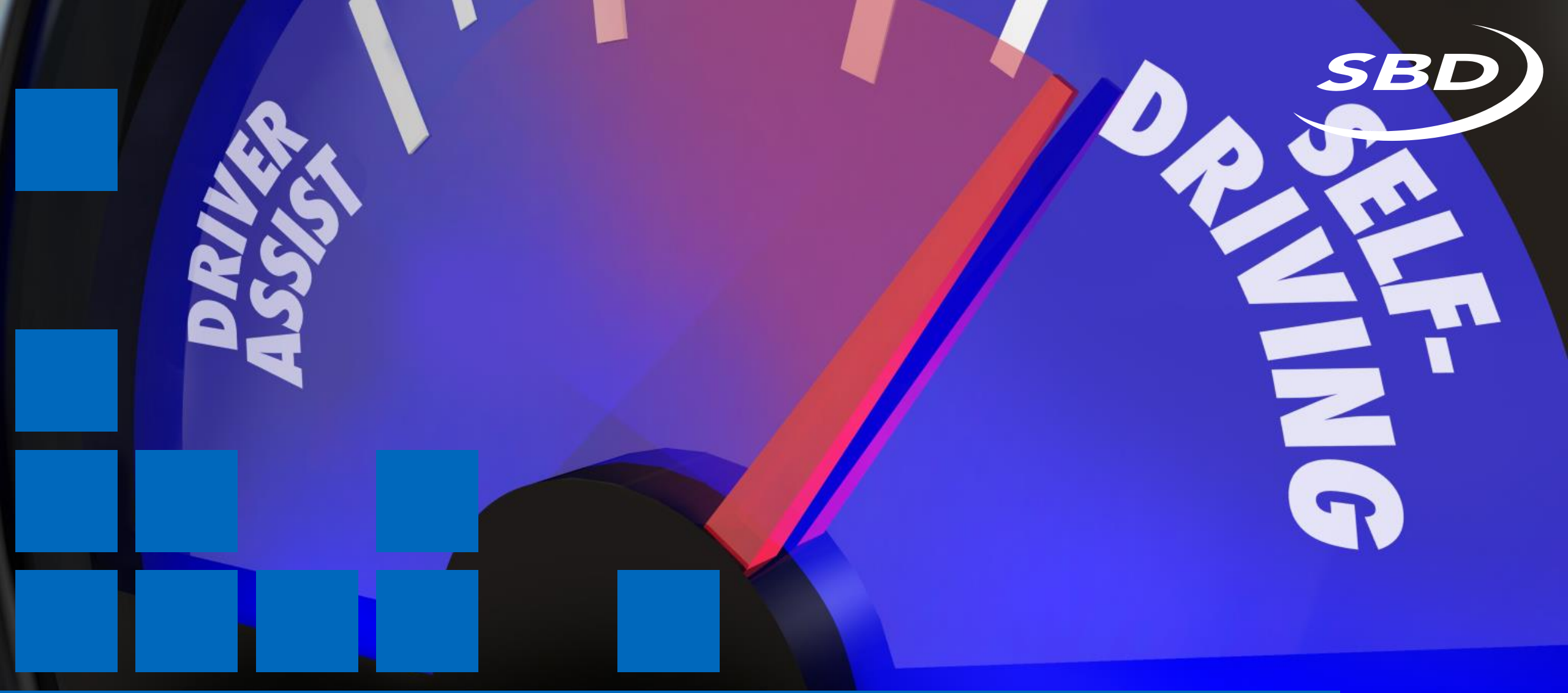


Vehicle autonomy – What will be the impact?

