CAT Coalition Infrastructure-Industry Working Group Meeting

March 25, 2021

1:30-3:00 pm (Eastern)

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Today's Agenda

- Welcome and Introductions
- I-I WG Work Plan Activity: Primer of Terms
- KPMG's AV Readiness Index
- Update on Physical Infrastructure Enhancements to Support AV Deployment
- Announcements and Closing Remarks
  - Update from Focus Area WG: IOO-OEM Forum
  - CAT Coalition and Partner Announcements or Updates: US DOT, ITS America, ITE, AASHTO
  - Ongoing Commitment to Outreach and Knowledge Transfer

I-I Working Group: Recap of Activities

- The role of this Working Group is to:
  - Support pre-competitive industry research that will advance infrastructure development and maintenance
  - Connect IOOs with industry
  - Support the natural evolution of infrastructure to accelerate CAVs
  - Clarify terms, definitions and target audiences
- Last meeting agenda recap:
  - Easy Mile Perspective on AV Deployment
  - Honda's Perspective on CAV Deployment
- Link: https://transportationops.org/CATCoalition/infrastructure_industry_WG

I-I WG Work Plan Activity: Primer of Terms

Ed Bradley, Toyota and Jeremy Schroeder, Athey Creek

Resource Introduction

- Primer of Definitions for AV Infrastructure and Related AV/CV Terms
- AV/CV terms provided by Ed as a starting point for this resource
- Definitions are not intended as a preferred definition or to be exclusive of variations or interpretations used by other organizations.
  - We do not intend this as an authoritative source, but as a introduction and reference to bridge the gap between IOO and OEM terms that are used
- Definitions are intended to serve as a starting point for practitioners to have a common understanding of terms used either by IOOs, original equipment manufacturers (OEMs), or both
  - We acknowledge similar work that has been conducted by other working groups

Resource Content

- Two sections:
  - CAT-Related Acronyms and Terms – with definitions
  - CAT-Related Organization, Project, and Initiative Acronyms – no definitions included

- Definitions sourced from formal sources where possible
  - e.g., CV Pooled Fund Study Glossary of Terms, SAE, and USDOT
  - All definitions include a reference to the source document
  - Definitions are not intended as authoritative or endorsement from CAT Coalition

Resource Content

CAT-Related Terms

Acronym	Definition (Reference)	Origin
ABS	Anti-Lock Braking System. A system that prevents wheel lock-up by automatically regulating the brakes. ABS can decrease braking distances on slippery pavement, prevent skidding, and provide greater control during sudden stops. (1)	OEM
ACC	Adaptive Cruise Control. An available cruise control advanced driver-assistance system for road vehicles that automatically adjusts the vehicle speed to maintain a safe distance from vehicles ahead. As of 2019, it is also called by 20 unique names that describe that basic functionality, including dynamic cruise control. Control is based on sensor information from on-board sensors. Such systems may use a radar or laser sensor or a camera setup allowing the vehicle to brake when it detects the car is approaching another vehicle ahead, then accelerate when traffic allows it to. (2)	OEM
ACN	Automatic Crash Notification. An emerging safety technology designed to notify emergency responders that a crash has occurred and provide its location. (3)	USDOT
ACR	Adjacent Channel Rejection. A measure of how well a receiver performs on its frequency channel when there is an interfering system in the vicinity operating on a nearby channel. (4)	OEM
ACSF	Automatically Commanded Steering Function. The function within a complex electronic control system where actuation of the steering system can result from automatic evaluation of signals initiated on-board the vehicle, possibly in conjunction with passive infrastructure features, to generate continuous control action in order to assist the driver in following a particular path, in low speed maneuvering or parking operations. (5)	OEM
ADAS	Advanced Driving Assistance Systems. Additional electronic systems in motor vehicles supporting the driver in certain driving situations. They often focus on safety aspects or on increased driving convenience. ADAS safety features are designed to avoid collisions and crashes by offering technologies that alert the driver to potential problems, or for example, automate the vehicle lighting to come on at dusk or sudden darkness, provide adaptive cruise control, give automated braking, assist a vehicle to stay in its lane, give automated traffic warnings via GPS, allow hands free voice activated smartphone connection, alert drivers to other cars or dangers, etc. There are many forms of ADAS available that function from data	

Resource Content

CAT-Related Organization, Project, and Initiative Acronyms

3GPP	3rd Generation Partnership Project (was European, now global) (this is where cellular standards are located for handsets and chip manufacturers)
AASHTO	American Association of State Highway Transportation Officials
AAMVA	American Association of Motor Vehicle Administrators
ACAS FOT	Automotive Collision Avoidance System Field Operational Test (NHTSA 2005 Report)
ADUS	Automated Driving for Universal Services, Strategic Innovation Promotion Program (SIP), Japan. https://en.sip-adus.go.jp/sip
ARIB	Japanese Association of Radio Industries and Businesses
ASTM	American Society for Testing and Materials
BASt	Federal Highway Research Institute of the Republic of Germany (Bundesanstalt für Straßenwesen)
CAMP	Crash Avoidance Metrics Partnership
CEN	European Committee for Standardization
CMAQ	Congestion Mitigation and Air Quality (Improvement Program)
CMC	CAMP Management Committee
CVPD	Connected Vehicle Pilot Deployment
CVTA	Connected Vehicle Trade Association
DOC	Department of Commerce
DOD	Department of Defense
DOT	Department of Transportation; U.S. Federal and/or State Transportation Agency(ies); plural: DOTs
EC	European Commission
EPA	Environmental Protection Agency
ETSI	European Telecommunications Standards Institute
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration

Next Steps for Resource

- Distribute resource to WG members in April for review
  - Are there terms that are missing that should be included?
  - Are there terms that should be removed?
  - Is there a definitive resource that should be used as a reference?

- Remember: definitions are intended as a starting point reference for readers, not intended as authoritative or an endorsement

