Autonomous Driving toward Mobility and Global Decarbonization

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Advantages and Potential obstacles of Autonomous Cars

The route to the autonomous car

Frank J. Goguen, CFA®*, senior research analyst and John D. Connolly, writer at The Boston Company Asset Management LLC⁵ explore the future economic and social potential of driverless cars.

THE BOSTON COMPANY
ASSET MANAGEMENT, LLC
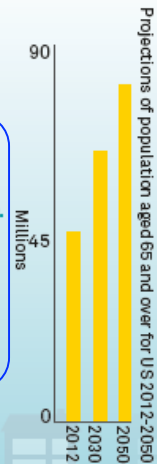
Advantages

Safety
90%
of road traffic accidents are currently caused by human error.[1]

Driverless cars could translate into approximately **36,000** lives saved each year and approximately **US$ 488 billion.**

Social
Greater mobility provided to elderly and disabled people.

People over the age of 65 expected to double in US by **2050.**[2]

Projections of population aged 65 and over for US 2012-2050

Millions: 90 / 45 / 0
2012 / 2030 / 2050

Economic
Morgan Stanley estimates Autonomous cars will result in
US$ 1.3 trillion savings every year for the US economy, globally this translates into
US$ 5.6 trillion.[3]

Economic benefits for drivers
• Fuel costs
• Productivity gains
• Accident costs

Potential obstacles

Liability
Who accepts responsibility in the case of an accident?

Legislation
US infrastructure deficiencies mean that **US$ 10.8 billion** had to be found to keep the Highway Trust Fund solvent until May 2015.[4]

Consumer adoption

Once people accept and trust the systems, adoption rates are expected to climb.
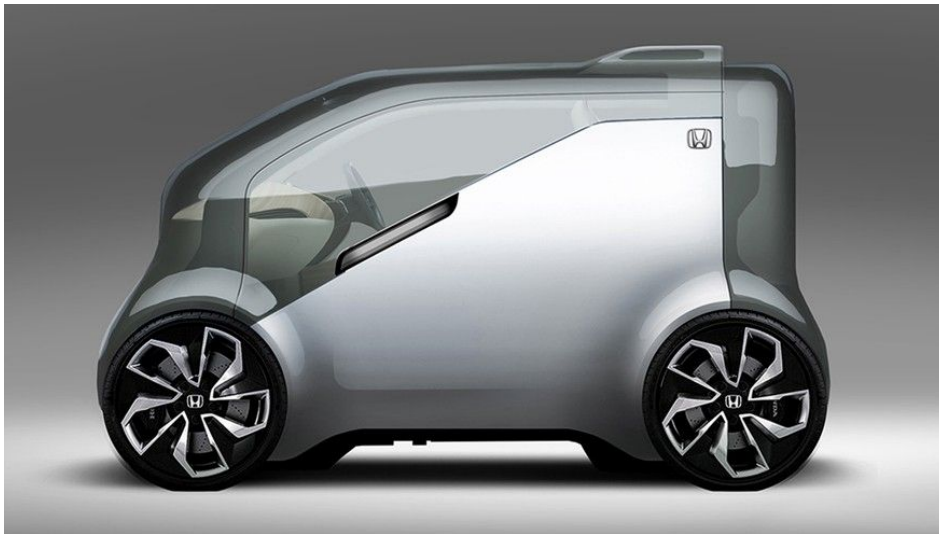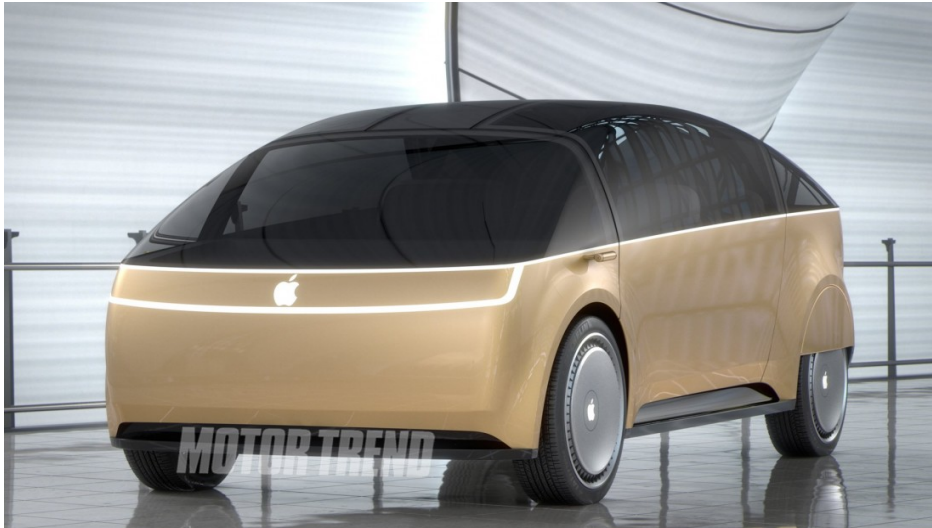
Welcome to the autonomous car

2030

Ref: BNY MELLON

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Levels of Autonomous Vehicles