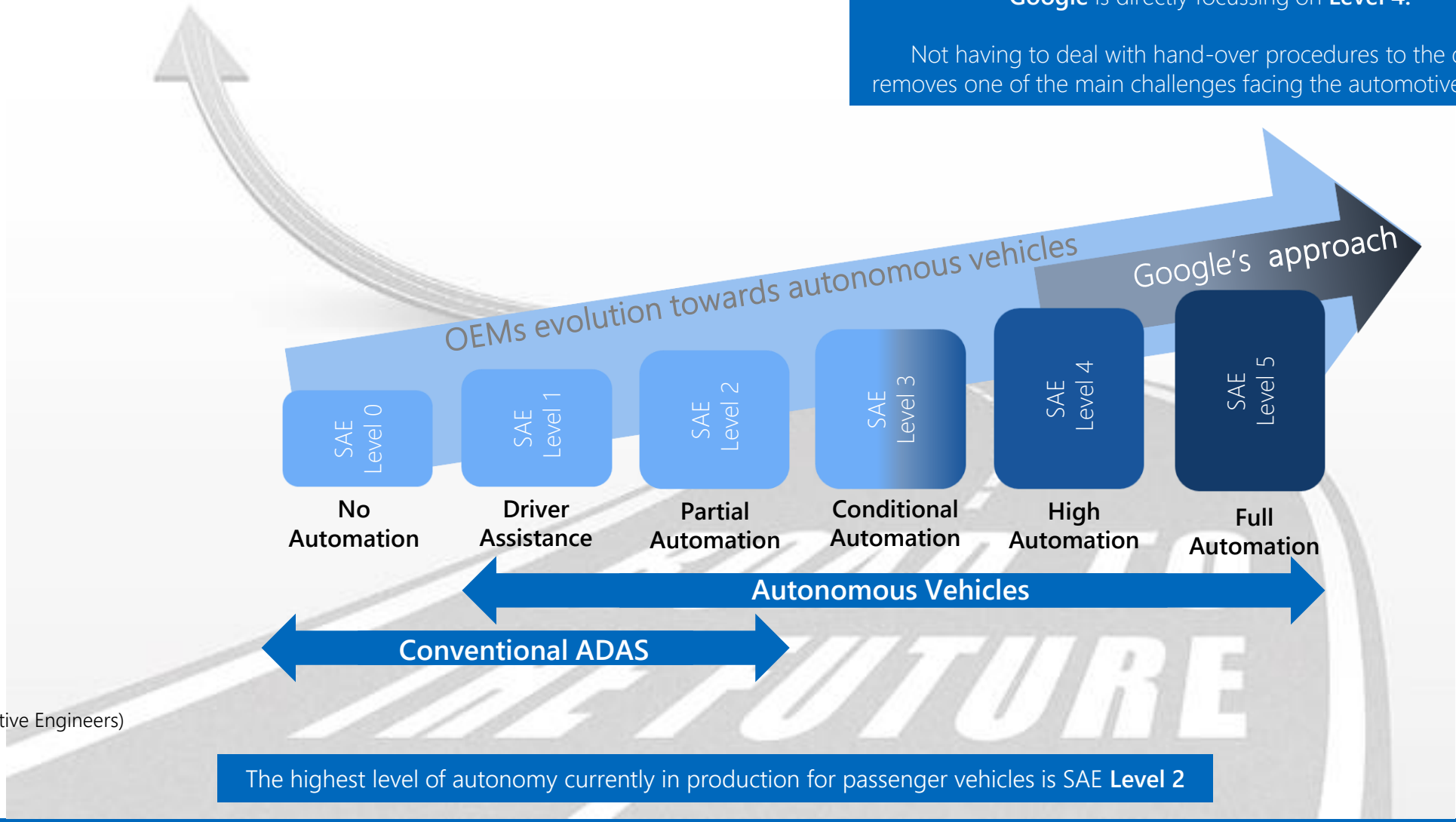
Deepa Rangarajan (SBD), Andy Graham (White Willow Consulting)

Different levels of vehicle autonomy

Car manufacturers are working towards deploying systems corresponding to **Level 3**.

Google is directly focussing on **Level 4.**

Not having to deal with hand-over procedures to the driver removes one of the main challenges facing the automotive industry.



