Autonomous Vehicles– A Landscape Study
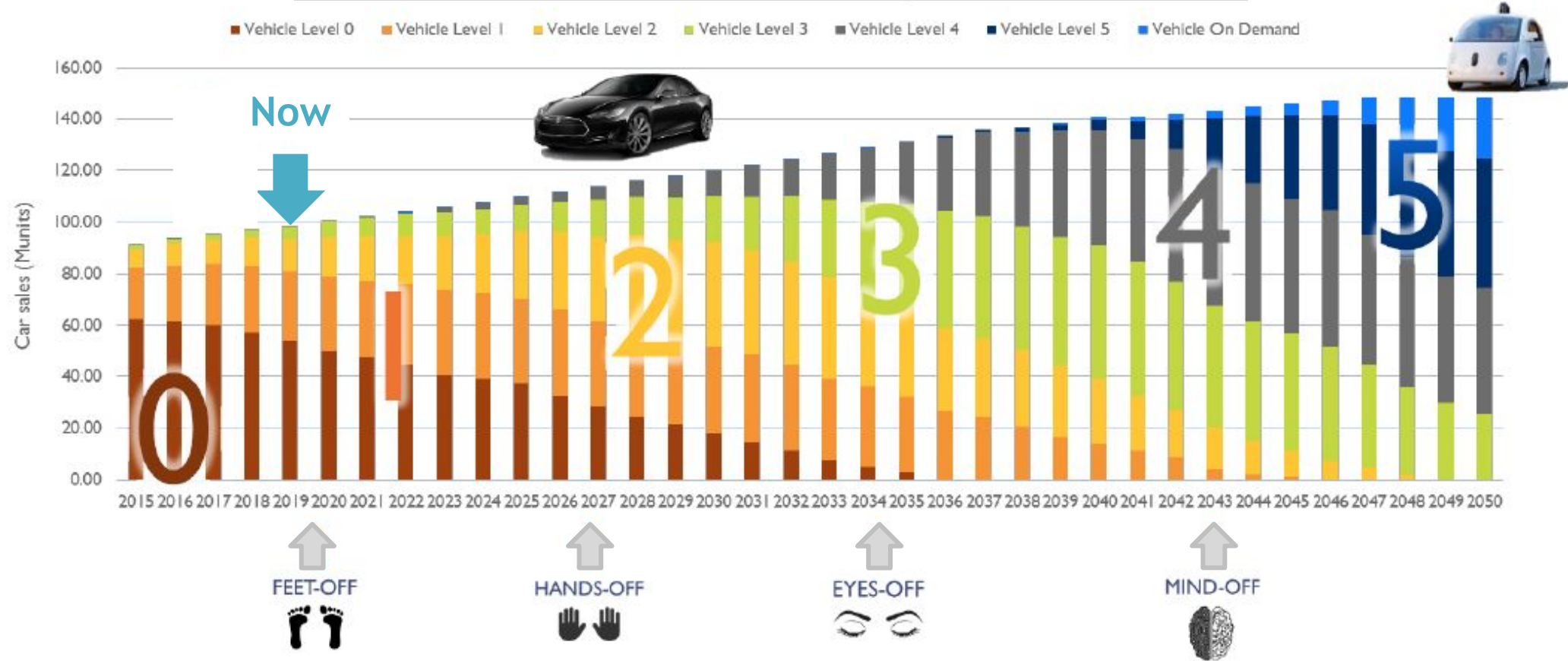
Authors: Butch Berney, Kevin Leung, Teris Liu, Sohini Roychowdhury, Afshin Shiravi, Iris Wang

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today and the reality of tomorrow

Autonomous Vehicles: An impending Reality
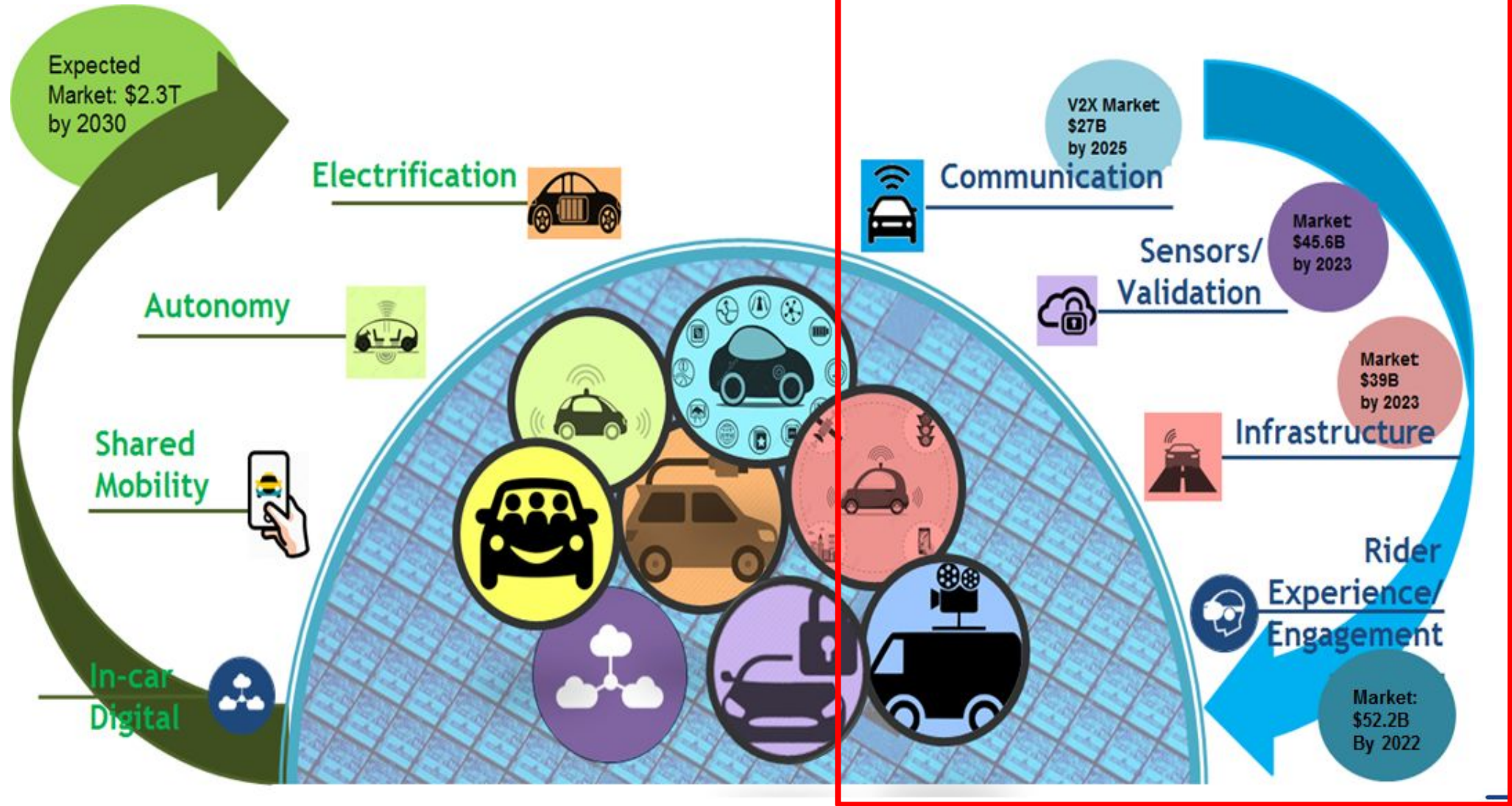

