Autonomy

The Outlook for Autonomous Vehicles

May Arthapan, Director, Asia Pacific
Automotive Summit 2019
Bangkok, 20 June 2019

Autonomous Vehicles – Outline

- Changing expectations
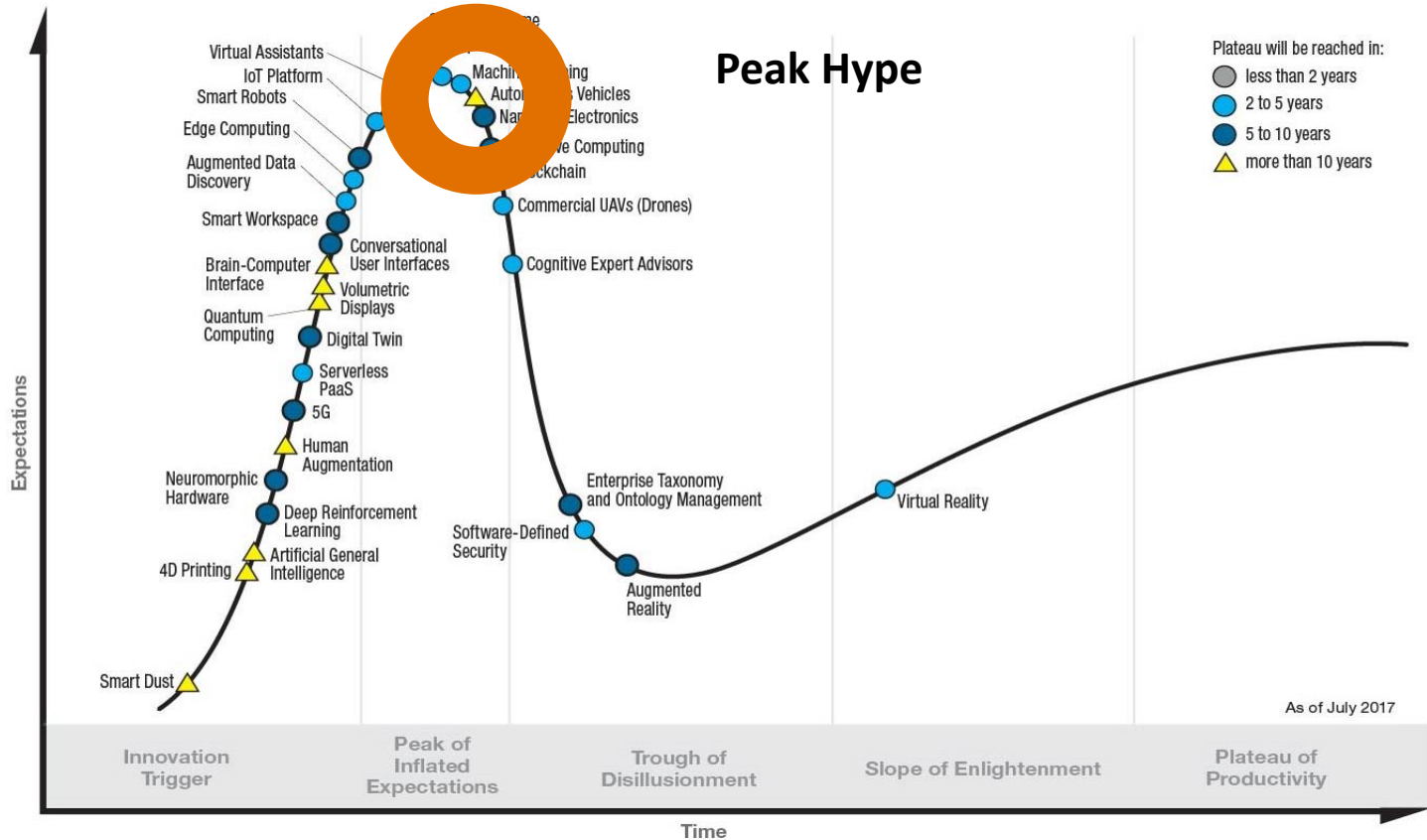
- The biggest barriers

- Forecasts

AV definitions (SAE)

