TOYOTA's Automated Driving Technologies

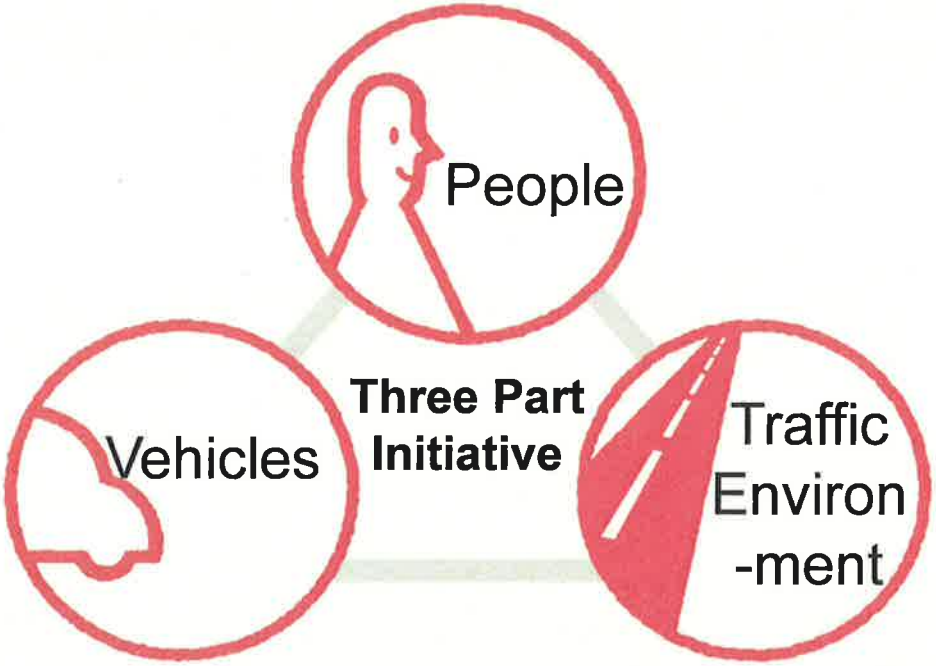
TOYOTA MOTOR CORPORATION

Topics

1. **Towards "Eliminating Fatalities":**
   Advanced Safety Support System
2. Directions of Automated Driving Technologies Development
3. Automated Driving System for Highways
4. Technology Development for Automated Driving on Surface Roads

Towards "Eliminating Fatalities"

