

Technical trends of driver assistance & automated driving

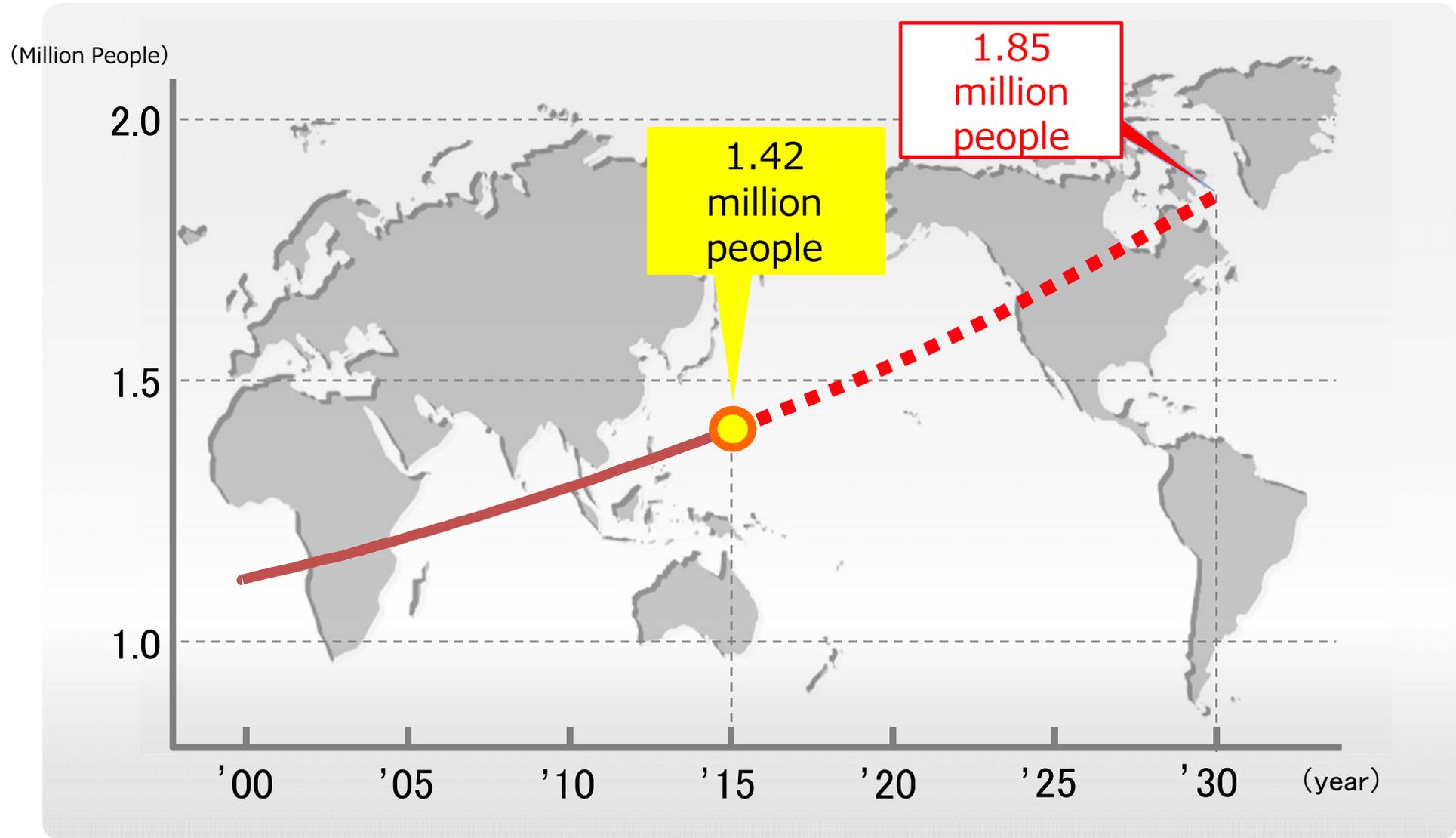
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TOYOTA MOTOR CORPORATION

Traffic Accidents – Global Fatalities



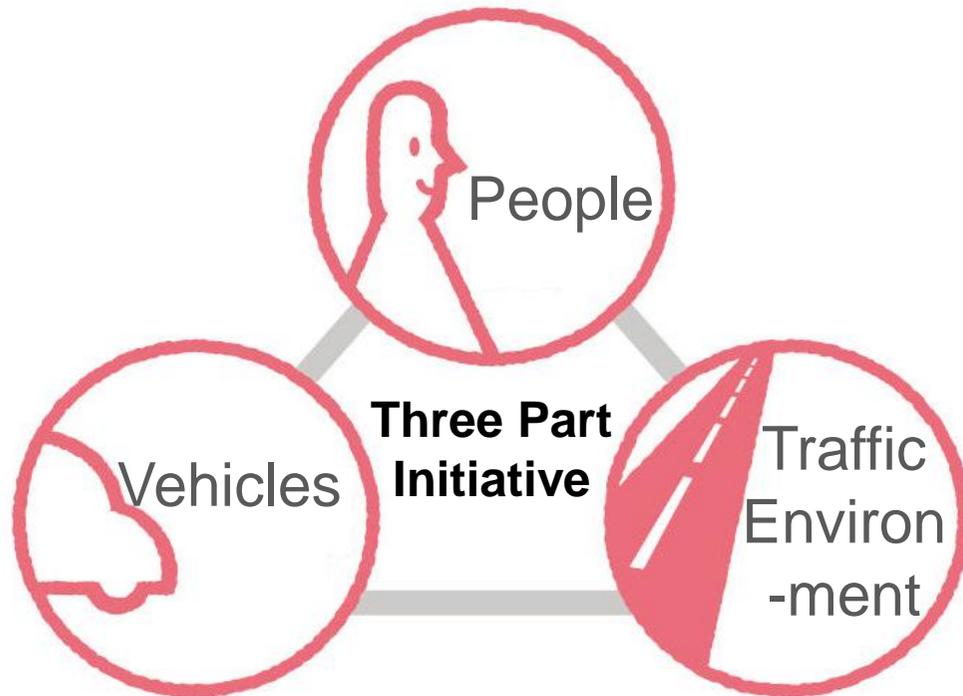
Source : Projections of mortality and causes of death, 2015 and 2030
BASELINE SCENARIO, 20 Leading Causes of Death
World Health Organization (WHO), 2015