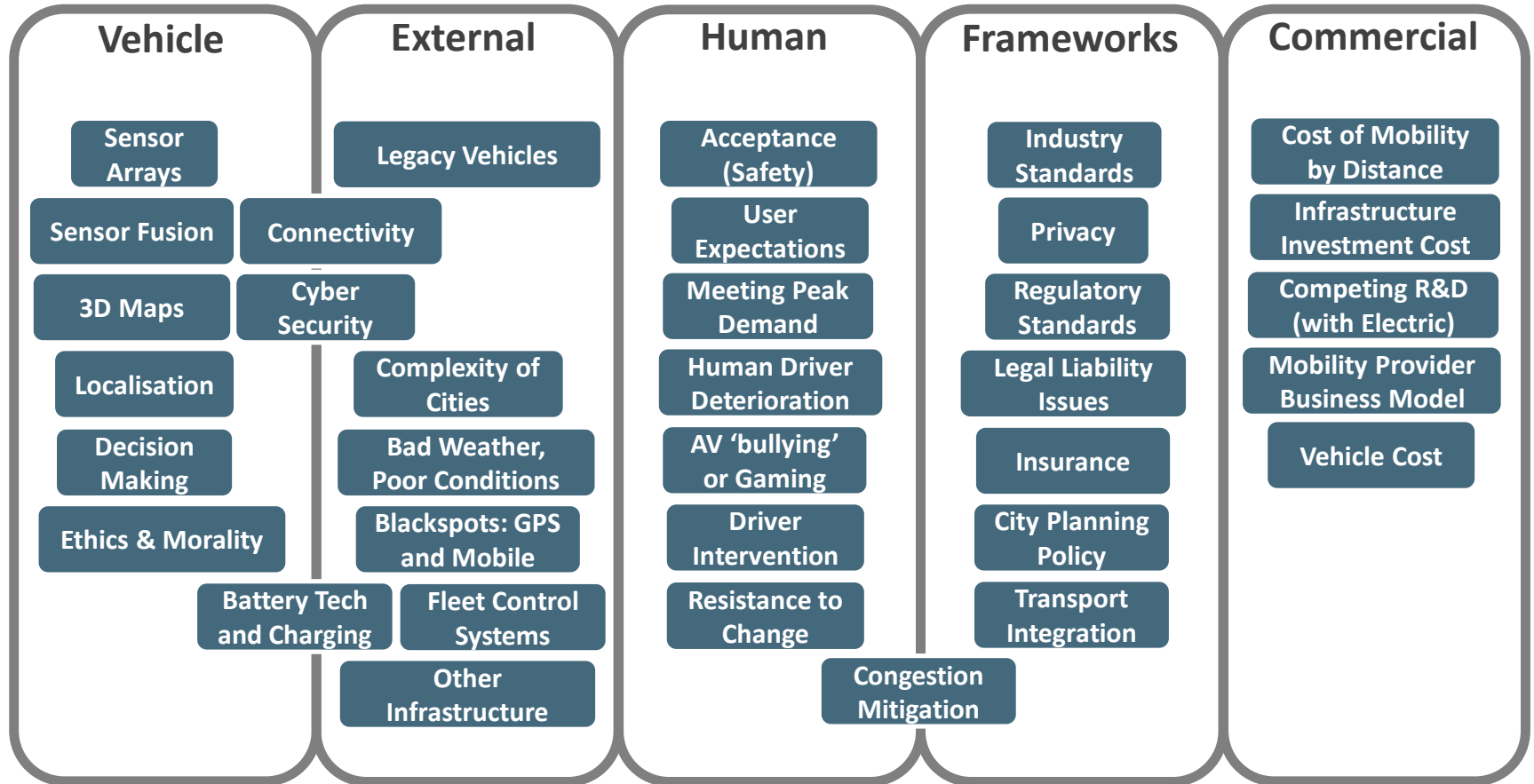| Level	Description	Human roles	Vehicle roles (typical)
0	None	All driver control	No autonomous functions
1	Limited + Safety	Almost all driver control	ABS, traction controls, …
2	Limited, Active Safety, Convenience	Mostly driver control	Lane keeping, emergency braking, adaptive cruise control, parking assist, …
3	Significant Autonomy	Driver can disengage completely sometimes	Advanced controls in simple conditions (highway, slow-moving congestion, good weather)
4	High Autonomy	Driver not needed in some locations/conditions	Full conditional autonomous capabilities, more difficult conditions/locations not autonomous
5	High/Complete Autonomy	No driver needed	Autonomous driving in all locations/conditions possible, driver controls (brakes, steering wheel) not necessary