KPMG’s AV Readiness Index

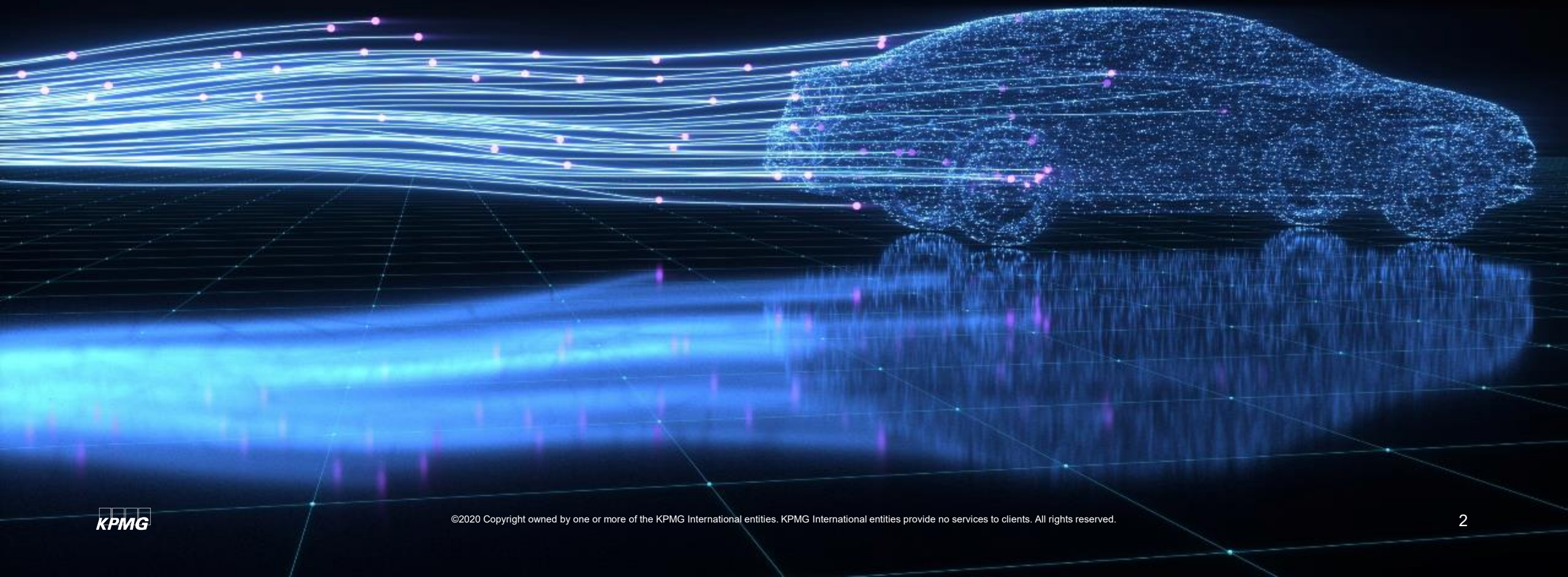
Ted Hamer, KPMG

KPMG

2020 Autonomous Vehicles Readiness Index

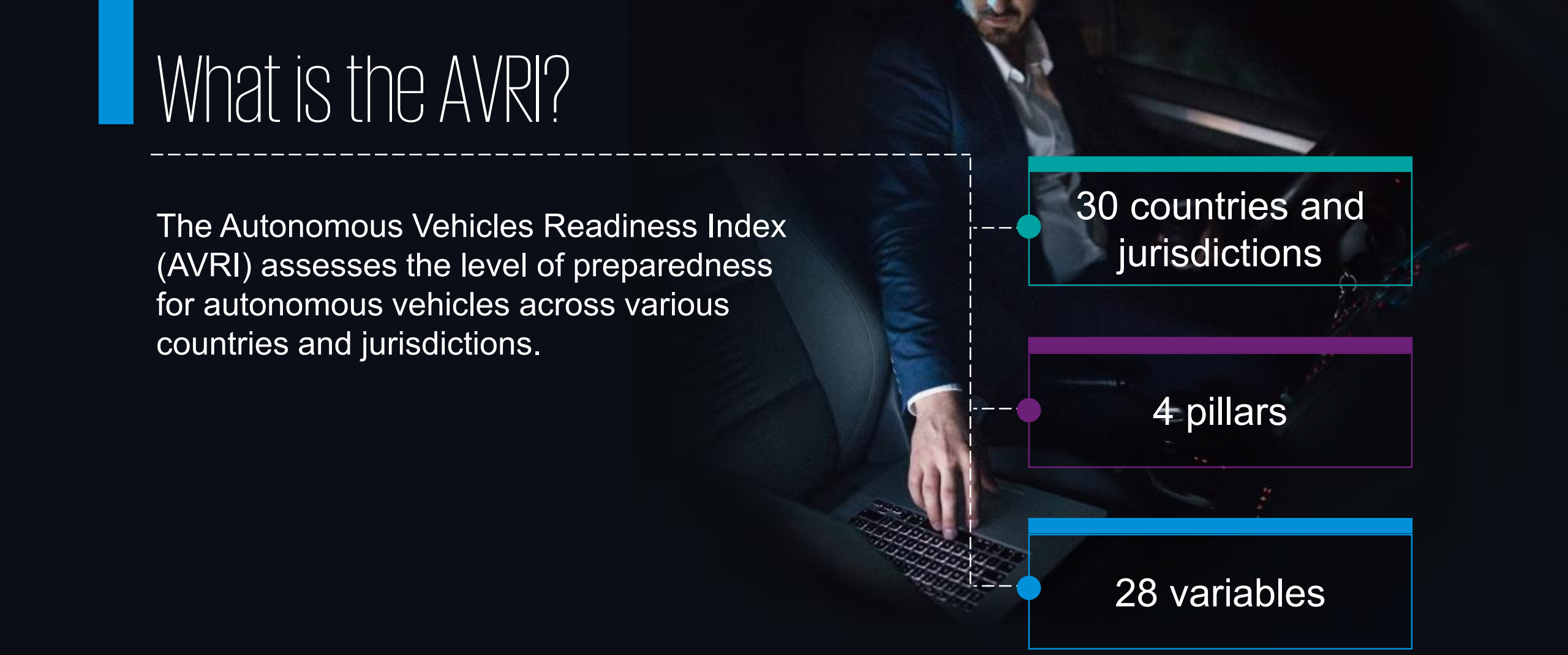
Study overview and highlights

Background



What is the AVRI?

The Autonomous Vehicles Readiness Index (AVRI) assesses the level of preparedness for autonomous vehicles across various countries and jurisdictions.



30 countries and jurisdictions

4 pillars

28 variables

28 variables

Policy & legislation

- AV regulations
- Number of government funded AV pilots
- AV department
- KPMG Change Readiness Index government capability pillar
- WEF future orientation of government
- WEF efficiency of the legal system in challenging regulations
- Assessment of the data-sharing environment new variable)

Technology & innovation

- Industry partnerships
- The number of AV firms with headquarters in the country
- The number of AV related patents
- Investment in AV related firms
- WEF NRI availability of the latest technology
- WEF NRI capacity for innovation
- Cybersecurity
- Huawei assessment of cloud computing, artificial intelligence and IoT
- Market Share of EVs

