

# 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
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- **Number of Components composing a Vehicle** ~ 30K/Vehicle
  - **Portion of Electronic Components** > 45%

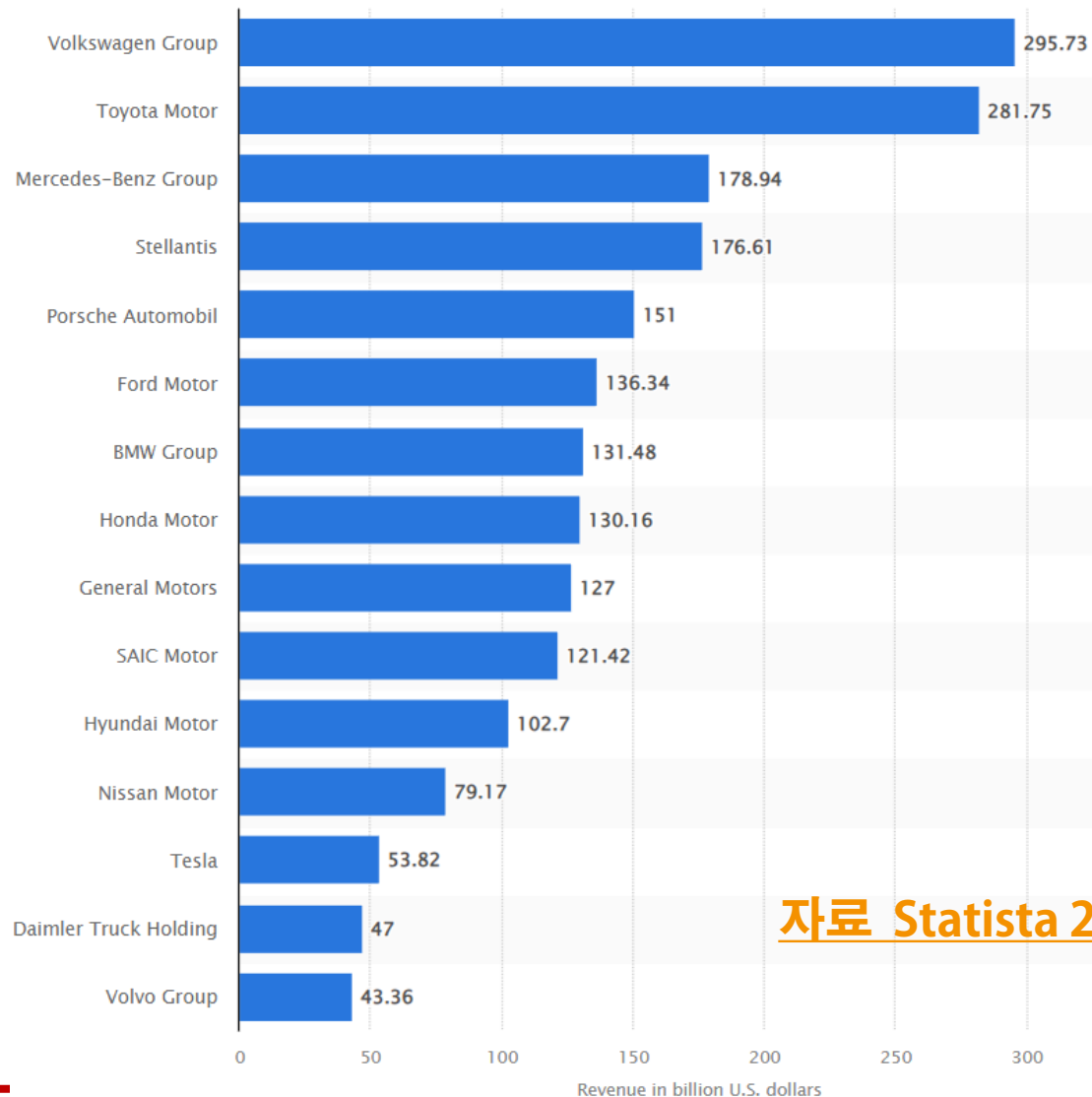
# Outlook of the Automotive Industry & Market

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Top 15 largest manufacturers by production volume (2017)

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

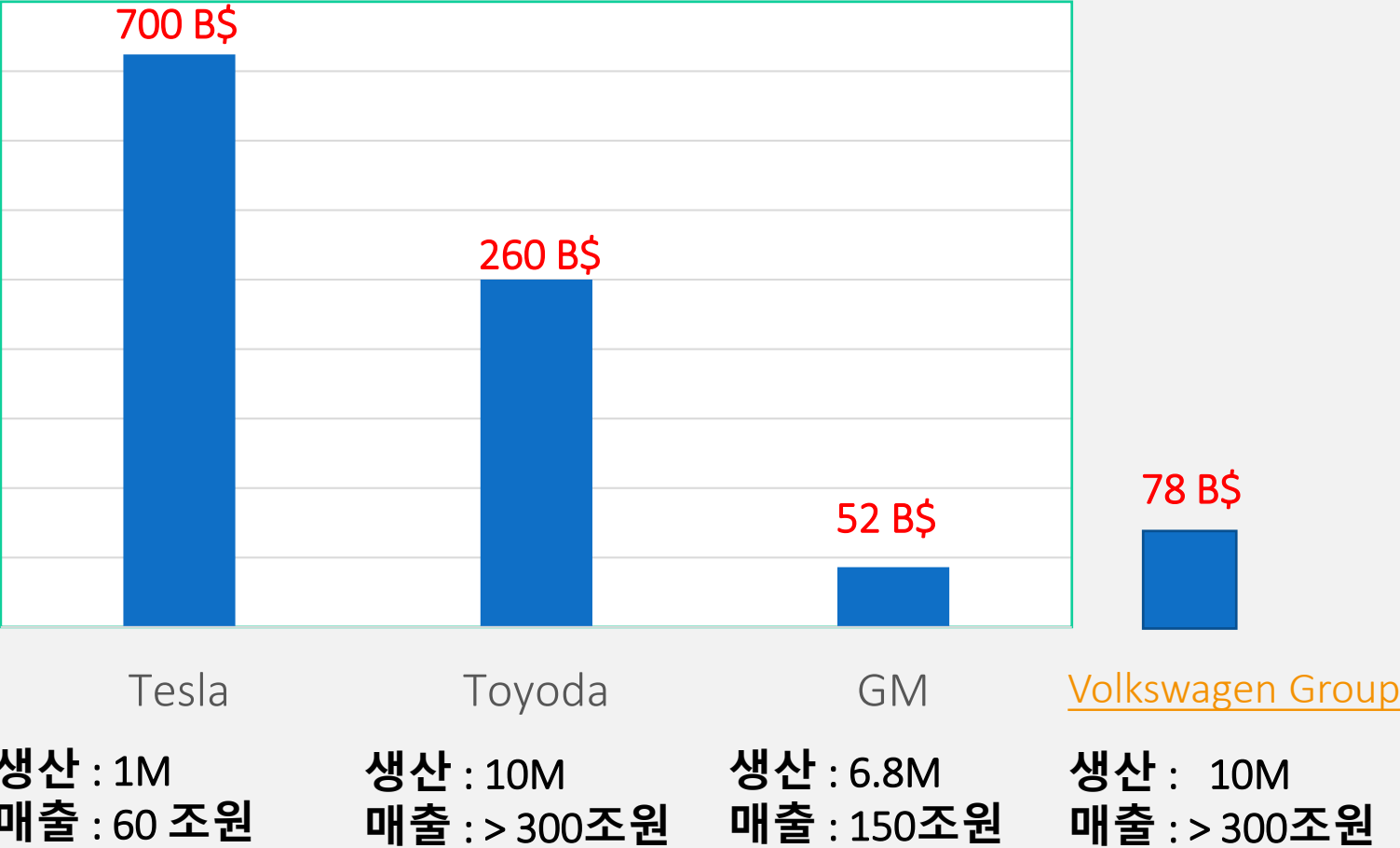
Revenue of leading automakers in 2021(US \$)