Source: SAE

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AVs on the Gartner Hype Cycle (2017)

Peak Hype

Plateau will be reached in:
- less than 2 years
- 2 to 5 years
- 5 to 10 years
- more than 10 years

Virtual Assistants
IoT Platform
Smart Robots
Edge Computing
Augmented Data Discovery
Smart Workspace
Brain-Computer Interface
Quantum Computing
Conversational User Interfaces
Volumetric Displays
Digital Twin
Serverless PaaS
5G
Human Augmentation
Neuromorphic Hardware
Deep Reinforcement Learning
4D Printing
Artificial General Intelligence
Smart Dust

Machine Learning
Autonomous Vehicles
Nanotube Electronics
Cognitive Computing
Blockchain
Commercial UAVs (Drones)
Cognitive Expert Advisors
Enterprise Taxonomy and Ontology Management
Software-Defined Security
Augmented Reality
Virtual Reality

Expectations
Time

Innovation Trigger | Peak of Inflated Expectations | Trough of Disillusionment | Slope of Enlightenment | Plateau of Productivity

As of July 2017

Source: Gartner

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AVs on the Gartner Hype Cycle (2018)

Source: Gartner

Barriers to widespread AV adoption

Vehicle

- Sensor Arrays
- Sensor Fusion
- Connectivity
- 3D Maps
- Cyber Security
- Localisation
- Decision Making
- Ethics & Morality
- Battery Tech and Charging
- Fleet Control Systems
- Other Infrastructure

External

- Legacy Vehicles
- Complexity of Cities
- Bad Weather, Poor Conditions
- Blackspots: GPS and Mobile

Human

- Acceptance (Safety)
- User Expectations
- Meeting Peak Demand
- Human Driver Deterioration
- AV 'bullying' or Gaming
- Driver Intervention
- Resistance to Change
- Congestion Mitigation

Frameworks

- Industry Standards
- Privacy
- Regulatory Standards
- Legal Liability Issues
- Insurance
- City Planning Policy
- Transport Integration

Commercial

- Cost of Mobility by Distance
- Infrastructure Investment Cost
- Competing R&D (with Electric)
- Mobility Provider Business Model
- Vehicle Cost

Source: LMC Automotive

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Colour = probably OK, or good enough, if still not fully ready

Colour = path clearer, but long development time (5+ or 10+ yrs)

Source: LMC Automotive

Ethics & morality – the trolley problem

The trolley problem

The person can choose to divert the tram from the main track, saving five people on the track, but killing the worker on the other track.

theconversation.com

Images adapted from shutterstock.com

Source: theconversation.com

The difference between seeing and understanding

Hey Siri: where's the road?

OK Google: do those flat bits look OK to you?

Source: LMC Automotive

STOP!

- Human visual and perception systems are extraordinarily good at handling and interpreting variation.

- But computer vision and perception systems still struggle, even at today's state of the art.

- These images were misclassified by deep learning vision systems after minor – and plausible real-world – changes were applied to otherwise reasonably presented signs.

Sign angle problem

Graffiti problem
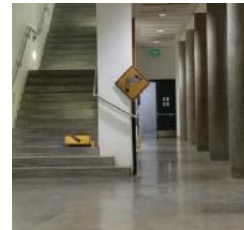
Context problem

Random problem

Source: CVPR 2018

And more …

Heavy rain, fog, dust

Heavy snow (in air and on surfaces)

Hills (passing over top of)

Unmapped hazards

Airborne debris

Pedestrians (interpreting intentions of)

Exiting vehicles

Emergency vehicles

Animals

Poor road conditions & unmarked sections

Transition to/from tunnels and bridges

Bad (human) drivers and erratic driving norms

Sep-18. John Leonard, Toyota Research Institute (US), on Autonomous Vehicles:

"Taking me from Cambridge to Logan Airport with no driver in any Boston weather or traffic condition – that might not be in my lifetime."