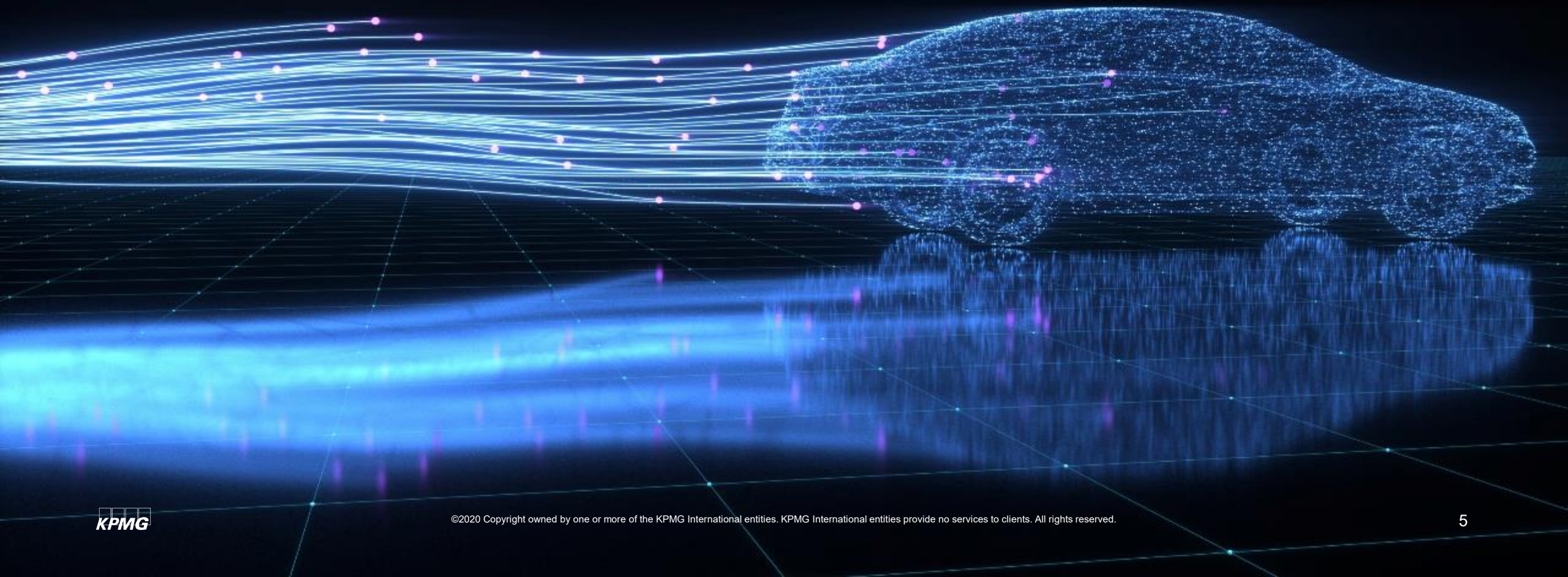
Infrastructure

- The number of electric vehicle charging stations
- 4G coverage
- WEF GCI road quality score
- KPMG Change Readiness Index technology infrastructure score
- Speedtest assessment of mobile connection speed
- Huawei assessment of broadband technology

Consumer acceptance

- Percent of the population living near AV test areas
- KPMG Change Readiness Index people and civil society technology use sub indicator
- WEF CGI ICT adoption
- WEF CGI digital skills
- NRI Individual readiness
- Ridesharing market penetration

Study highlights



30 countries and jurisdictions part of AVRI 2020

1. Singapore
2. The Netherlands
3. Norway
4. United States
5. Finland
6. Sweden
7. South Korea
8. United Arab Emirates
9. United Kingdom
10. Denmark*
11. Japan
12. Canada
13. Taiwan*
14. Germany
15. Australia
16. Israel
17. New Zealand
18. Austria
19. France
20. China
21. Belgium*
22. Spain
23. Czech Republic
24. Italy*
25. Hungary
26. Russia
27. Chile*
28. Mexico
29. India
30. Brazil

*Added in 2020

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27. Chile*
28. Mexico
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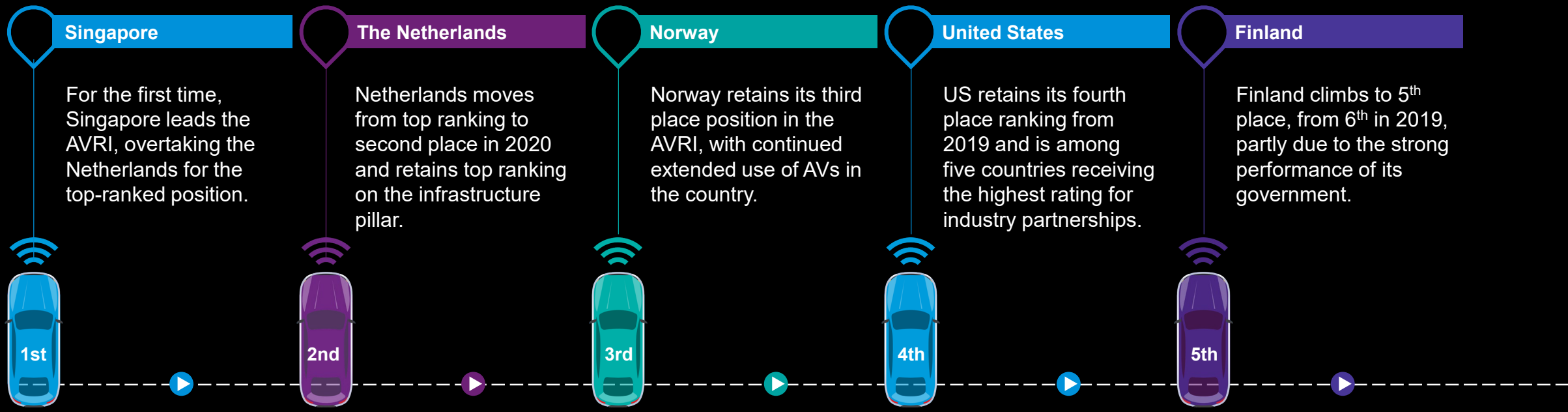
30. Brazil

*Added in 2020

Top ranked countries

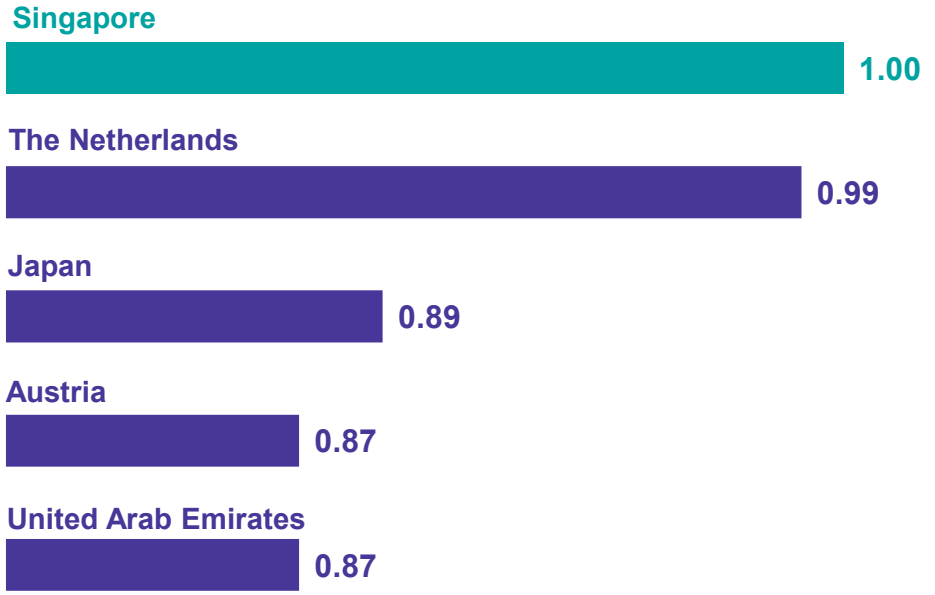


1 | Singapore

1	11	5	1
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

- Singapore in the lead for the first time
- Leading on consumer acceptance and policy and legislation pillars
- Expanded AV testing to cover all public roads in Western Singapore
- Aims to serve three areas with driverless buses from 2022
- Charging points to increase significantly with incentives for buying EVs