☐ **57% of global consumers trust driverless cars.**

☐ **Free of driving stress, and More time for entertainment or work**

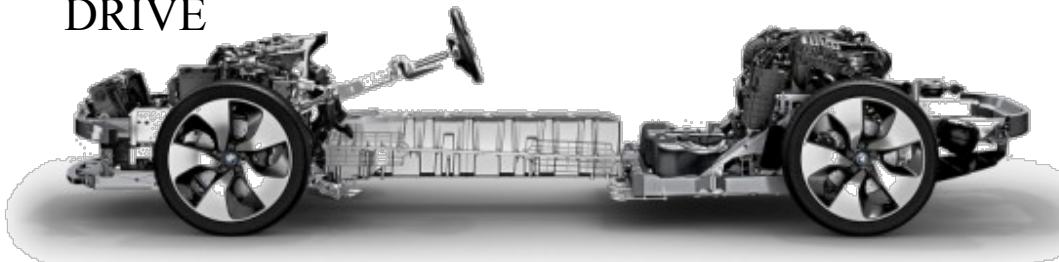# How to Design Autonomous Cars ??

WORLD MATERIALS FORUM
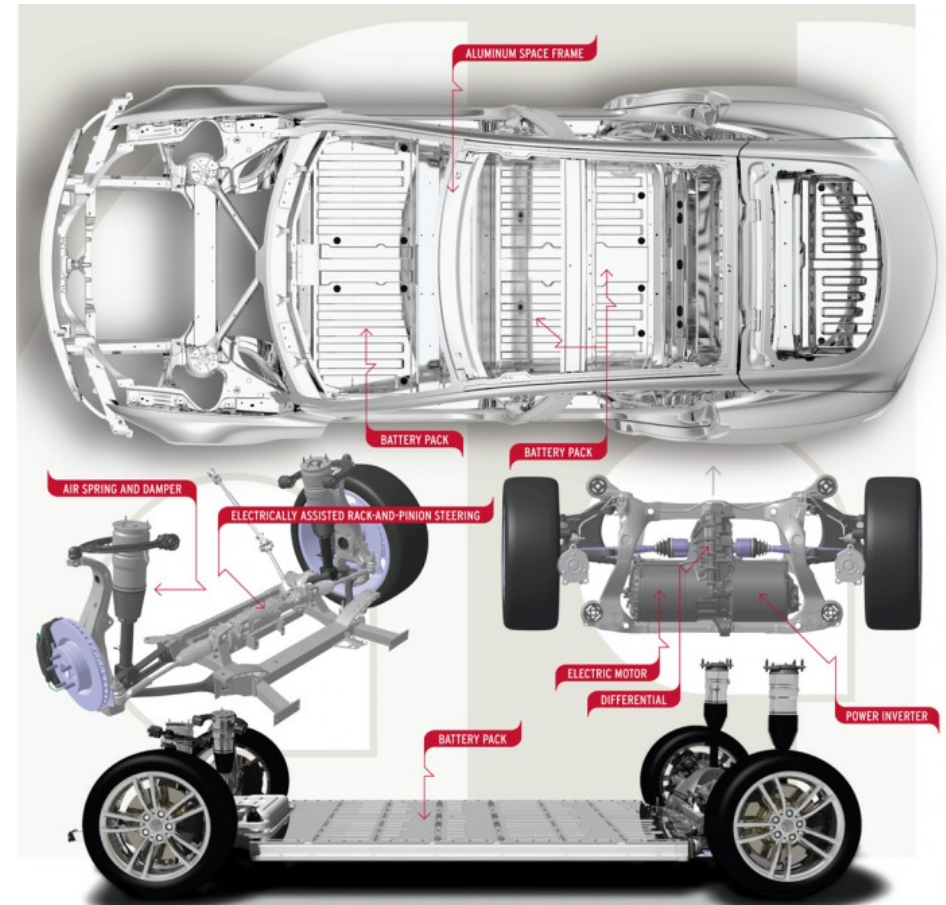
LIFE-DRIVE Architecture

LIFE

DRIVE

The unique **Life-Drive** architecture allows the BMW i8 to distribute its weight optimally across both axles.

ALUMINUM SPACE FRAME

BATTERY PACK

BATTERY PACK

AIR SPRING AND DAMPER

ELECTRICALLY ASSISTED RACK-AND-PINION STEERING

ELECTRIC MOTOR

DIFFERENTIAL

POWER INVERTER

BATTERY PACK

UNDER THE TESLA'S SKIN

The Model S's spacious five-plus-two-passenger cabin is enabled by its compact propulsion system and clever component layout. The AC drive motor, power-inverter circuits, and final-drive differential are contained within compact housings supported by a rubber-isolated rear subframe. More than 7000 cylindrical battery cells are vertically oriented inside a large aluminum box that also serves as the body structure's floor. Liquid cooling circuits keep the driveline and battery pack within desired temperature limits during strenuous driving. A rigidly attached front crossmember supports the suspension system's lower control arms and the power rack-and-pinion steering gear. An aluminum space frame—augmented by high-strength steel B-pillars and bumper beams—supports the above components as well as the formed-aluminum body panels.