Source: LMC Automotive

'Safety first' for the world's AV leader …

August 2018

Waymo vehicle hesitating at intersection — 0:17 / 0:17

15 seconds to take an easy right turn. This is not a big deal, but it hints at a number of things:

AVs are not '*just around the corner*' – this vehicle did not know how to proceed safely within an acceptable timeframe.

Extra-safe AV driving is likely to be around for a number of years – not workable at scale.

Human driver inputs – in vehicle but also remote – might be involved for a number of years more.

Source: Waymo/Google

Shared services add to total miles driven

August 2018. New York curbs ride hailing expansion

New York became the first US city to curb the expansion of Uber, Lyft and other ride-hailing services as lawmakers approved a 12-month halt on issuing new for-hire vehicle licences.

Financial Times

Bill de Blasio, mayor of New York, said: "We are halting the flood of new cars grinding our streets to a halt."

Uber: "Demand for rides has grown every year since Uber entered New York City, and with a public transit system in crisis, this trend is likely to continue. If there are not enough driver-partners on the road to meet growing demand, reliability for riders could decline, and they would likely choose other transportation options instead of requesting Uber trips."

Defining the expected deployment matters

Greater London:

Approximately 1600 km^2 – 15,000 km of roads

Population close to 9 mn people

Shared Level 4 AV services operating in all of this area, most of the time, would be a game changer.

Source: UK DfT, NSO

Defining the expected deployment matters

AV roll-out likely to be constrained, step by step and not like a Sci-fi movie.
Note: these examples are all, by definition, Level 4 AVs.
Many more examples like this.

Dublin 2018, 1 km

Singapore, 2022, aimed at first/last mile

Rotterdam, 2getthere, since 1999!

Multicity, US & Singapore, since 2016

Source: LMC Automotive

Autonomous Vehicles – Outline

- Changing expectations

- The biggest barriers

- Forecasts

Having said all that …

… it's important to see the (near) inevitability of AV adoption. Why?

- Safety improvements are already being demonstrated – there will be much more of this as Level 2, and Level 3, systems demonstrate safety credentials.

- Well-planned adoption of AVs, especially shared with good transport system integration, can mitigate growth in congestion.

- More effective use of vehicles as assets (the <5% usage statistic).

- Parking is wasteful in some of the highest land-price locations in the world.

- AVs can be inclusive for the young, old and disabled.

- Expansion in time for productive and leisure activity (when not driving).

- New service opportunities will be a commercial imperative.

- New competition is coming.