Today's Topics

- 1. Towards “Eliminating Fatalities”:
Advanced Safety Support Systems**
2. Direction of Automated Driving
Technologies Development
3. Technology Development for
Automated Driving on Surface Roads

Towards “Eliminating Fatalities”

Integrated Three Part Initiative



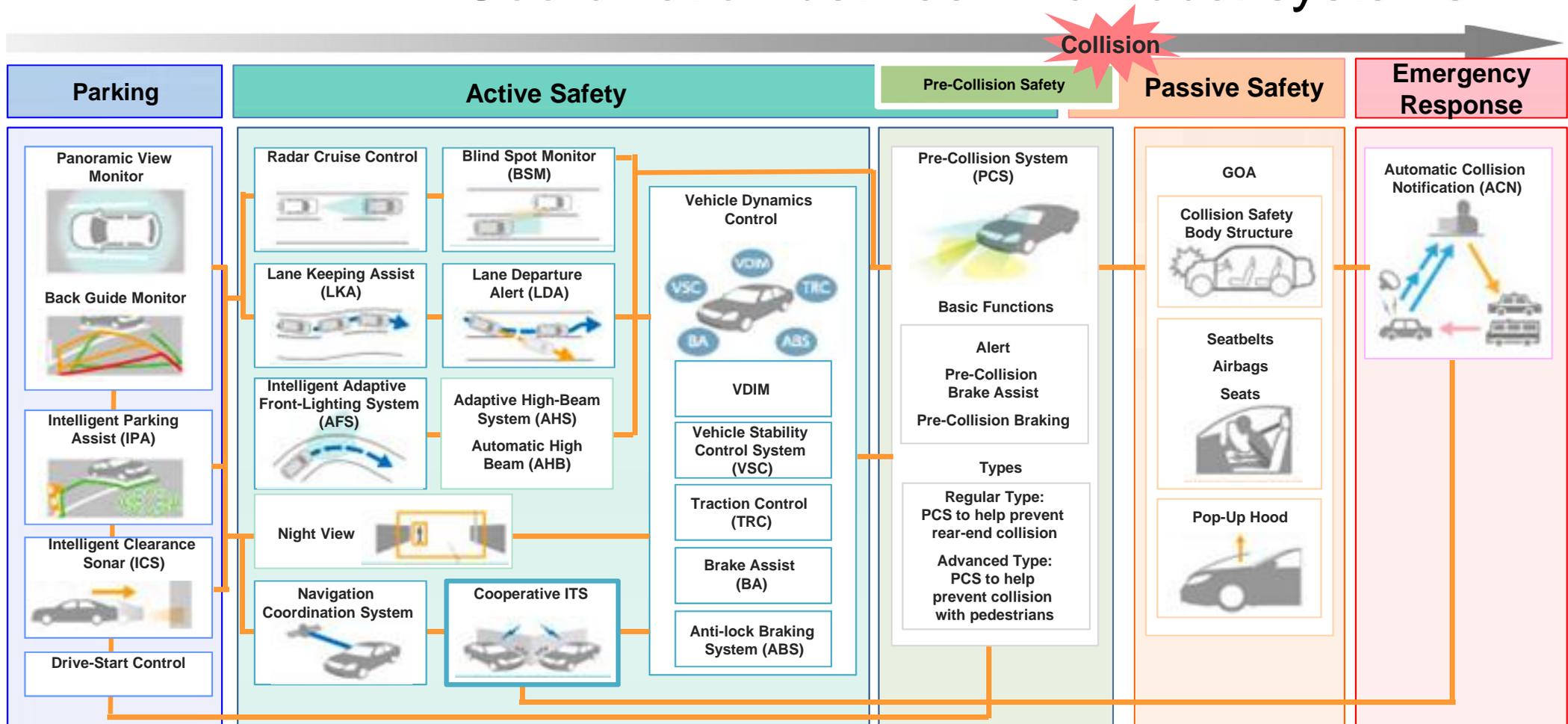
Pursuit for Vehicle Safety



Toyota's Approach to Safety

Integrated Safety Concept

- Optimal support in all driving conditions
- Coordination between individual systems



