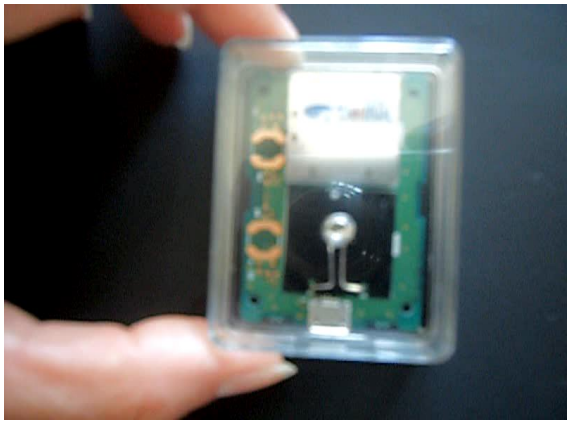
THHINK
WIRELESS TECHNOLOGIES LTD

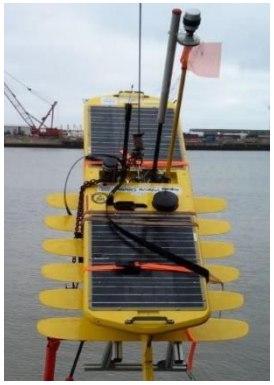
THHINK Group 2018

Smart Anything Everywhere (Anytime)

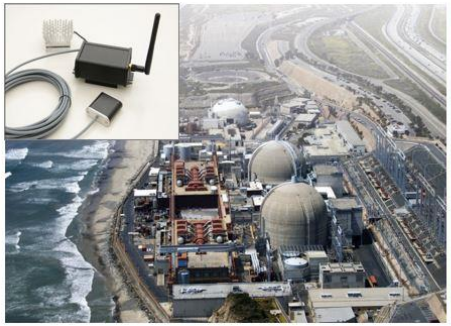
Smart Applications



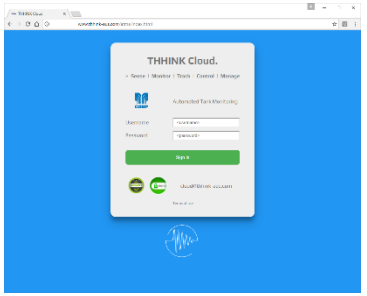
Micro-generator



Autonomous Vehicles



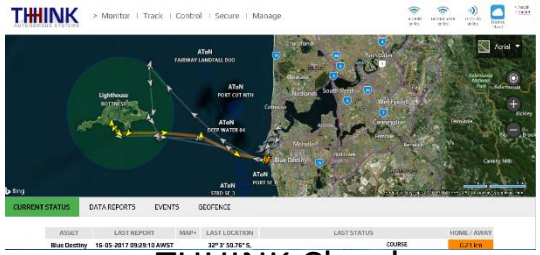
Nuclear Monitoring



Satellite Comms.

Remote Monitoring

Self-Powered Phone



THHINK Cloud

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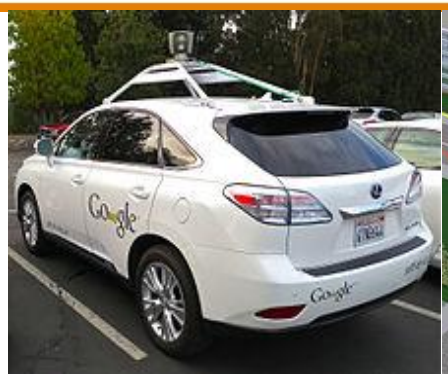
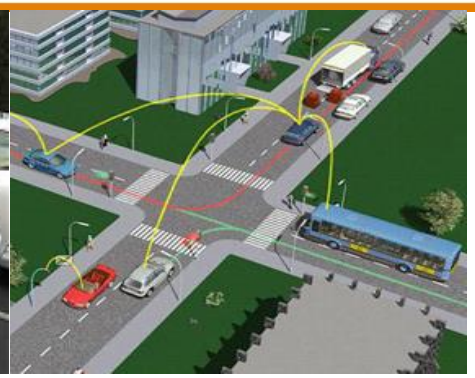
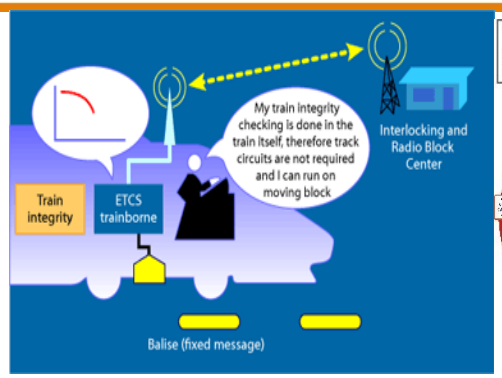
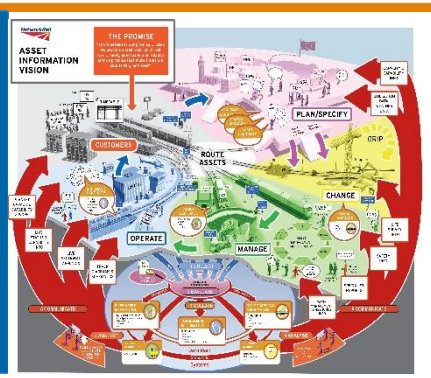
Trends in Transportation