Integrated Three Part Initiative

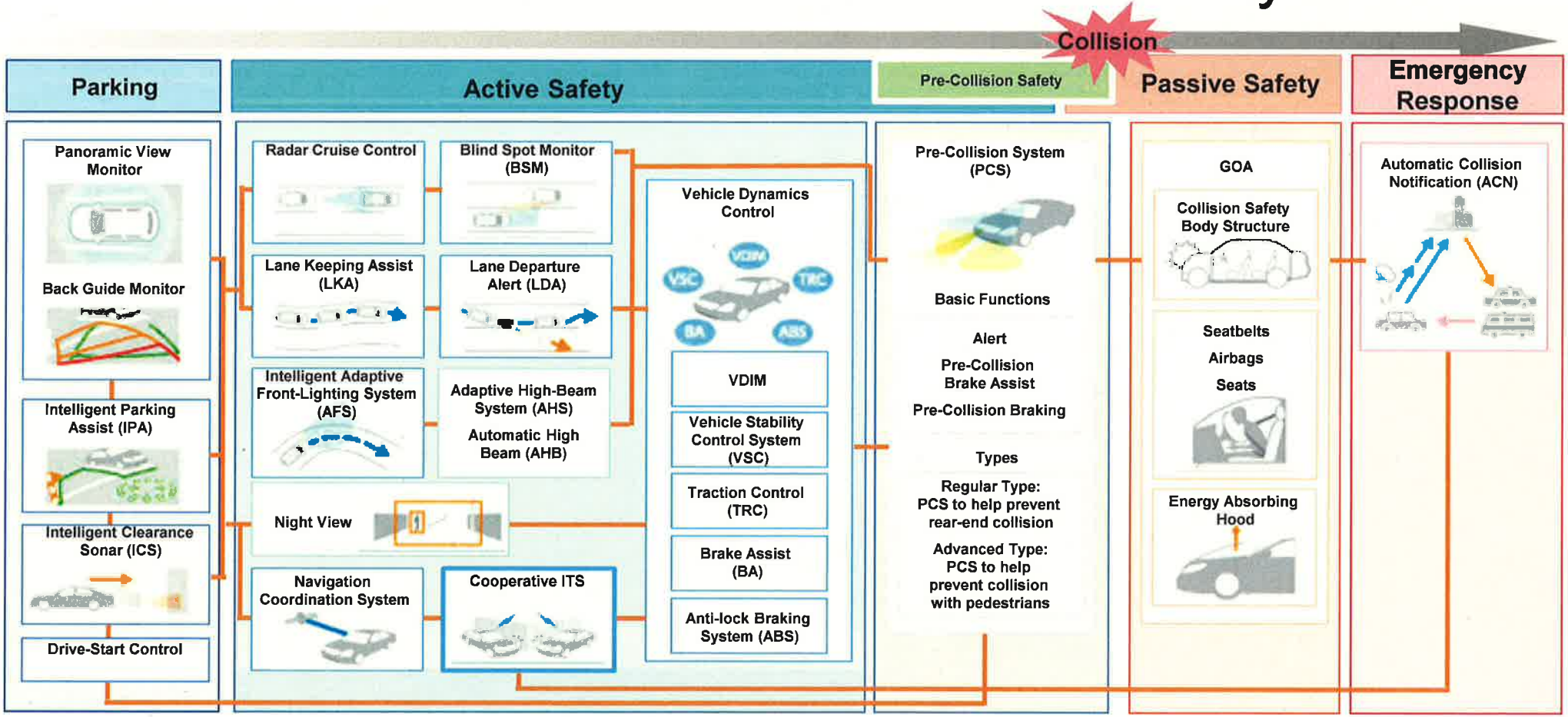


Pursuit of Vehicle Safety

Toyota's Approach to Safety

Integrated Safety Concept

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

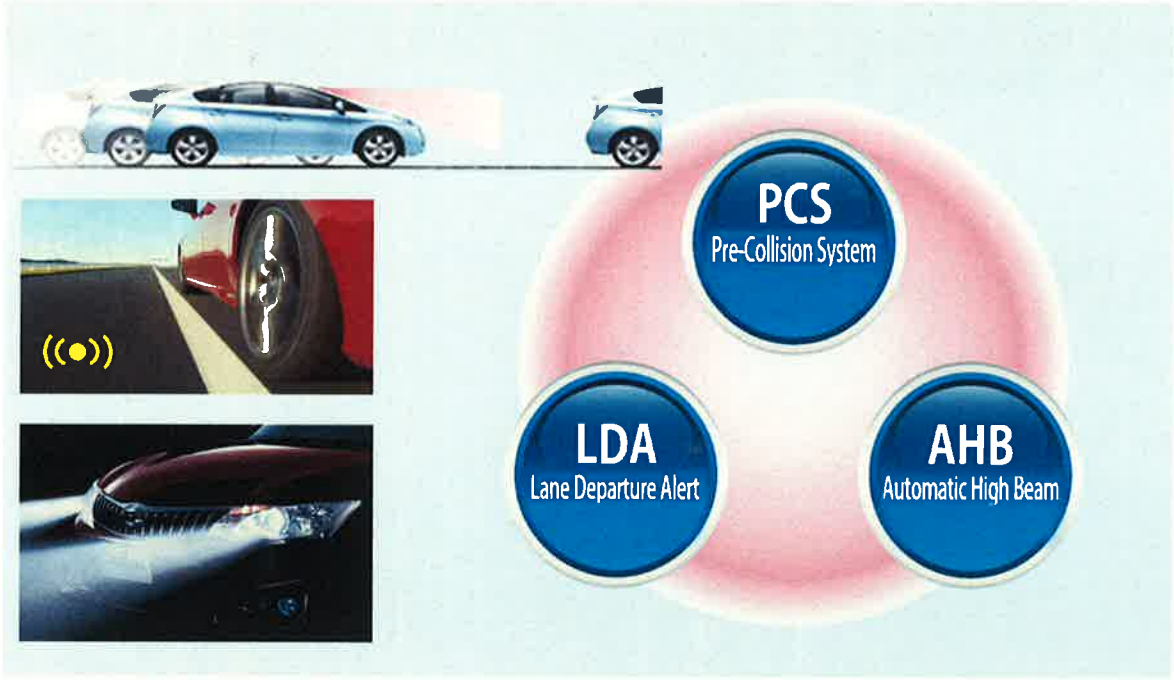


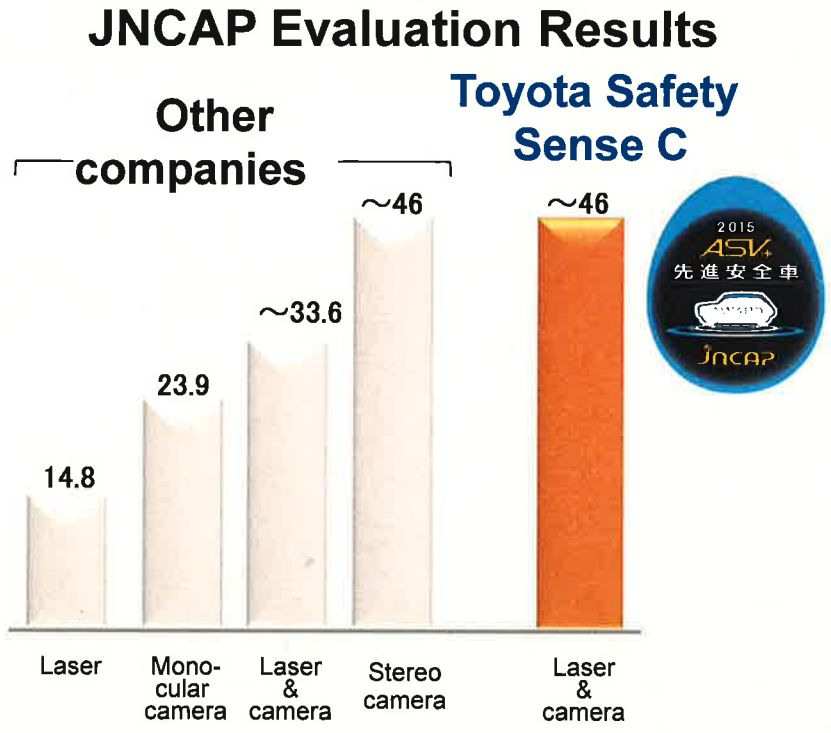
Toyota Safety Sense