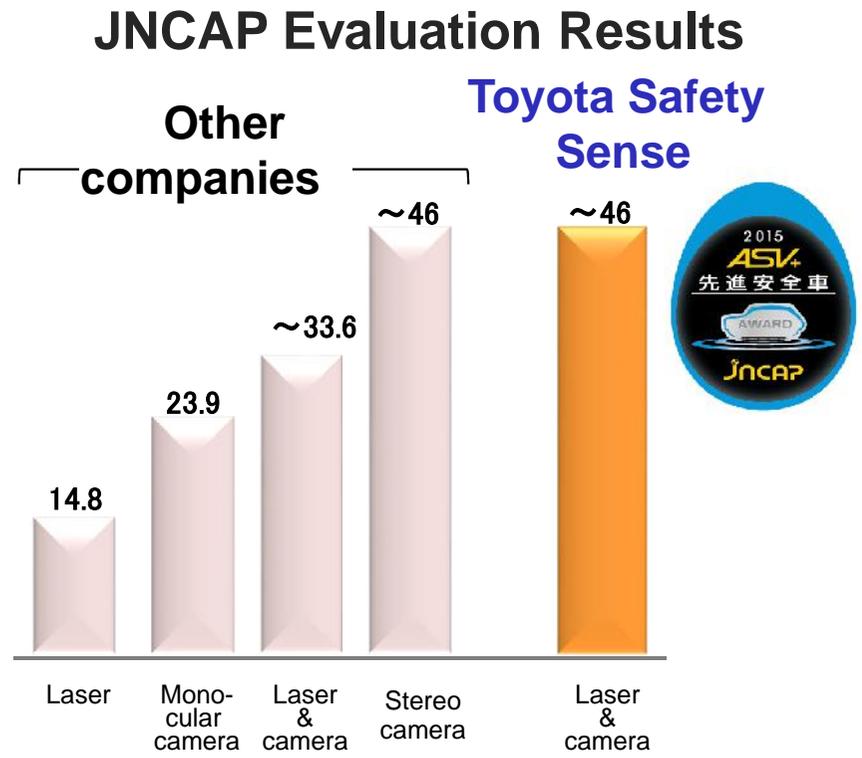
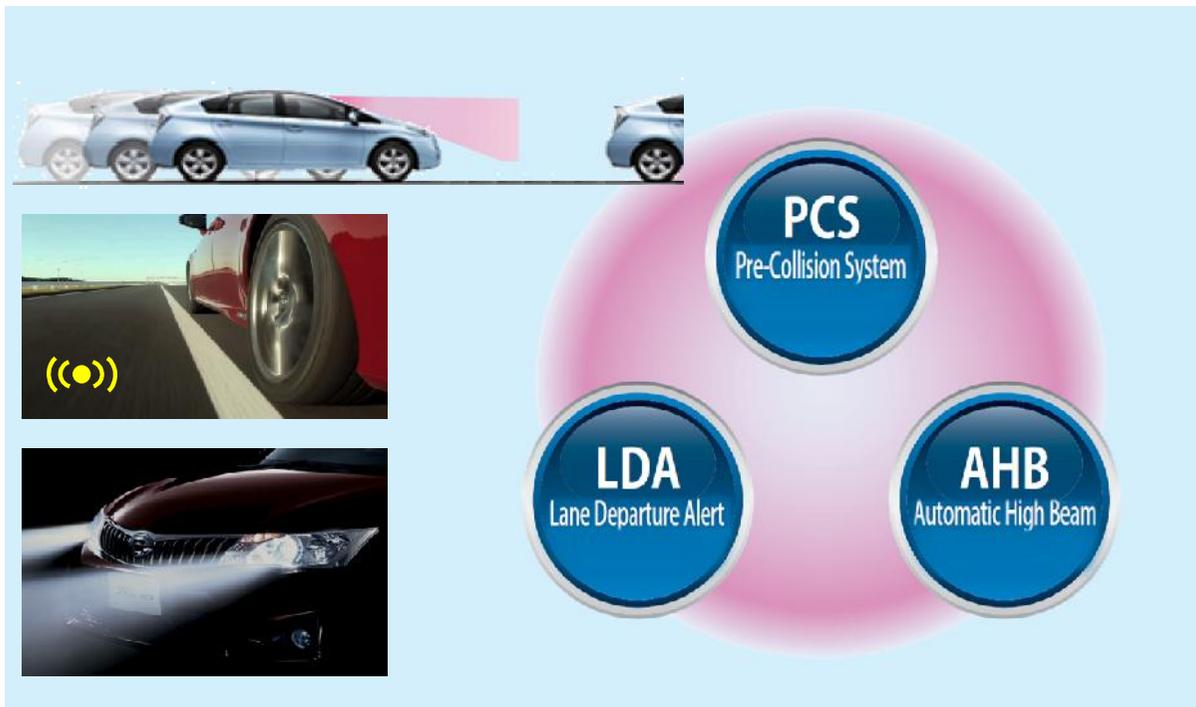
Toyota Safety Sense

- Combines cameras and radar for outstanding performance and reliability
- Functions chosen for their effectiveness in reducing traffic accidents



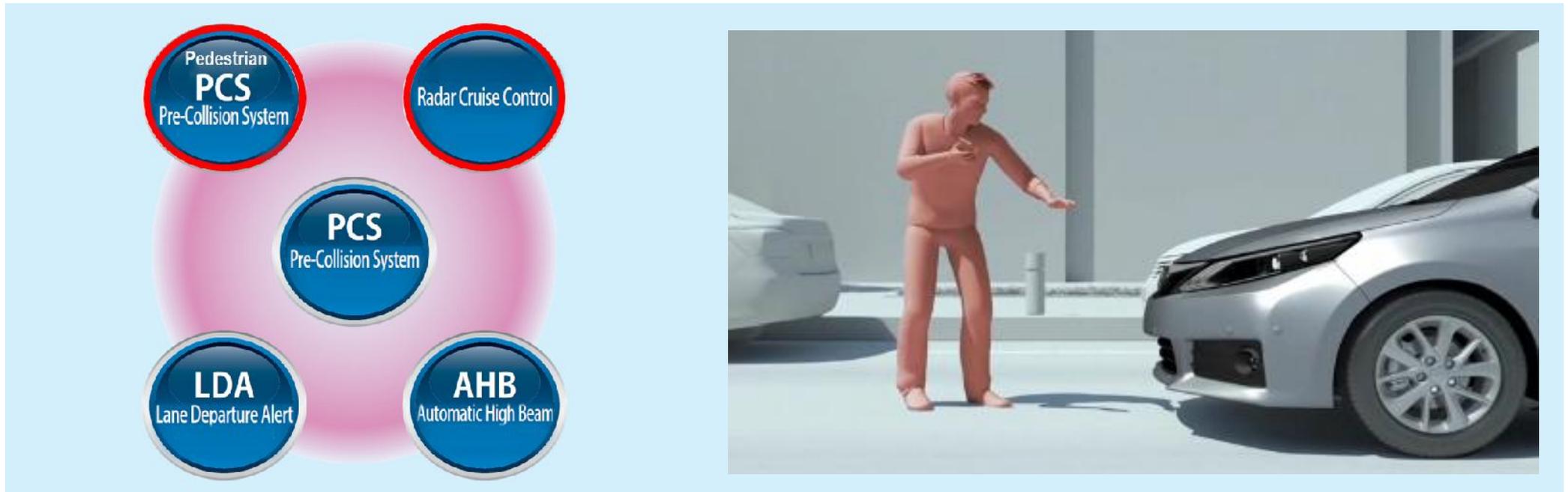
Toyota Safety Sense (Laser & Camera)

- First available in EU on AURIS, June '15 (followed by Avensis, Yaris, Aygo....)
- Passed Euro NCAP and JNCAP assessment with success