자료 Statista 2022

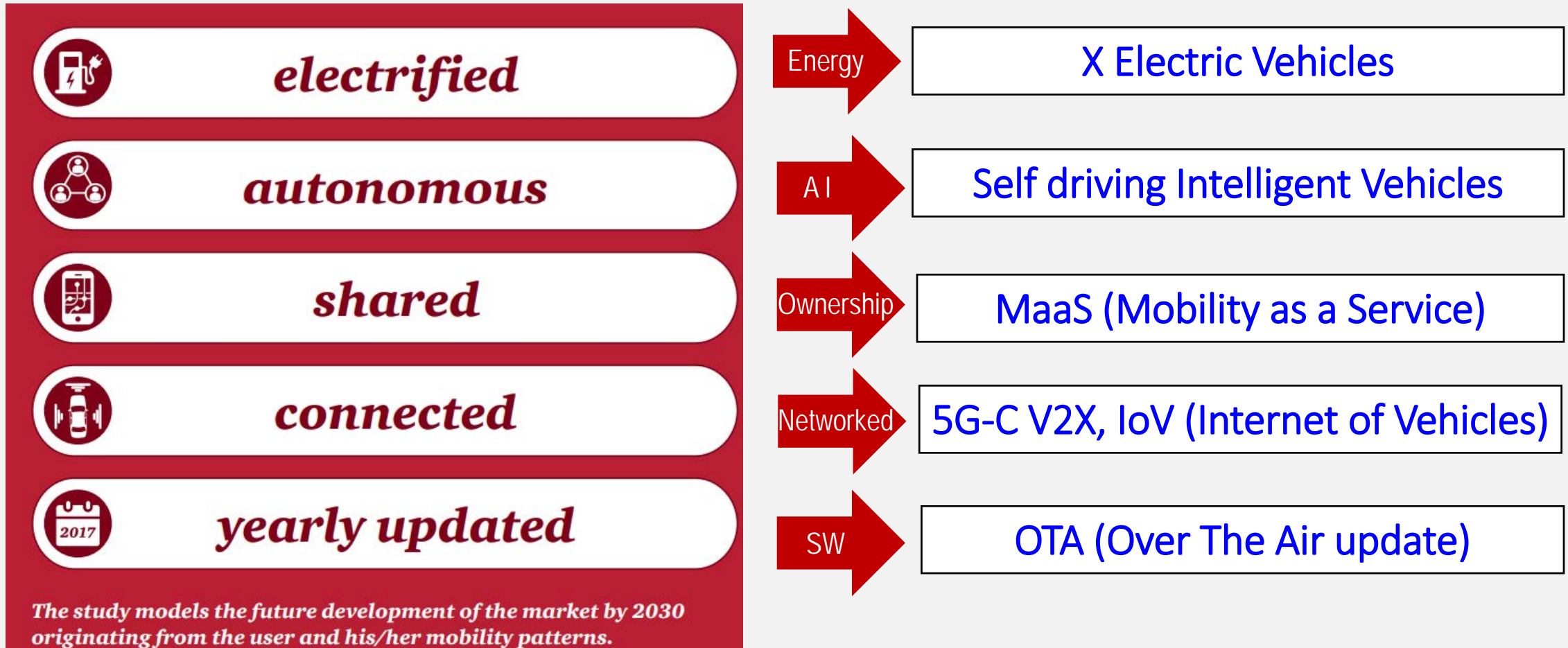
# Outlook of the Automotive Industry & Market

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



# 5 Mega Trends : (Digital) Transformation of Automotive Industry

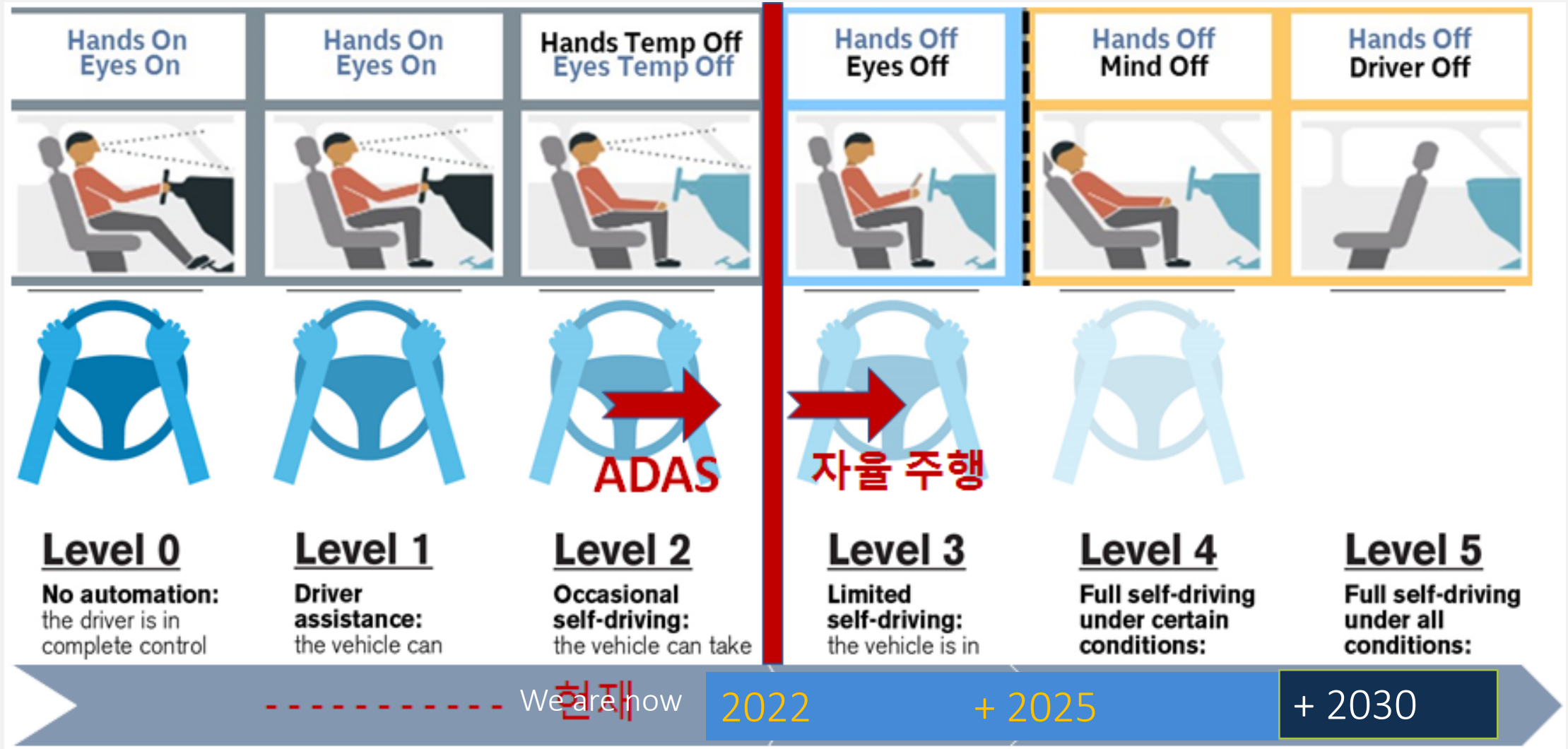
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# Roadmap of Autonomous Vehicle (AV)