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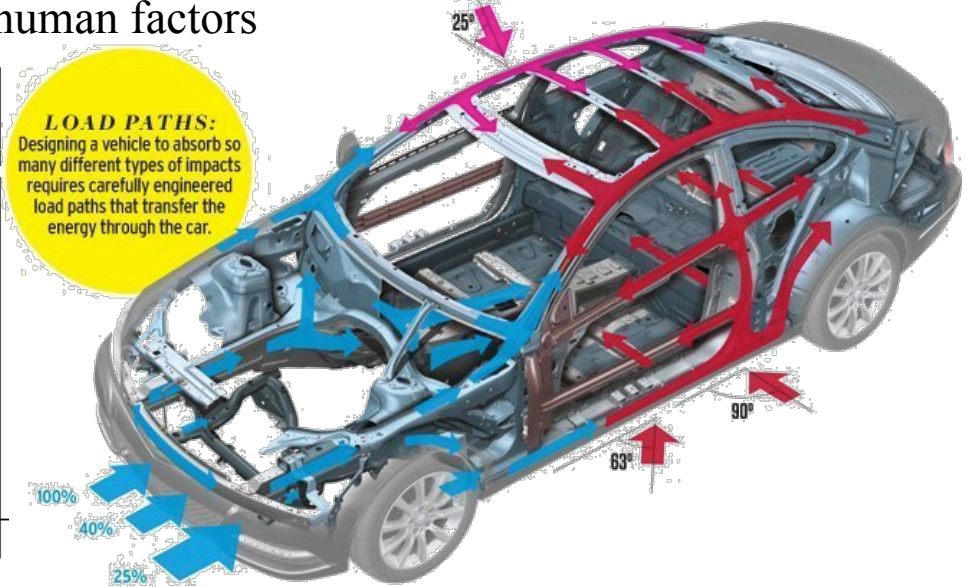# Conventional LIFE Design to Protect against Crash

Crash happens mainly by human factors


MY15 CHEVY TRAX
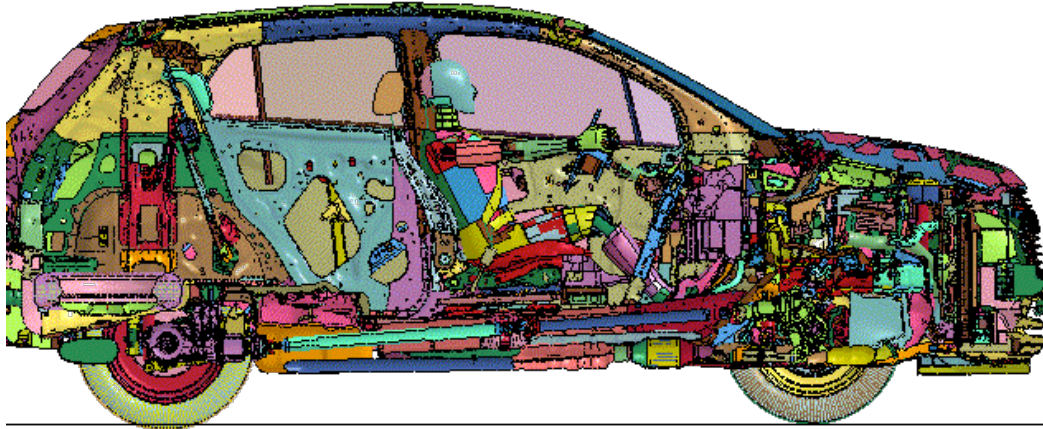
Simulation Postprocessor

HONDA
The Power of Dreams

LOAD PATHS:
Designing a vehicle to absorb so many different types of impacts requires carefully engineered load paths that transfer the energy through the car.

- Ultra High Strength Steel
- Extra High Strength Steel
- Very High Strength Steel
- High Strength Steel
- Mild Steel / Forming Grades
- Aluminium
- Magnesium
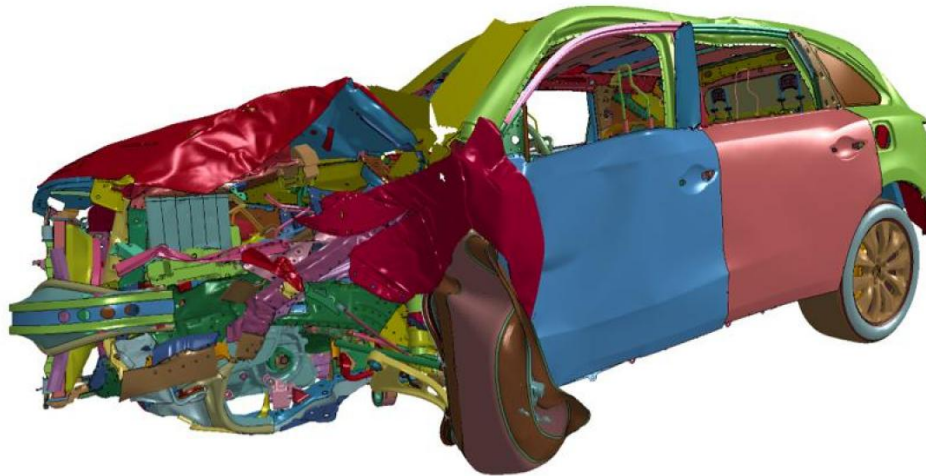
In six months of working with 3DXCITE we realized a dream of going from *this* ...