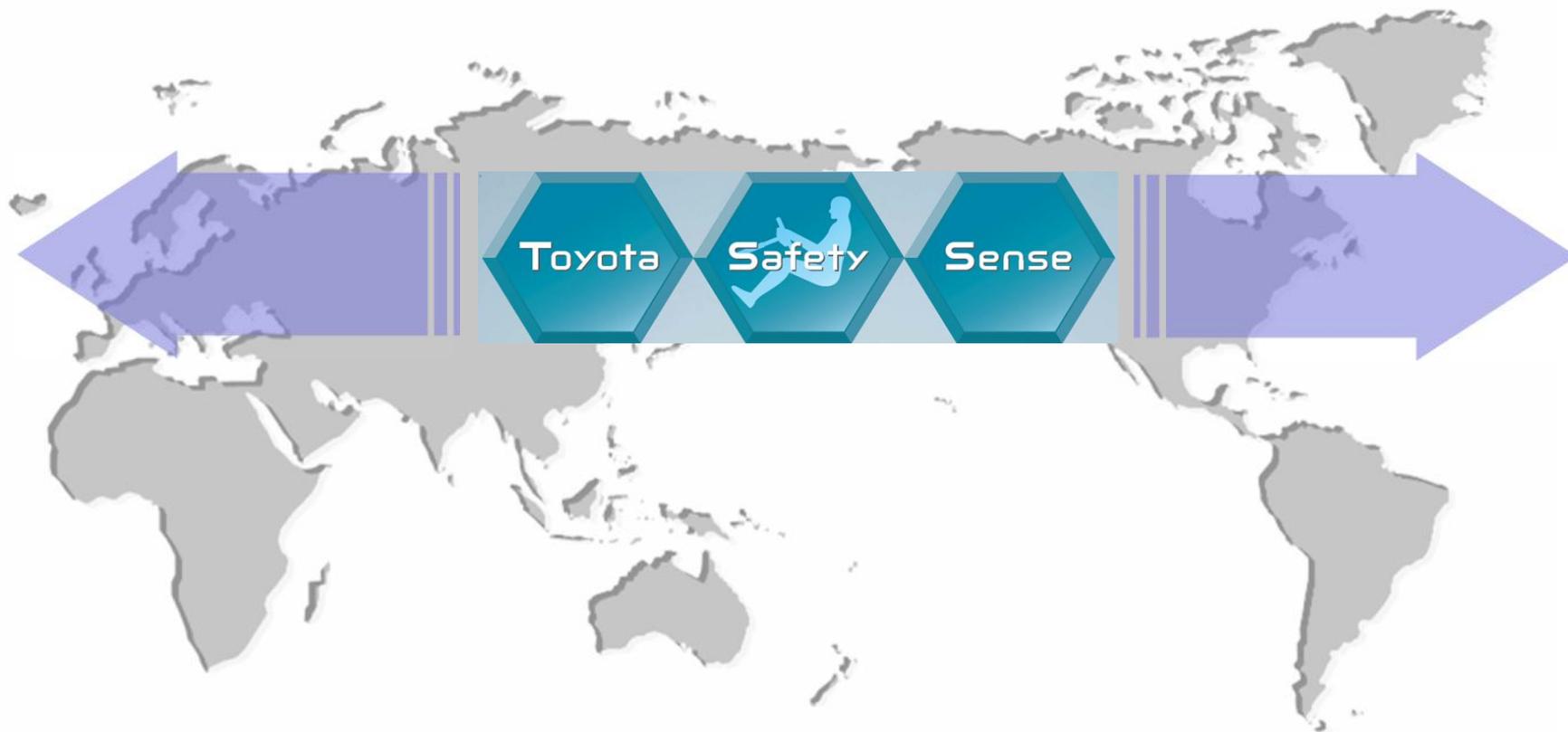
Toyota Safety Sense (Radar + Camera)

- First available on Land Cruiser (Japan) in August '15 (followed in EU by Prius, RAV-4, C-HRand Lexus)
- Features Radar Cruise Control, Pre-Collision System with pedestrian detection function



Toyota Safety Sense Deployment & Expansion

We aim to equip Toyota Safety Sense on almost all passenger vehicles in Japan, Europe, and the U.S. by the end of 2017.



Towards Eliminating Traffic Accident Fatalities



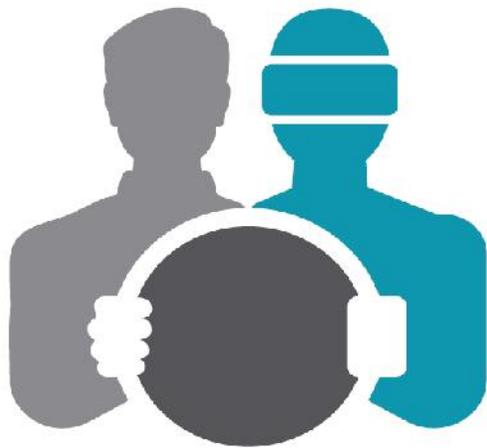
Next Step

Research

-
1. Towards “Eliminating Fatalities”:
Advanced Safety Support Systems
 - 2. Direction of Automated Driving
Technologies Development**
 3. Technology Development for
Automated Driving on Surface Roads

Our Concept of Automated Driving

- ① To provide mobility for all people
- ② All drivers can experience the fun of driving, when they want to
- ③ If driver requests, driver can rely on the automated driving
- ④ Design based on the [Mobility Teammate Concept](#)



MOBILITY
TEAMMATE
CONCEPT
Automated Driving Tech.

Building relation between people and cars that share the same purpose, like close friends who sometimes watch over each other and sometimes help each other out.