## Levels of automation (SAE J3016)

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

# Challenges for Autonomous Vehicle System

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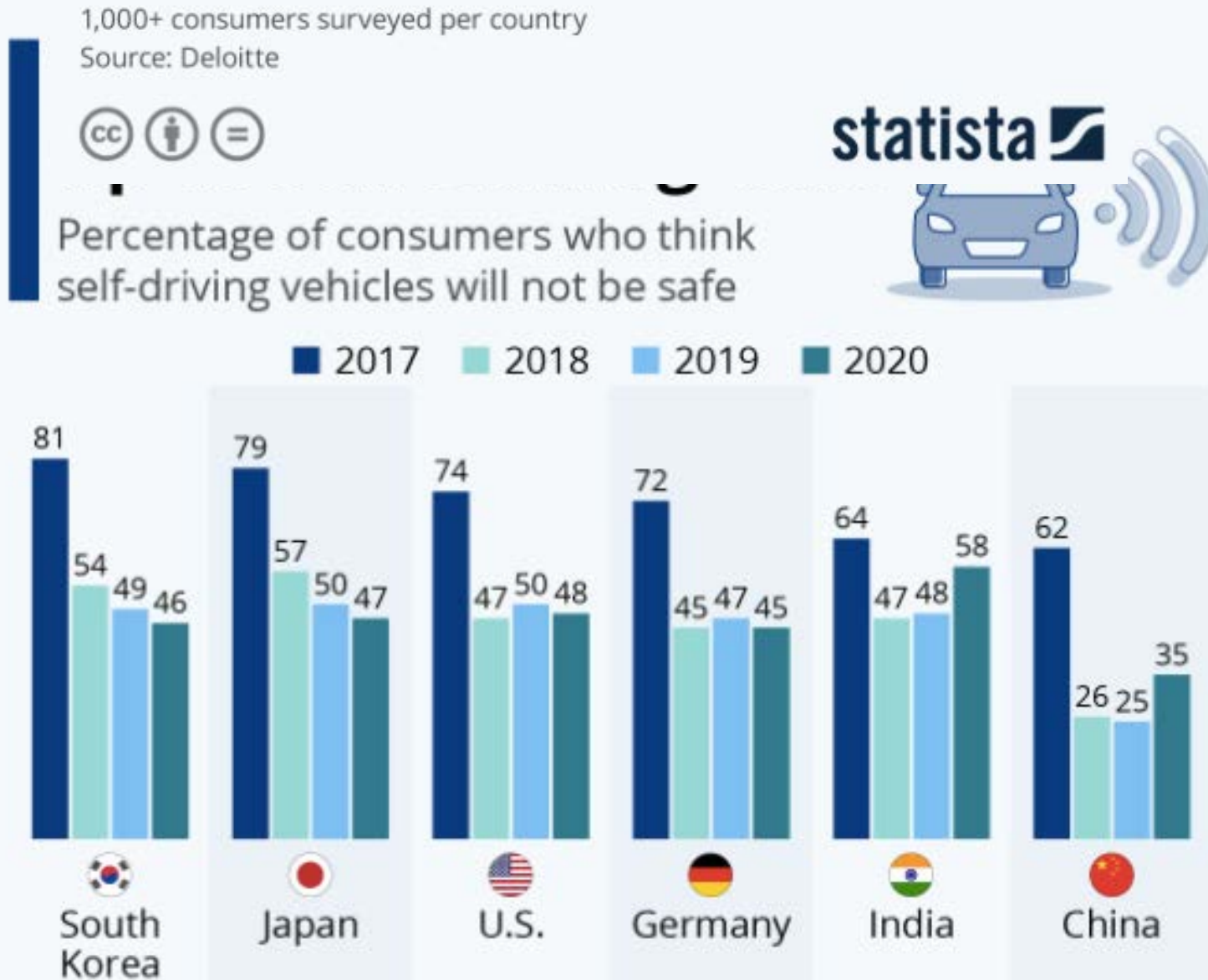
## ❖ Challenging Issues

