

Challenge and Opportunity for Autonomous Vehicles beyond Level 5.0

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- Autonomous and intelligent mobility for **Transportation**
- AI(Artificial Intelligence) for Digital **Transformation**
- Metaverse, VR for **Transition**

- **Outlook of the Automotive Industry and Market**
- **Roadmap of Autonomous Vehicle (AV)**
- **Challenges and Opportunity of AV**
- **Tesla vs. Google Waymo and the others**
- **AV developed by Yonsei STL**
- **Concluding remarks**

Outlook of the Automotive Industry & Market (Y2017)

- **Global Vehicle Manufacturing** : ~ 90M /Year (약 9천만대/년)
 - **Global Vehicle Market** : ~ 2000B US \$ (약 2400조원/년)
 - The world's largest producing Country : China (~ 25M/Y)
 - **No. of Vehicles Produced in Korea** : ~ 4.5M/Y
 - **No. of Korean Brand Vehicles** : ~ 7.8M/Y
 - **No. of Vehicles sold in Korea** : ~ 1.7M/Y
 - **No. of Vehicles Registered in Korea** : ~ 22M
-
- **Number of Components composing a Vehicle** ~ 30K/Vehicle
 - **Portion of Electronic Components** > 45%

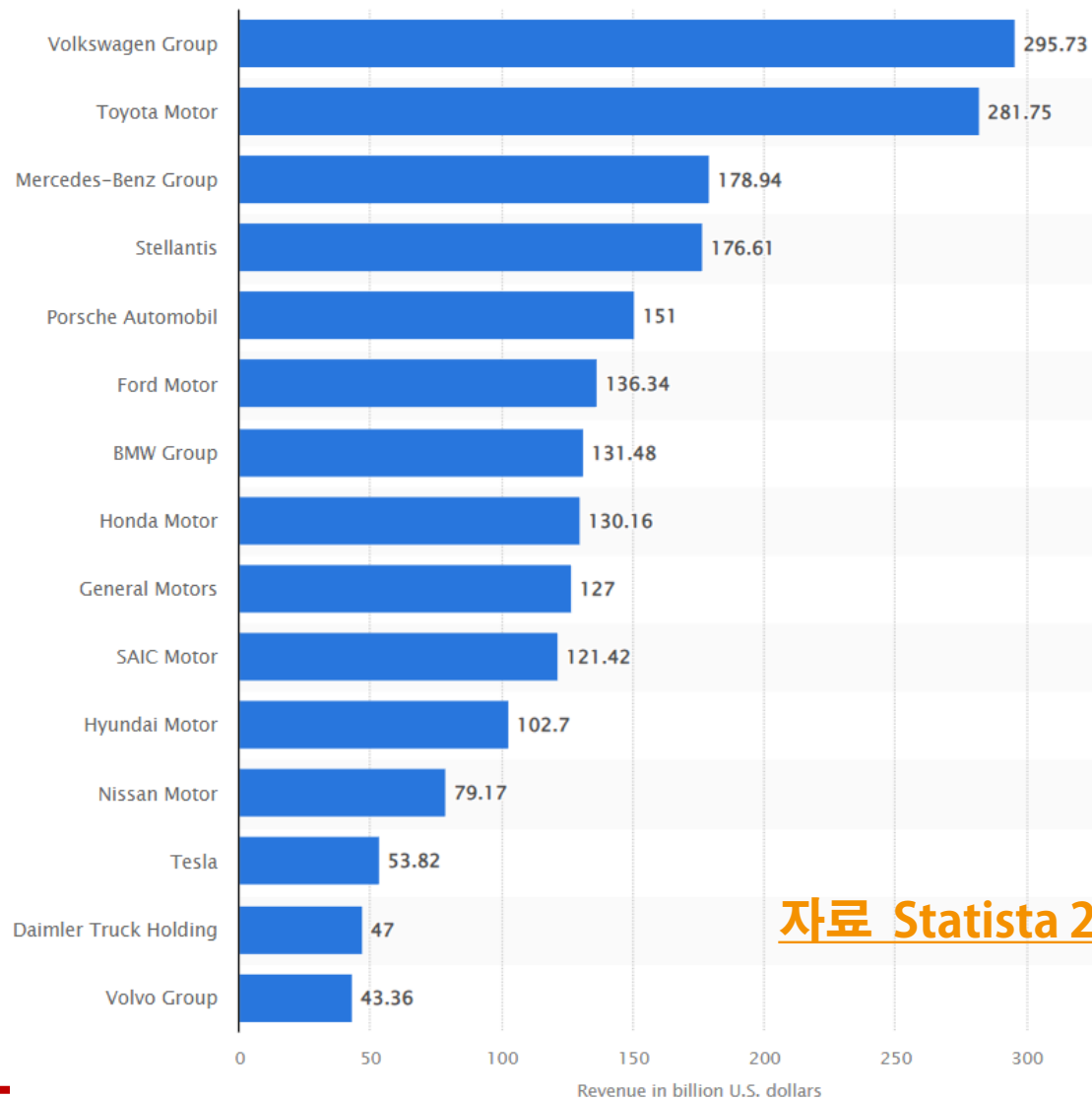
Outlook of the Automotive Industry & Market

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Top 15 largest manufacturers by production volume (2017)

Rank	Group	Vehicles
1	Toyota	10,466,051
2	Volkswagen Group	10,382,334
3	Hyundai	7,218,391
4	General Motors	6,856,880
5	Ford	6,386,818
6	Nissan	5,769,277
7	Honda	5,236,842
8	Fiat Chrysler	4,600,847
9	Renault	4,153,589
10	PSA Group (Stellantis)	3,649,742
11	Suzuki	3,302,336
12	SAIC Motor(중국)	2,866,913
13	Mercedes Benz	2,549,142
14	BMW	2,505,741
15	Geely (중국)	1,950,382