Quality of roads top five



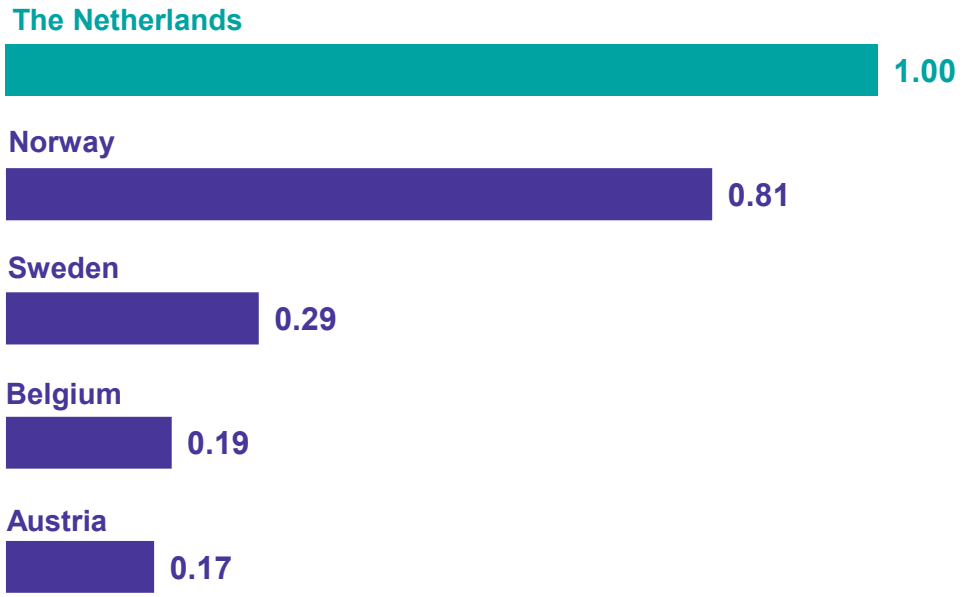
Source: World Economic Forum, *Global competiveness report* (2019)

2 | The Netherlands

3	10	1	7
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

- Leading on EV charging stations per capita
- Second only to Singapore on road quality
- An extensive series of pilots in the region means over 80% of population live near AV testing sites
- Extended its use of smart road furniture

EV charging stations top five



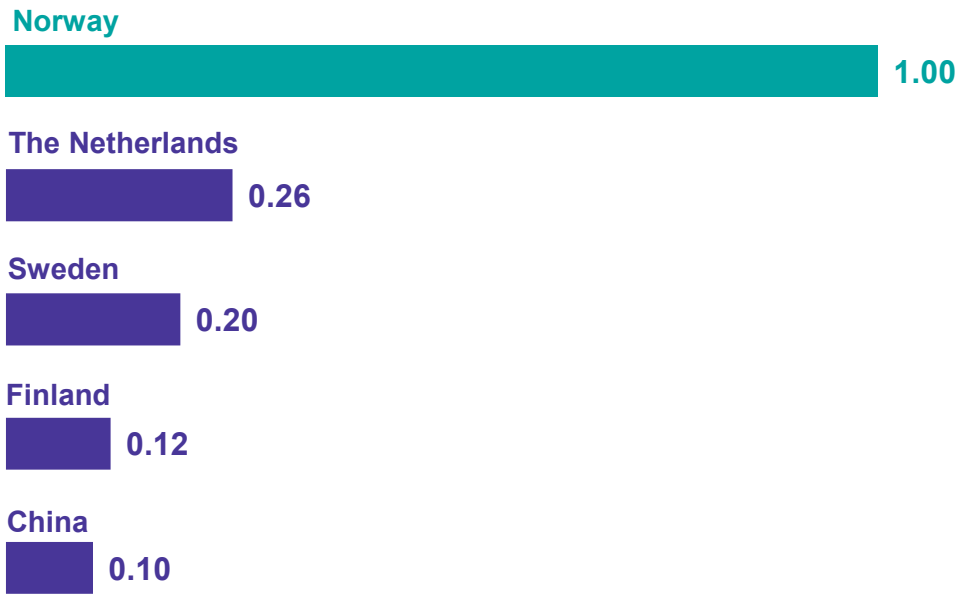
Source: International Energy Agency, Global EV outlook (2019). Scaled by population.

3 | Norway

10	5	3	5
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

- Extended use of AVs with several bus routes in Oslo now driverless
- Speed limit for driverless vehicles increasing from 16kph to 20kph
- Majority of passenger vehicles bought in Norway in 2019 were battery or plugin hybrids
- Taxes on internal combustion vehicles/fuels and subsidies for EVs
- Testing AVs in extreme weather, with pilots of driverless trucks, cars and buses in the Svalbard islands

Market share of electric cars top five



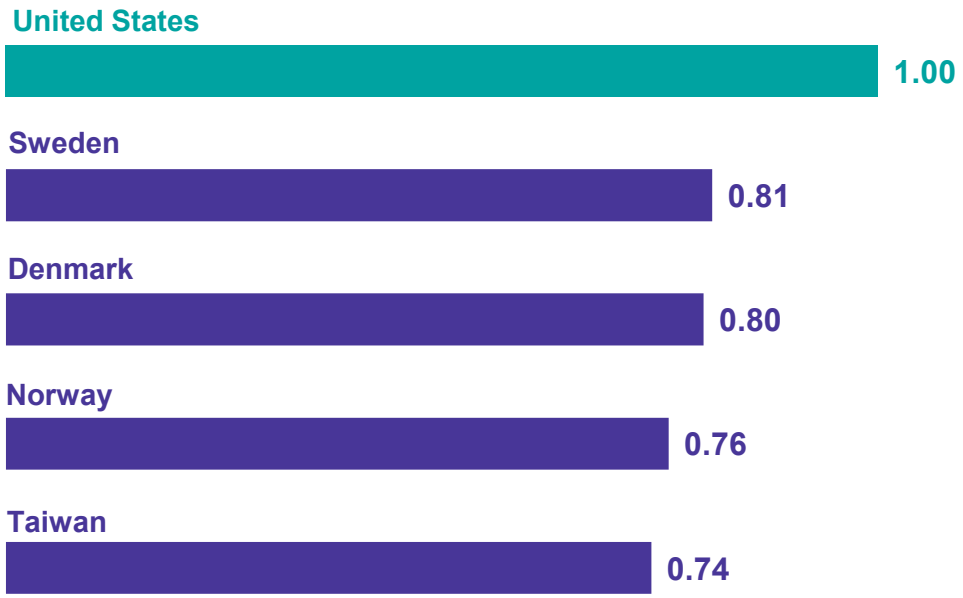
Source: EV-Volumes.com (2019)

4 | United States

6	2	9	6
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

- US is second only to Israel on technology and innovation pillar
- 420 AV company headquarters, 44% of all tracked in the AVRI study
- Cities including Detroit and Pittsburgh undertaking innovative work to introduce and promote AVs
- American technology companies and vehicle makers continue to dominate AV development

Cloud computing, AI and IoT top five



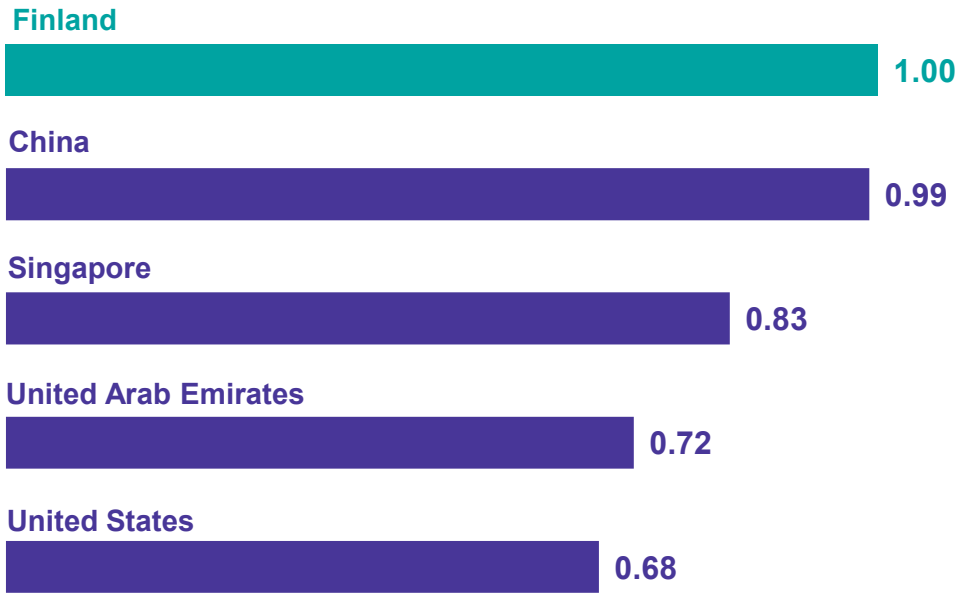
Source: Huawei, Global connectivity index (2019)