- 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.<sup>1</sup>



### 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.<sup>2</sup>



**56%** less fuel emissions for driverless cars.<sup>3</sup>



### Environmentally Friendly

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

### Greater Freedom

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

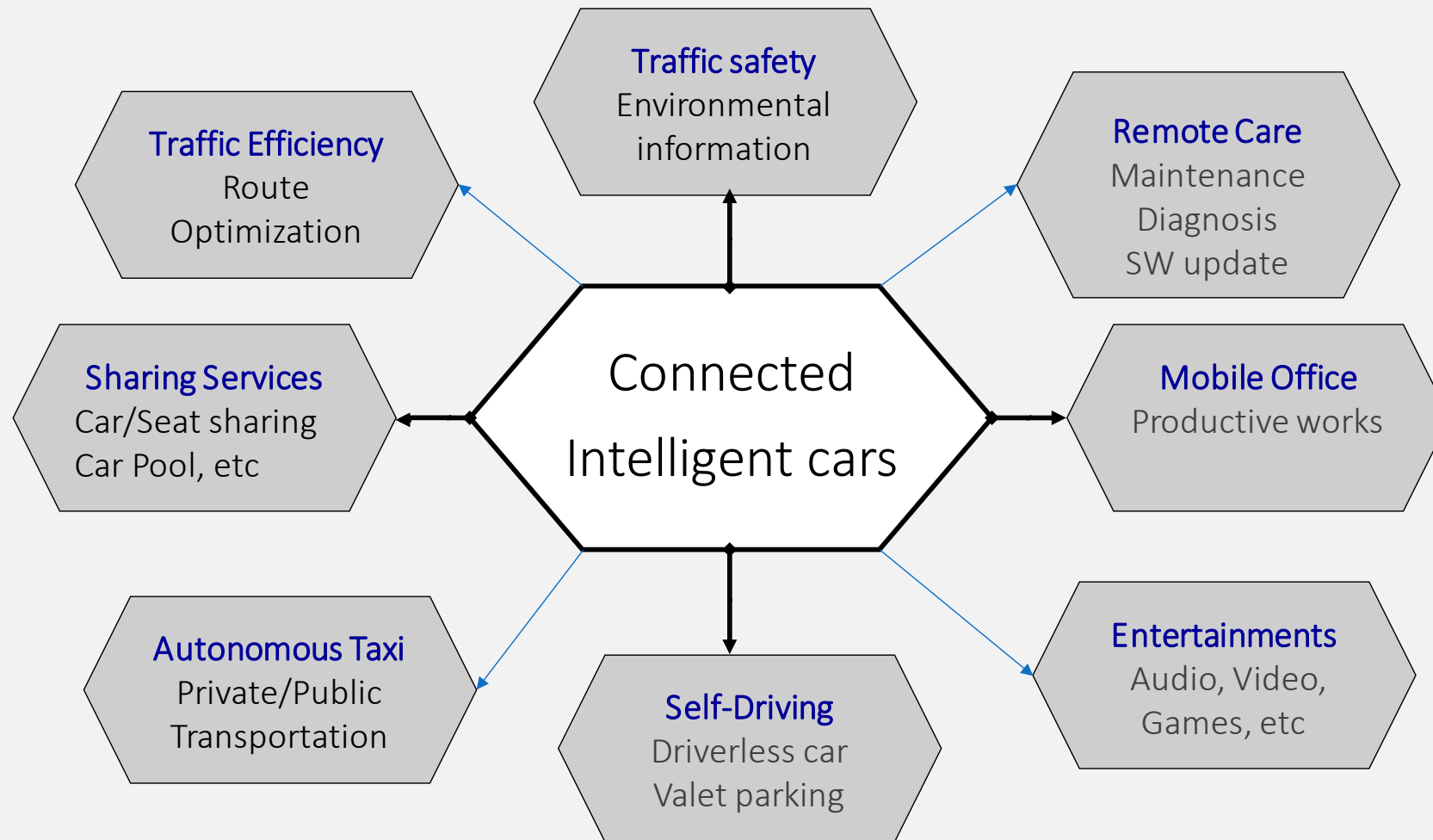


There will be **~3x more** 80+ years old in just a few decades.<sup>5</sup>

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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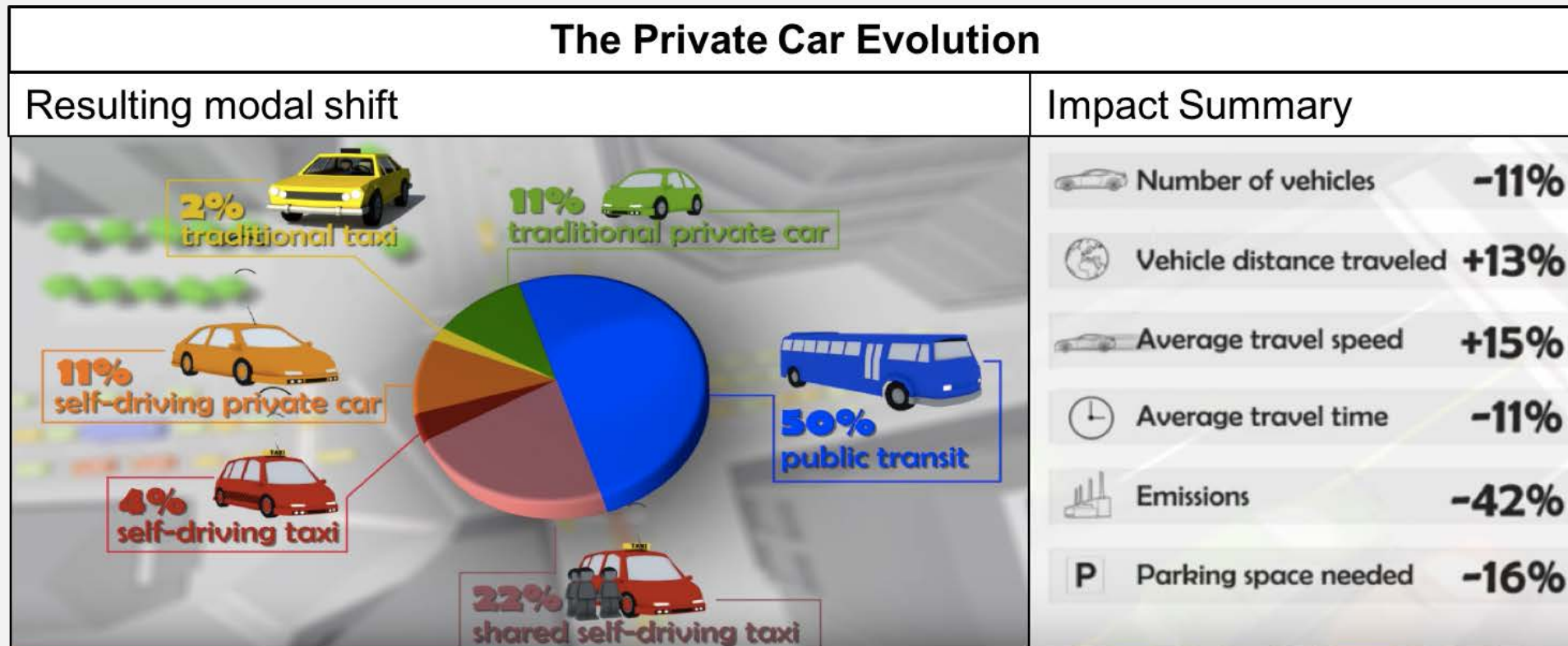


# Impact on Life style, new business, and economy

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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.