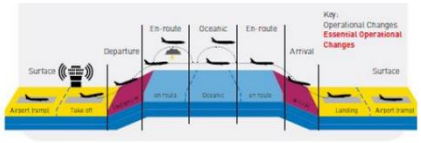



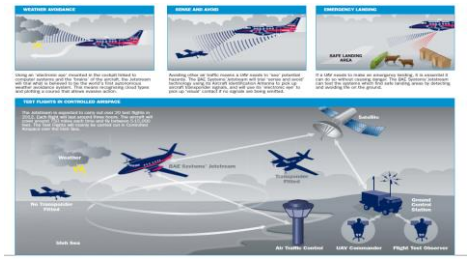
Autonomous Cars
Optimised Traffic Flow
Health Monitoring



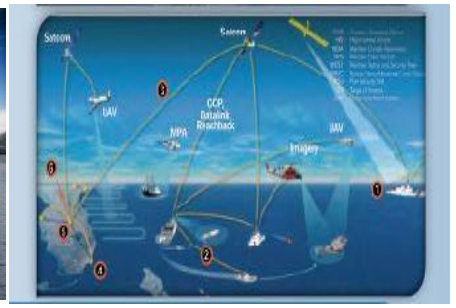


Autonomous Trains – ERTMS
Optimised Operations
Health Monitoring



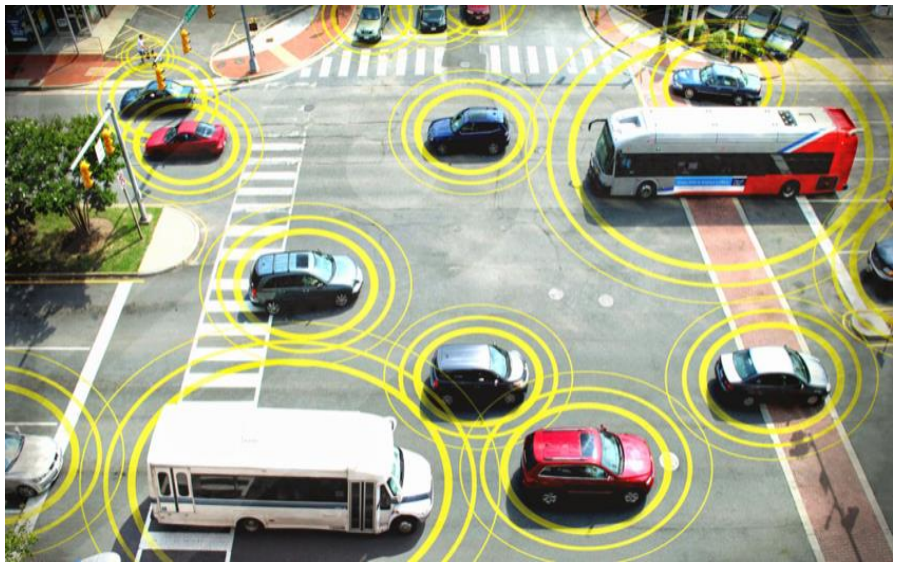


Autonomous Aircraft
SESAR – 4D Traffic Management
Health Monitoring

Autonomous Ships – Rolls-Royce
Traffic Management
Health Monitoring/Surveillance

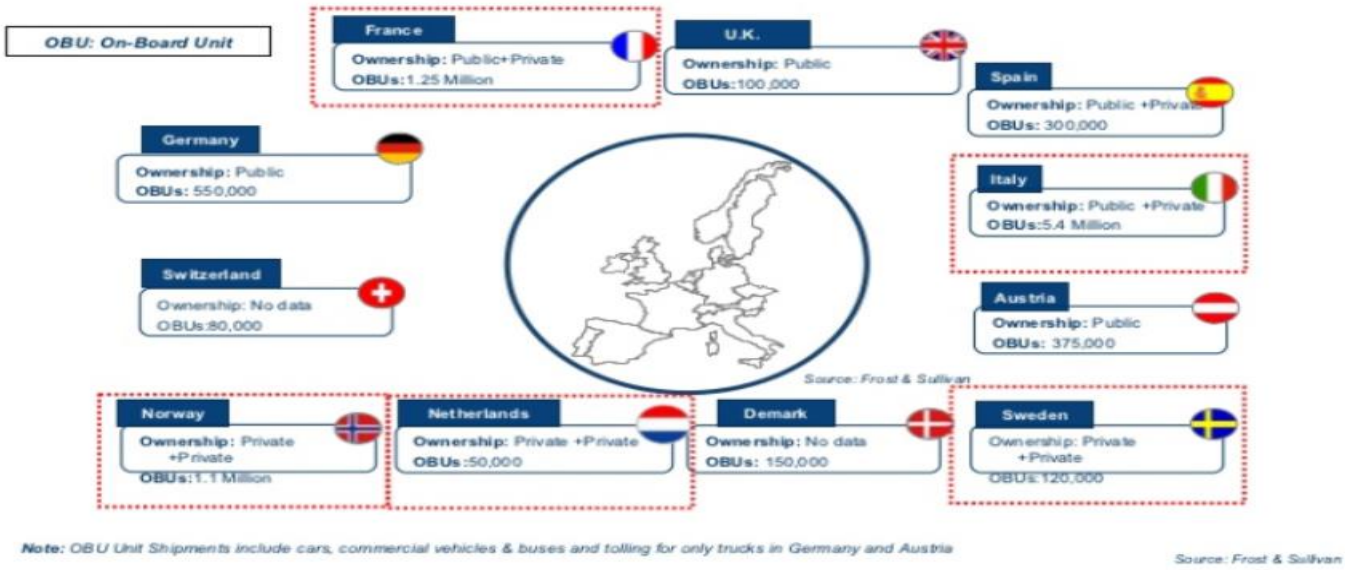
Intelligent Transportation Systems



Source US DOT

- Traffic management represents a highly complex cyber physical system of systems coming under increasing demands for additional capacity, greater safety, and lower costs while meeting strict environmental regulations
- The global car fleet is predicted to double from currently 800 million vehicles to over 1.6 billion vehicles by 2030
- Without integration of information and flow control systems, severe congestion
- Markets and Markets predicts that the global traffic management market is expected to grow from USD 4.12 Billion in 2015 to USD 17.64 Billion by 2020

V2X Communications in Europe



- Industry has been working for 10-15 years already on car-to-infrastructure and car-to-car communications
- A critical issue is the quality of the standard. This needs to work in all the member states and also worldwide, covering Europe, America, Japan, and China.
- A study by Frost and Sullivan identified that for vehicle-to-vehicle and vehicle-to-infrastructure communications countries with significant private ownership of road infrastructure are more likely to invest in cooperative systems infrastructure. These countries are highlighted with red boxes