Source: LMC Automotive

AVs: distinction between Shared and Owned

Shared (fleet) AVs

- Shuttles, taxis, ALCVs
- Public transport integration
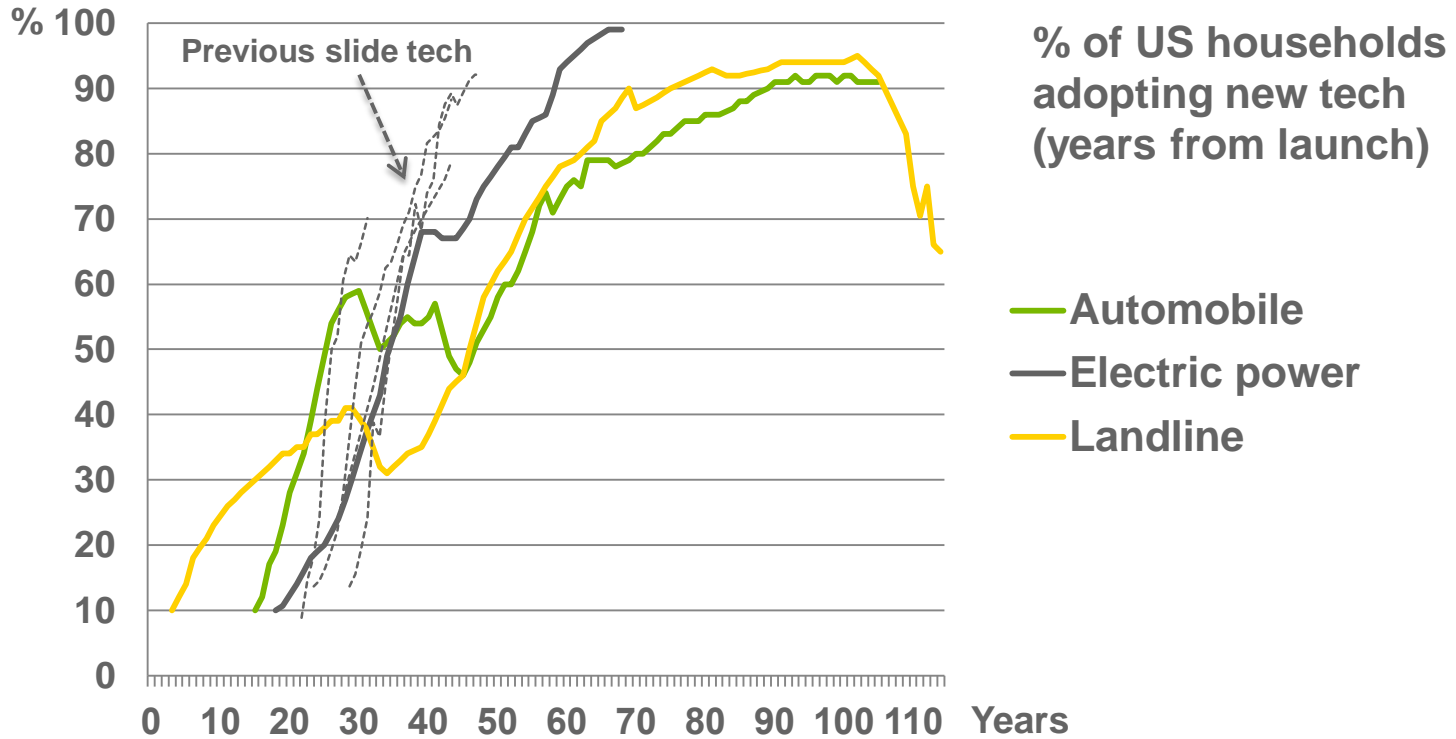- Will ultimately substitute ownership
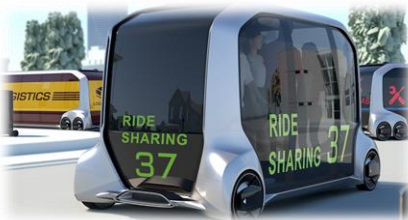
Owned (private) AVs

- Evolutionary development
- Premium first, or option
- Minimal ownership impact
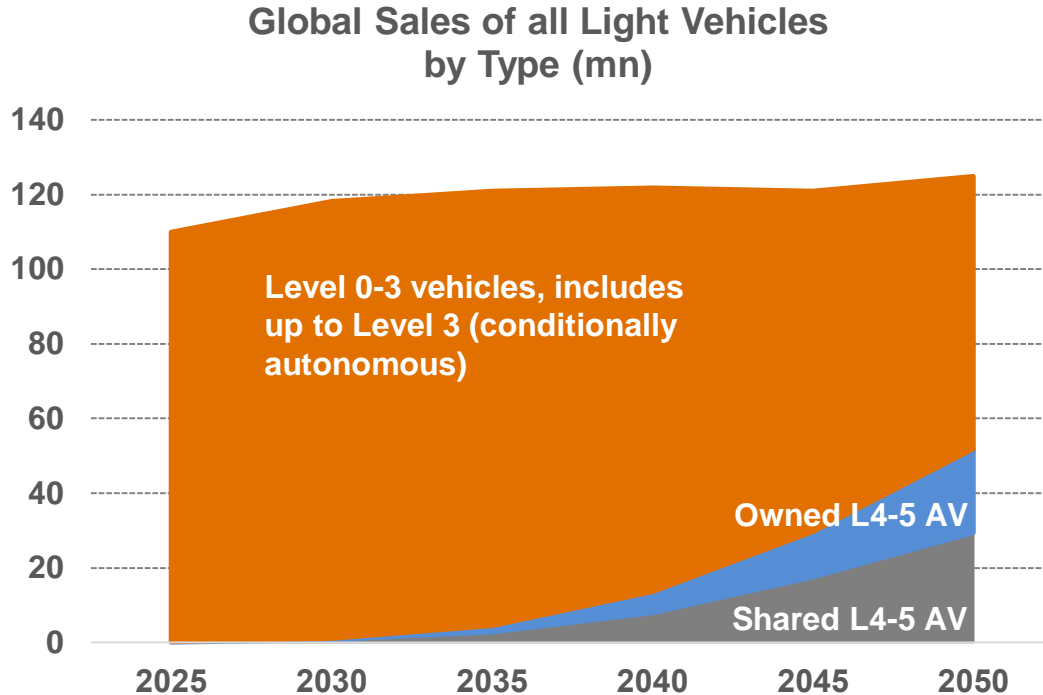(but will slowly grow over time)