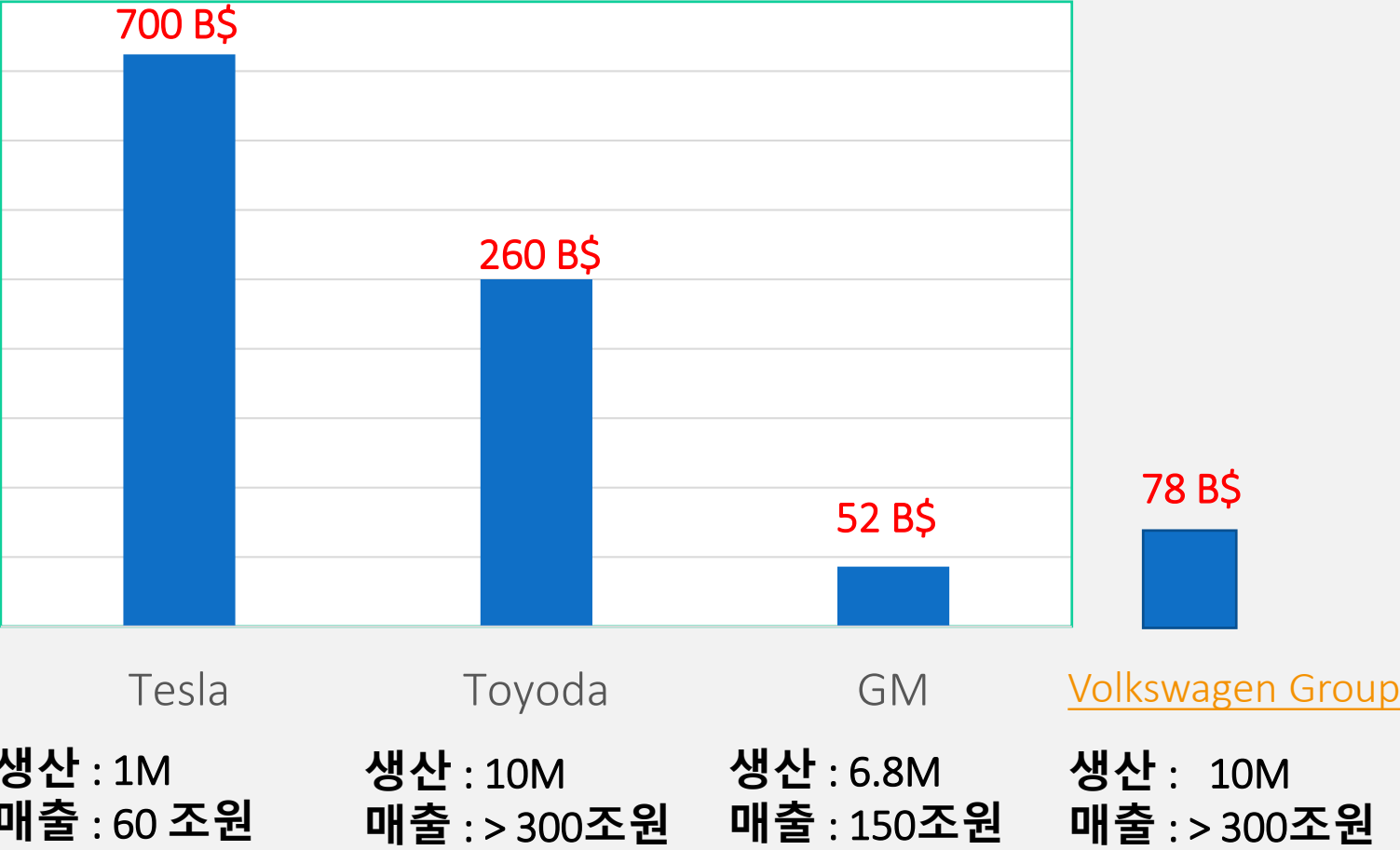
Revenue of leading automakers in 2021(US \$)



자료 Statista 2022

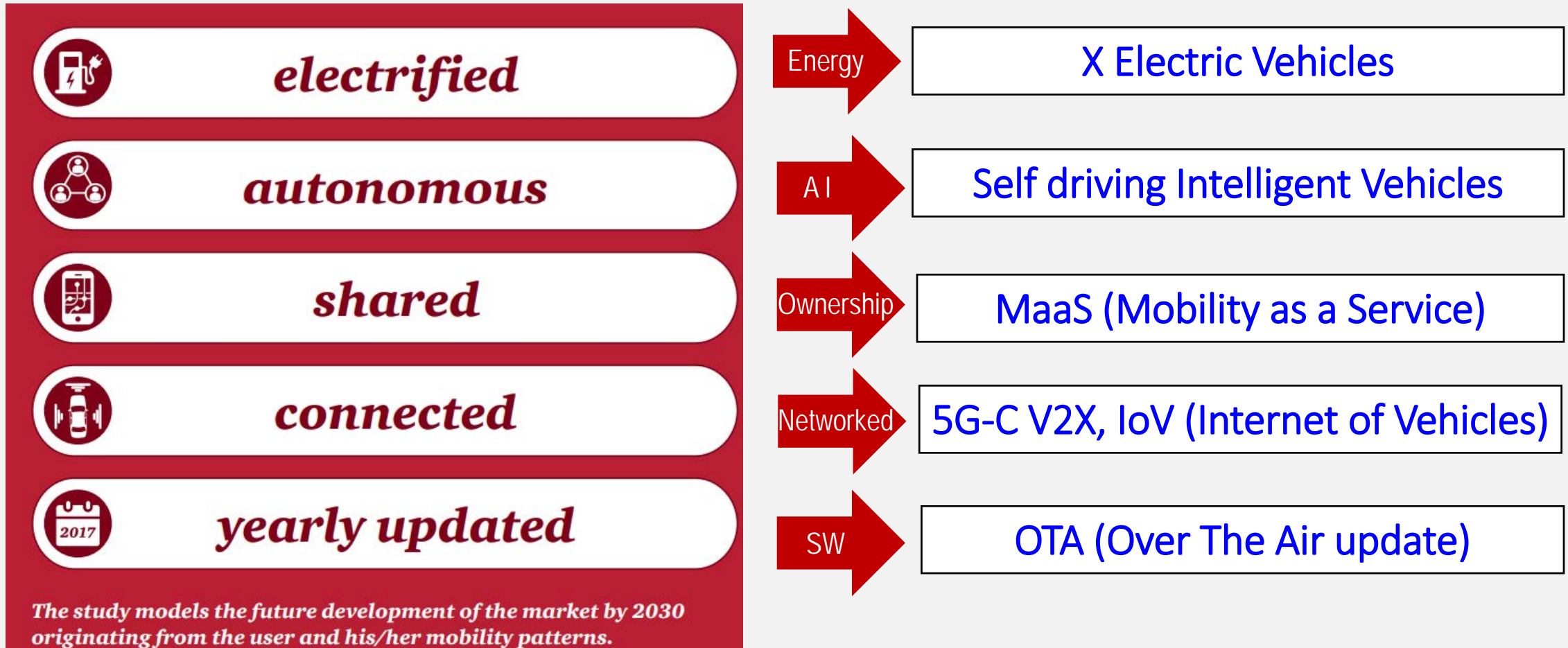
Outlook of the Automotive Industry & Market

Total stock Value (B\$) (21st May 2022)