Our Goals for Automated Driving

Safety



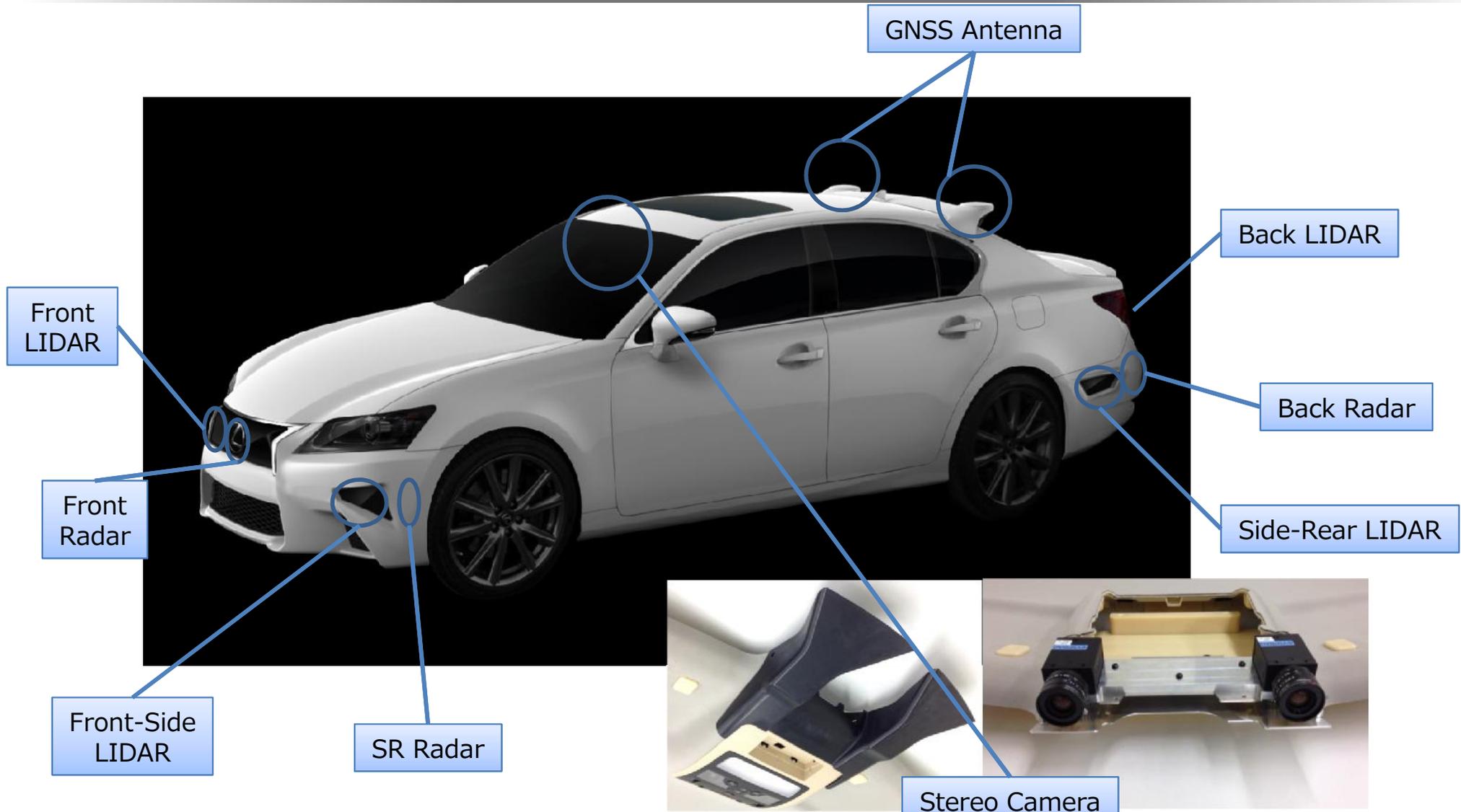
Freedom



Efficiency

Achieve a society where mobility means safety, efficiency, and freedom

Product Study Vehicle



**Structure enabling mass-production,
aiming for early product deployment**

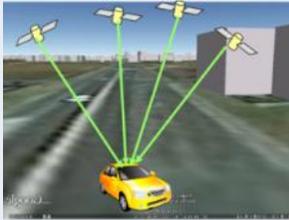
GPS: Accuracy insufficient for Automated Driving

Localization technology comparison

Method

Accuracy
(worst case)

GPS



~50m

GPS + dead reckoning
(Conventional technology)



~30m

GPS + dead reckoning
(Improved by latest software
technology, TRCDL)