SAE (Society of Automotive Engineers)

The highest level of autonomy currently in production for passenger vehicles is SAE **Level 2**

ADAS landscape: Two different paths

Autonomy for collision mitigation / avoidance
Conventional ADAS

Brief intervention & Control
(sub second to a few seconds)

Focus is on **Collision Avoidance**

Autonomy for convenience
Autonomous Vehicles

Continuous intervention / Control
(minutes to hours)

Focus is **Regaining Time & New Mobility** business models

Autonomy for Safety

Collision avoidance

Road fatalities

1.2 Million road fatalities every year globally…

…equivalent to **1846** A380-800 crashing every year

and this is only for fatalities …

casualties numbers are probably 13X more for serious injuries and 93X more for slight injuries (applying the 2015 UK accident statistics ratio).

Damage only accidents are around 2 Million in the UK, so worldwide 1154X

Serious injury: An injury for which a person is detained in hospital as an "in-patient".

Slight injury: An injury of a minor character such as a sprain (including neck whiplash injury), bruise or cut which are not judged to be severe, or slight shock requiring roadside attention.

Summary

	% change since '14
1,732 fatalities	↓ 2%
22,137 seriously injured	↓ 3%
162,340 slightly injured	↓ 4%
317 billion vehicle miles (motor vehicle traffic)	↑ 2%

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/533294/rrcgb-main-results-2015-infographic.pdf

Impact of conventional ADAS

Unprecedented impact on accidents but… still a lot of work needed

Low Speed AEB technology leads to a **38%** reduction in real-world rear-end crashes

Euro NCAP and ANCAP publication
"Effectiveness of Low Speed Autonomous Emergency Braking in Real-Life World Rear-End Crashes in the online edition of the journal 'Accident Analysis & Prevention'.

Subaru accident statistics in Japan

	Subaru vehicles sold in FY2010-2014	Total accidents	Vehicle-to-pedestrian	Vehicle-to-vehicle /Other	Of which, rear-end crashes
Vehicles with EyeSight	246,139	1,493	176	1,317	223
Accidents per 10,000 units : <A>		61	7	54	9
Vehicles without EyeSight	48,085	741	67	674	269
Accidents per 10,000 units : <B>		154	14	140	56
(A-B)/B		-61%	-49%	-62%	-84%

ADAC tests

Car	Sensors	Crossing adult (up to 60 km/h)	Adult along (up to 60 km/h)	Child behind car (up to 50 km/h)	Slow cyclist (up to 40 km/h)	Night with reflective vest (up to 45 km/h)	Night with dark cloth (up to 45 km/h)
Audi A4	Mono camera	72 %	88 %	93 %	50 %	71 %	17 %
Subaru Outback	Stereo camera	89 %	100 %	46 %	0 %	100 %	100 %
KIA Optima	Radar and camera	72 %	75 %	54 %	0 %	50 %	0 %
Daimler C-Class	Stereo camera and radar	67 %	75 %	43 %	25 %	0 %	0 %
Volvo V60	Radar and camera	39 %	50 %	21 %	0 %	0 %	0 %
BMW 3er	Mono camera	28 %	38 %	7 %	13 %	0 %	0 %

Many OEMs are only developing their active safety strategy as a function of EuroNCAP 5 stars rating. Very few are trying to over-achieve…

Impact of conventional ADAS

Unprecedented impact on accidents reduction but… the technology is deployed where it is least needed…

More than 90% of fatalities take place outside of NA, EU, Japan and Australia

Impact of conventional ADAS

What is needed

AEB is effective and can drastically reduce road accidents, however we need

- Much wider deployment around the world (Safety should not be just for rich markets)
- Consumer awareness campaigns
- Accelerate deployment by potentially mandating the technology
- Develop poor / emerging countries specific solutions

Autonomous vehicles are NOT the answer globally to road fatalities.