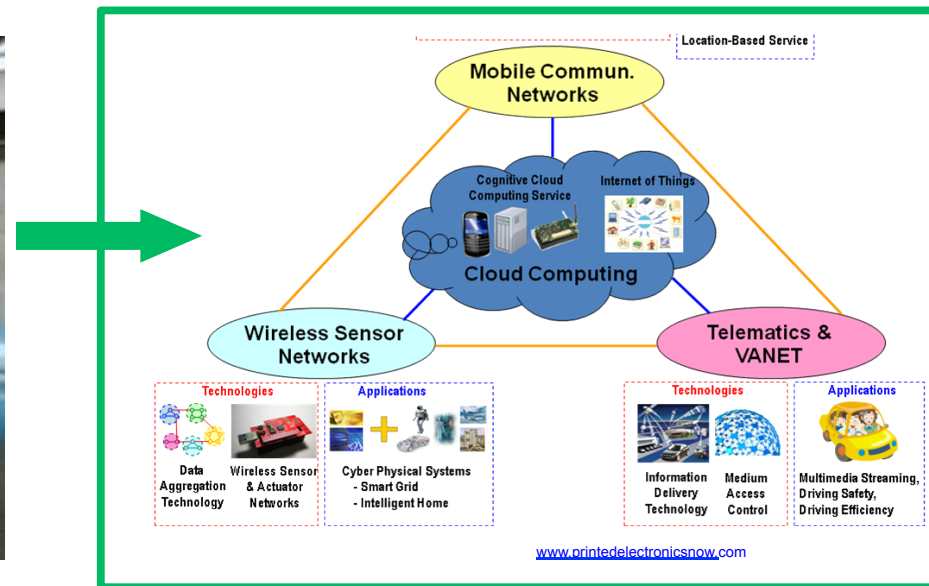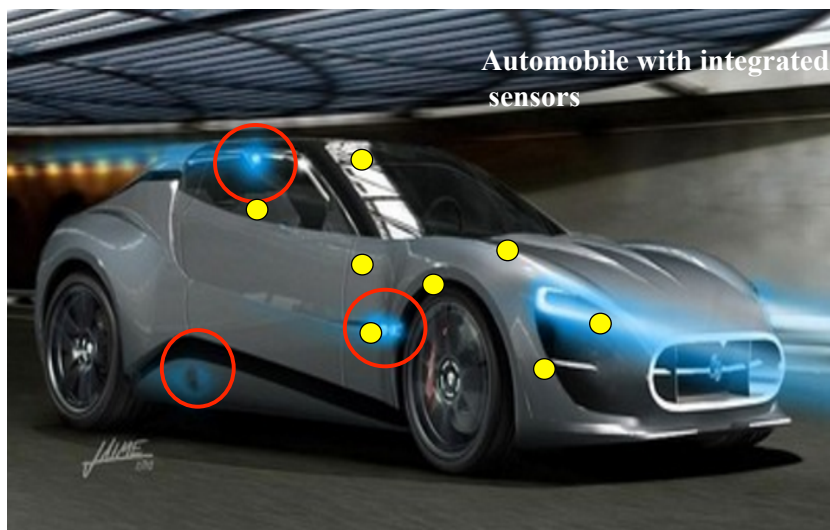# ADAS and Protecting against Crash

Automatic Drive Assistant System (ADAS)