Potential Evolution of Autonomous Cars

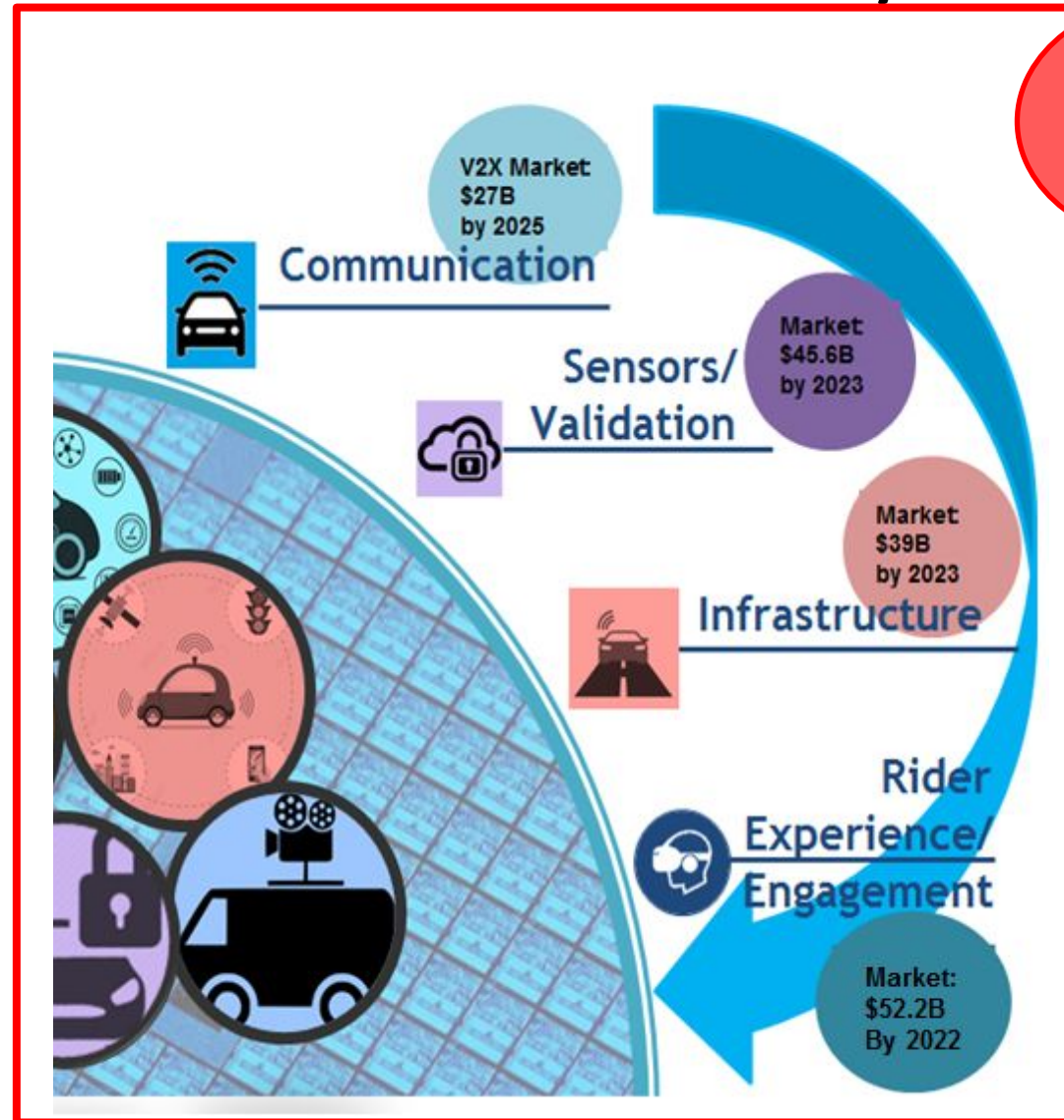By 2035, more than 50% of all vehicles sold will have level 3 autonomy

Multi-Faceted AV Industry Growth

Multi-Faceted AV Industry Growth

Expected Market: $164B by 2023

V2X Market $27B by 2025

Communication

Market $45.6B by 2023

Sensors/ Validation

Market $39B by 2023

Infrastructure

Rider Experience/ Engagement

Market: $52.2B By 2022

- **Ensure Safety**: Concern from 64% of US population.