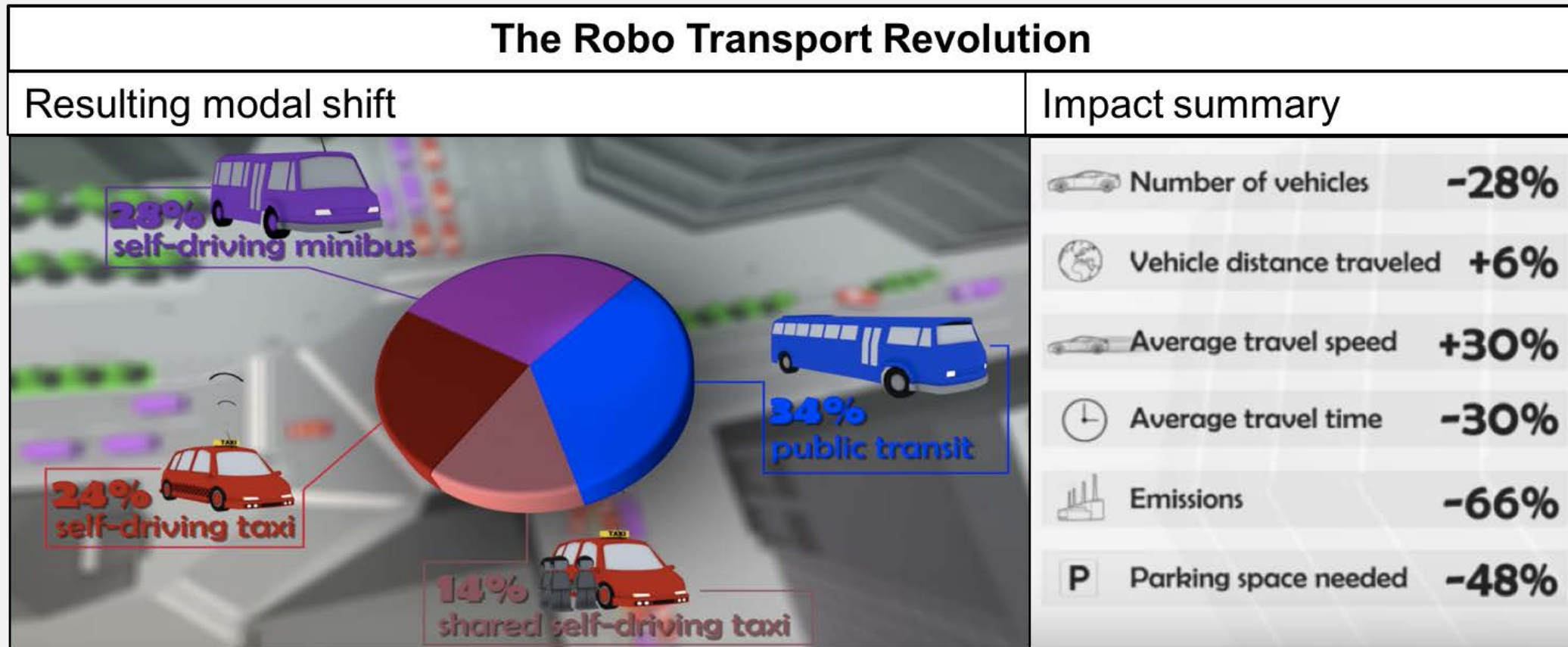


# Impact on Life style, new business, and economy

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

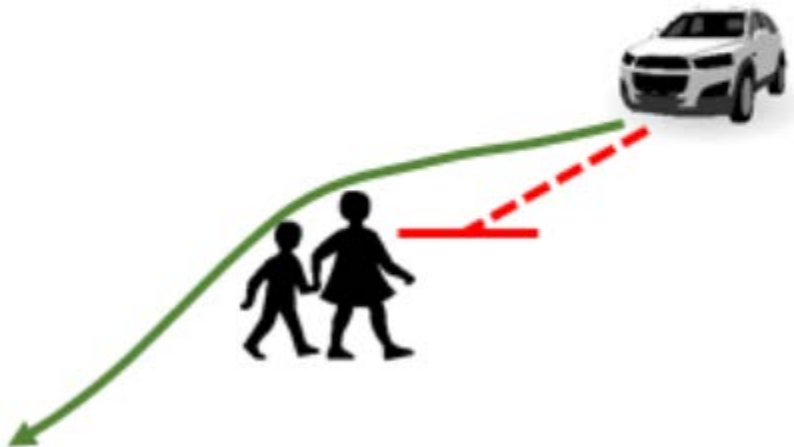
- ❑ The scenario of "**The robo-transport revolution**", the personal car is completely replaced by self-driving taxis (with and without ride-sharing) and mini buses.



## Autonomous Vehicle : DDT



### *Object and Event Detection and Response (OEDR)*



DDT fallback

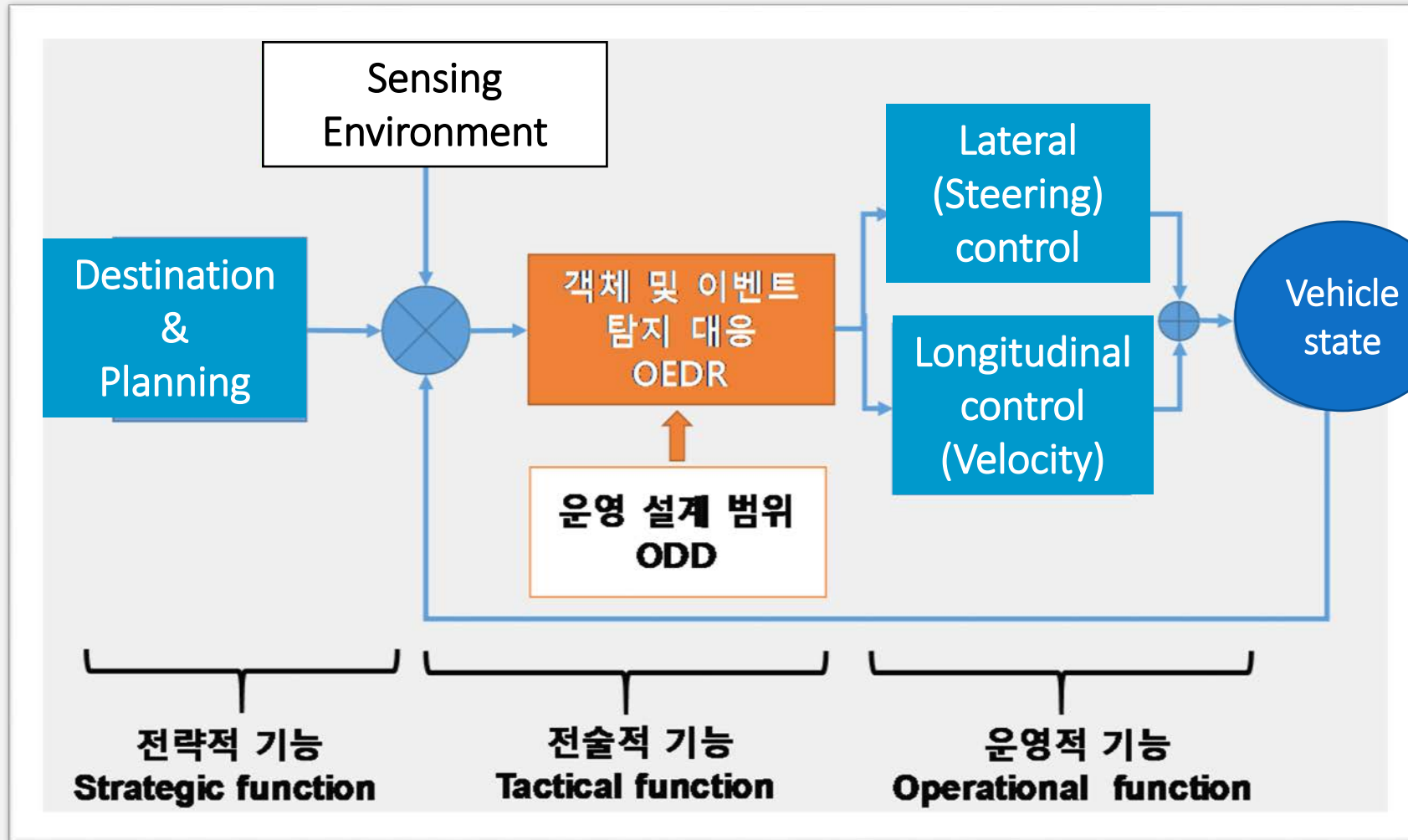
**Guaranty Safety**

Operational Domain  
Design (ODD)