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

Toyota Safety Sense C (Laser & Camera)

- First available on Corolla (Japan), April '15
  (followed by Auris, Sienta, Vitz, Avensis)
- Earned Corolla JNCAP's top preventative safety rating (ASV+)



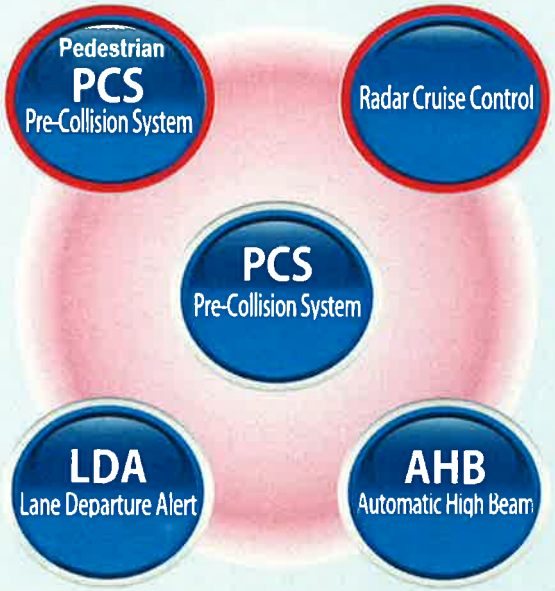


Toyota Safety Sense P (Radar + Camera)