~10m

GPS + dead reckoning
+ Vision
+ Precise map



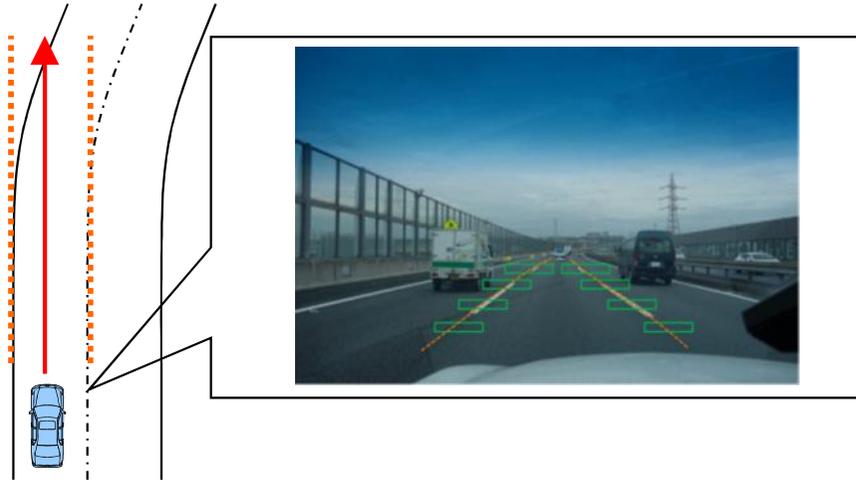
Lateral
0.1m
Longitudinal
0.5m



Accurate localization only possible by using sensors & maps

Localization Technologies on Highways

1) Current technologies



Lane-keeping by detecting only white lines

【Limitations】

1. Miss/Loss detection
2. Cannot keep away from moving objects

2) Localization by white lines + landmarks + HD map

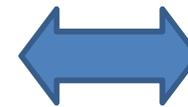
White lines

Landmarks

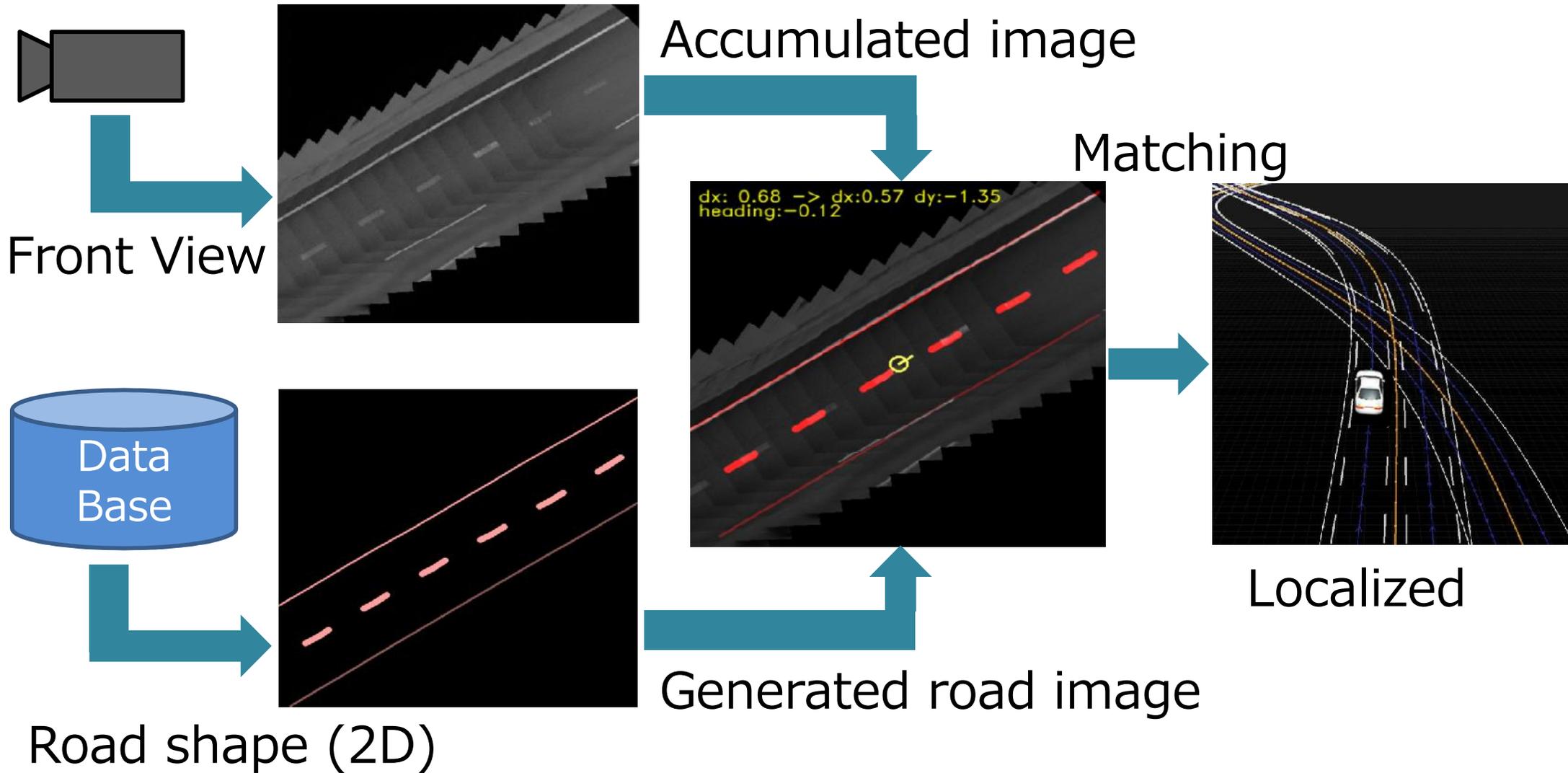
Map

matching

+



Using HD Maps for Accurate Localization



**Match camera view with road pictures
generated from road database**

-
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Difficulties of Surface Road

Highway



Clearly marked lanes



Cars only, same direction



Junctions
Constructions

Surface road

Poorly maintained. Various rules and designs.



• No lane markings



• Road condition



• Traffic lights



• Various rules



• Hand signal

Many types of mobility. Moving in various directions.



• Pedestrians



• Various mobility



• Crossroads



• Multiple directions

Decisions for complicated situations are required.



Giving way/cutting in?



Instructions not clear?



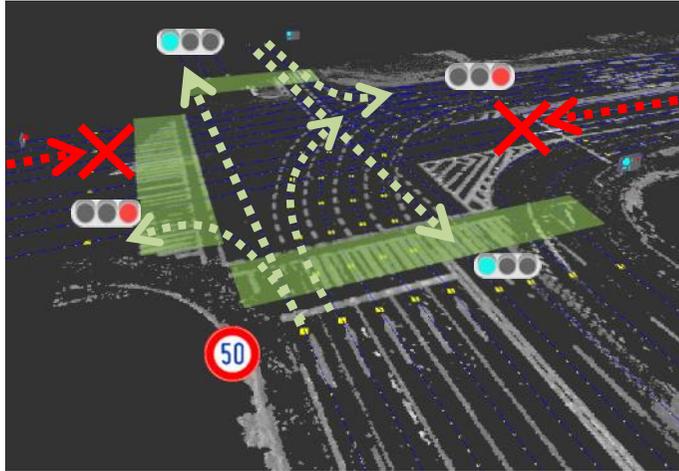
Waiting to park?



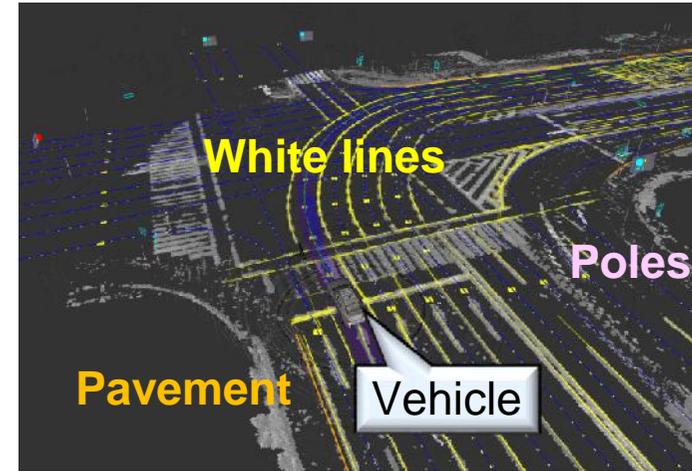
Interaction

Importance of Maps

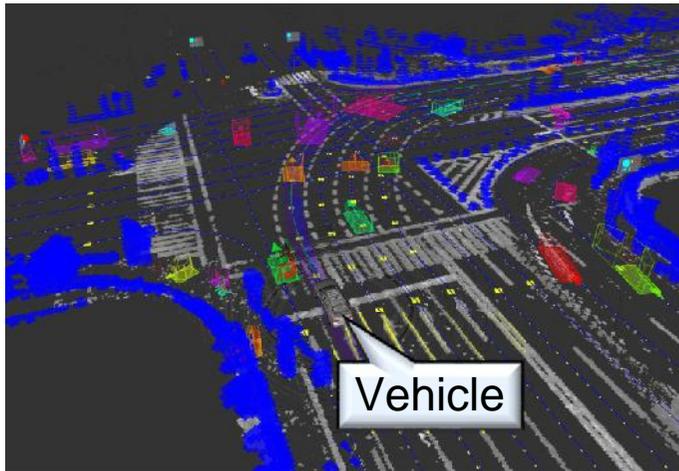
1. Obtain road network data, traffic rules/lights