**Limitation of  
Driving  
environment**

# Dynamic Driving Task (DDT) and Self-Driving Process

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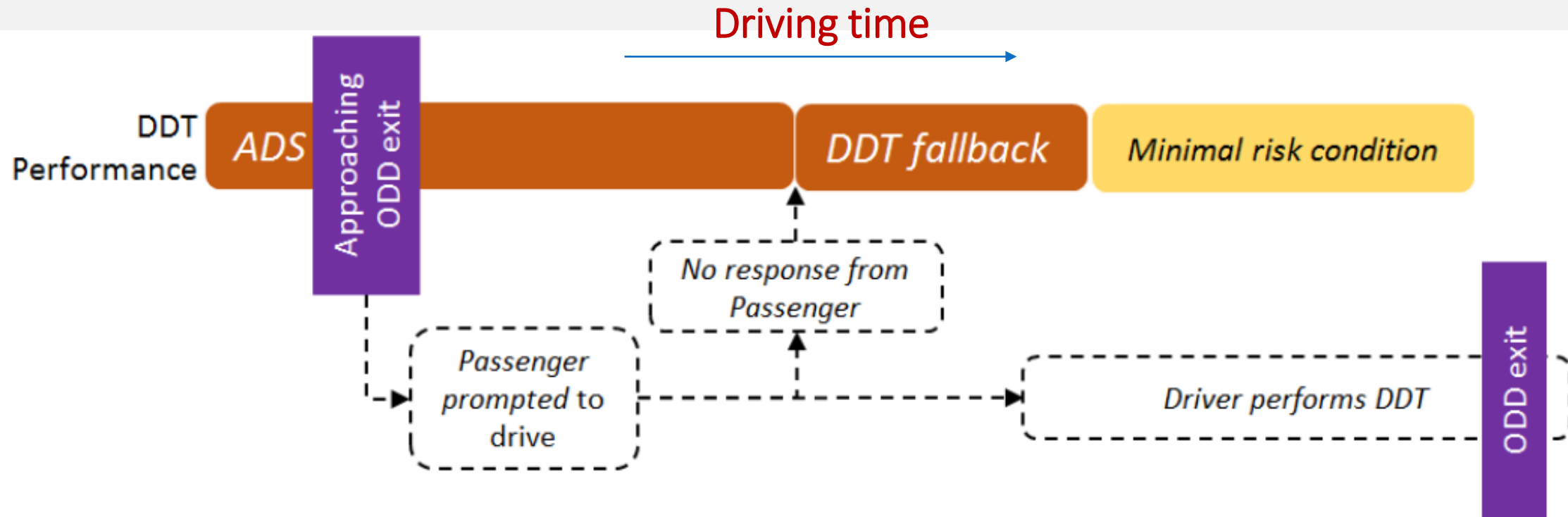


**ODD(Operational Design Domain)**  
**OEDR(Object and Event Detection and Response)**



# 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)

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## 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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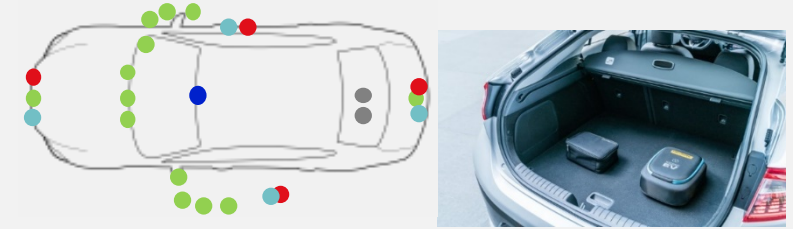
## 1<sup>st</sup> AV (2011)

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



## 2<sup>nd</sup> AV (2017)

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



## 3<sup>rd</sup> AV (2019)

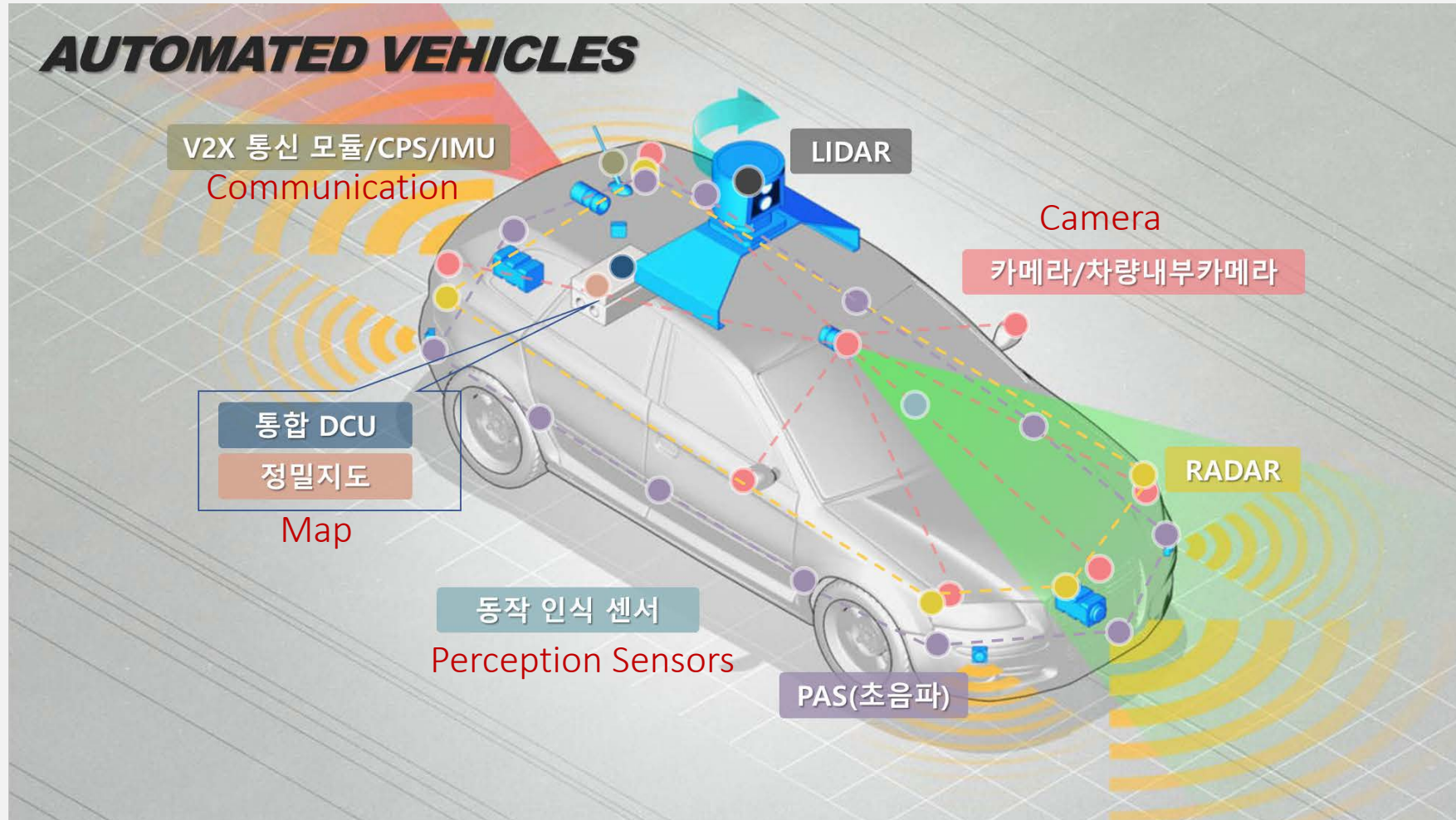
Camera, LiDAR/Rader  
Linux PC + Neural Processing Unit  
Learning based Control