- **LIDAR** (light detection and ranging) monitors the vehicle's surrounding
- **GPS**, most accurate positioning
- **Radar** for blind-spot detection
- **Ultrasonic Sensors**, to measure the object distance
- Parking assistance & Collison Avoidance
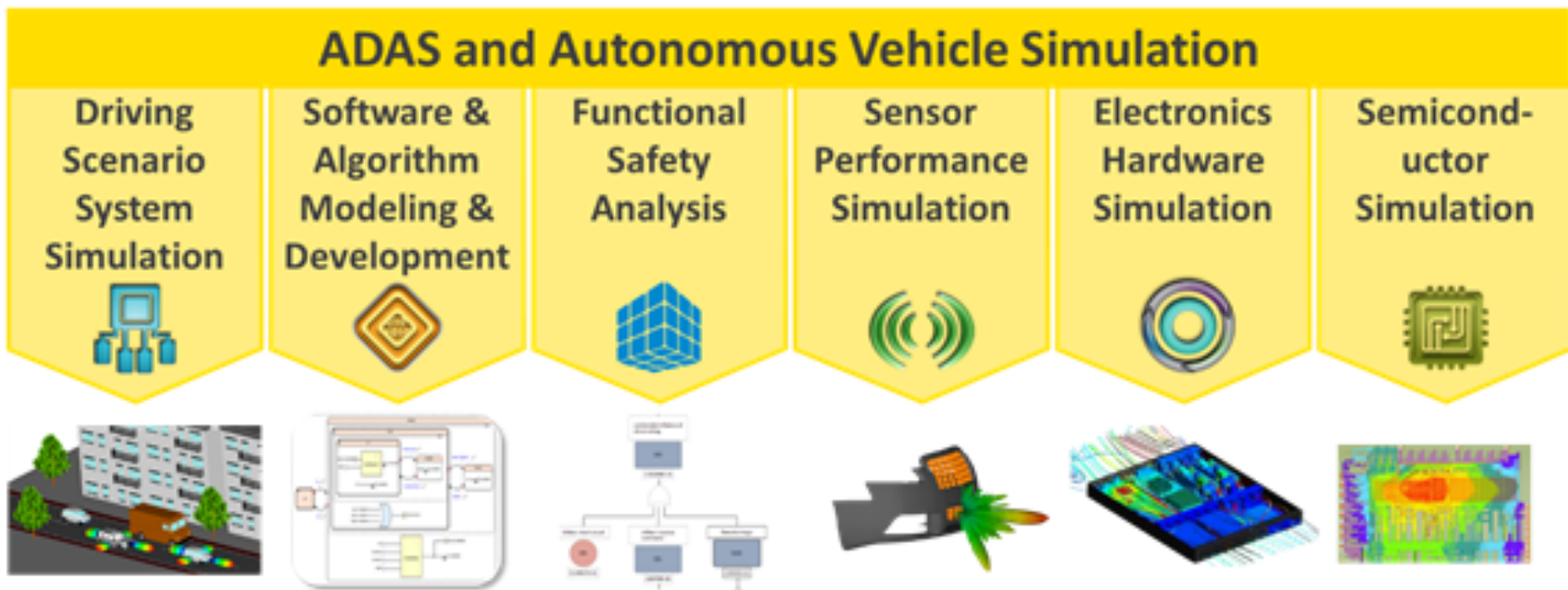- Fully equipped with Protection System
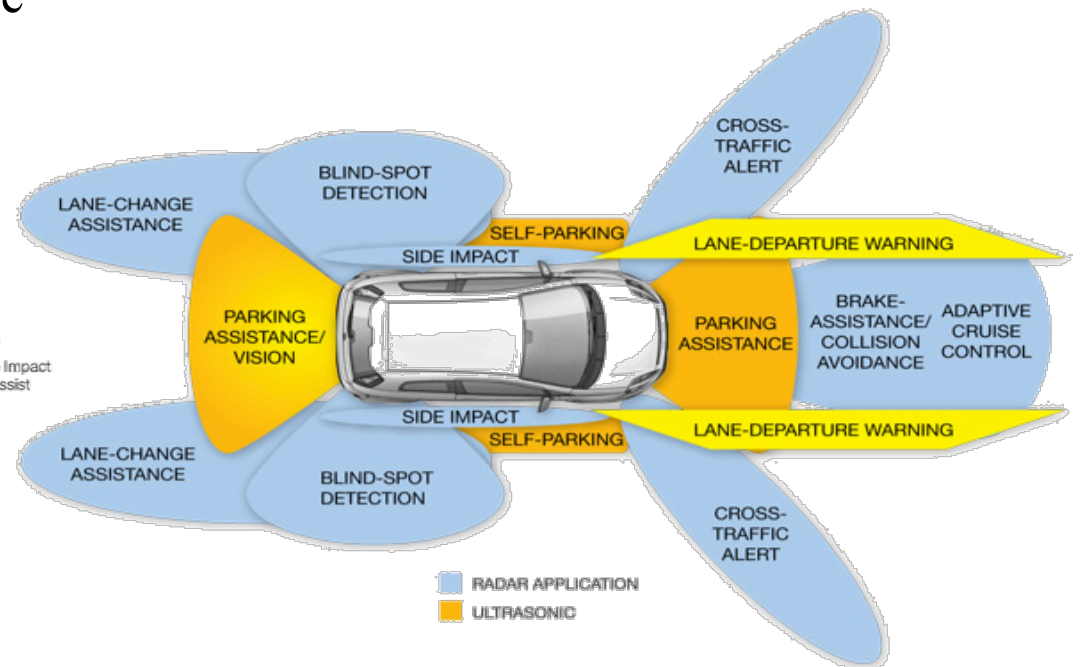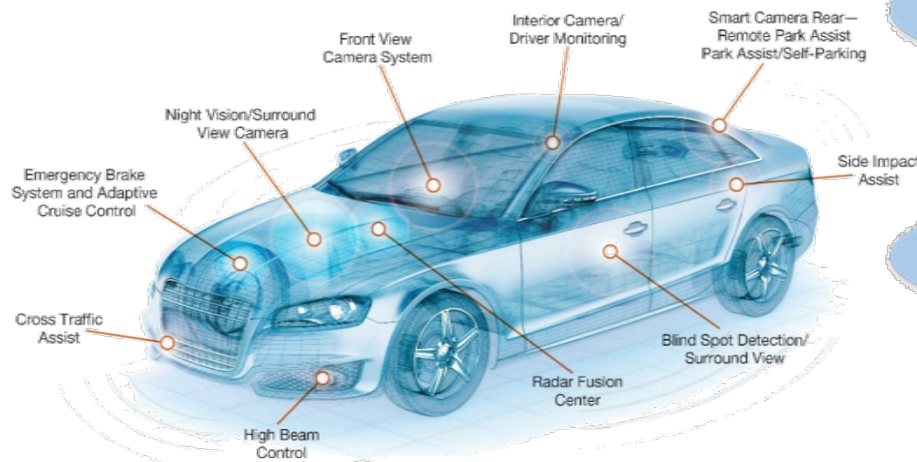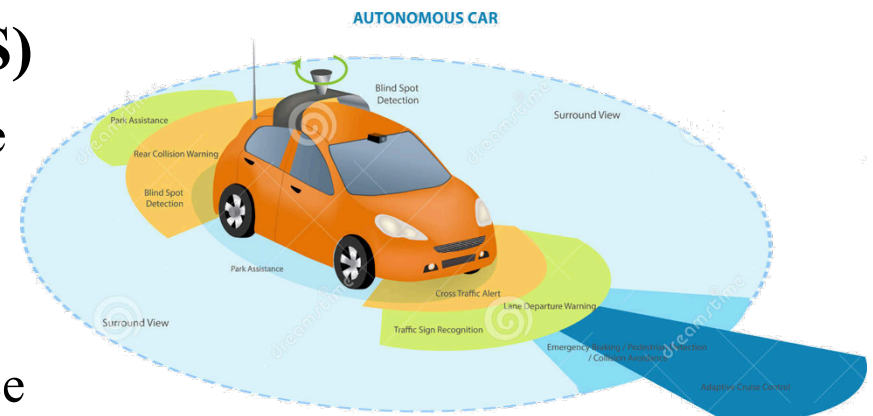
Sensor and Structure Health Monitoring (SSHM)