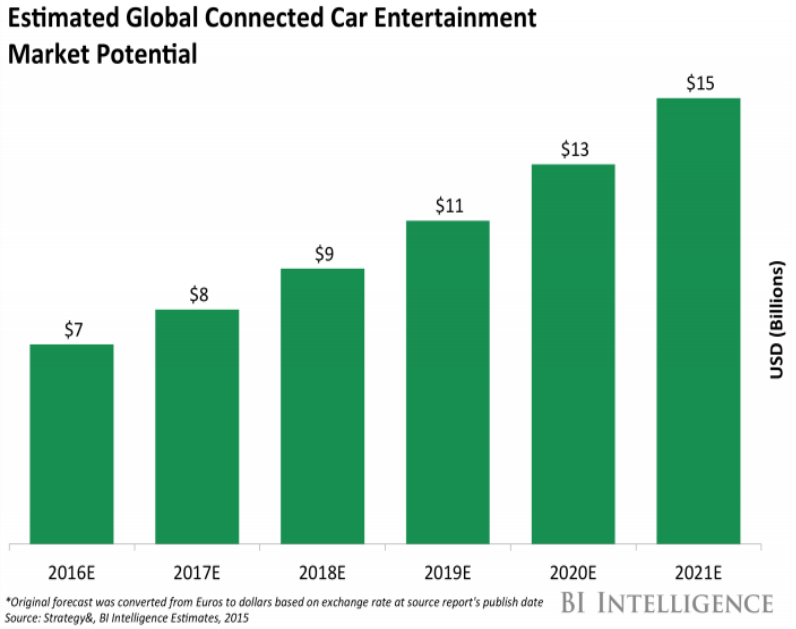
Infotainment

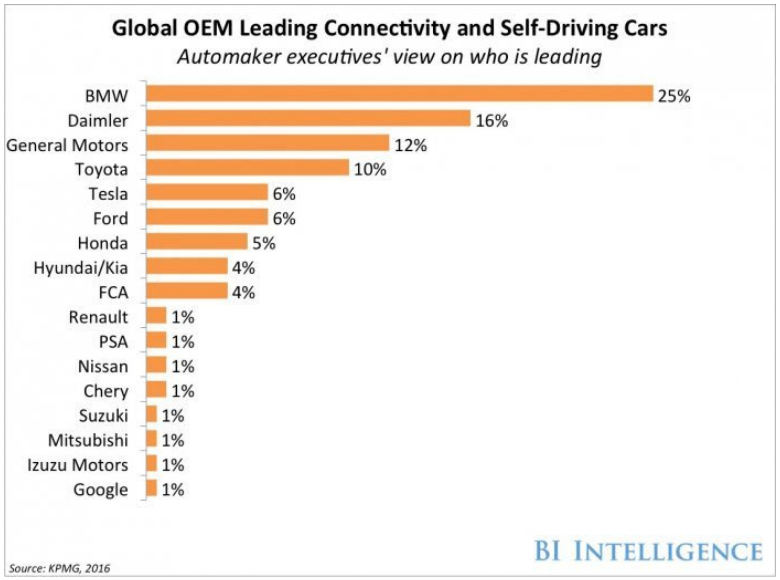
- Two types of connection
  - Embedded connection cars use a built-in antenna and chipset
  - Tethered connections use hardware to allow drivers to connect to their cars via their smartphones
- The ability to integrate Apps into cars is becoming commonplace in today's vehicles. Google Maps and other navigation tools are replacing built-in GPS systems in many cars. Music Apps replace the need for a traditional radio or music player

Advantages

- Internet connectivity in vehicles allows car companies to release software updates in real time (extremely important during a recall)
- Automotive companies can use data from the car to analyse performance and obtain valuable data on how drivers use their cars
- Automotive companies can find even more ways to cross-sell their products and services to customers