5 Mega Trends : (Digital) Transformation of Automotive Industry

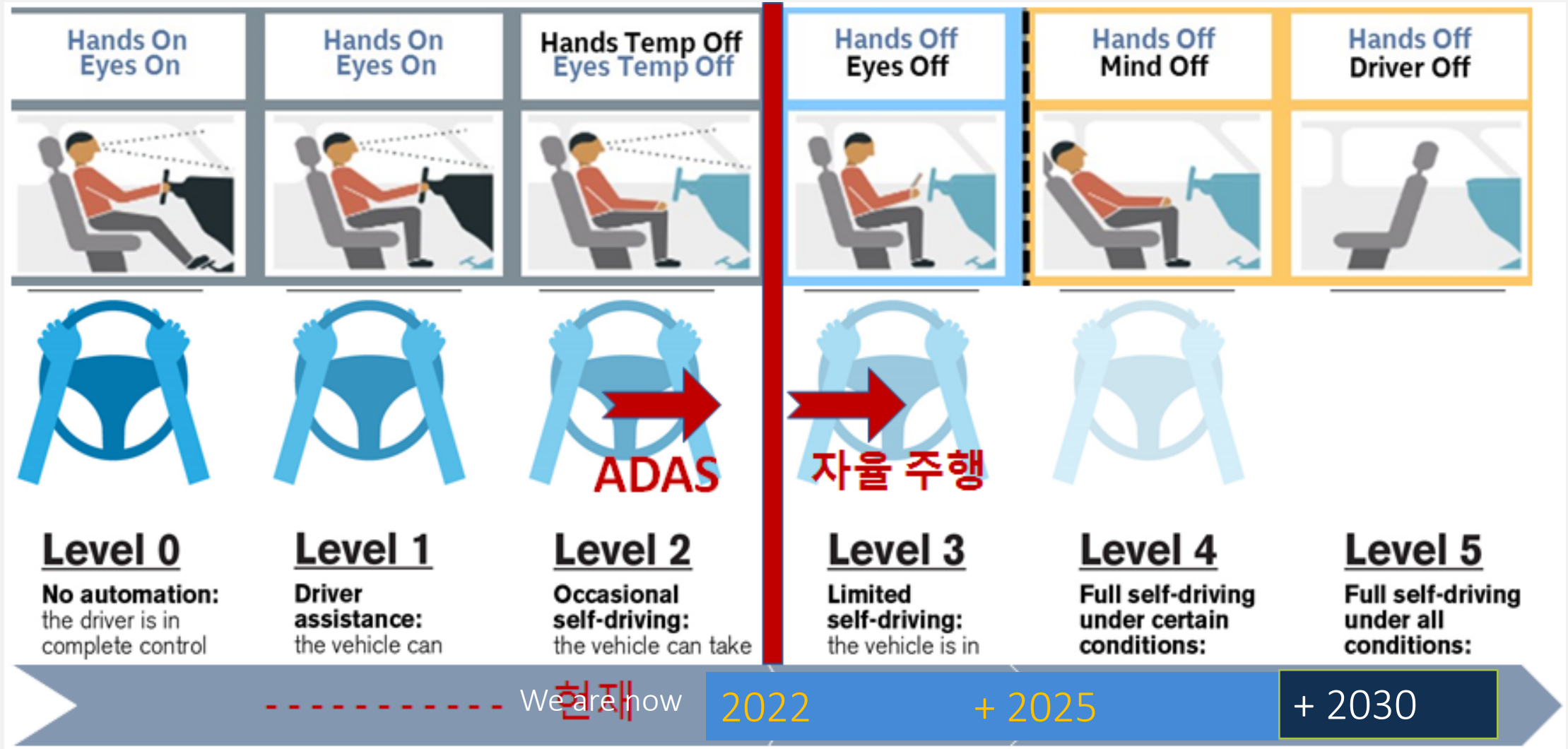
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Roadmap of Autonomous Vehicle (AV)

Levels of automation (SAE J3016)

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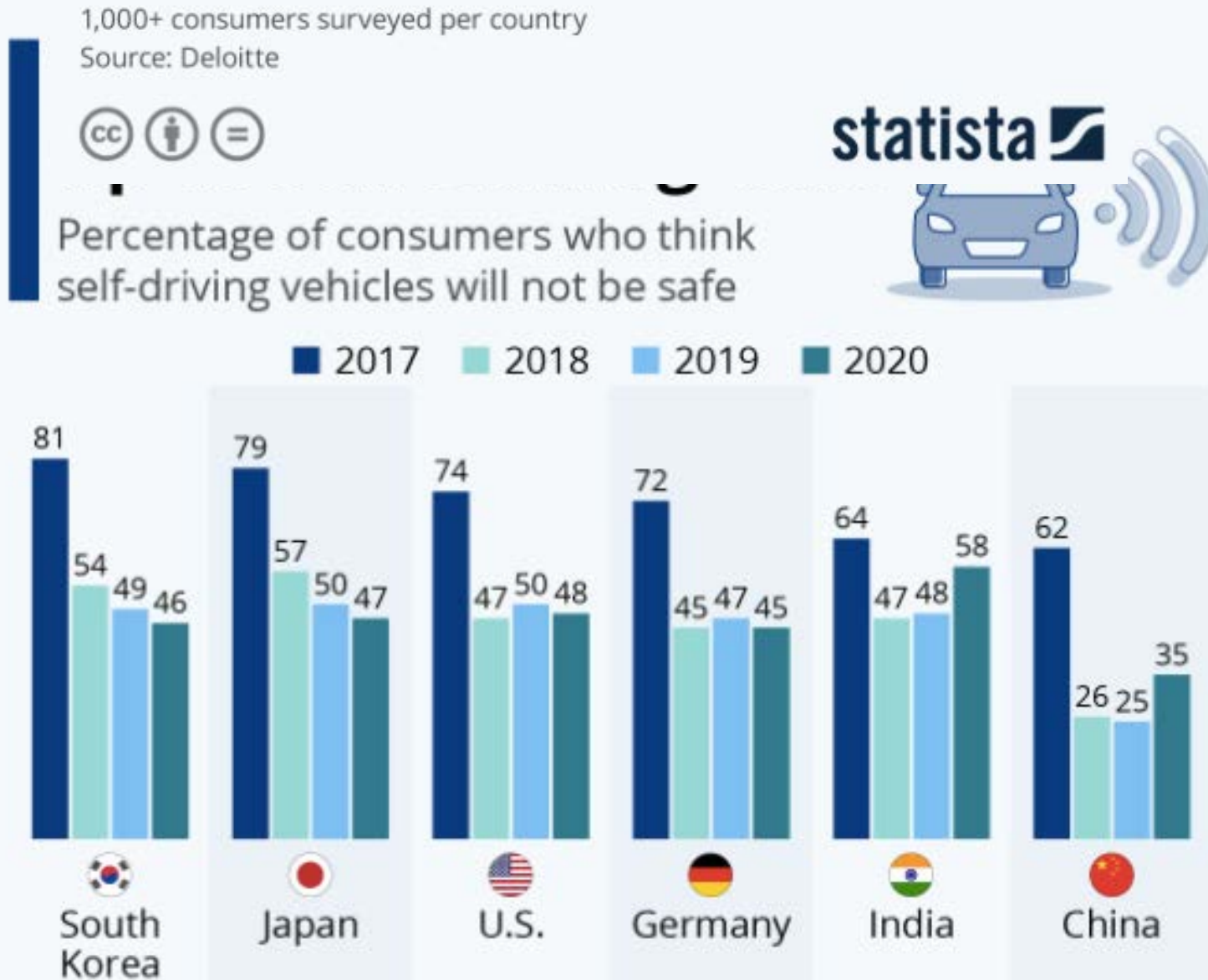
ADAS : (Advanced Driver Assistance Systems), AV: Autonomous Vehicle

❖ Challenging Issues

- Technology - Performance, Safety, Cyber-Security
- Social Acceptance - Comfort, Congestions, Driving Behavior
- Business Model – Vehicle Ownership, Mobility as a Service (MaaS)

Social Acceptance

Impact on Life style, new business, and economy



- **Intelligent vehicle industry**
- **Connected Cars**
- **Impact on Life style, new business, and economy**

Impact on Life style, new business, and economy

Benefits of Autonomous Vehicles

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93% of all accidents are caused by human error.¹



Improved Safety

Sensors and cameras using Intel technology make "things" smarter so you get where you want to go more safely.

Increased Productivity

Imagine safely collaborating with coworkers, friends and family inside your car—the ultimate connection hub.



5.5 billion hours of potential productivity is lost in traffic.²



56% less fuel emissions for driverless cars.³



Environmentally Friendly

If one out of five cars were driverless, fuel consumption would decline by **724,000,000 gallons.**⁴

Greater Freedom

Intel technologies can help the elderly and disabled be more mobile and independent with self-driving cars.