- Increasing need for sustainable, reliable function of **Autonomous Cars**
- **Sensor and Structure Health monitoring** sense malfunction and damage and transmit data in real-time
- Minimized parasitic effects on the host structure
- Collected sensor data can be processed as Big Data in a cyber network server
- Used for Vehicle Maintenance

Automobile with integrated sensors

Location-Based Service

Mobile Commun. Networks

Cognitive Cloud Computing Service   Internet of Things

Cloud Computing

Wireless Sensor Networks   Telematics & VANET

Technologies   Applications   Technologies   Applications

Data Aggregation Technology   Wireless Sensor & Actuator Networks   Cyber Physical Systems - Smart Grid - Intelligent Home   Information Delivery Technology   Medium Access Control   Multimedia Streaming, Driving Safety, Driving Efficiency

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Simulation Based Design of Autonomous Cars

ADAS and Autonomous Vehicle Simulation

- **ADAS** (Automatic Drive Assistant System) must function flawlessly. (OPEN vs CLOSED)

- **Materials** should be optimally used.

- **Optimize the Autonomous Cars** thru **Virtual Tests** of thousands of drive scenarios, ensuring autonomous function, safety and ride comfort.
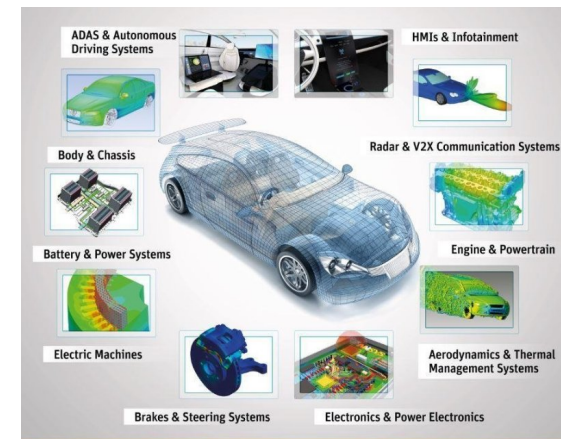
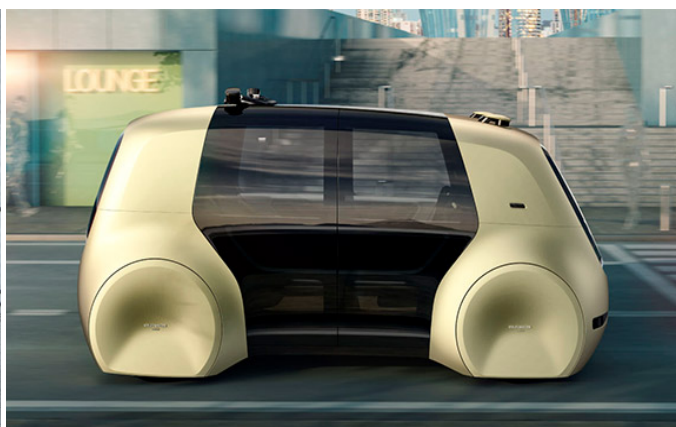# Autonomous Cars: Mobile Space, need new safety regulations

- **New crash tests and safety regulations for the Autonomous Cars**
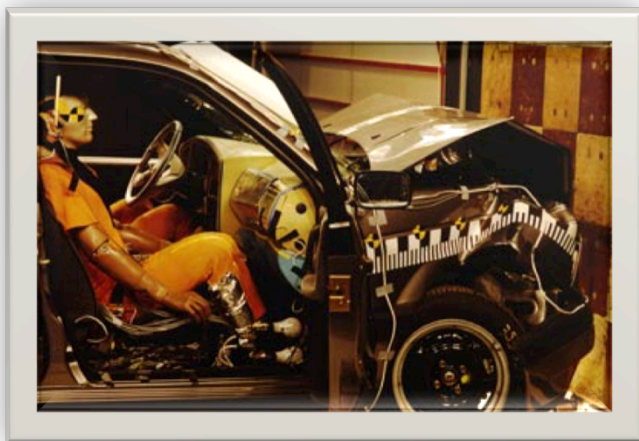
  - Various Driver and passenger sitting position