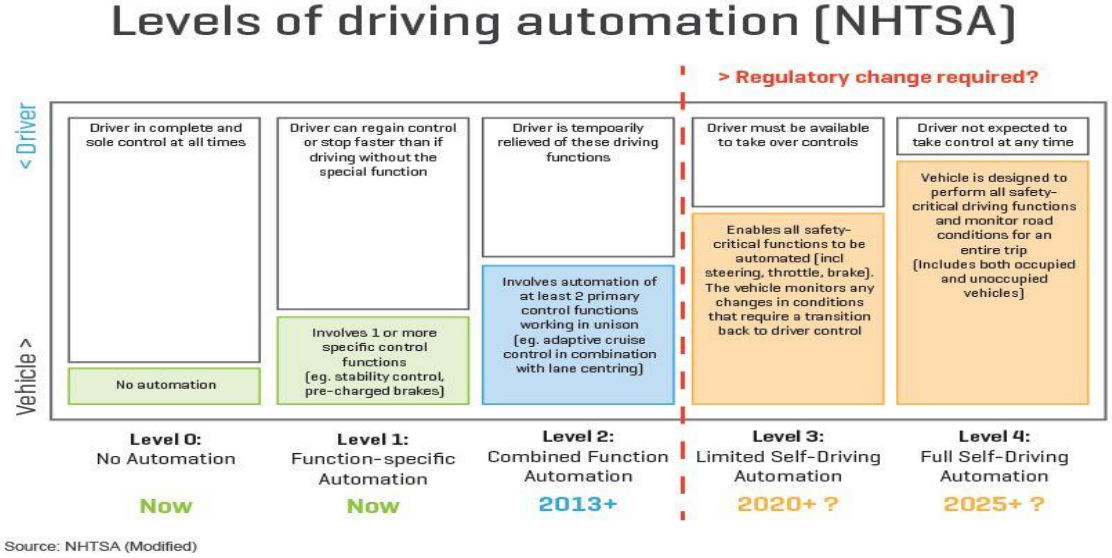
Infotainment





- Driven by the Internet of Things the "Connected Car" is seen as a major business opportunity
- BI Intelligence predicts that 94 million connected cars will be shipped in 2021 (82% will be connected)
- 381 million connected cars to be on the road by 2020, up from 36 million in 2015
- Connected cars will generate $8.1 trillion between 2015 and 2020
- Although the car companies are providing the connection interface in the car it is other companies that provide data services that are driving this change. AT&T added 2.7 million connected cars in the U.S. in the first three quarters of 2015. Major players such as Microsoft, Apple, Pandora, Sprint, Google, etc., all see the opportunity for getting their platforms onto connected cars.

Autonomous Cars



Source: NHTSA (Modified)

Different levels of autonomy

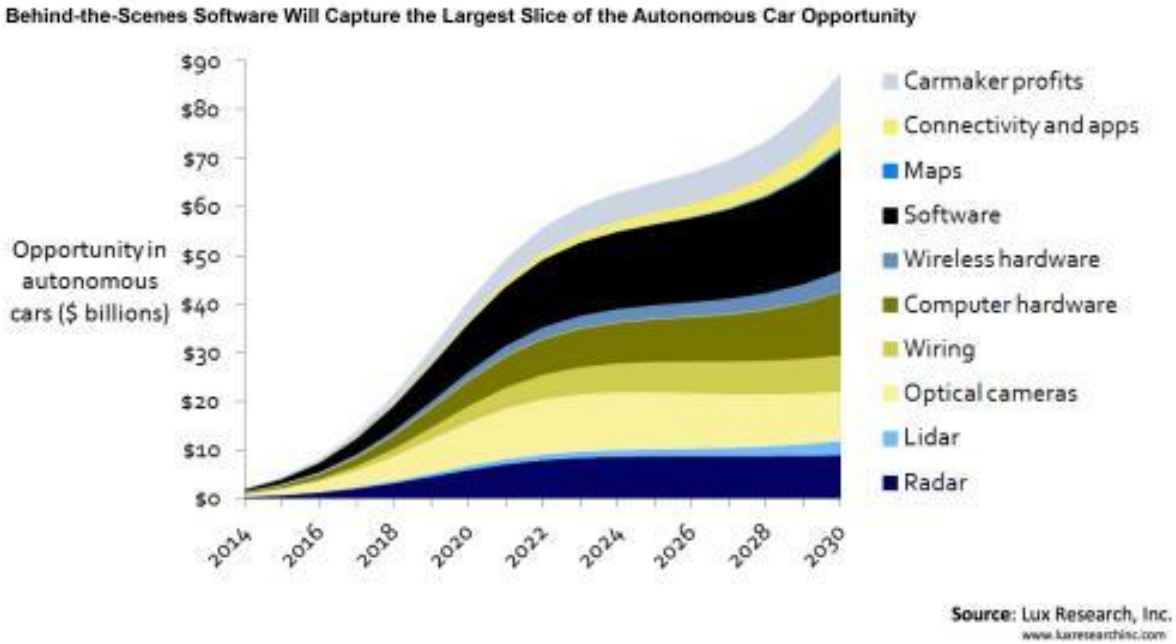
Different levels of technology

Traffic Ahead

Many carmakers are developing prototype vehicles that are capable of driving autonomously in certain situations. The technology is likely to hit the road around 2020.