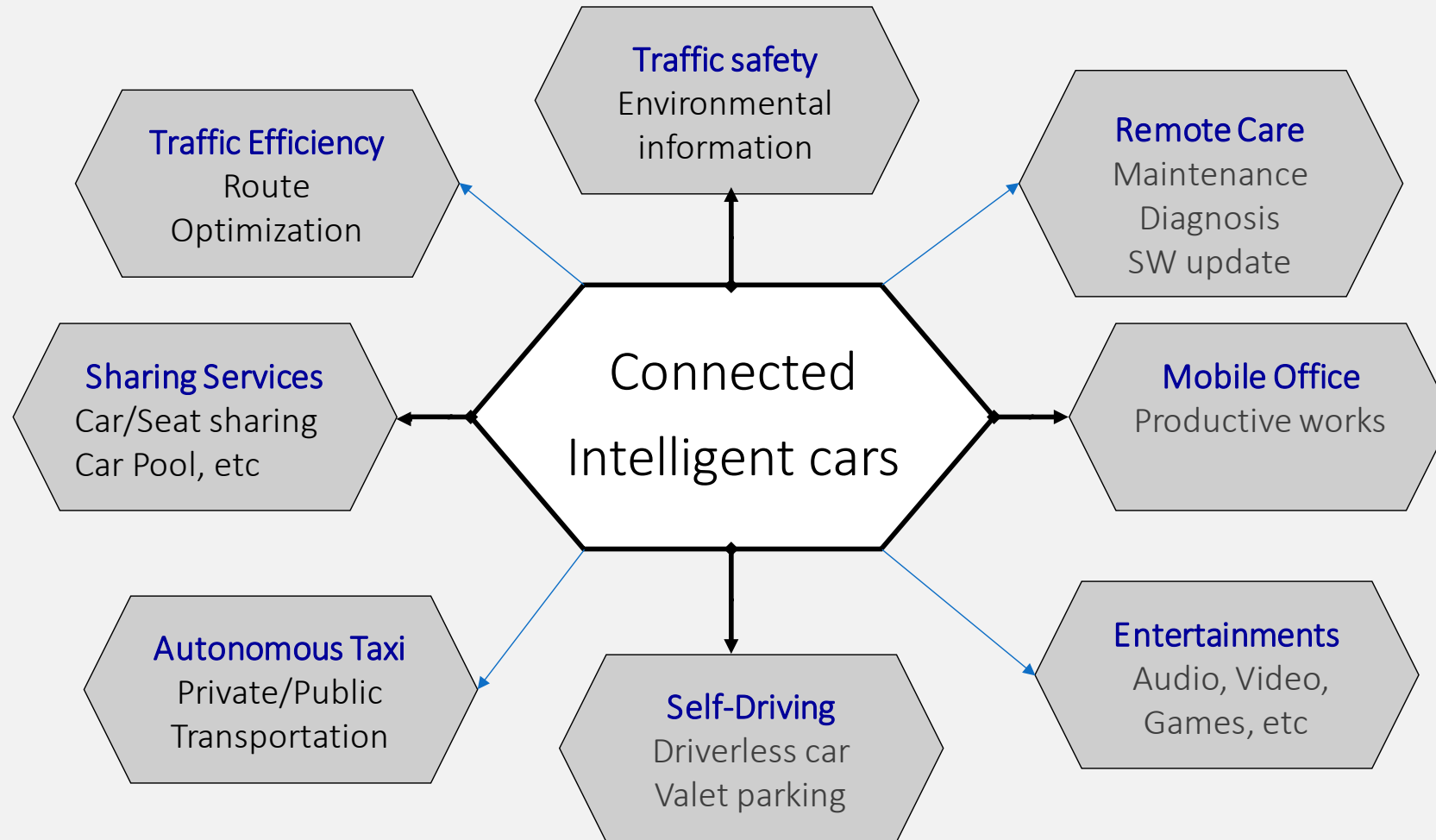


There will be **~3x more** 80+ years old in just a few decades.⁵

Traffic fatality(교통 사고 사망자) : 104/1M (Korea) , In USA 30,000 Deaths/Y

Opportunity for AV : Service and applications of connected cars

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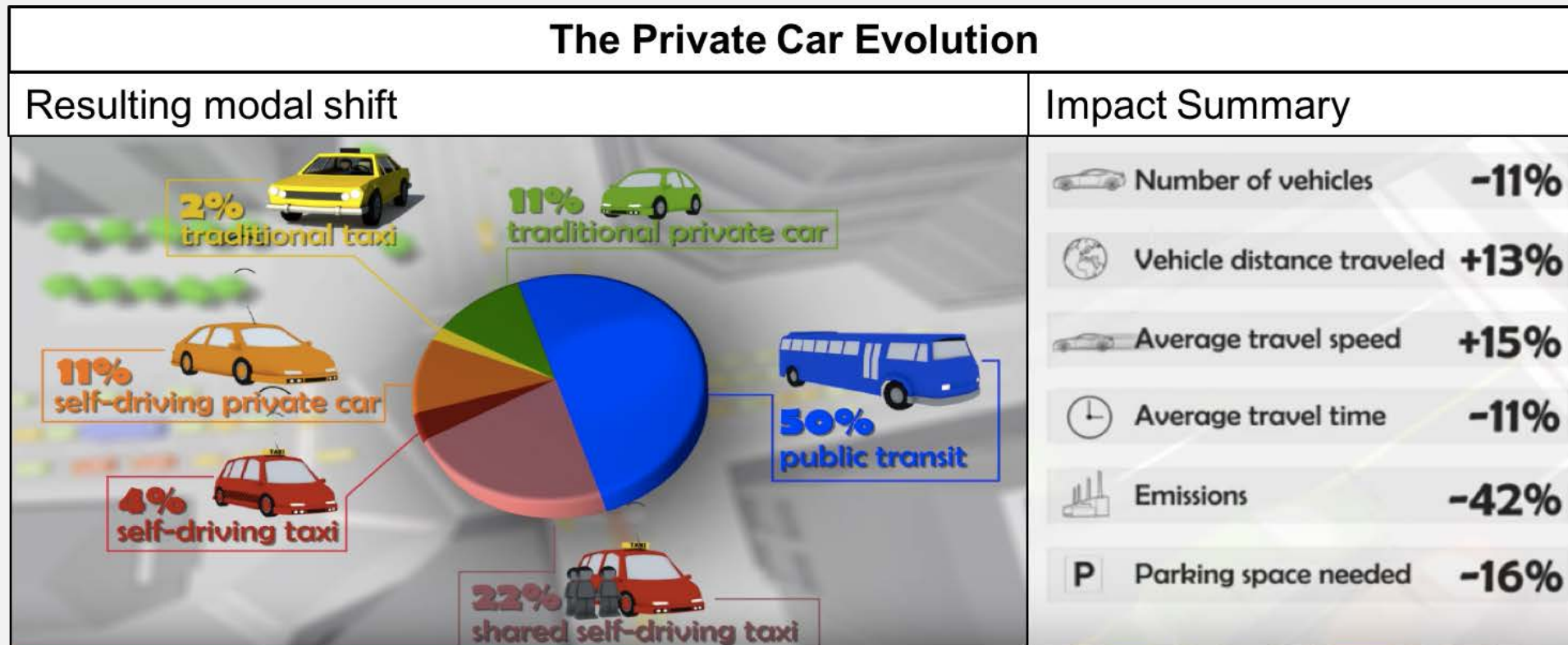


Impact on Life style, new business, and economy

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The project Boston 2030 : Modelling Boston City Traffic with Autonomous Vehicles

- ❑ The World Economic Forum in collaboration with the Boston Consultancy Group and the city of Boston, intend to pilot autonomous vehicles in the city.
- ❑ The **project Boston 2030** will look into 1) AV technology, 2) Business models for reliable and safer transportation, 3) Infrastructure to support AVs.