# Tesla vs. Google Waymo and the others

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- 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

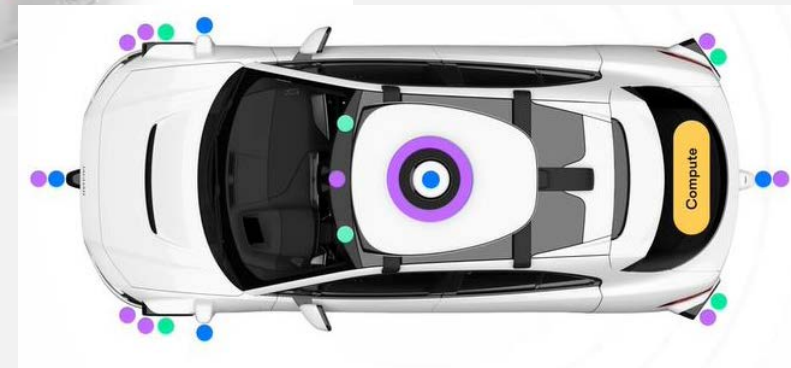
Vision (Camera) System

Lidar 360 System

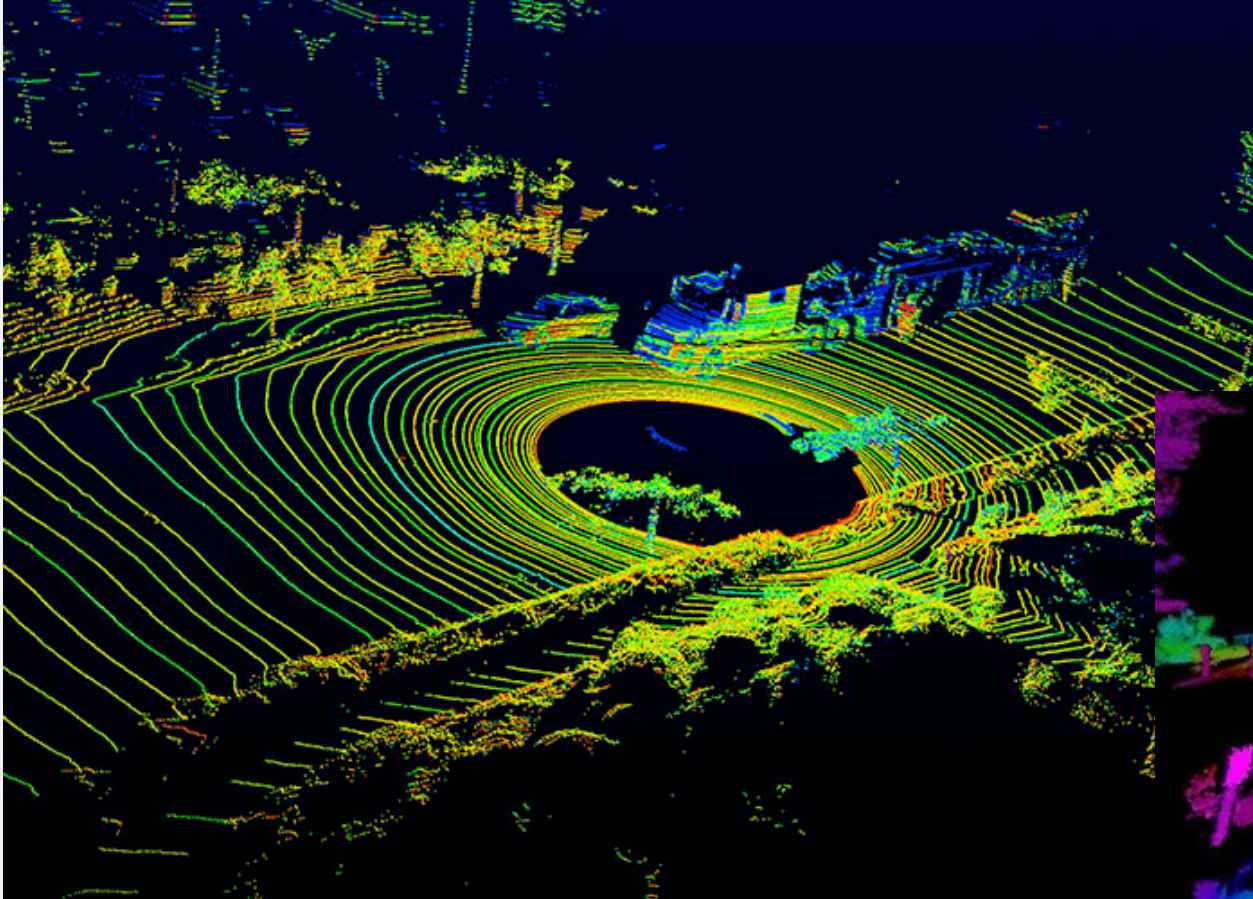
Inertial Measurement Unit (관성 센서)

Supplemental Sensors (GPS etc...)