5 | Finland

4	8	11	2
Policy and legislation	Technology and innovation	Infrastructure	Consumer acceptance

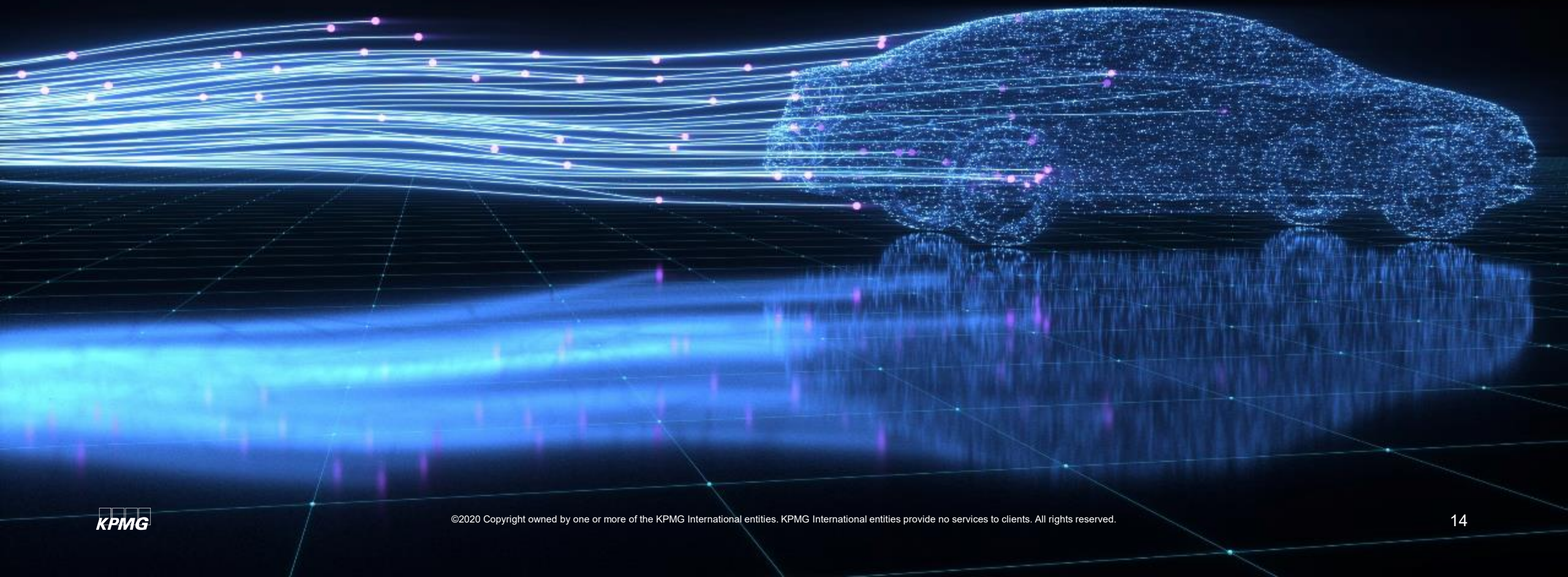
- Highest rating for AV-specific regulations
- Country's entire road network is open for AV trials
- Helsinki and Espoo run public AV bus services with latter using all-weather vehicle
- Leads on measures of digital skills, benefiting from breadth of talented engineers
- Makes greatest use of ride-hailing services

Online ride-hailing market penetration top five



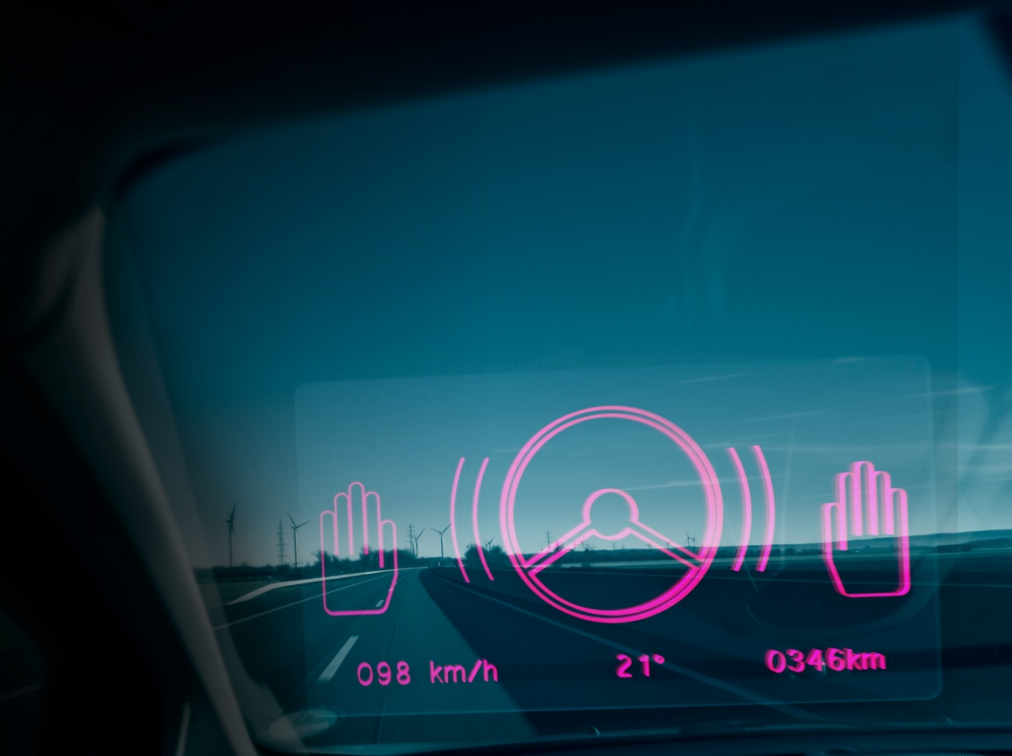
Source: Statista (2020)

Key messages



Key messages

- Since last edition of the AVRI, countries and jurisdictions have some of the appropriate legislation and regulations in place to enable AVs
- Much of the hard work on national implementation remains – putting infrastructure in place, establishing data protocols, and setting policies on licensing and insurance
- Many of the most exciting developments are taking place at the local level, led by cities
- Shared AV vans and buses may be at least as important as private driverless cars
- AVs can be used to help transform an area's transport
- The safety case for AVs is getting stronger
- AVs will need both local and national government focus and support to become ubiquitous



Thank you

home.kpmg/AVRI
kpmg.com/socialmedia

Update on Physical Infrastructure Enhancements to Support AV Deployment

Paul Carlson, Road Infrastructure Investment Holdings, Inc.

