in fact has the potential to be a significant revenue driver for mobile operators and service providers – both because of the sheer volumes of data it will generate, but also because mobile operators can support the provision of interesting new retail services. Strategy& predicts²⁰ that connected car entertainment services will deliver revenues of Euro13 bn by 2021, more than double those of 2015, and that well-being related services (including in car cameras to monitor driver status) will deliver another Euro7.9 bn.

19 - <http://www.alibabagroup.com/en/news/article?news=p160706>

20 - <http://www.strategyand.pwc.com/cn/home/report/connected-car-2015-study>



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