Lidar (Laser) System

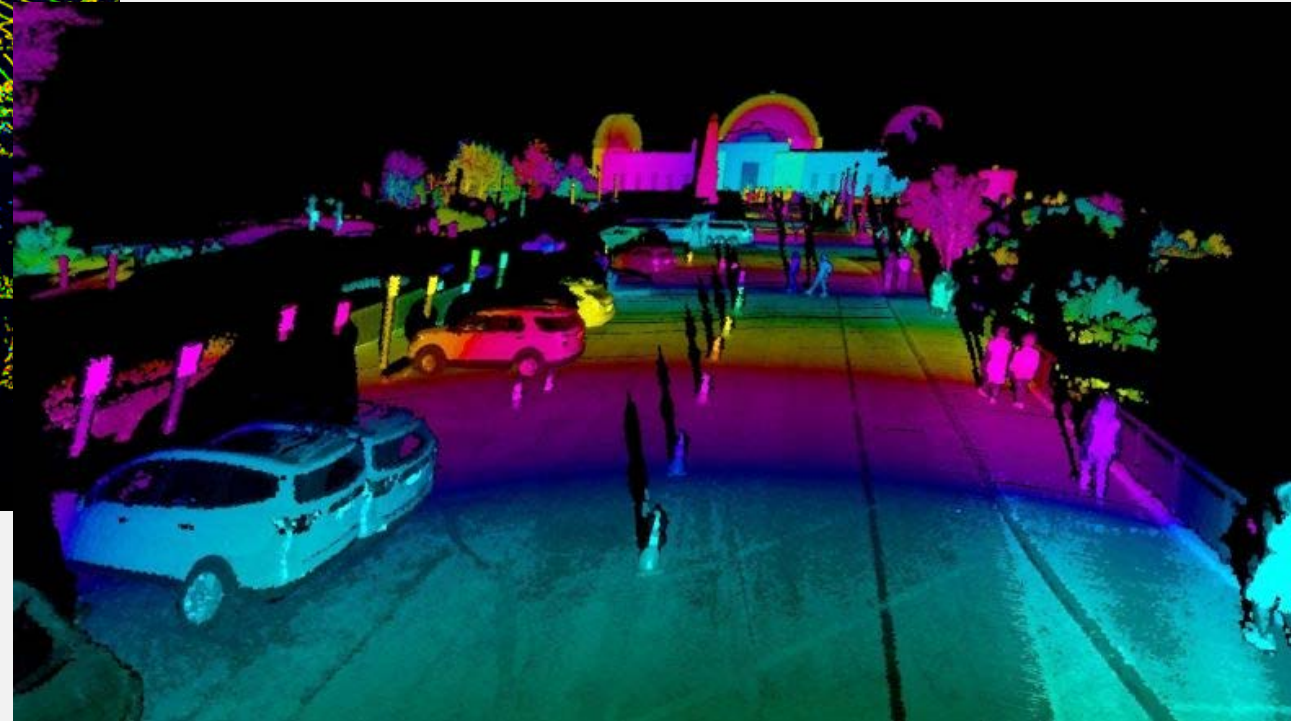


Ref: Waymo safety report, Feb. 2021



Lidar Point Cloud

Waymo's 3D Lidar

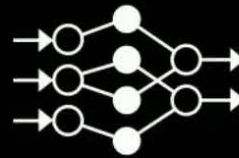




# Tesla: Vision Based approach (Camera only)

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8 Cameras



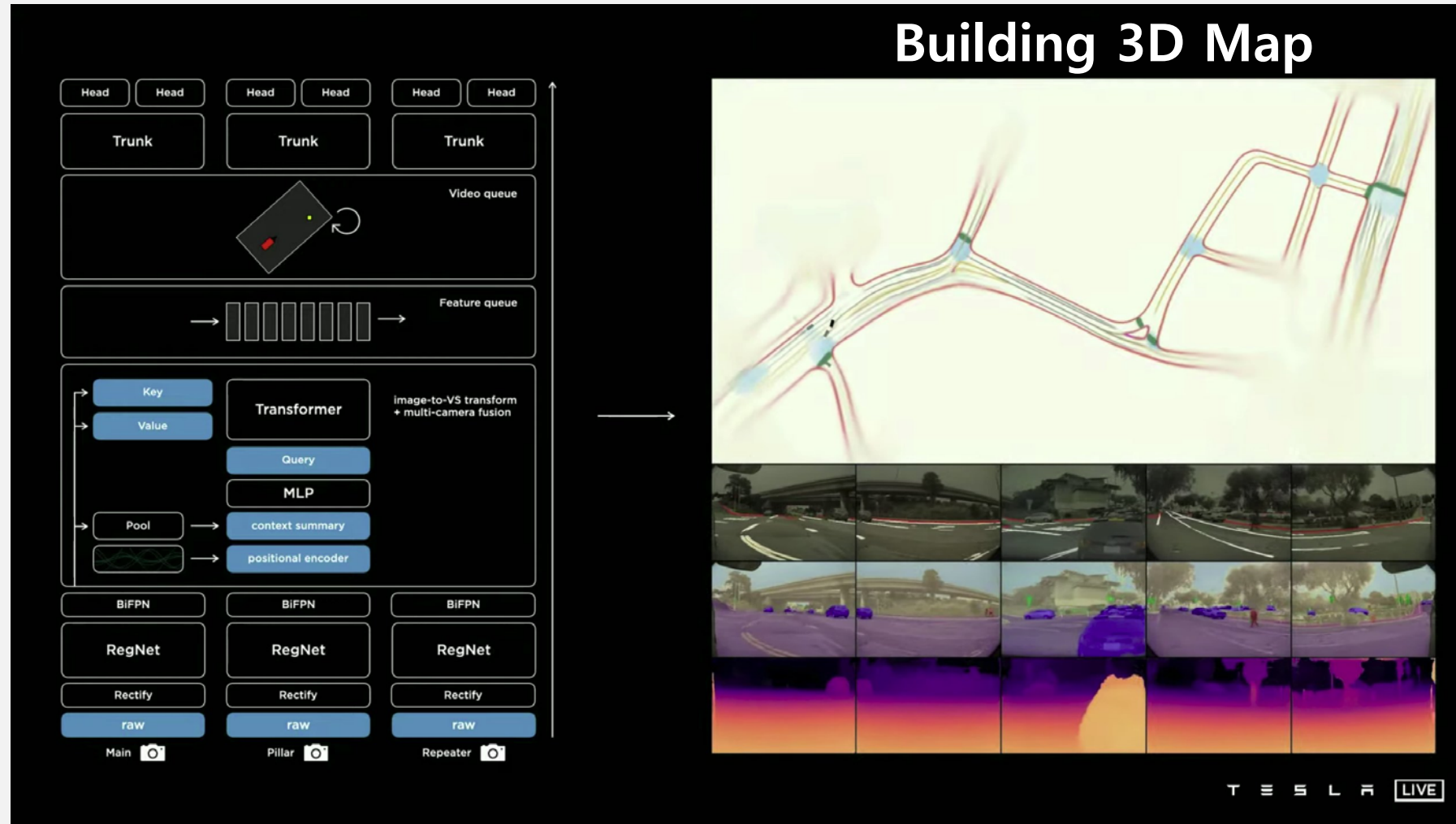
3-Dimensional "Vector Space"





# Tesla: Vision Based approach (Camera only)

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- ❑ 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