Source: LMC Automotive
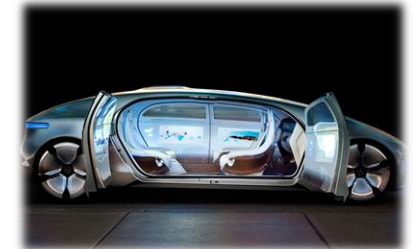
Technology adoption curves – it now happens quickly

% of US households adopting new tech (years from launch)

— **Mobile phones**
— **Internet**
— **Social media**
— **Home computer**

Source: Various
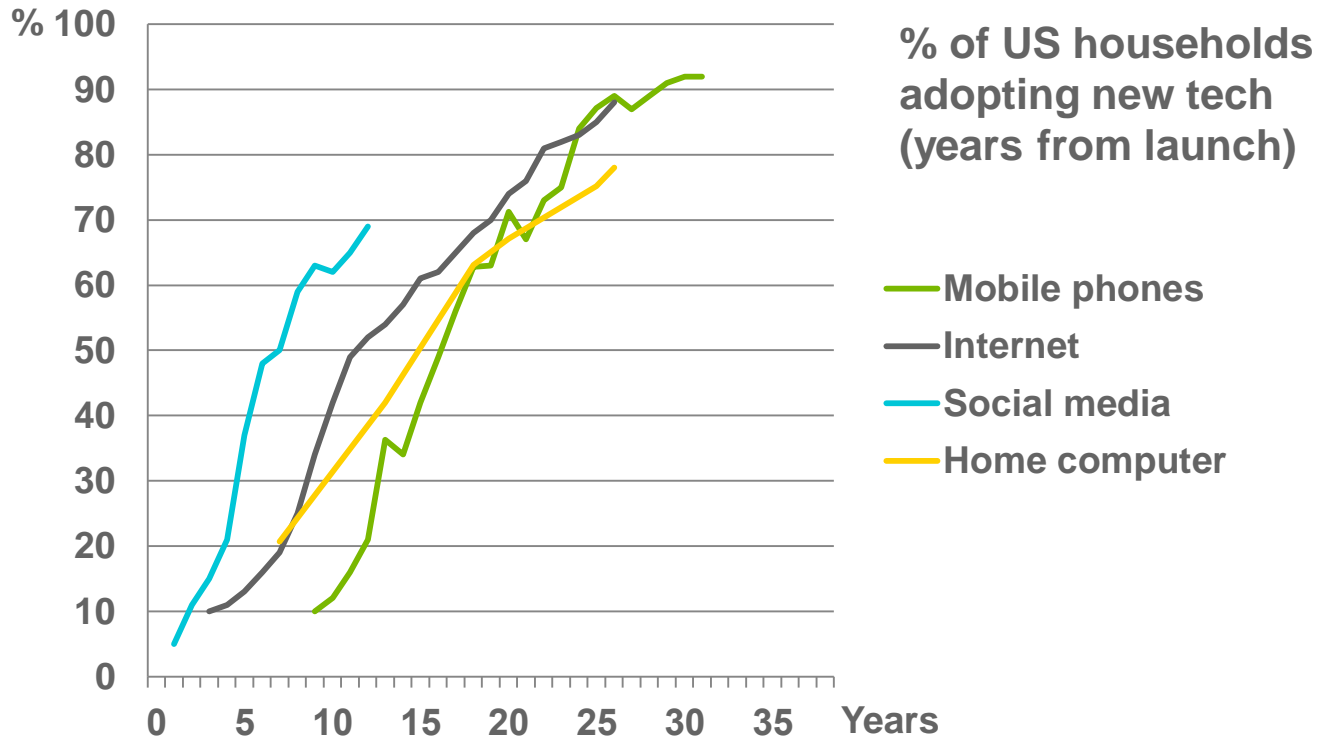
Adoption slower if: complex, costly, needs infrastructure