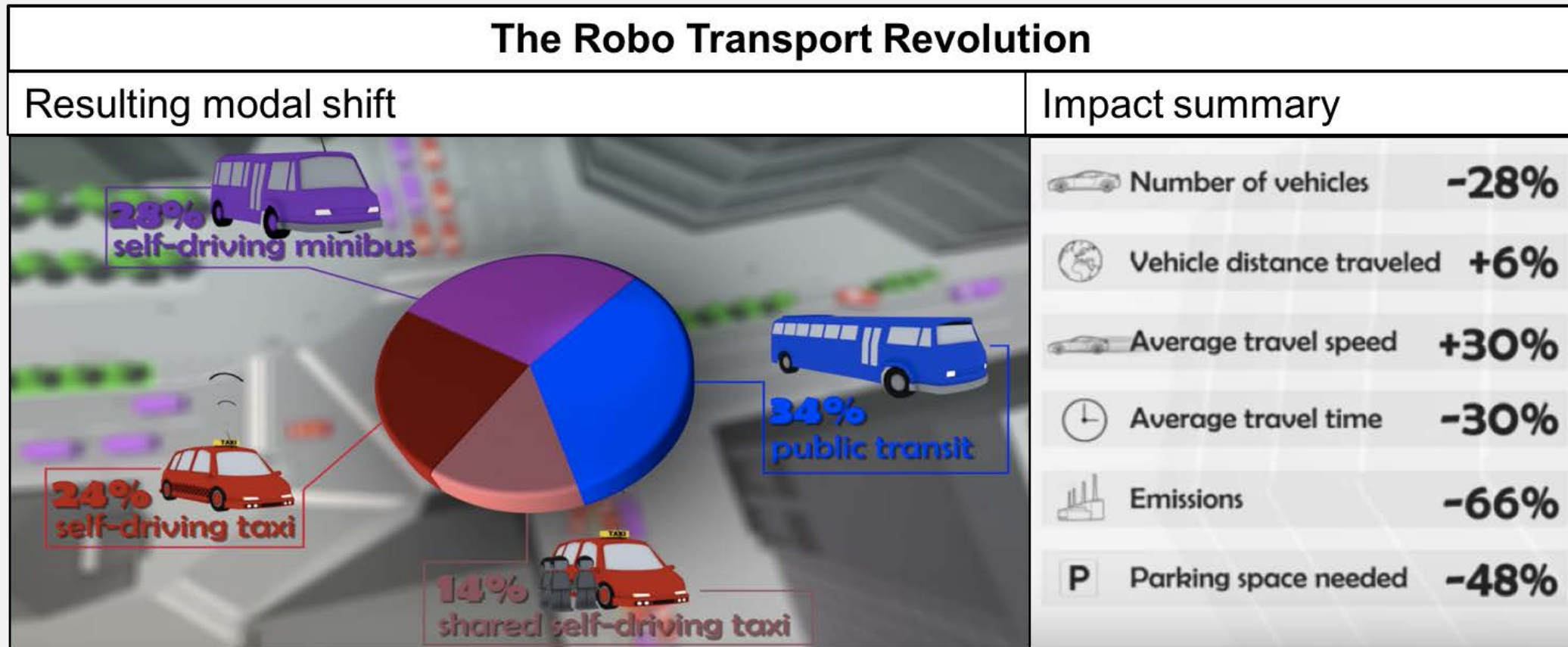


Impact on Life style, new business, and economy

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The project Boston 2030 : Modelling Boston City Traffic with Autonomous Vehicles

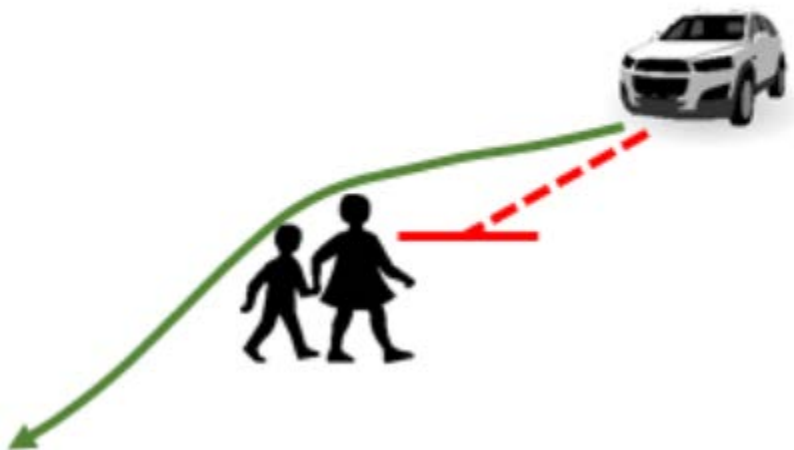
- ❑ The scenario of "**The robo-transport revolution**", the personal car is completely replaced by self-driving taxis (with and without ride-sharing) and mini buses.



Autonomous Vehicle : DDT



Object and Event Detection and Response (OEDR)