The solution is conventional ADAS (AEB) together with improvement with the existing technologies (pedestrians, junctions, night time performance, etc.)

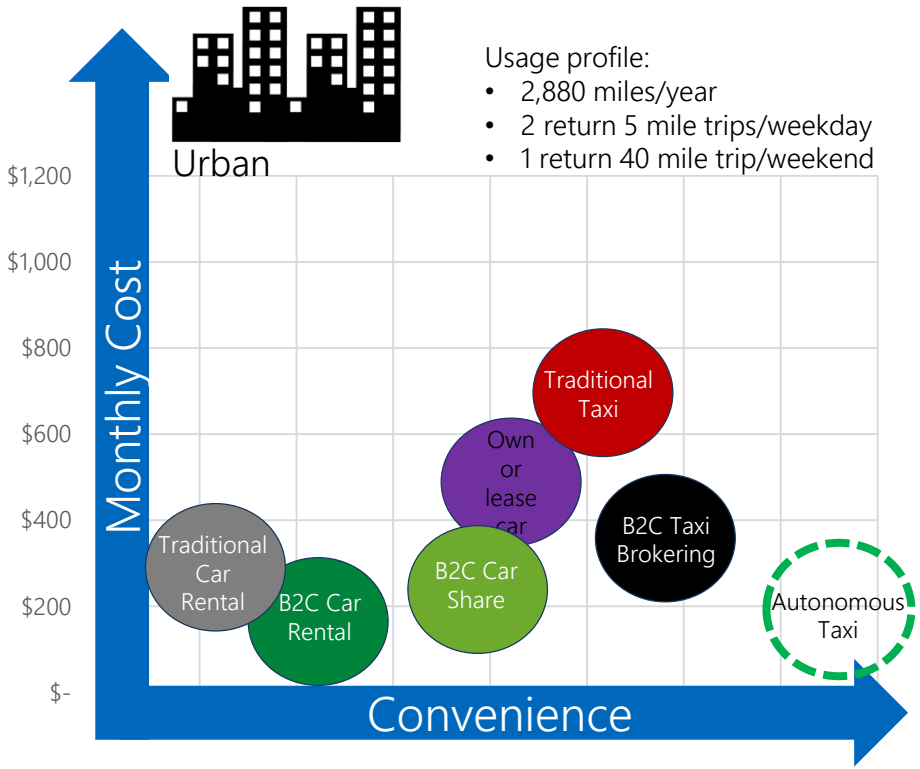
Autonomy for Convenience

Regaining time / New mobility

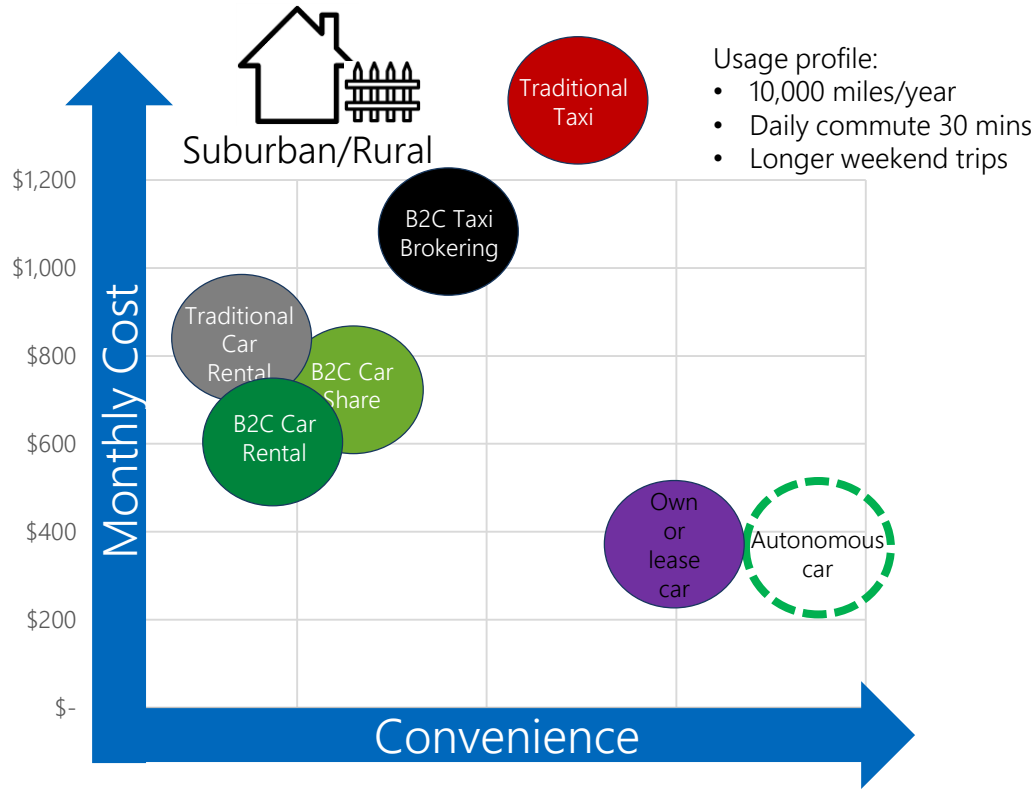
Automotive mobility?