- First available on Land Cruiser (Japan) in August '15

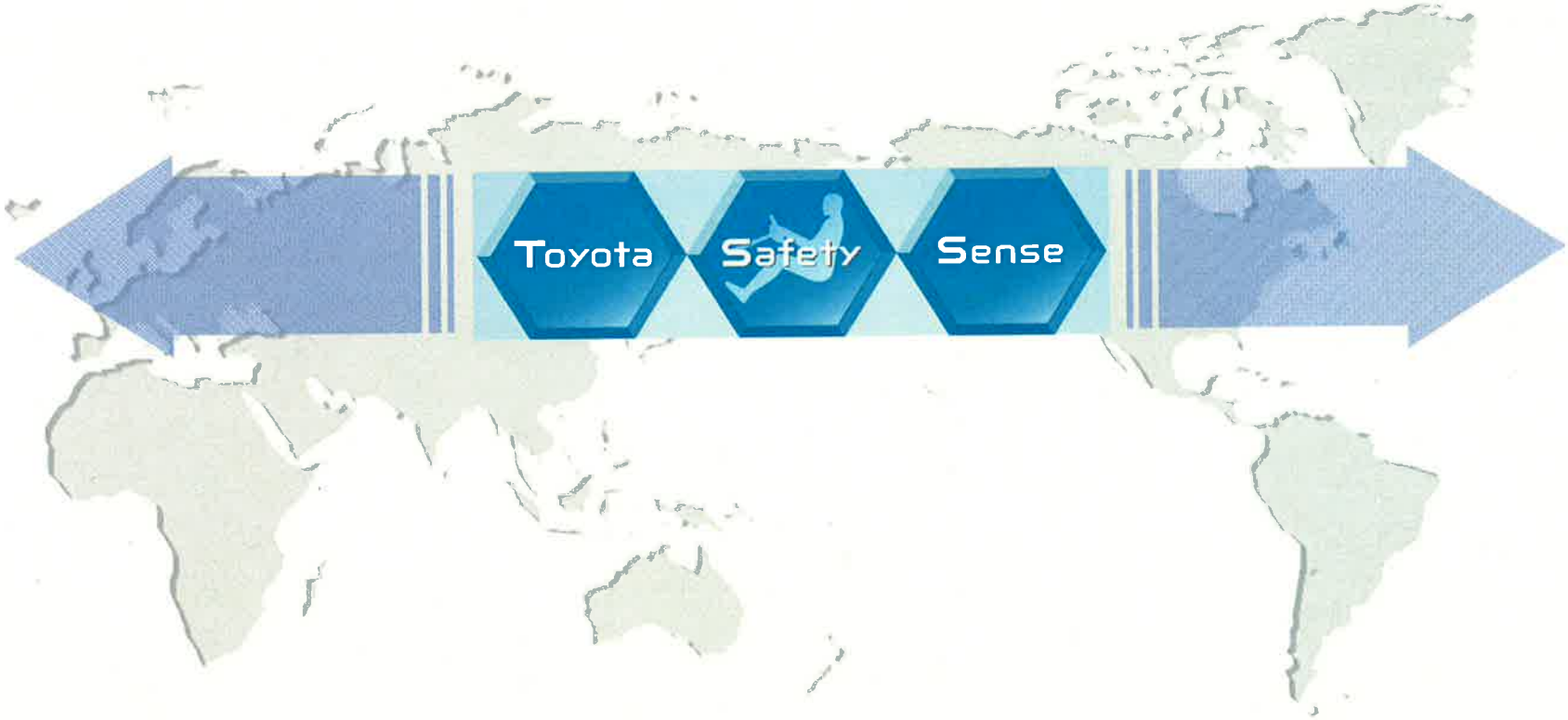
  Rollout to five models within '15 (including Lexus)

- Features Radar Cruise Control, Pre-Collision System with pedestrian detection function



Toyota Safety Sense Deployment & Expansion

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



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   Advanced Safety Support System
2. **Directions of Automated Driving Technologies Development**
3. Automated Driving System for Highways
4. 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 relations 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