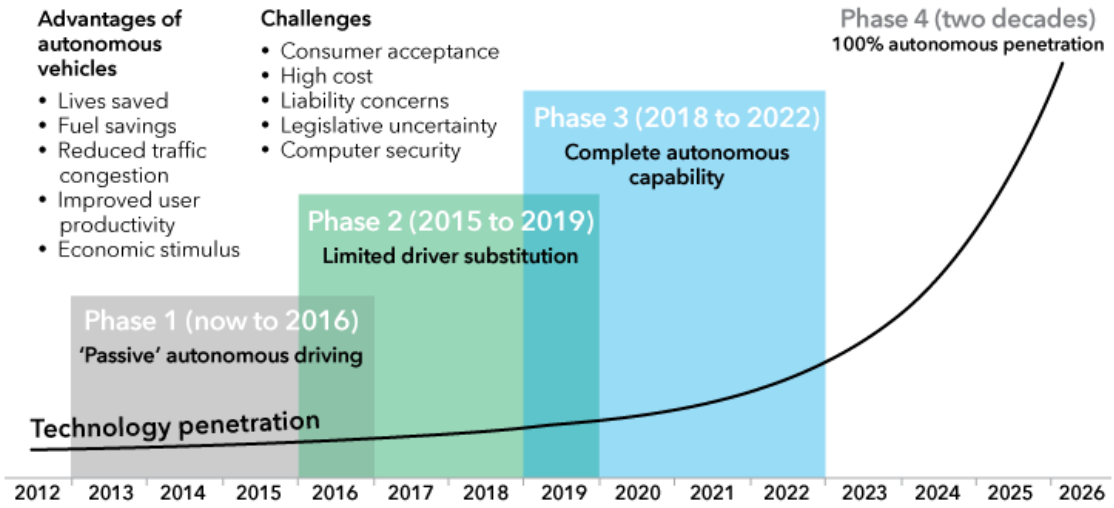
	BMW	Mercedes-Benz	Nissan	Google	General Motors
VEHICLE	5 Series (modified)	S 500 Intelligent Drive Research Vehicle	Leaf EV (modified)	Prius and Lexus (modified)	Cadillac SRX (modified)
KEY TECHNOLOGIES	• Video camera tracks lane markings and reads road signs • Radar sensors detect objects ahead • Side laser scanners • Ultrasonic sensors • Differential GPS • Very accurate map	• Stereo camera sees objects ahead in 3-D • Additional cameras read road signs and detect traffic lights • Short- and long-range radar • Infrared camera • Ultrasonic sensors	• Front and side radar • Camera • Front, rear, and side laser scanners • Four wide-angle cameras show the driver the car's surroundings	• LIDAR on the roof detects objects around the car in 3-D • Camera helps detect objects • Front and side radar • Inertial measuring unit tracks position • Wheel encoder tracks movement • Very accurate map	• Several laser sensors • Radar • Differential GPS • Cameras • Very accurate map

Predicted Opportunities



- Software industry will be main benefactor in a move to autonomy
- Lux Research predicts that the market for self-driving cars will be $87 Billion by 2030 (however in their prediction no cars are expected to be fully autonomous to Level 4 by this date)
- 92% of vehicles will have simple Level 2 driver assist features such as adaptive cruise control, lane departure warning and collision avoidance braking
- Level 3 cars using high resolution maps are expected to gain an 8% share of the market