Many different mobility approaches, however convenience over cost is key to success.

Urban living



Sub-urban living



Autonomy - car sharing Vs vehicle ownership

Car Sharing / Taxi brokering

Unlike bicycle share programmes, where bikes can easily be re-distributed in the city to meet customer needs, re-distributing cars can provide a logistical nightmare.

Being able to re-distribute vehicles autonomously would therefore present a business model advantage (car sharing) on top of potentially not having any drivers when carrying customers (car brokering).

Many schemes have now been initiated to investigate feasibility.

Vehicle ownership

The ultimate scenario for convenience would be the ability to engage full autonomy as and when required.

Many obstacles (technical and cost in particular) remain.

Consumer appeal is also unclear, especially if allowed unsupervised period are short.

Impact of autonomy for convenience

Road capacity – Motorways

The impact of autonomous vehicles on road capacity is mainly a function of **penetration** and **time headway** (time between vehicles).

Many research papers have assumed 100% penetration of autonomous vehicles in order to give a "best case" scenario.

- More realistic work have shown little capacity impact until high penetrations rate are achieved **(>40-75%).**
- Some detrimental impact have been indicated as vehicle density will decrease due to conservative headways (>1.2 s) compared to current driving*.
- Some research has highlighted that ACC can even degrade string stability and therefore lead to congestion**.
- Co-operative ACC can dampen this effect.

The obvious solution for capacity would be to decrease the headway significantly, however this is unlikely initially as shorter headway are not going to feel comfortable as well as presenting some safety and litigations issues.

*(Bierstedt et al, Princeton University)
**(Vincente Milanes, Shladover: Modelling co-operative and autonomous adaptive cruise control dynamic responses using experimental data. Transportation Research C 2014)

Impact of autonomy for convenience

Road capacity – Urban environment

For comfort reasons to allow work on a laptop for example, autonomous vehicles may need to follow acceleration profiles less aggressive than the one normally applied by manually drivers.

Assuming the longitudinal accelerations implemented by the railway industry (around 1.3 m/s^2), a capacity reduction at signalized intersection and increases in delays has been demonstrated*.

To see the benefit of vehicle autonomy in terms of road capacity, "more aggressive" driving behaviour than currently tested may need to be implemented.