  - Inside-out Design: more interior space, new LIFE module

New Design of LIFE Module

LIFE module for the AUTONOMOUS CARS, newly optimized, together with DRIVE module

LIFE Module

DRIVE Module

❑ **LIFE module**

- **New structure and material design (more Space and safer with ADAS)**
- **Plastics & Composites or Hybridization**
- **More thermoplastics (recyclable)**
- **Continuous fibers→ Short fibers**
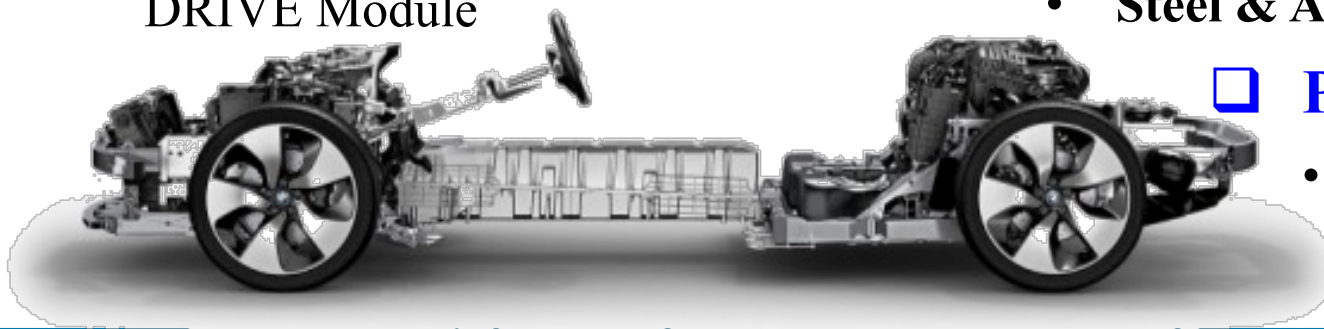- **Injection, SMC, Hybrid Insert, LFT**

❑ **DRIVE module**

- **Steel & Aluminum**

❑ **Power train**

- **Li-Ion Battery, New Battery (Zinc-Air) or Fuel Cell**

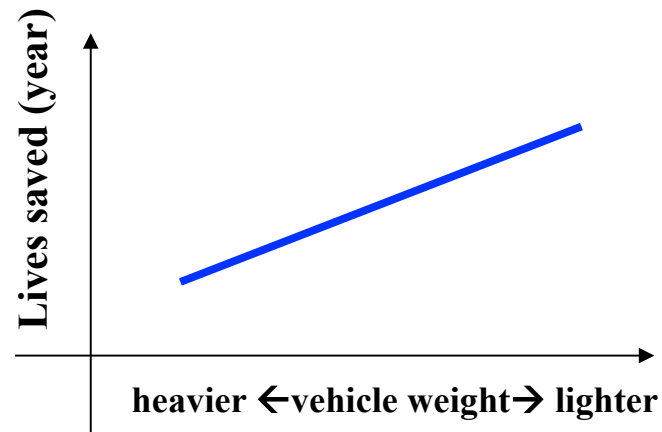**HANYANG UNIVERSITY**

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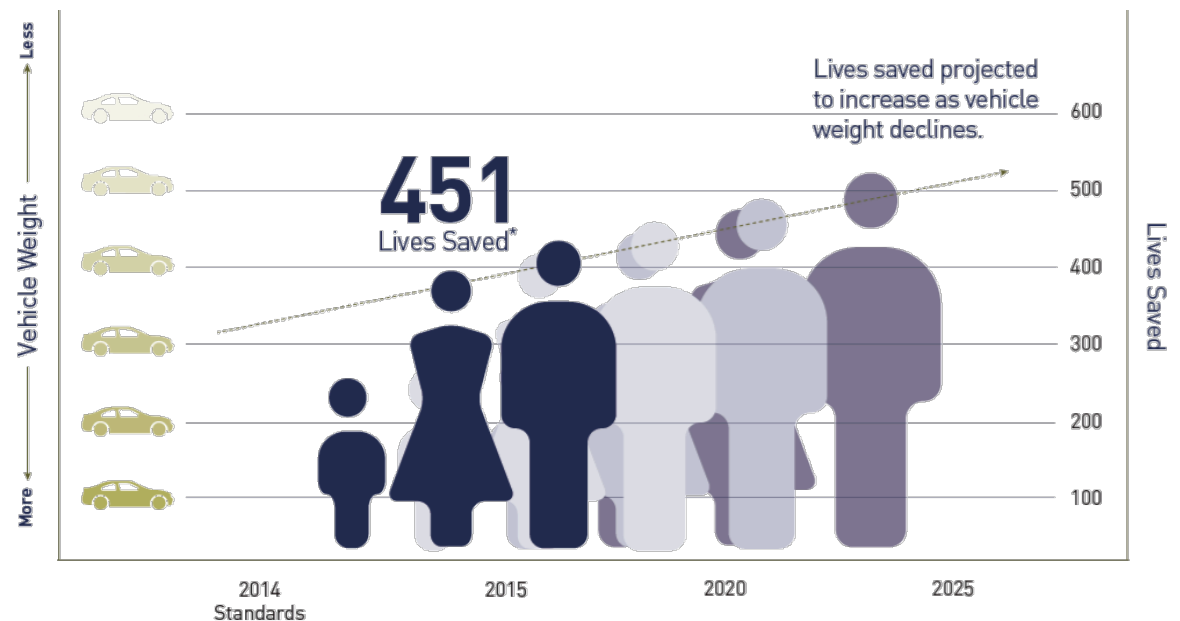
Lightweight Vehicle secures more Safety...