Highway Infrastructure Impacts of Automated Vehicles

CAT Coalition AV Infrastructure-Industry Working Group

Webinar – March 25, 2021

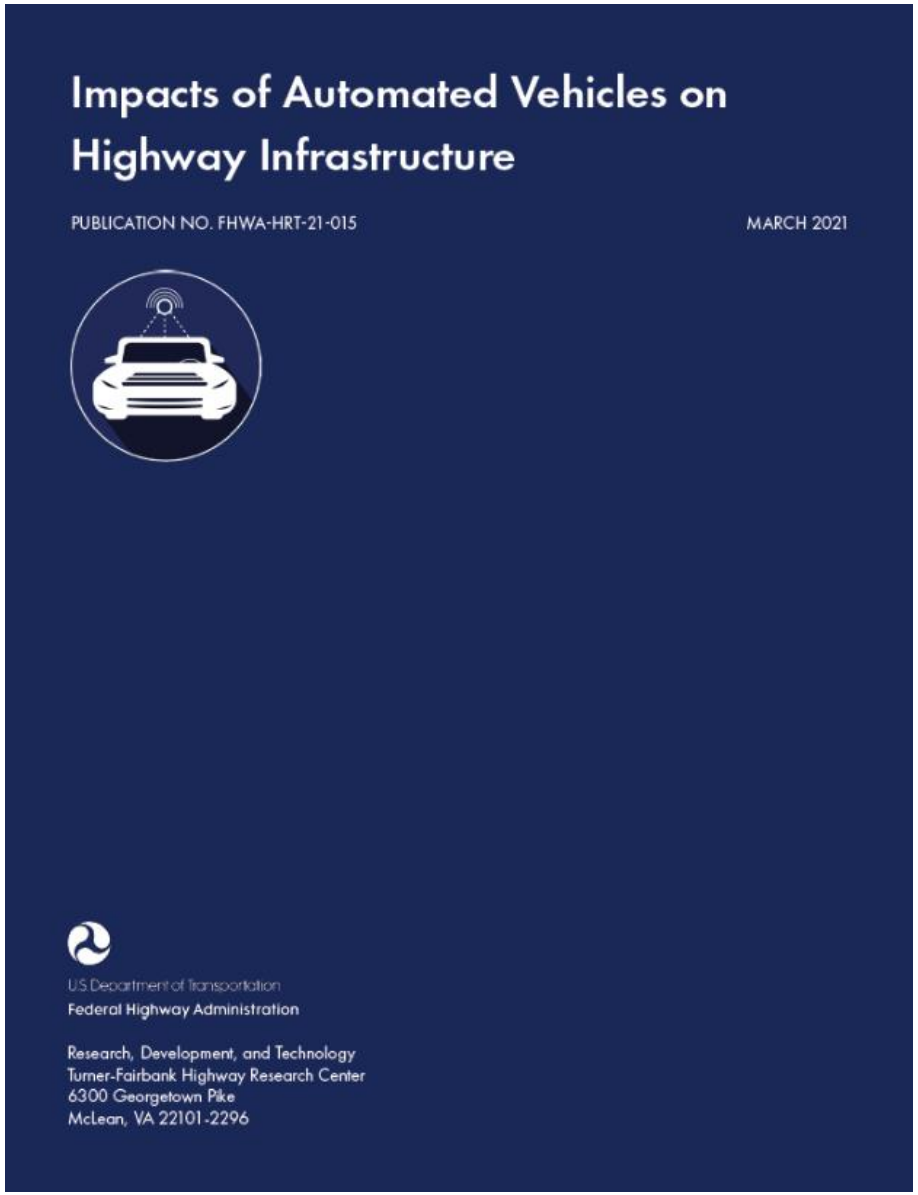
Paul Carlson, PhD, PE

Agenda

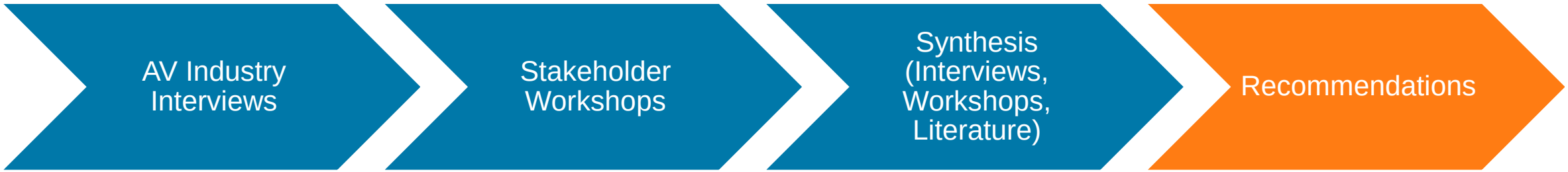
- AV Impacts on Highway Infrastructure
  - New FHWA research report (March 2021)
  - https://www.fhwa.dot.gov/publications/research/operations/21015/index.cfm
- Proposed MUTCD (open for comments 12/15/20 through 5/14/21)
  - 647 major changes, 2000+ total changes
  - Includes new TCD provisions to support to AV deployment
  - https://www.federalregister.gov/documents/2020/12/14/2020-26789/national-standards-for-traffic-control-devices-the-manual-on-uniform-traffic-control-devices-for

AV Impacts – Highway Infrastructure

- Project concluded with 3 webinars
- Links to recorded webinars:
  - AV Impacts Webinar 1: Traffic Control Devices (October 9, 2020)
  - AV Impacts Webinar 2: Physical Infrastructure and Operations (October 16, 2020)
  - AV Impacts Webinar 3: Agency Readiness (October 23, 2020)



Approach


AV Industry Interviews
Stakeholder Workshops
Synthesis (Interviews, Workshops, Literature)
Recommendations