DDT fallback

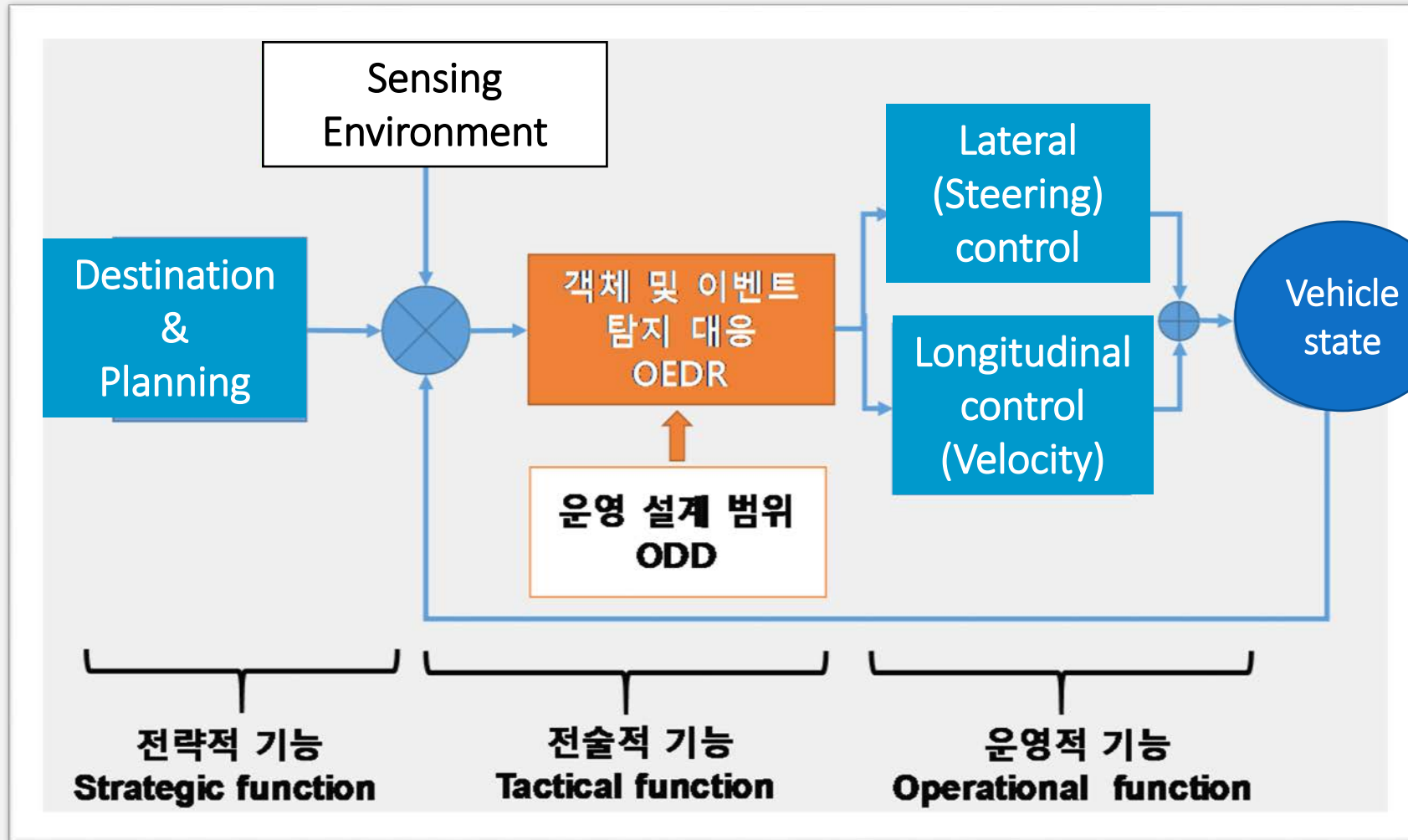
Guaranty Safety

Operational Domain
Design (ODD)

**Limitation of
Driving
environment**

Dynamic Driving Task (DDT) and Self-Driving Process

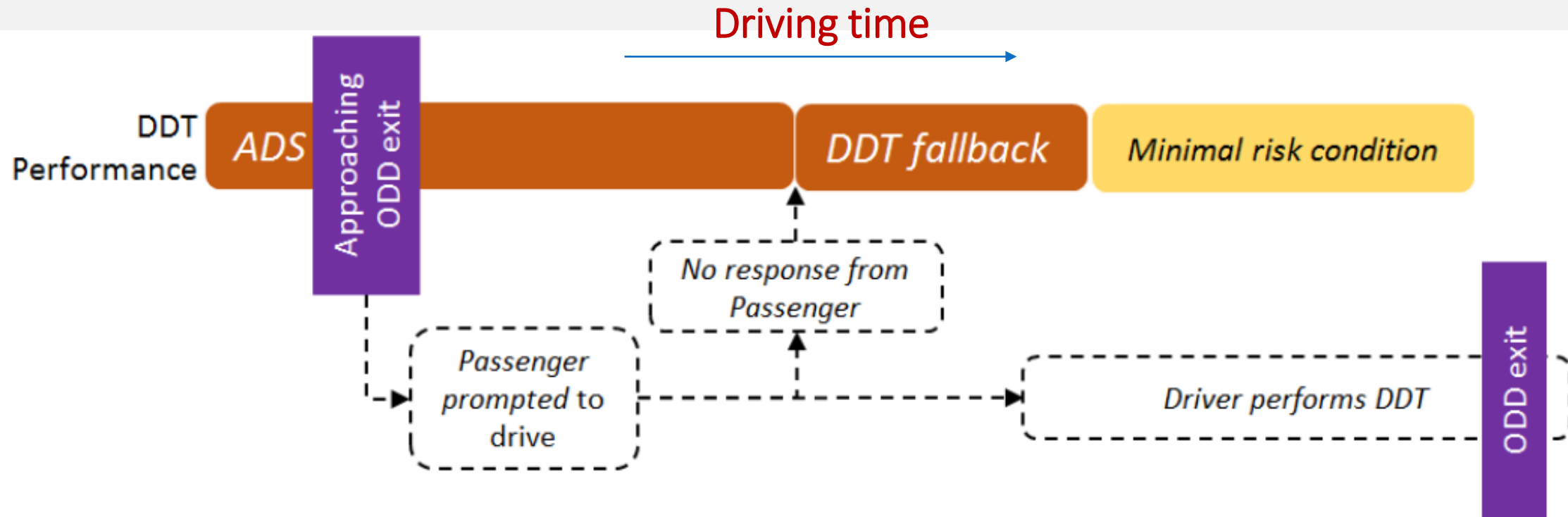
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ODD(Operational Design Domain)
OEDR(Object and Event Detection and Response)

Autonomous Driving Process and Dynamic Driving Task

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Note: dotted lines represent optional condition

DDT = Dynamic Driving Task

ADS = Automated Driving System

Minimal Risk Condition: the vehicle will park itself safely until the passenger or remote supervisor takes control as a driver; or the circumstances change so that the ODD again applies

SAE 2016

ODD(Operational Design Domain)
OEDR(Object and Event Detection and Response)

Challenges for L5.0 AV (on going research at STL)

Human like driving, but Overcoming Human's Capability

- Driving comfort: Comfortable driving experience based on Occupant Preference Metric
- Dynamic Localization using Vision and HD map matching
- 3D Object detection and tracking
- Recognition and Understanding irregular situations and environment

Autonomous Vehicles developed by STL

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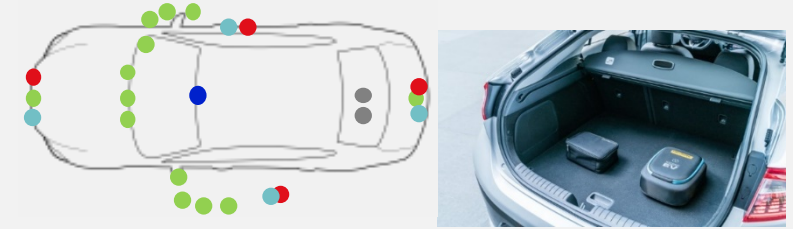
1st AV (2011)

DGPS, LiDAR, Camera,
Labview, PC
Tracking pre-planed Path



2nd AV (2017)

LiDAR, Camera, Rader
Nvidia GPGPU PX2
End-to-End steering
(Learning based)