Lightweight Cars, carrying less kinetic energy,
- **exert less impact force to the other cars in crash accident,**
- **reducing fatalities per vehicle miles traveled.**

→ Regulation and penalties need to be imposed on heavier vehicle.

$$Kinetic\ energy = \frac{1}{2}Mv^2 \qquad Force = M\frac{v_{after} - v_{before}}{dt}$$

Lives saved (year)

heavier ←vehicle weight→ lighter

Vehicle Weight — Less / More

451 Lives Saved*

Lives saved projected to increase as vehicle weight declines.

600
500
400
300
200
100

Lives Saved

2014 Standards   2015   2020   2025
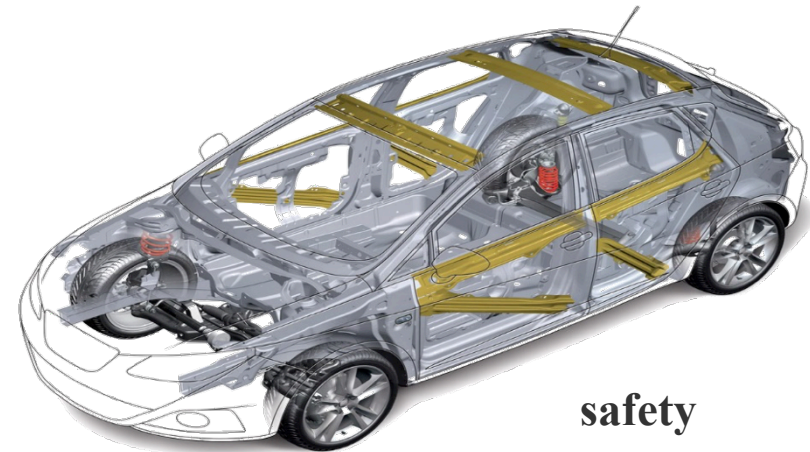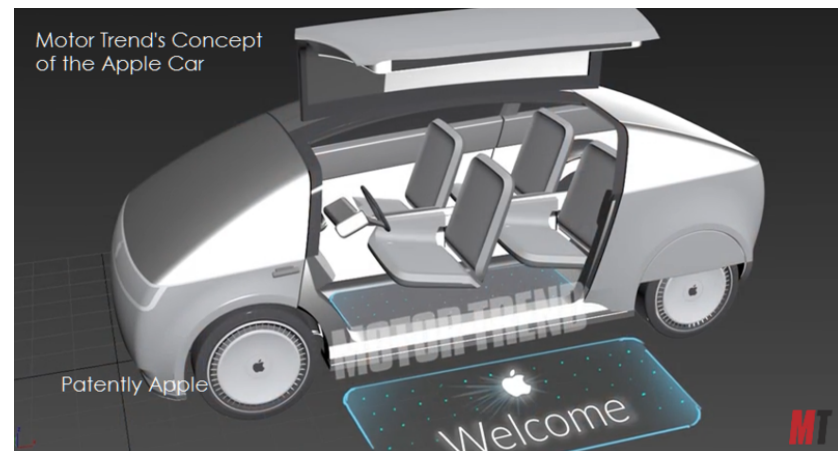
*Per billion miles traveled

ref, American Chemistry Council

Design of Autonomous Car: Inside-Out

- **Traditional Cars**: designed from the **outside in**, individual ownership of vehicles, a stylistic expression of the owner: exterior styling and safety,


exterior styling

safety

- **Autonomous Cars**: designed from the **inside out**, more space and functions inside

Autonomy toward Mobility and Global Decarbonization

❑ **Autonomous Cars**

- Provide free time while driving
- Less traffic thru CONNECTIVITY
- Ensure Safety (less human factors)
- Lighter weight→ **Global decarbonization**
- *Dilemma of the Self Driving:*
    - *Less pain of driving. Living further away from Urban City*
    - *More private space in autonomous cars*
    - *Zero or less passenger*

    → *more Energy consumption & Traffic congestion*

Mobility ↑

Global Carbon ↓

❑ **Autonomous Drive**

❑ **Electrification**
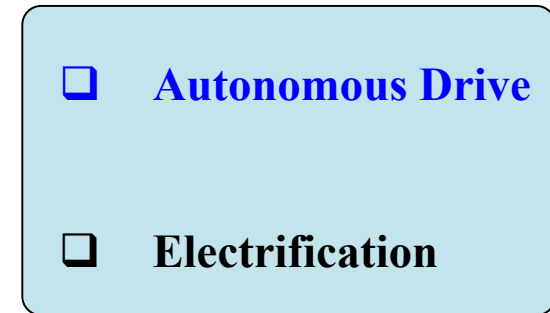
❑ **Carsharing**

- Reduce traffic → Mobility
- Passenger / Car-Body-Weight / Time → key index for Global Decarbonization

Which way? OPEN vs CLOSED Autonomous CARS

CLOSED Source Development

Which way is more RELIABLE and SECURE?

OPEN Source Development

5G network

A laser sensor scans 360 degrees around the vehicle for objects.

A processor reads the data and regulates vehicle behavior.

Radar measures the speed of vehicles ahead.

An orientation sensor tracks the car's motion and balance.

A wheel-hub sensor detects the number of rotations to help determine the car's location.

LIFE module	ADAS
DRIVE module	SENSORS & Electronics

LIFE module	ADAS
DRIVE module	SENSORS & Electronics