- Timely **deployment** components.

Multi-Faceted AV Industry Growth

Survey on "*What excites or concerns you about AVs?*": 121 responses
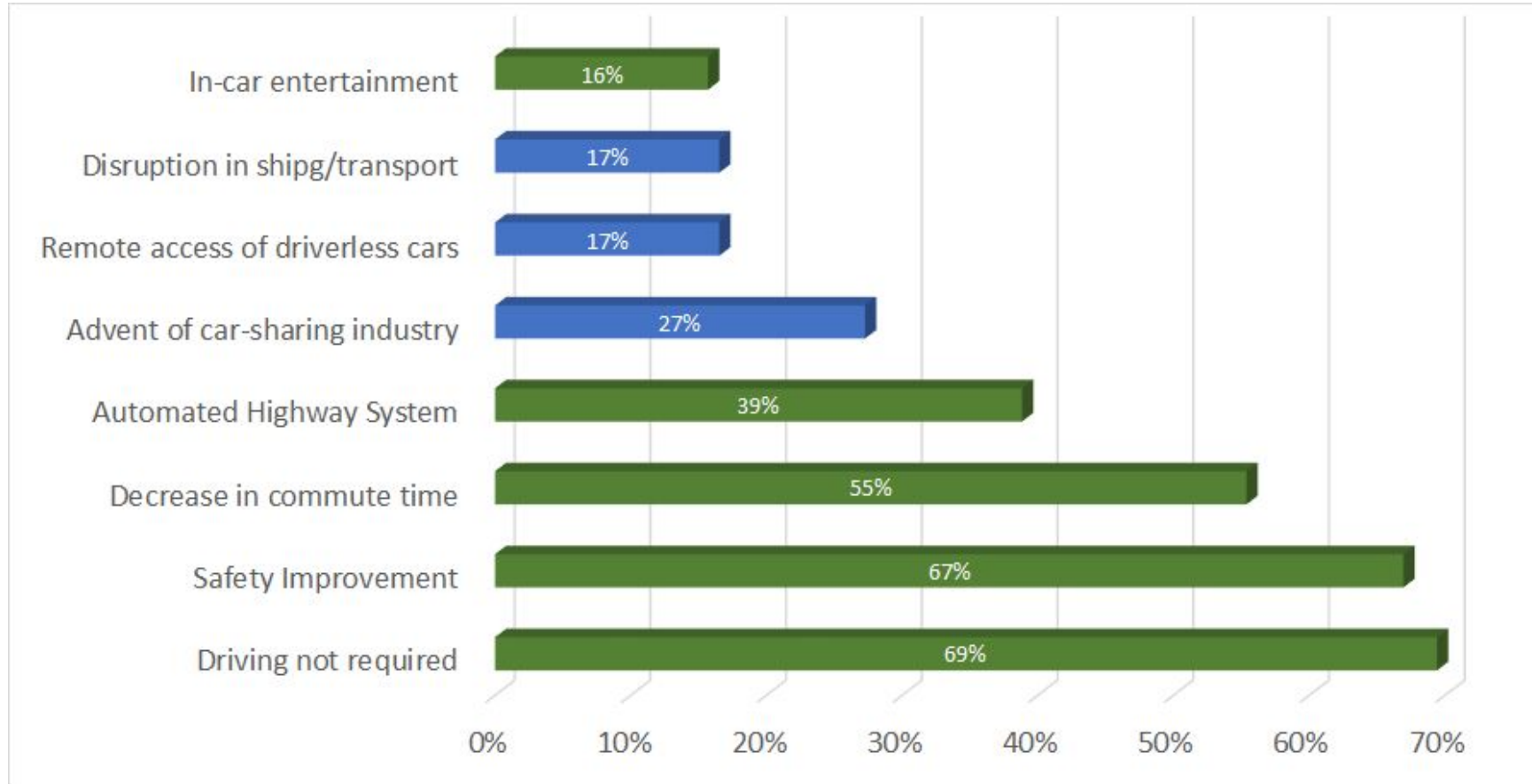
5G unified connectivity