% of US households adopting new tech (years from launch)

— Automobile
— Electric power
— Landline

Source: Various

AV forecast: world by main SAE autonomy level

Global Sales of all Light Vehicles by Type (mn)

Level 0-3 vehicles, includes up to Level 3 (conditionally autonomous)

Owned L4-5 AV

Shared L4-5 AV

Source: LMC Automotive

AV forecast: scenarios

Global Sales of Shared and Owned AVs (mn)

Year	Value
2025	0.2
2030	1.2
2035	4.5
2040	13.7
2045	29.8
2050	52.0
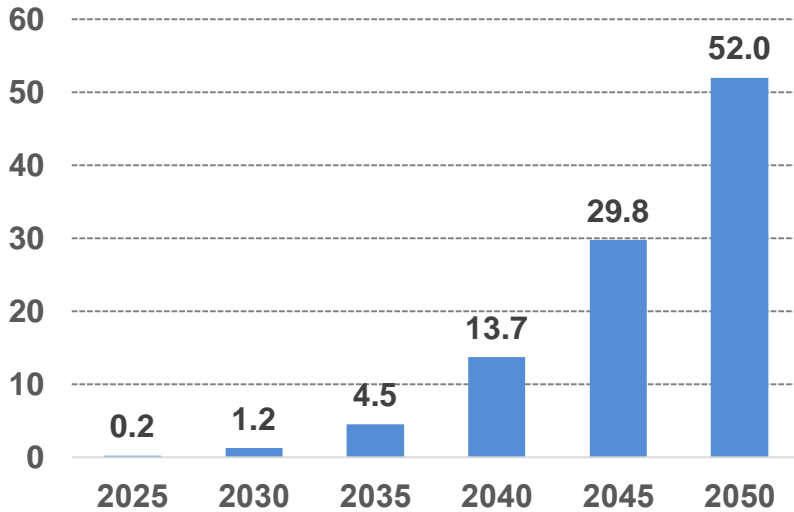
Global Sales of Shared and Owned AVs (mn), by Scenario

Breakthrough

Central

Constrained

Source: LMC Automotive
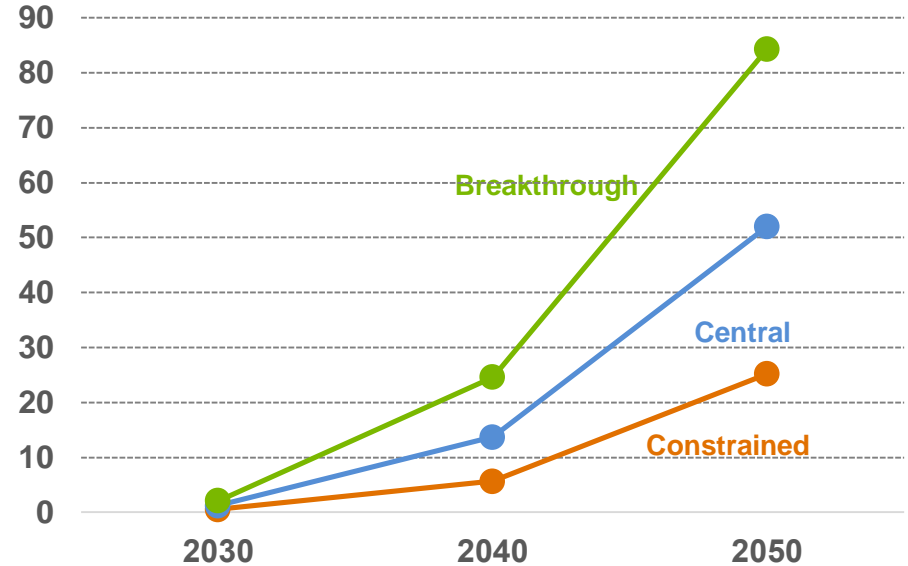
Shared AV forecast