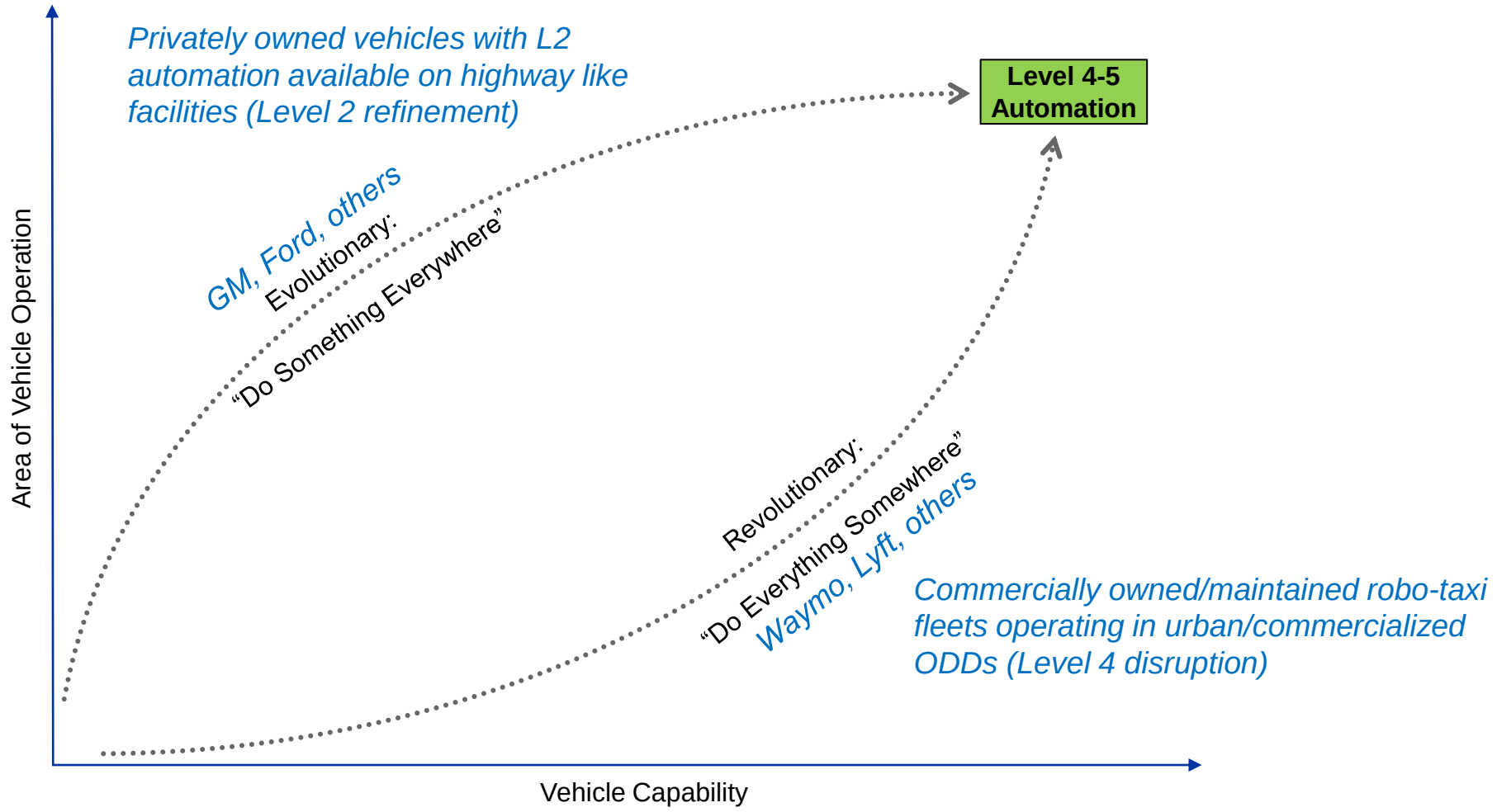
Scope of Project

Gather stakeholder feedback

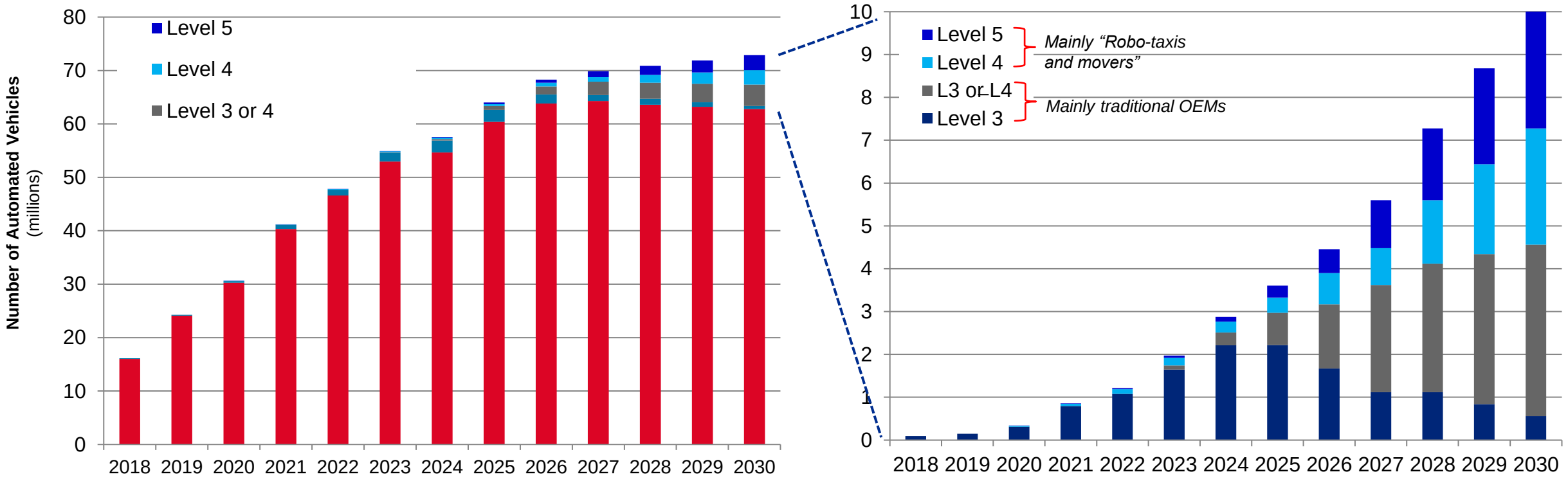
Synthesize available information

Develop official guidance, recommendations or policy for FHWA

AV Development – Two Converging Paths?



Global ADAS / ADS Market Growth



Source: Automotive Safety Council

- Majority of AV market for the next 15 years will be ADAS-equipped, Level 2-capable vehicles
  - By the end of 2022, 99% of new light vehicles sold in the USA will be equipped with camera and / or radar-based AEB systems
- Highly automated vehicle market expected to grow steadily to about 10% of the global vehicle market by 2030
  - Split between dedicated low-speed shuttles and passenger vehicles with use-case specific automation (e.g. full access-controlled, divided highway driving)
- Certain infrastructure and TCD enhancements can benefit both segments of the ADAS / ADS market

Findings

Traffic Control Devices - Review of Findings

Prioritizing opportunities to support AV deployment

- Pavement markings and their role in both ADAS and ADS deployment
  - Uniformity in application and appearance
  - More consistent maintenance practices
  - Standard for contrast marking patterns on light-colored pavements
- Careful sign positioning to avoid confusion
  - Speed Limit signs on parallel routes (e.g. frontage roads)
  - Stop signs at the nose of Freeway entrance ramps

Hard Infrastructure & Operations - Review of Findings

Focus: Pavements, Bridges, and Operations

- Heavy vehicles equipped with lane-centering technologies may accelerate pavement rutting
- Early AV deployment may lead to increased congestion increasing need and role of TSMO
- Digital signing can be problematic for some in-vehicle camera systems
- Approaches and exits from toll booths can be challenging

LED Flicker issue

Agency Readiness - Review of Findings

State DOTs concerns

- What is needed, when, and how to maximize return on investment (ROI)?
- More guidance and standards needed
- Existing road condition inadequate
- Additional funding will be needed
- Lack of maintenance plan/funding
- AV industry is not stable (rapidly developing solutions/technology)
- Public confidence is low