Intelligently connecting the car to cloud and surroundings

Vehicle-to-pedestrian

Vehicle-to-infrastructure
3D HD live map updates

Teleoperation   AR / VR   HD video

Vehicle-to-network

Vehicle-to-vehicle
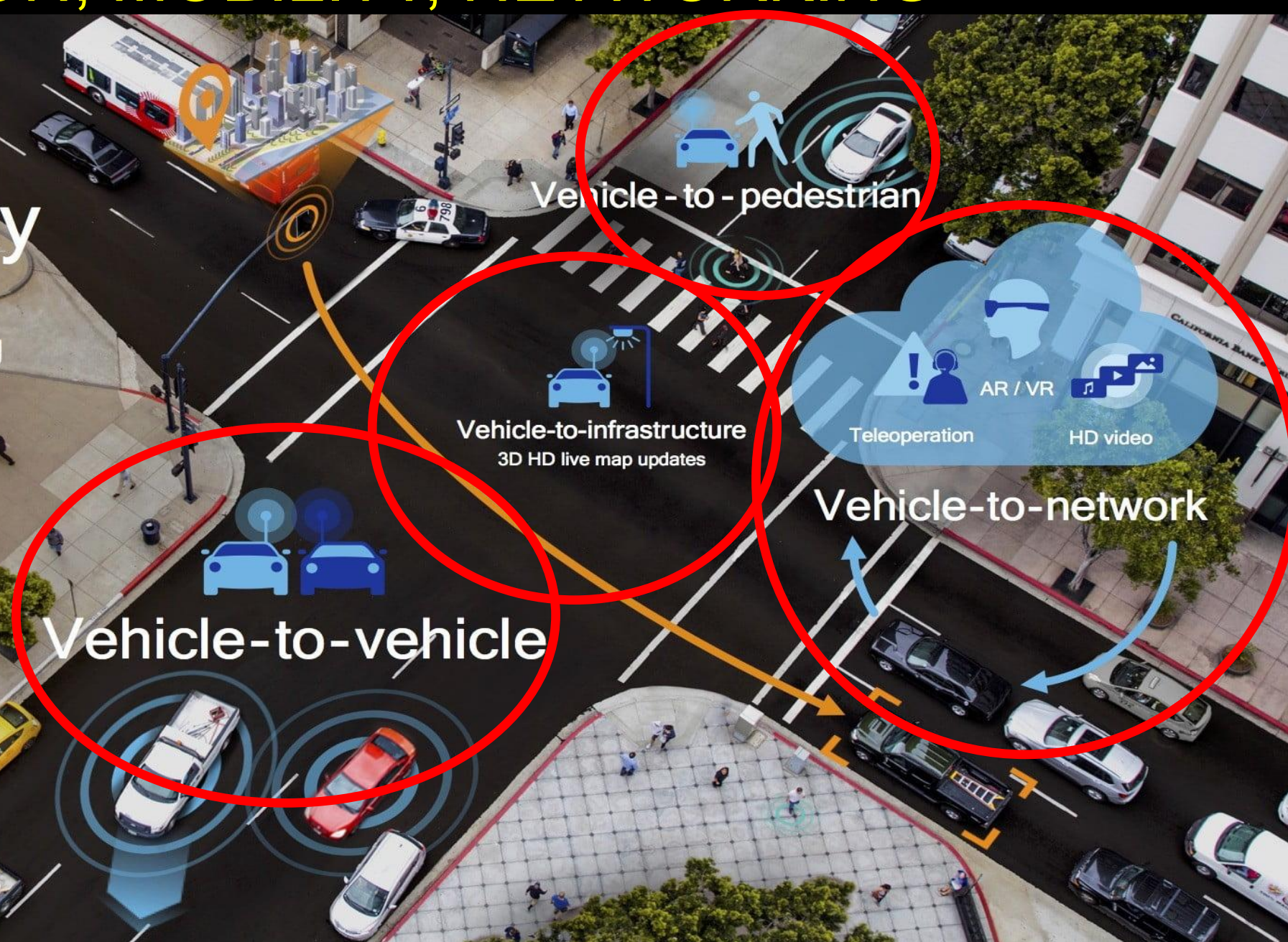
Battle over Standard

DSRC

TOYOTA

GM

C-V2X

intel

ERICSSON

vodafone

SoftBank

Ford

Continental
The Future in Motion

BMW

T...