2. Localization



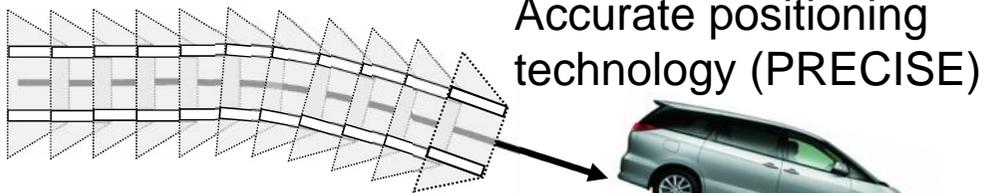
3. Obstacle detection by matching with sensor data



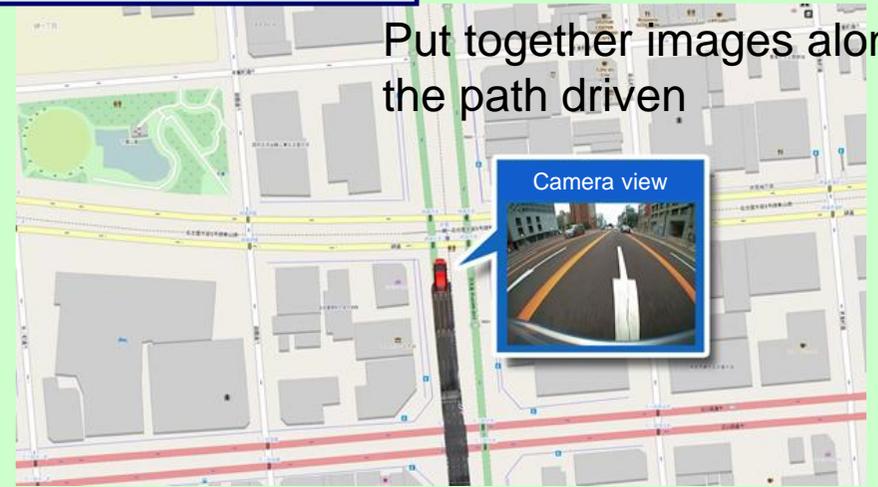
Enable precise localization and also rich recognition

Automatic Spatial Data Generation

Rear-view camera + Accurate positioning



Generate road image



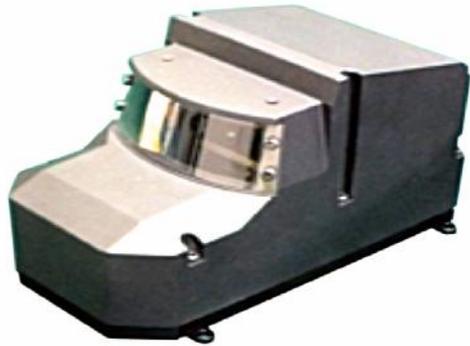
Spatial data



Integrate road image



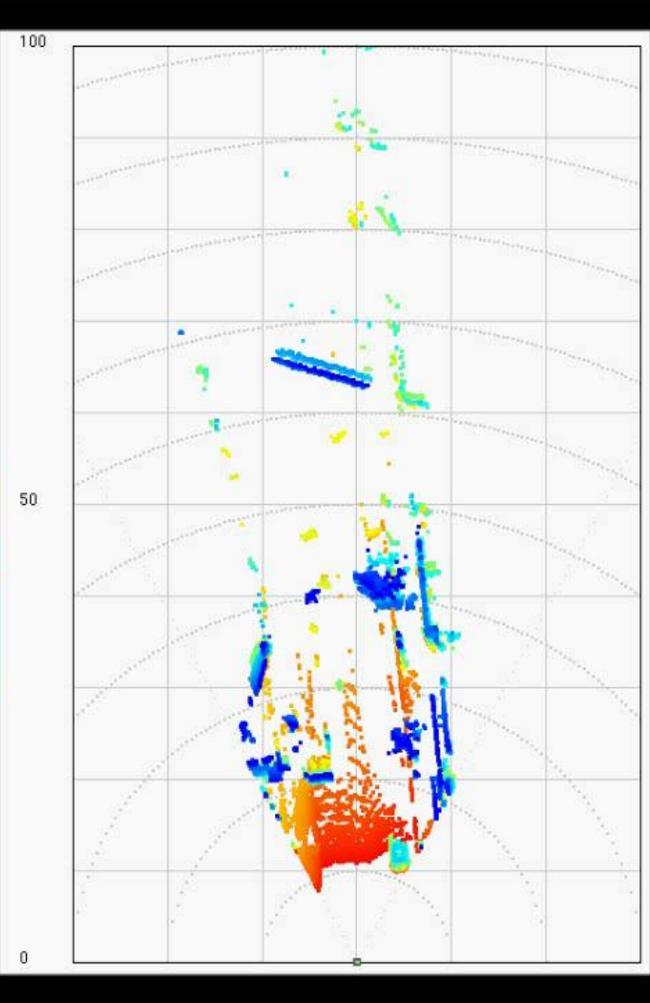
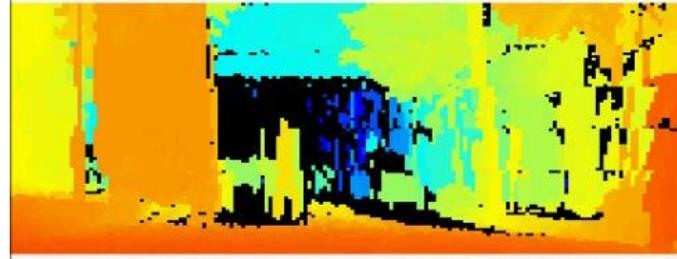
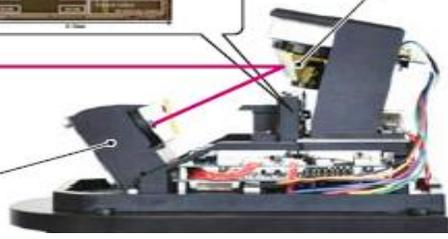
High Resolution 3D SPAD LIDAR