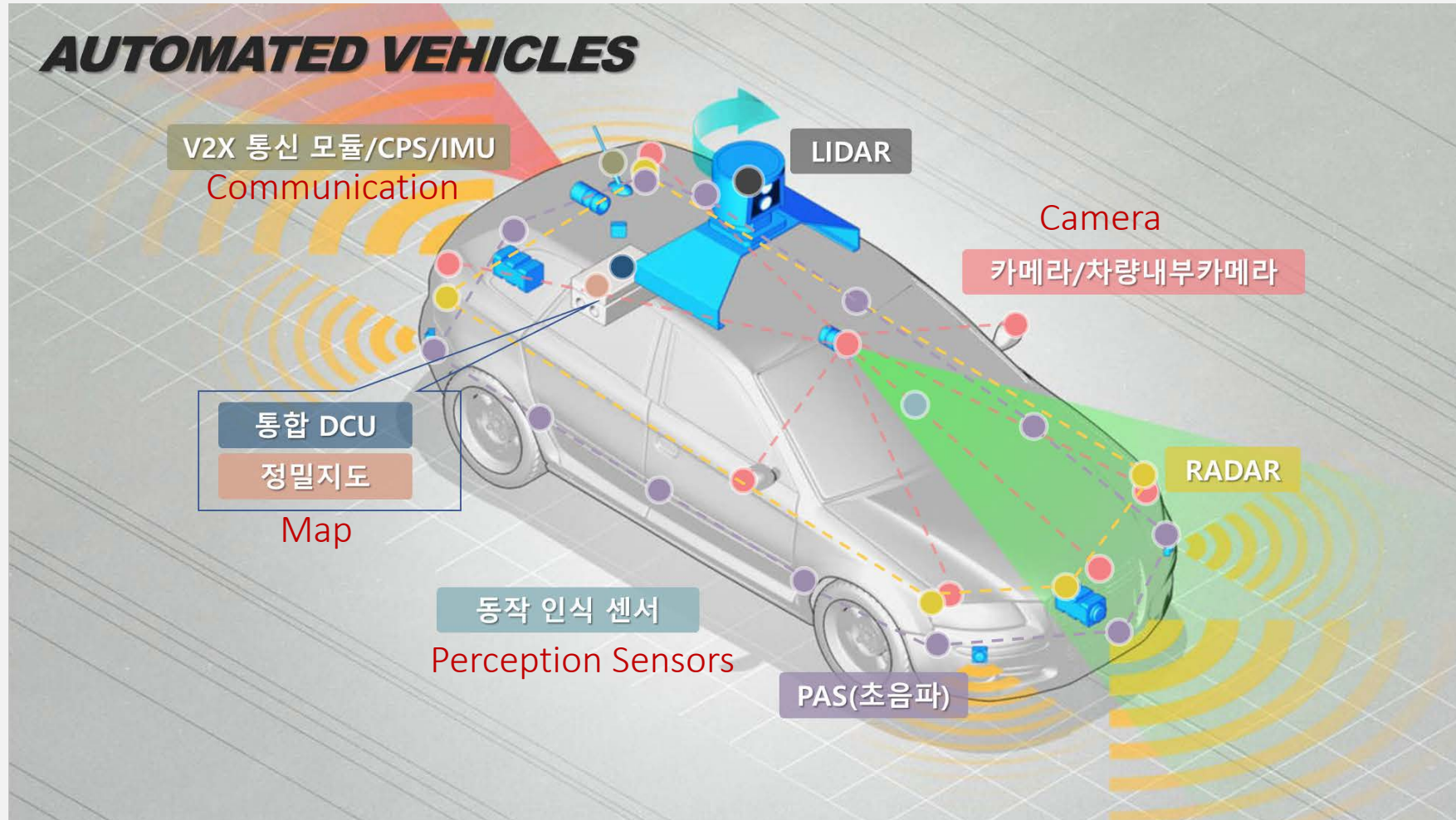
3rd AV (2019)

Camera, LiDAR/Rader
Linux PC + Neural Processing Unit
Learning based Control

Tesla vs. Google Waymo and the others

- Typical Configuration of sensors and equipment
- Waymo : Lidar + Camera based sensing
- Tesla : Cameras Only

Configuration of sensors and other equipment of typical AVs



(Google) Waymo : vehicle sensors

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Radar System

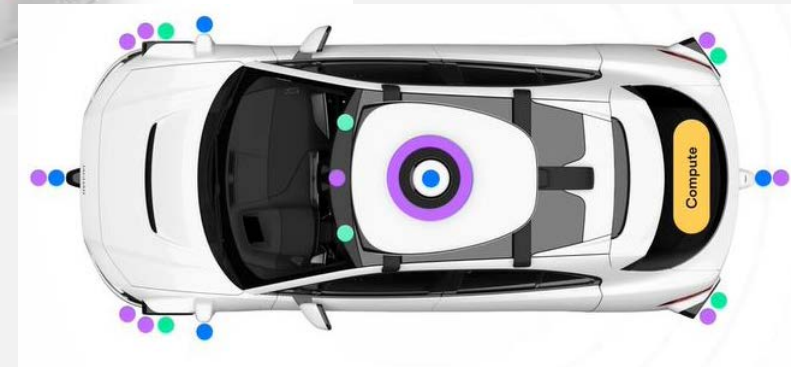
Vision (Camera) System

Lidar 360 System

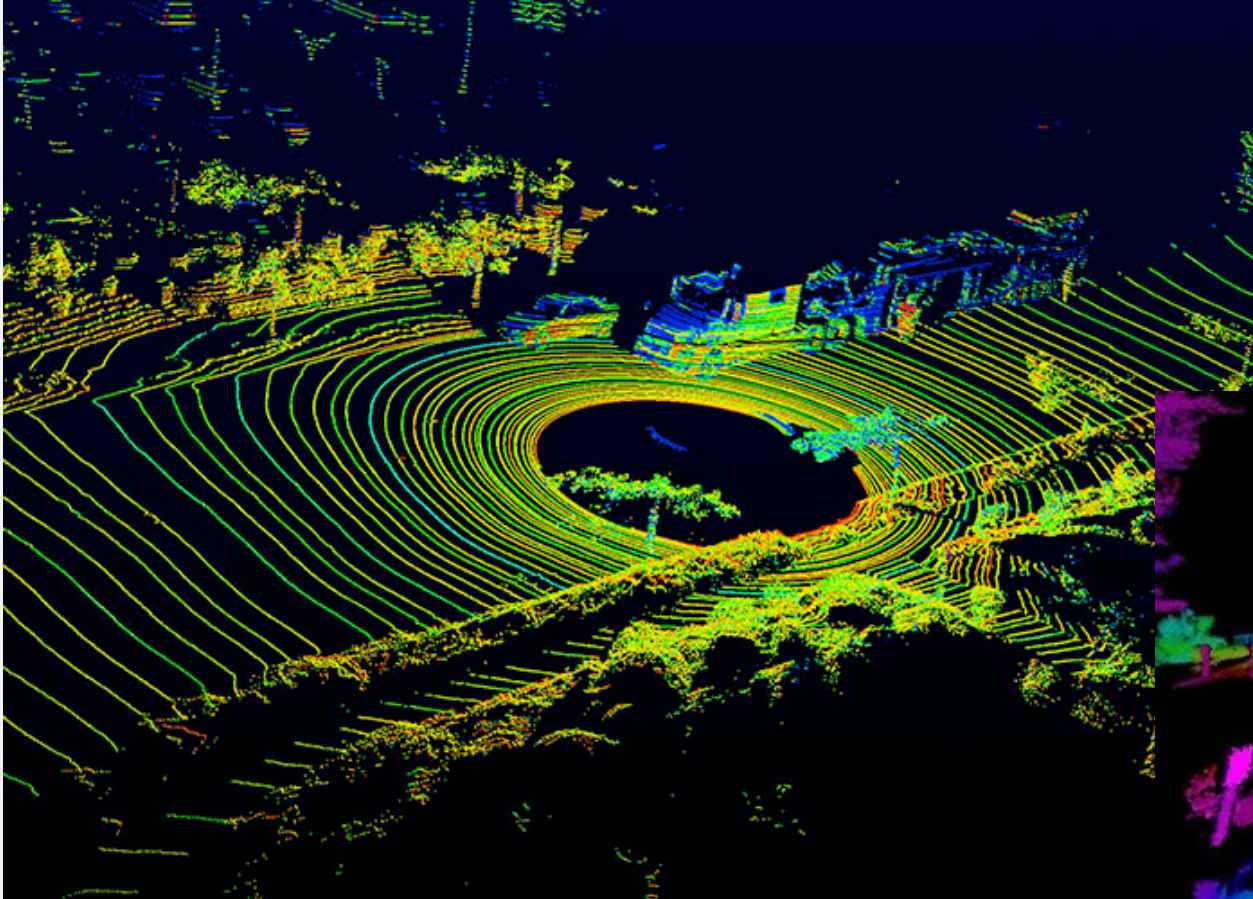
Inertial Measurement Unit (관성 센서)

Supplemental Sensors (GPS etc...)