QUALCOMM

GEELY

NTT
docomo

HUAWEI

NISSAN
MOTOR CORPORATION

verizon✓

DAIMLER

中国移动
China Mobile

Audi

JAGUAR

LAND ROVER

NOKIA

HYUNDAI
MOBIS

SAMSUNG

C-V2X: New Business Models and Timelines

=>ALL NEW AV TECHNOLOGY MUST ADHERE TO C-V2X STANDARDS
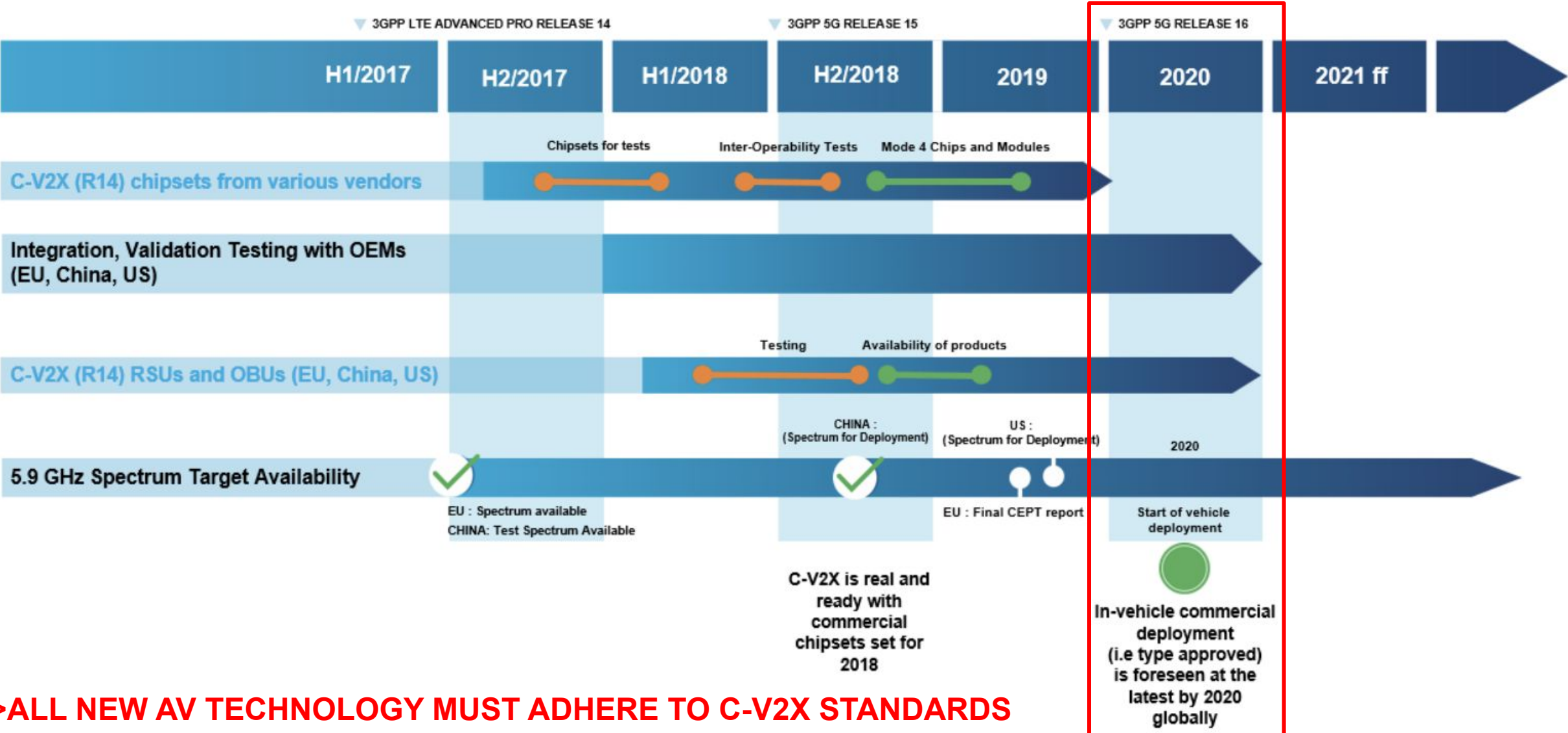
SENSORS AND VALIDATION
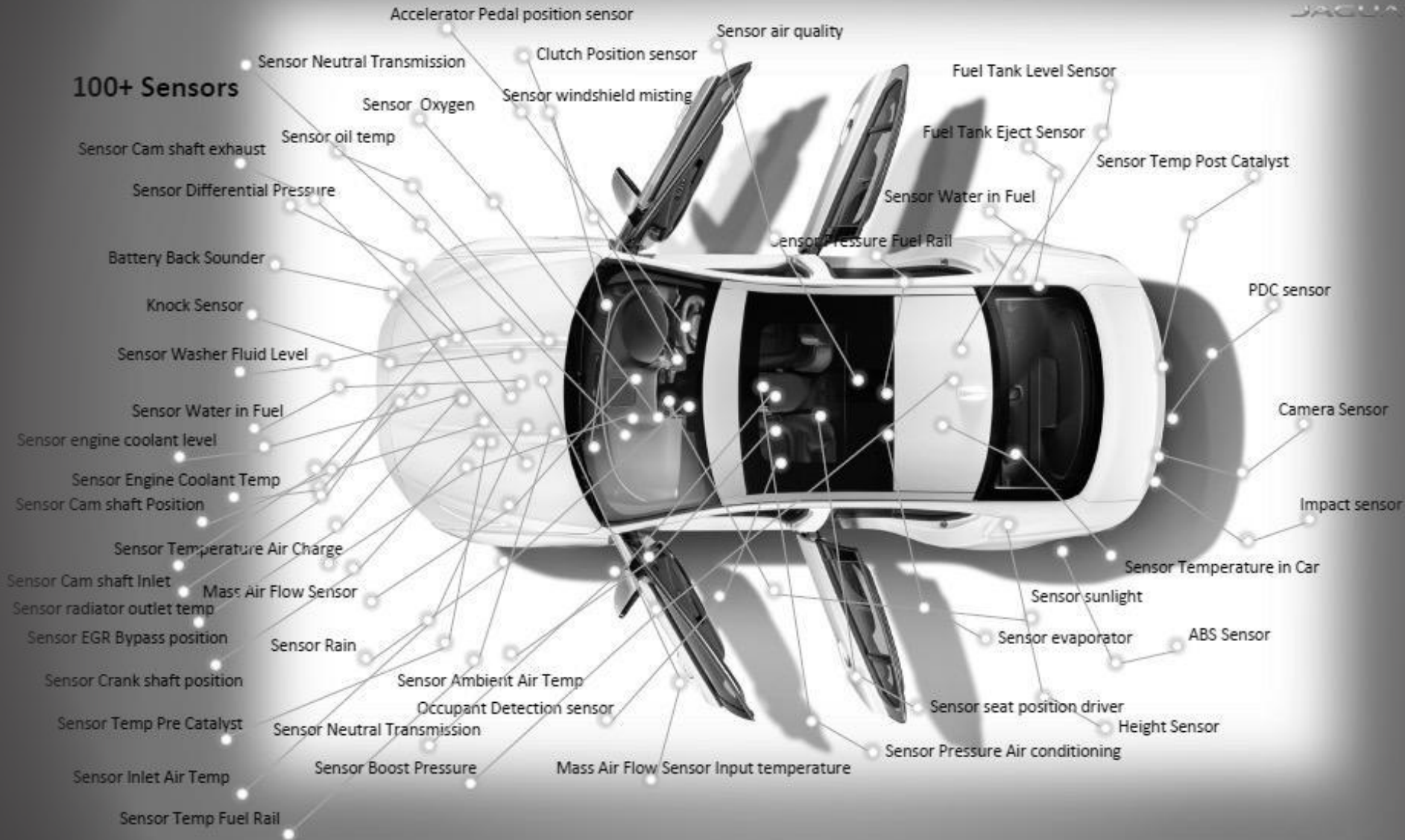
Automotive In-Car Sensor Forecast:
Driven by Need of Redundancy