ポリゴンミラー
Polygon Mirror

レーザービーム
LASER Beam

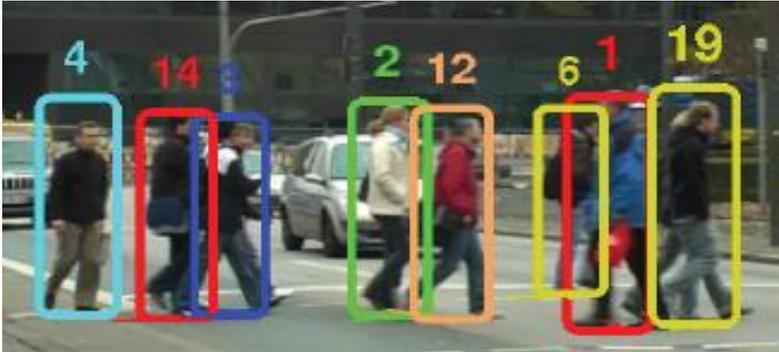
レーザー発振器
LASER Emitter



※ SPAD: Single Photon Avalanche Diode
LIDAR: Light Detection And Ranging

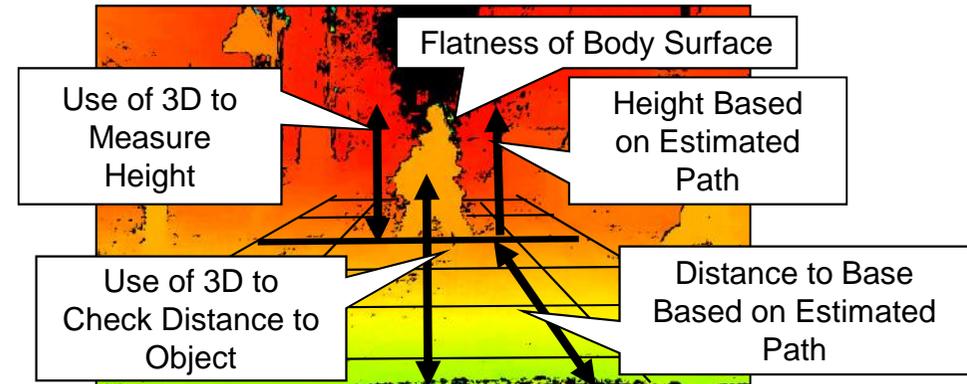
Recognition Technology using Camera

Challenging Conditions; Recognition Not Possible So Far



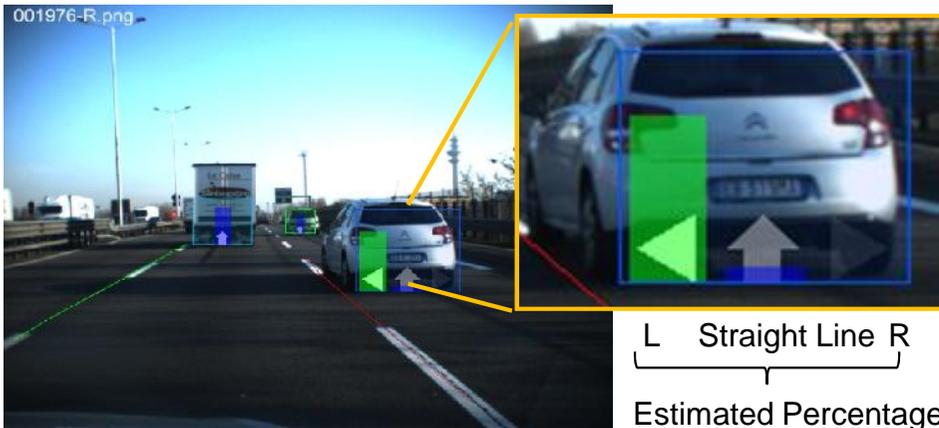
B. Schiele@Max Planck Inst.

e.g. Recognition of Partially Visible Pedestrians

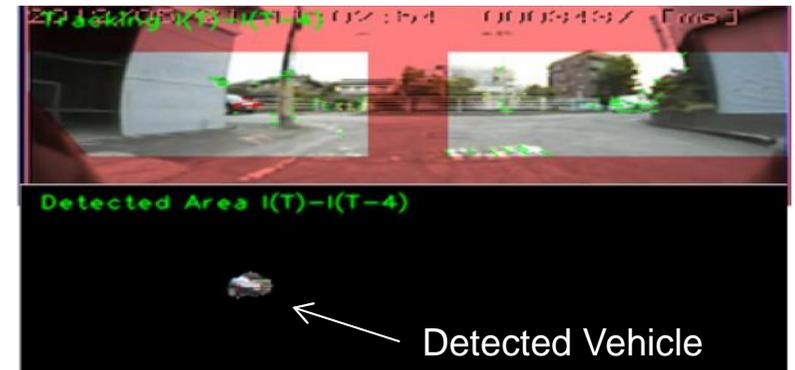


e.g. Recognition Based on Multiple Clues

Various Conditions not Noted in Rules



e.g. Projection of drive behavior based on statistical models



e.g. Detection of Moving Objects that Differ from Surroundings

Deep Learning

CES2016: Automated Vehicles learn to “avoid collisions”

For Deep Learning of automated vehicles, “Chainer”, the Deep Learning development framework by Preferred Networks, in which Toyota has invested, was used. Written in CUDA running on NVIDIA GPU.



In the beginning, automated vehicles had collisions, but as deep learning progressed, collisions were decreasing, vehicles were giving way to each other and what seemed like driving lanes appeared.

Questions?

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