Reserved lane may also need to be put in place in order to avoid mixed traffic latencies. If a manually driven vehicle happens to be very slow leaving a junction then the entire queue behind will be equally slow…

Local driving habits in Rome

*(Scott Le Vine, Zolfaghan, Polak: Autonomous cards: The tension between occupant experience and intersection capacity: Transport Research part C : arch 2015)

Impact of autonomy for convenience

Road capacity – will get worse before it gets better

The introduction of autonomous vehicle is likely to decrease road capacity initially, mainly because:

- High penetration of such vehicles will be needed before seeing some benefit
- Early autonomous vehicles will have to have a conservative behaviour

Additionally, junctions are a challenge and so far roundabouts seem to have been not researched.

Human driver to autonomous vehicle interaction will be the key and human behaviour varies by city in the same country as well as by nation*.

*LSE research for Goodyear

Impact of autonomy for convenience

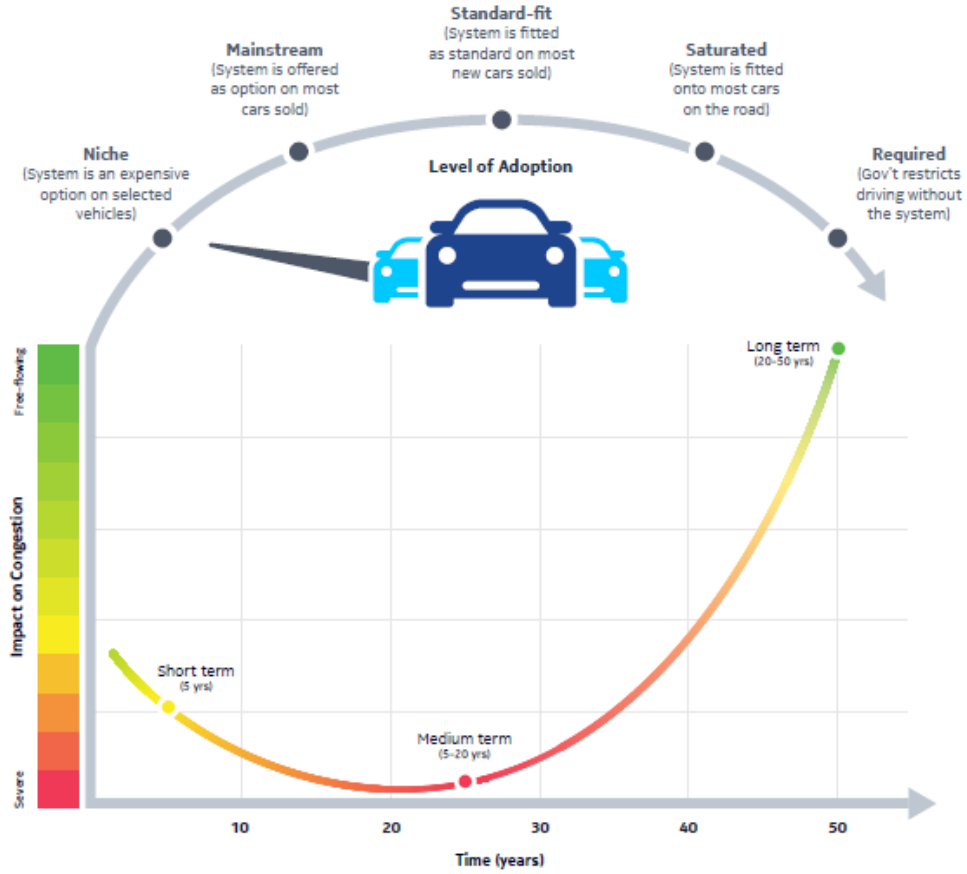
Conclusions

There is good evidence that using data from vehicles can improve effective capacity, in particular for

- Traffic signal setting
- Speed control
- Avoiding road closures due to roadworks and accidents
- Data for better planning roads operations and new build

Collaboration is key to avoiding negative impact

- Culture of sharing - using probe data to understand the impact of autonomous vehicles in real mixed traffic and optimise road networks
- Bridging the gap - V2V can provide a bridging mechanism between autonomous and traditional cars



Thank you!