Barriers

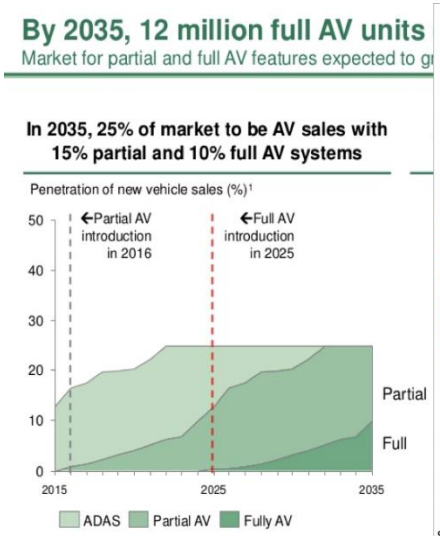


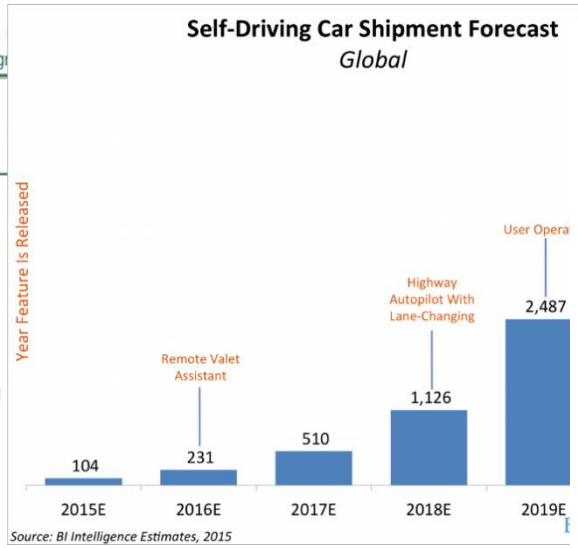
- The majority of the work is currently concentrated on technical solutions, e.g. processor architectures, sensor technologies, and data processing algorithms
- The key challenge here is to make the technologies cheap enough for mass usage. The systems used on the Google Car, for instance, to make it fully autonomous currently cost $150,000.
- More of a concern, however, is how will autonomous vehicles actually behave when mixed with more traditional vehicles, especially under fault conditions. Designers will not be able to anticipate all possible eventualities and put in place necessary and sufficient mitigations as the scope of the system is effectively unbounded and the number of eventualities is very large.
- Need for intensive real-time monitoring of the performance of the systems to spot potential issues arising before they develop into accidents. This leads to other potential barriers such as the loss of driver's privacy.

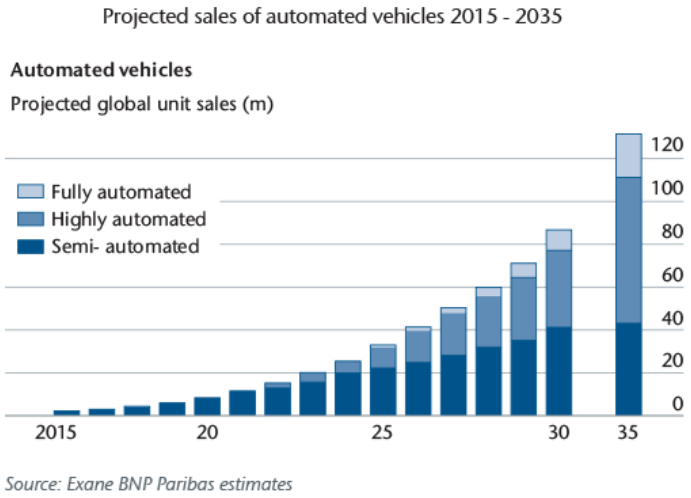
Staged Uptake

- The introduction of autonomous cars will happen in phases as the technology develops and users develop trust.
- BCG surveyed 1,500 U.S. drivers as well as interviewing executives of some leading car making companies. The study revealed that :
  - 55% of the respondents would like to buy a fully autonomous car within 5 years
  - 44% would consider to do so within a 10-year time
  - 20% would pay an extra $5,000 for highway and urban autopilot features
- Benefits : increased safety, lower insurance and fuel costs.
- First - highway and traffic jam autopilot modes.
- Later – urban autopilot.
- Japan and Western Europe are predicted to be the fastest adopters of intelligent self-driving cars, followed by the U.S. and China.

Staged Introduction







- Not all cars will be fully autonomous in the future and looking at the global market there will be a mix of vehicles on the road with Advanced Driver Assist Systems (ADAS), partial autonomy and full autonomy.
- Highly autonomous cars being dominant by 2035 with fewer fully autonomous cars.
- This leads to a global market prediction of $42 Billion in 2025 and $77 Billion market in 2035