Automotive sensor forecast by Technology

CAGR 2017-2024: 7%

- Image sensors — 15%
- Radar sensors — 18%
- Silicon magnetic — 8%
- MEMS — 3%
- NTC temperature sensors (Thermistors & Thermocouple) — 7%

Conventional sensors
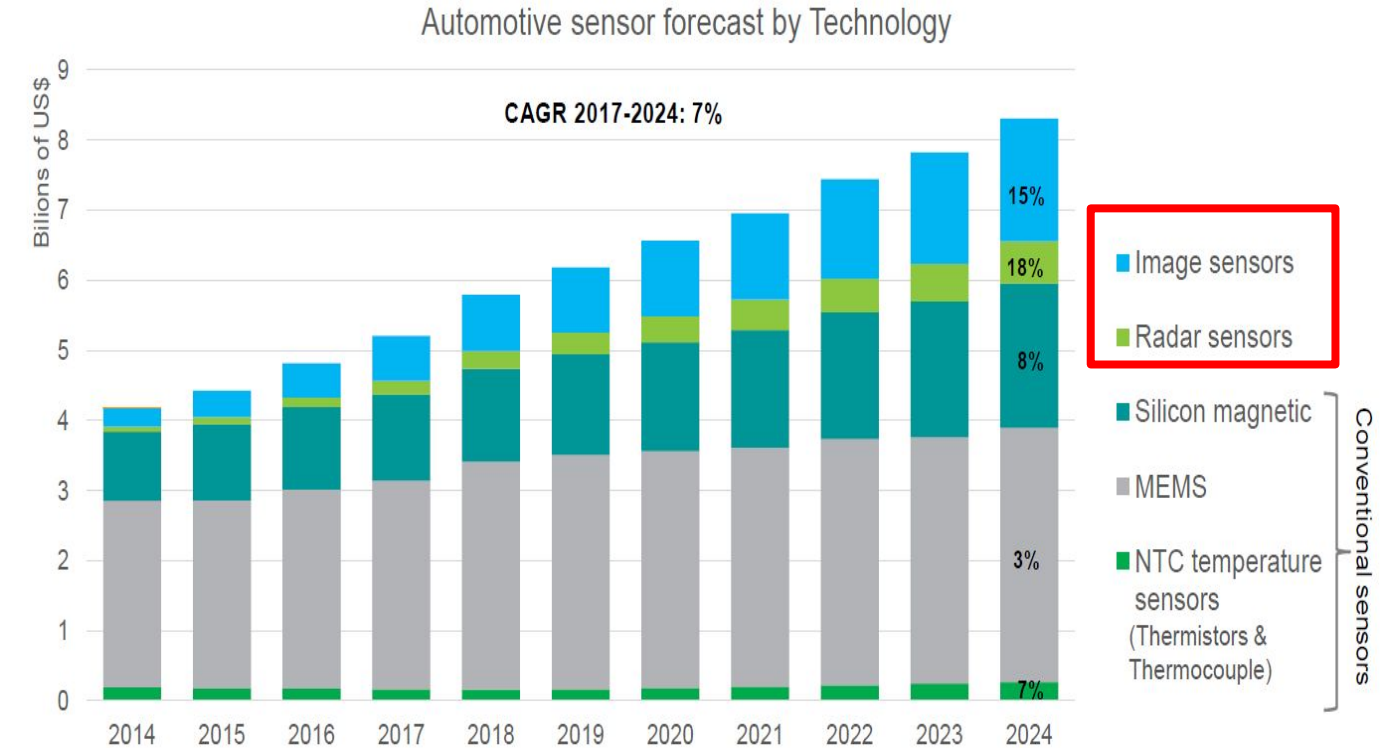
Sensor components: does not include sensor modules for Internal Combustion Engines e.g. lambda probe nor shunt current sensors and resolvers

- **Concentrated Market with Major players:**

Continental AG (Germany), Tele Tracking Technologies Inc. (U.S.), Delphi Automotive (U.K.), Denso (Japan), NXP Semiconductors (Netherlands), Robert Bosch Gmbh (Germany), Valeo (France), Asahi Kasei (Japan) etc.

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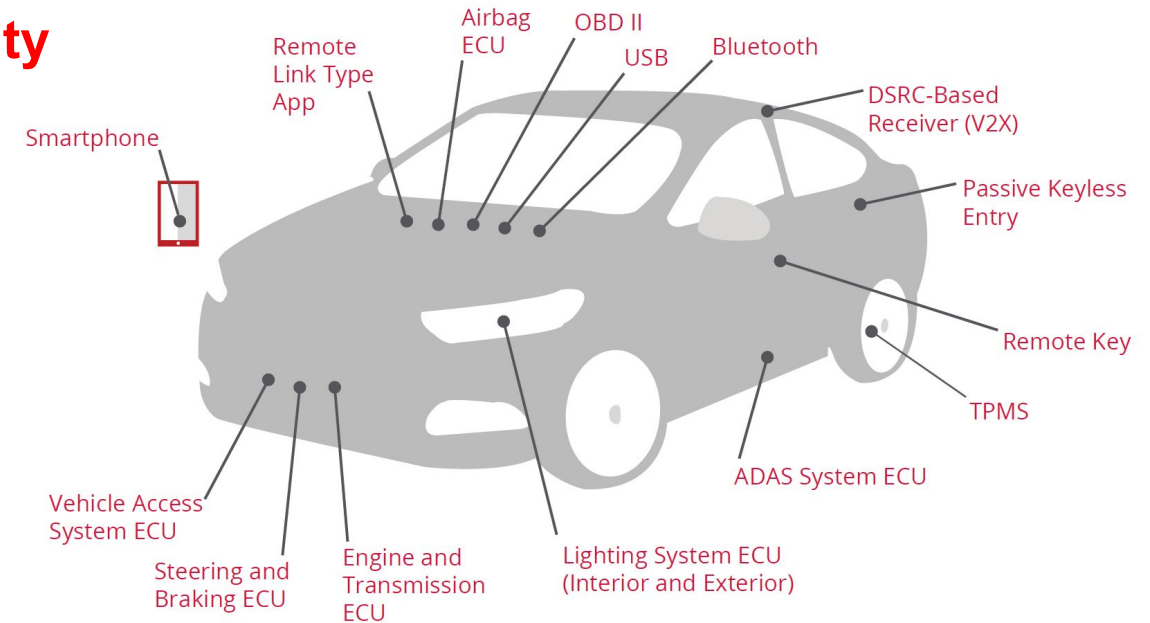
Data Security – Risks and Vulnerabilities