Lidar (Laser) System

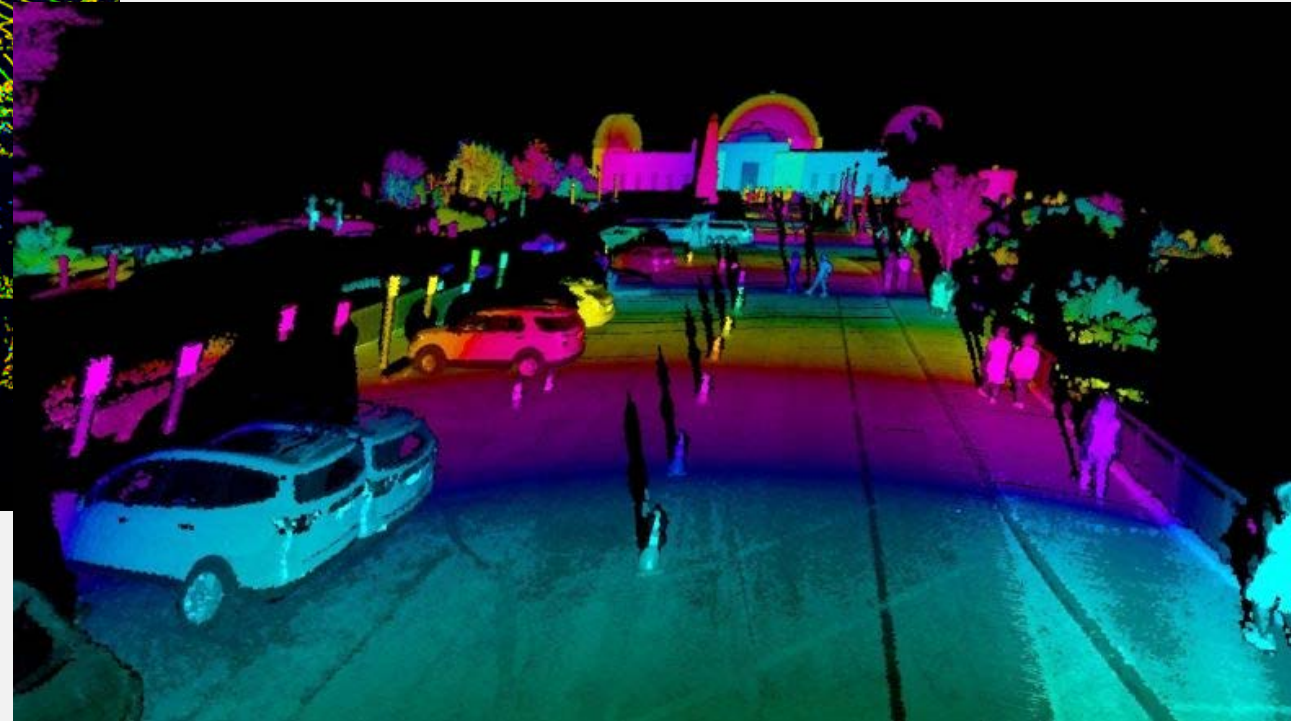


Ref: Waymo safety report, Feb. 2021



Lidar Point Cloud

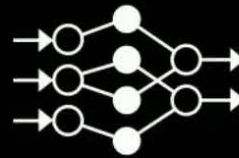
Waymo's 3D Lidar



Tesla: Vision Based approach (Camera only)

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8 Cameras

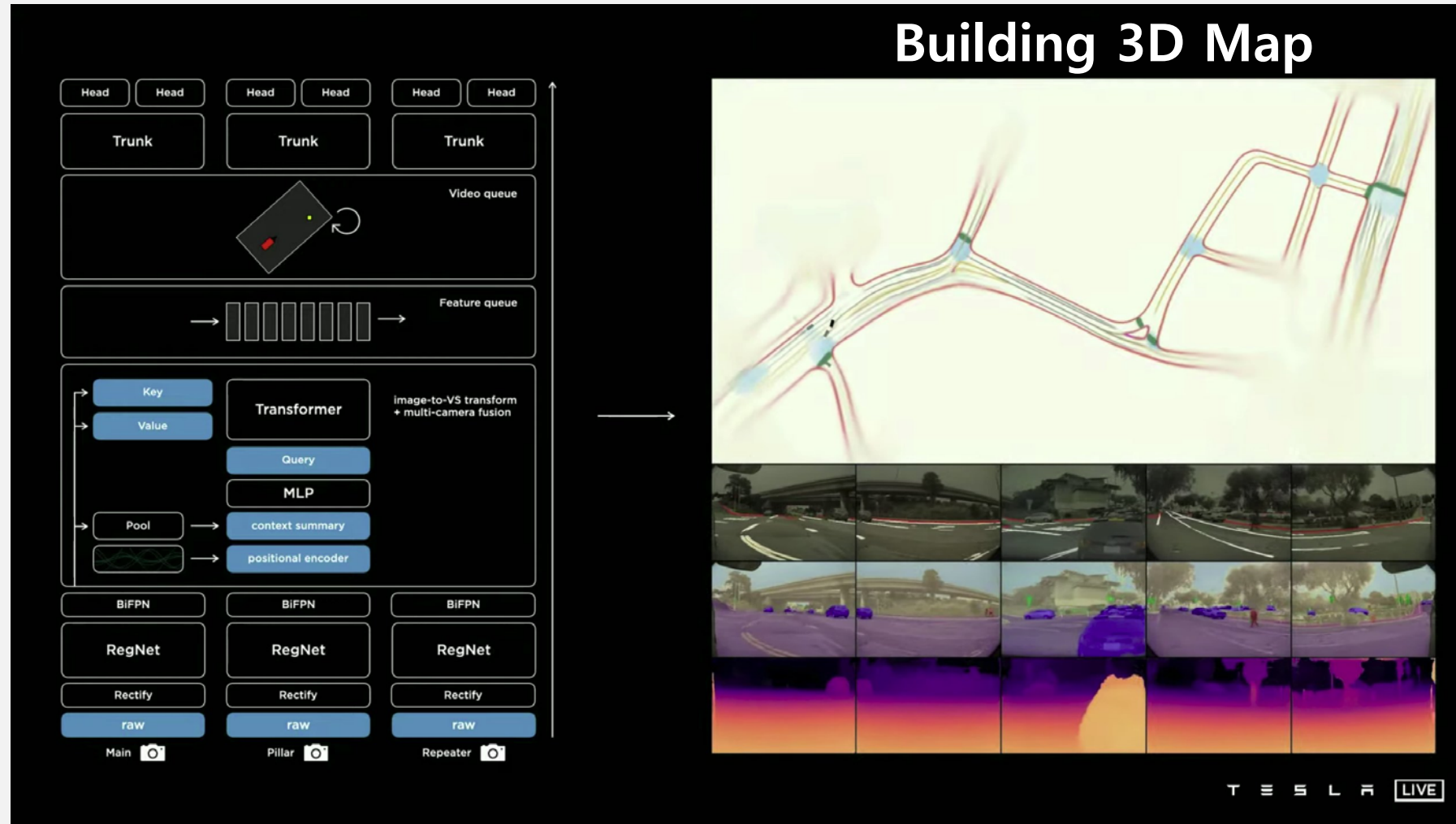


3-Dimensional "Vector Space"



Tesla: Vision Based approach (Camera only)

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Reconstruction
Segmentation

- ❑ Outlook the current Status, Challenges and Opportunity of AV
- ❑ Vehicle Industry facing a destructive revolution
 - Automotive Industry is the last industry of digital destructive transformation
- ❑ AV will change the life style as well as ICT Industry
 - Autonomous Vehicle providing next ICT platform
- ❑ Artificial Intelligence is the key enabling technology