Agency Readiness - Review of Findings

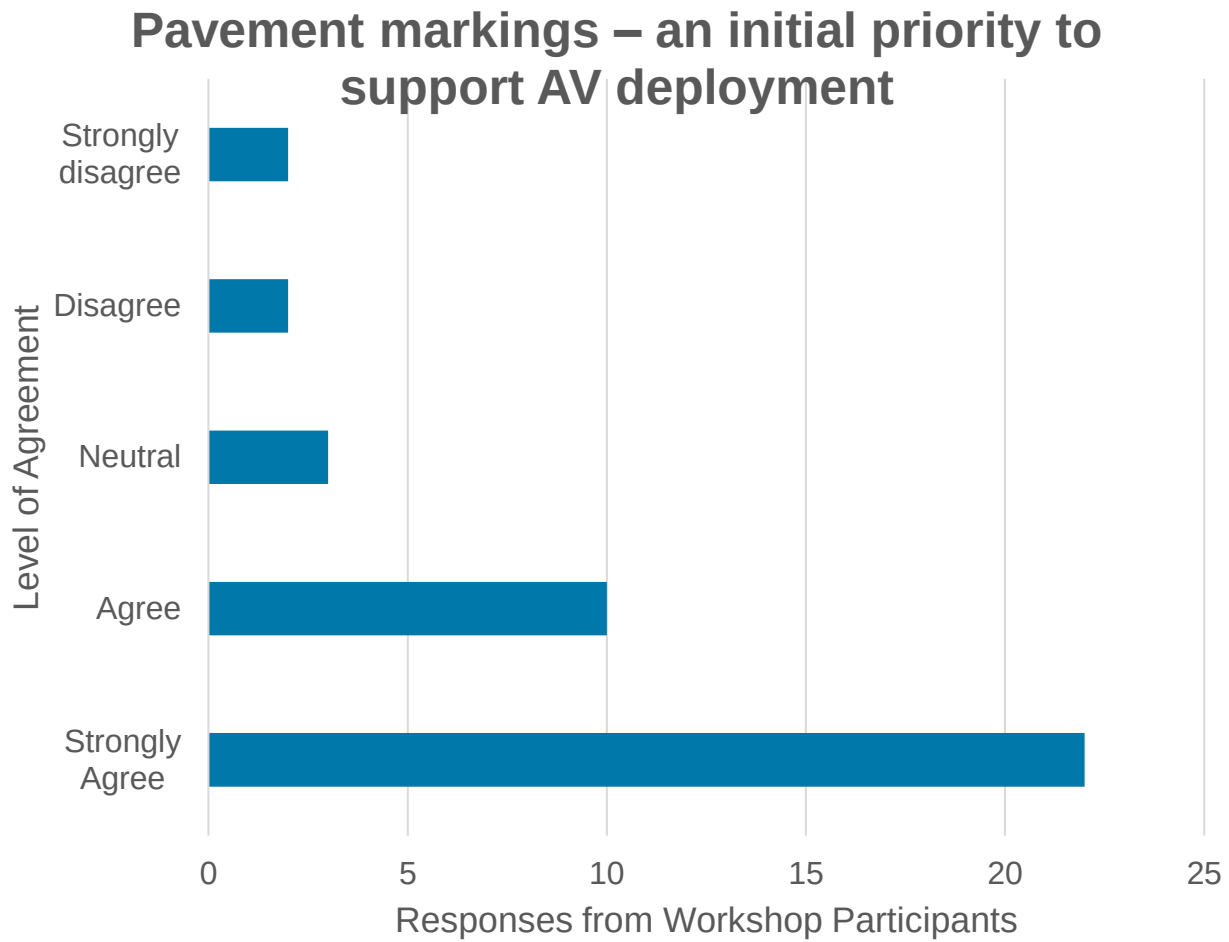
State DOT actions

- Already started with early stages of planning
- AV champion at executive level
- Existing AV position/office
- Engagements with AV developers/automotive original equipment manufacturers (OEMs)
- Agency is beginning to train staff
- Updating standards and policies
- Conducting targeted research

Examples of AV Preparation Underway

As reported by State DOTs

- Upgrading pavement marking policies
- Initiating internal task forces
- Engaging with automotive OEMs
- Supporting legislation
- Updating traffic control
- Upgrading intelligent transportation system (ITS) equipment
- Funding State-level research
- Nothing (wait and see)



Proposed MUTCD – 11th Edition

- Announced rule-making activities (NPA) regarding a new edition of the Manual on Uniform Traffic Control Devices (MUTCD).
- The MUTCD is the national standard for traffic signs, signals, pavement markings, and work zone devices that guide us on our nation's streets and highways. *Last major update was 2009.*
- "The proposed updates to the manual smartly envision the future of transportation by considering the preparedness of our nation's highways for automated vehicles," said Federal Highway Administrator Nicole R. Nason. "They also renew attention on safety for our most vulnerable road users, including the nation's highway workers, emergency responders, cyclists, and pedestrians."
- …the proposed updates reflect state-of-the-art traffic research to help transportation agencies prepare for automated vehicles and other cutting-edge technologies.

Major Changes

1. General	Items 1 – 28	
2. Signing	Items 29 – 315	
3. Pavement Markings	Items 316 – 381	
4. Traffic Signals	Items 382 – 447	
5. Automated Vehicles	Items 448 - 460	⟵(All new material)
6. Work Zones	Items 461 – 516	
7. School Areas	Items 517 - 527	
8. Railroad Grade Crossings	Items 528 – 581	
9. Bicycle Facilities	Items 582 – 647	

Getting to the information

- Federal Register link:
  - https://www.federalregister.gov/documents/2020/12/14/2020-26789/national-standards-for-traffic-control-devices-the-manual-on-uniform-traffic-control-devices-for
- Agency/Docket Number:
  - www.federalregister.gov
  - Search using: FHWA Docket No. FHWA-2020-0001

New Part 5A – Automated Vehicles

- Proposed MUTCD includes a new chapter (Part) – Automated Vehicles
- 5A.01 Purpose and Scope
- 5A.02 Overview of CAVs
- 5A.03 Definitions and Terms
  - Reference to SAE J3016 and use of definitions and automation levels
- 5A.04 Traffic Control Device Design and Use Considerations

New Part 5B – Automated Vehicles

Agencies should consider…

- 5B.01 – Signs
  - The illuminated portion of electronic-display signs using LEDs should have a standard refresh/flicker rate. The refresh rate of the LEDs should be greater than 200 Hz to be easier for the camera to detect.
- 5B.02 – Markings
  - Normal-width longitudinal lines on freeways, expressways, and ramps of at least 6 inches wide (see Section 3A.04).
  - Edge lines of at least 6 inches in width on roadways with posted speeds greater than 40 mph (see 28 Section 3B.09).
- 5B.03 – Highway Traffic Signals
  - The refresh rate of the LED traffic signals should be consistent throughout the jurisdiction and be greater than 200 Hz to allow greater consistency in machine vision detection.

New Part 5B – Automated Vehicles

Agencies should consider…

- 5B.04 – Temporary Traffic Control (Work Zones)
  - To better accommodate machine vision used to support the automation of vehicles, channelizing devices should be at least 8 inches wide with retroreflective material for reliable machine detection in all weather conditions. Markings entering the work zone and through lane shifts should be made with highly visible and continuous materials, not intermittent buttons and reflectors.
- 5B.05 – Railroad Crossings
  - For passive and active grade crossings, placement of signs and markings should be consistent along a corridor to promote uniformity and to improve the ability of machine vision technology to recognize highway-rail grade crossings.
- 5B.06 – Bicycle Facilities
  - To better accommodate machine vision used to support the automation of vehicles, bicycle facilities should be segregated from other vehicle traffic using physical barriers where practicable.

Questions

Paul Carlson, PhD, PE
pcarlson@roadinfrastructure.com
979-777-7457

Chair, National Committee on Uniform Traffic Control Devices, CAV Task Force
Chair, SAE ORAD Committee, Highway Infrastructure Task Force

Announcements and Closing Remarks

Brief Updates and Announcements from Partners

Ongoing Commitment to Outreach and Knowledge Transfer

- Suggestions from WG Members on Ways to Enhance Impact:
  - Proposed new WG Members
  - Communications with/involvement in other initiatives outside the CAT Coalition
  - Knowledge resources to include on CAT Coalition website
  - E-mail suggestions to schroeder@acconsultants.org

Next Infrastructure-Industry WG Meetings

- Thursday, May 27, 1:30-3:00 pm (Eastern)
- Thursday, July 29, 1:30-3:00 pm (Eastern)
- Thursday, September 30, 1:30-3:00 pm (Eastern)
- Thursday, November 18, 1:30-3:00 pm (Eastern)