Global Sales of Shared AVs by Region (mn)

Legend: EU, NA, AP, CIS, ROW
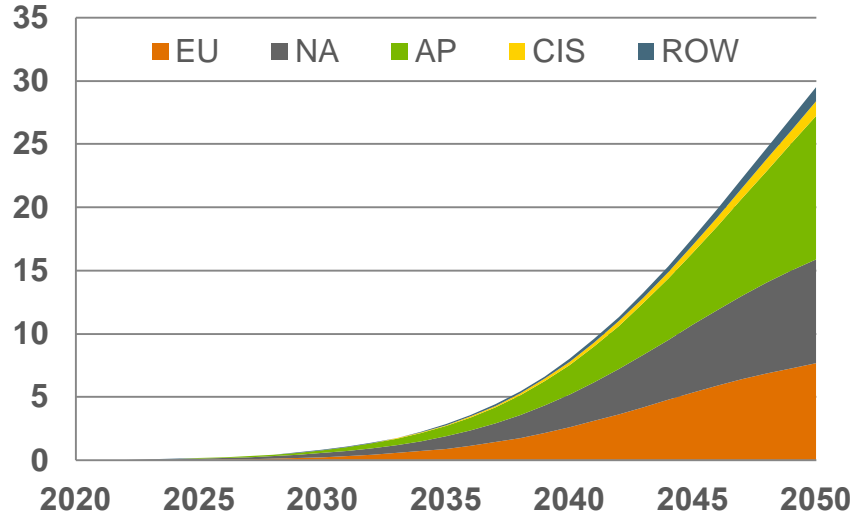
Asia Sales of Shared AVs by Market (mn)

Legend: China, Japan, Australia, SEA, India

Source: LMC Automotive
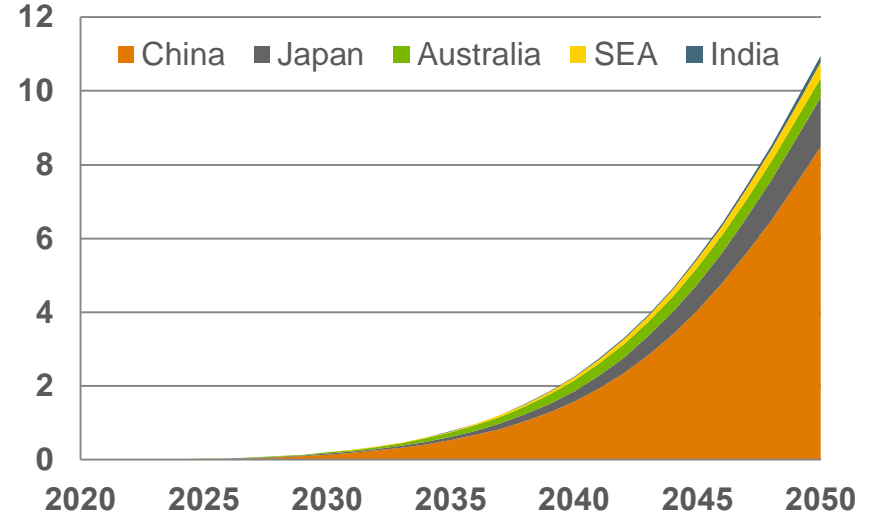
Concluding remarks

- Technical challenges are proving difficult to solve quickly. While a Breakthrough scenario cannot be ruled out at this point (e.g. Tesla), we don't think it is likely.

- Challenges can ultimately be met, but competition for investment with a return on a reasonable timescale (especially with electrification increasingly dominating spend) is high. When is the pay-off from AV R&D spending?

- Even as technical difficulties are progressively overcome, resistance is likely to emerge from policymakers seeking to avoid uncontrolled AV expansion (of shared type). Not to mention permissions and other regulatory issues.

- Meanwhile, the inherently slow pace of necessary infrastructure change will be a persistent drag.

- Substitution of ownership by Shared AVs is not expected to be a major factor in Light Vehicle markets before the 2030s. AV deployments are likely to be patchy and localised, spreading slowly, with different paths in different locations.

**For experts
by experts**

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Thank you

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