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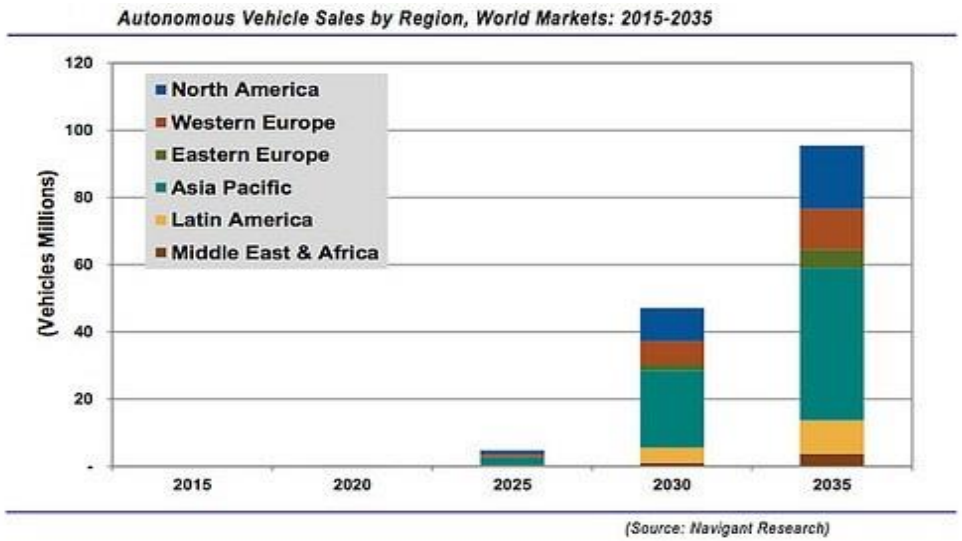
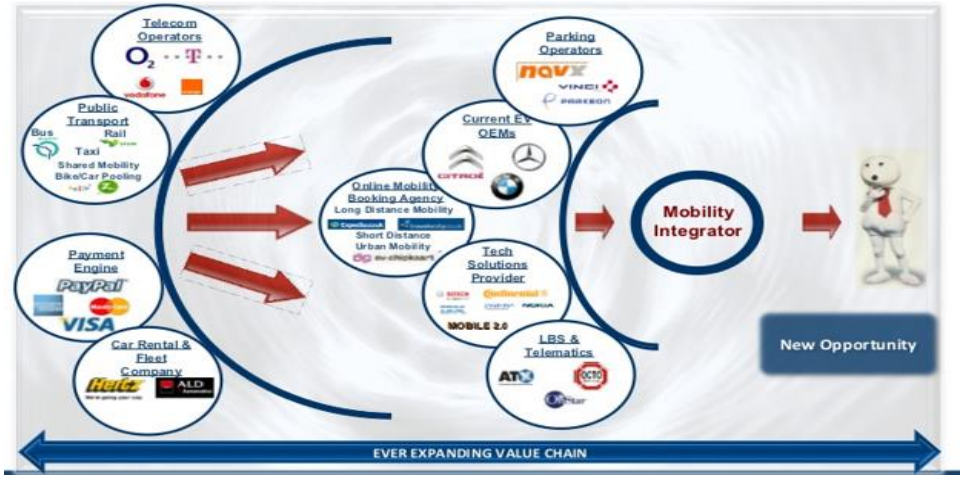
Worldwide Market



- Future market will be dominated by the Asia Pacific region with roughly equal numbers of cars being sold in Europe and North America.
- Worldwide the total number of autonomous car sales was considered to be about 95 million.
- The biggest opportunities for companies are in the software sector as this will be a differentiator and also key to safety. This is expected to grow from $0.5 Billion today to $10 Billion in 2020 and $25 Billion in 2030. Here it is expected that Google and IBM will be major players.

Car Sharing and Mobility Integrators



- Car ownership is predicted to decrease in the future with more and more people using mobility solutions and services
- Uber (founded 2009) has revolutionised the taxi industry operating worldwide with an estimated worth of $62.5 billion. Use of self-driving cars would be a major saving for the company.
- GM has bought a $500 million stake in Lyft a rival to Uber in the US and also bought Cruise Automation for $1 billion which has key self-driving technology.
- The provision of mobility services and “ride-sharing” is a natural fit for self-driving cars.
- Personal vehicle ownership is not a high priority - removes the hassle of driving which may not be possible if combined with social drinking – no responsibility for maintaining and insuring the car.
- Elon Musk, has also highlighted plans to implement car sharing which would allow Tesla owners to earn money by lending out their cars.

Societal Changes Introduced by Autonomous Vehicles

Key Changes

- The introduction of Internet connectivity to cars
- The move to autonomous vehicles to improve safety, improve traffic flow and reduce emissions
- The introduction of mobility services

- Many positive impacts

However

- Threat of automation and AI to jobs

Concluding Remarks

- Major research opportunities – global market
- Opportunities are in developing systems for vehicles but also for the supporting infrastructure – increased connectivity and automation is a driver in all domains
  - Increased automation (CPS) – trust, safety, liability, AI
  - Traffic management (CPS) – big data analytics, AI optimisation
  - Health monitoring (IoT) – big data analytics
  - Infotainment (IoT) – 5G
- There are also new opportunities for services, e.g. Mobility Integrators, which is likely to lead to new players in the market
- An issue will be the societal changes that this may bring