☐ **Increased connected sensors increase opportunity for attacks....**

☐ **Following areas for Business Development:**

✔ Software Security Services:
anti-malware, biometrics, over air updates.

✔ Hardware Security Services:
identification, authentication etc.

✔ Hardware Security Building Blocks:
storage keys/data, communication, intrusion sensing etc.

Smartphone · Remote Link Type App · Airbag ECU · OBD II · USB · Bluetooth · DSRC-Based Receiver (V2X) · Passive Keyless Entry · Remote Key · TPMS · ADAS System ECU · Lighting System ECU (Interior and Exterior) · Engine and Transmission ECU · Steering and Braking ECU · Vehicle Access System ECU

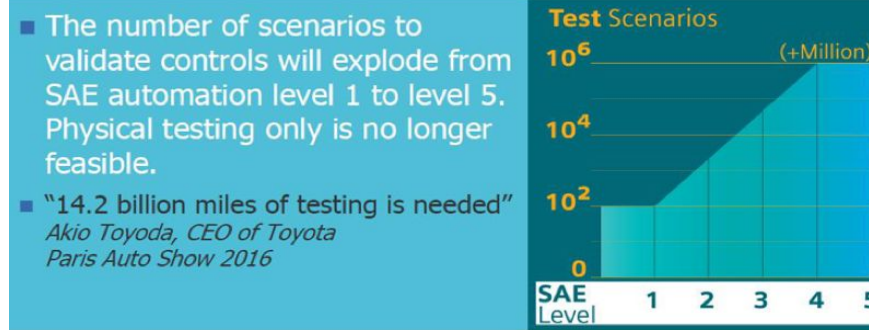Top 15 Most Exposed Attack Surfaces on a Next-gen AV.

Data Security – Risks and Vulnerabilities

"…no one's ready for this…"

AV Testing and Validation

□ Infeasibility of exhaustive testing: 1 billion hrs between catastrophes (aircraft equivalency).

■ The number of scenarios to validate controls will explode from SAE automation level 1 to level 5. Physical testing only is no longer feasible.

■ "14.2 billion miles of testing is needed"
Akio Toyoda, CEO of Toyota
Paris Auto Show 2016

Test Scenarios

koopman16_sae_autonomous_validation.pdf

□ Recent increase in Simulated vs Actual autonomous driven miles.

The Self-Driving Car Companies Going The Distance
Number of test miles and reportable miles per disengagement in California in 2018

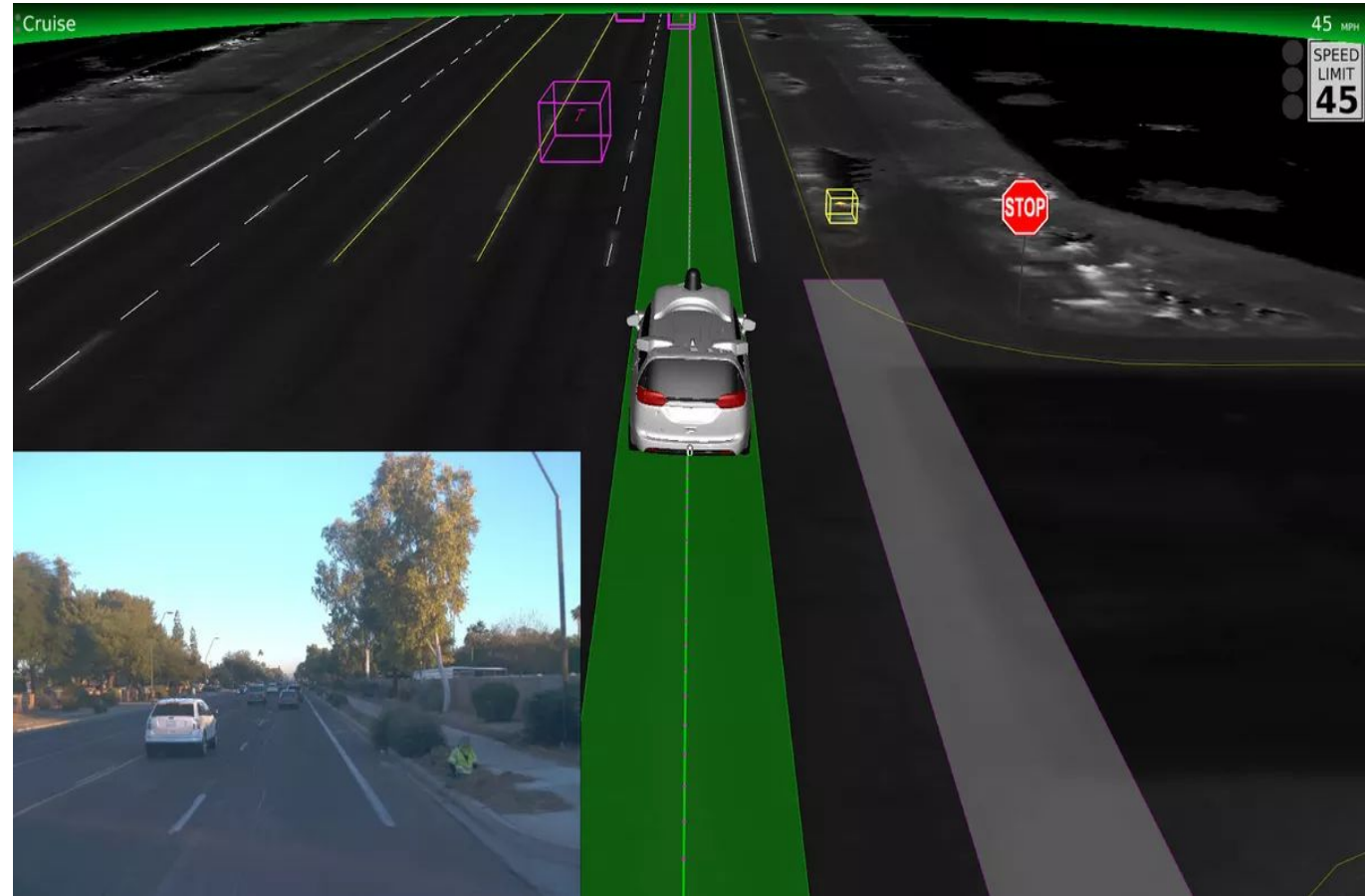|			Miles	Miles per Disengagement*	
Waymo		🇺🇸	1,271,587		11,154.3
GM Cruise		🇺🇸	447,621		5,204.9
Zoox		🇺🇸	30,764		1,922.8
Nuro		🇺🇸	24,680		1,028.3
Pony.AI		🇨🇳	16,356		1,022.3
Nissan		🇯🇵	5,473		210.5
Baidu		🇨🇳	18,093		205.6
Aurora		🇺🇸	32,858		99.9
Drive.ai		🇺🇸	4,617		83.9
Nvidia		🇺🇸	4,142		20.1
Mercedes-Benz		🇩🇪	1,749		1.5
Apple		🇺🇸	79,745		1.1
Uber		🇺🇸	26,899		0.4

* Cases where a car's software detects a failure or a driver perceived a failure, resulting in control being seized.
@StatistaCharts   Source: DMV via thelastdriverlicenseholder.com

statista

https://www.ecnmag.com/article/2019/02/paving-way-verify-and-validate-design-first-generation-automated-driving-vehicles

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AV Testing and Validation

☐ Areas for Growth:

✔ Waymo: Carcraft – Daily simulations for autonomous miles.

✔ NVIDIA / AIMotive – Simulations.

✔ Cognata / Metamoto – Sensor Integration.

✔ Hardware-centric Integration and Simulation.

Source: https://www.theverge.com/2018/5/9/17307156/google-waymo-driverless-cars-deep-learning-neural-net-interview

SMART ROADS, AUTOMATED HIGHWAY SYSTEMS (AHS)

Source: Smart Transportation Alliance, A Strategic Road Research Agenda 2015-2025, Technical Report

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CUMULATIVE POLLUTION

AVERAGE DELAY PER CAR

AUTONOMOUS INTERSECTION

CUMULATIVE POLLUTION

AVERAGE DELAY PER CAR
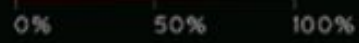
TRADITIONAL INTERSECTION

OPTIMAL SPEED

0%   50%   100%

L4+ INFRASTUCTURE WILL MAXIMIZE VEHICLE FLOW RATES=> VEHICLE NEVER STOPS, THUS NO TRAFFIC LIGHTS ANYMORE!

RIDER EXPERIENCE & ENGAGEMENT

2017,
Intel+Warner Bros: Batman-themed self-driving experience using in-car 270-degree viewing by ScreenX

2017,
Panasonic's concept for AV interior at CES.
- ☐ The two front seats turn to share a table with rear passengers.
- ☐ Four 4k touchscreen tablets.
- ☐ Connected Interactive Table (CIT) for digital board games.

2019,
Audi+Disney+Marvel+Holoride: VR content based on the car's data/movement.
- ☐ Goal: Use of AR/VR in ride shares.

Timeline of Events

RIDER PRODUCTIVITY:

- AV reduces unproductive hours Americans spend on driving by 2.7 billion hours.
- Global in-vehicle entertainment market will reach $52.2 billion by 2022.
- INRIX estimates the cost of traffic congestion at $87 billion a year in lost time for drivers.

RIDER EXPERIENCE:

Opportunities for high-end AV interior design:

- Luxurious and aesthetic interiors
- Multiple large displays.
- Interior surfaces as displays.
- Entertainment experiences (movies, music, conferencing)
- Chatting, messaging, virtual interactions.

RIDER ENGAGEMENT:

- Dynamic billboards changing with locations.
- Estimated annual advertisement market: $190 billion.
- Engagement of AVs with Ride-sharing and mapping companies for location data.

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Recommendations

- AV Eco-system components tentatively to contribute upto 10% of Expected Market by 2023-2030.

- Recommendations ordered by investment scope:

1 Technology that adhere to C-V2X standards for connectivity and communication.

2 AV sensor simulation, integration, security and validation.
Scope => hardware-centric simulation/validation platforms.

3 Smart automated highways: maximize vehicle flows, ensure safety, reduce urban congestions.
Large Scope=> Global vehicle flow estimation and real time path planning systems and platforms.

4 Rider Experience/Engagement.
Large Scope => in-car design, virtual conferencing, movies, advertisements, gaming (AR/VR).

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