Safety

Freedom

Efficiency

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

Our Directions

Automated driving: Highway Teammate

Full-scale automated driving technology targeted mainly on highways

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2. Directions of Automated Driving
   Technologies Development
3. **Automated Driving System for Highways**
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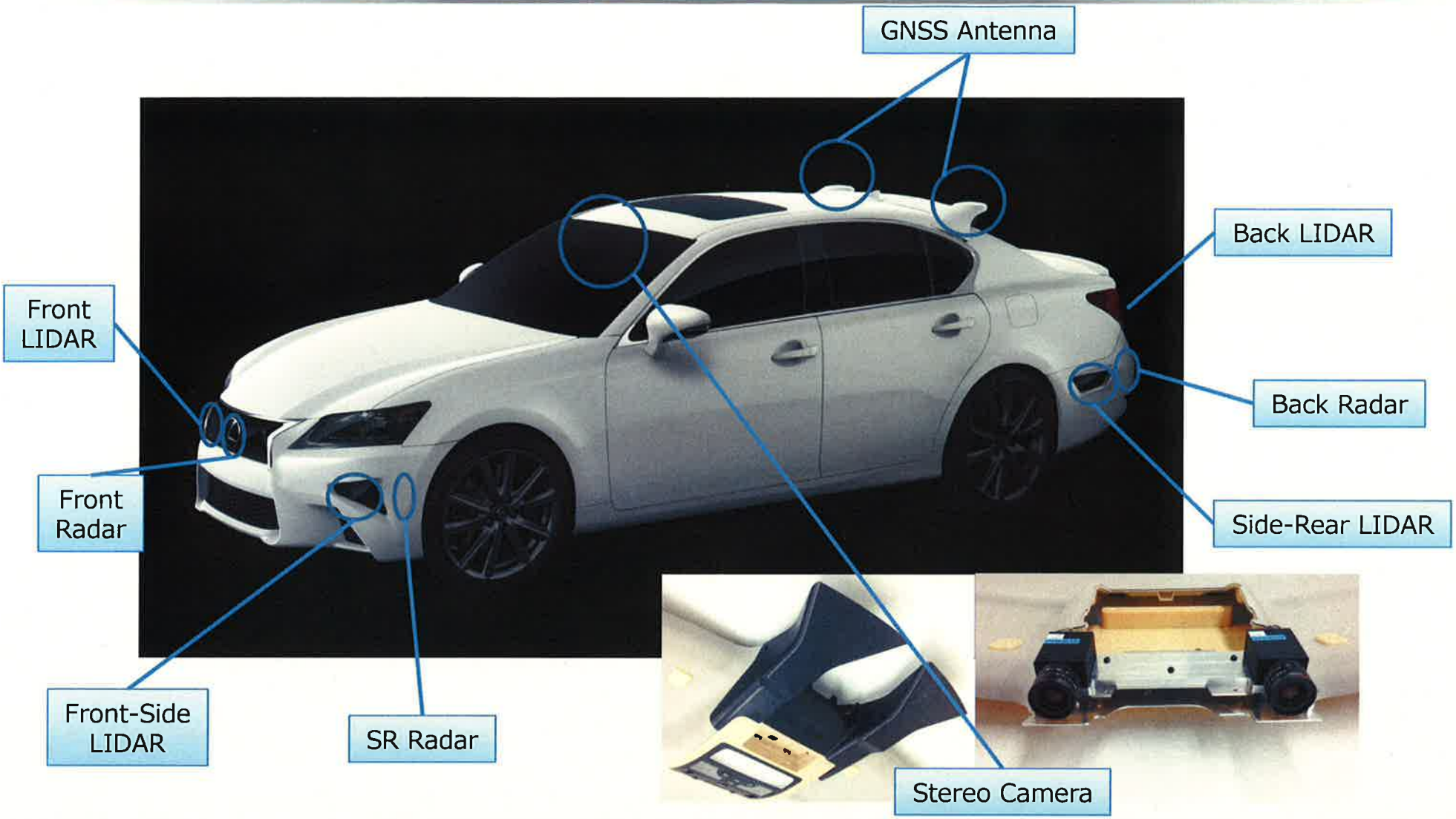
Product Study Vehicle on Highway



Structure enabling mass-production, aiming for early product deployment

Localization Technologies on Highways

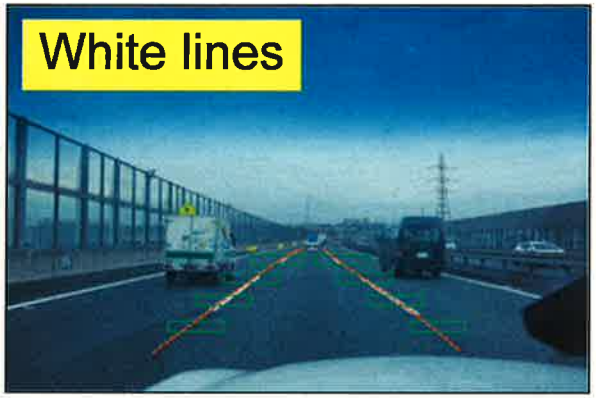
1) Current technologies

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



+

matching

System Evaluation on Urban Highway

Evaluate the system in challenging situations of public urban highway

Test vehicle

Test route
(Tokyo metropolitan highway)

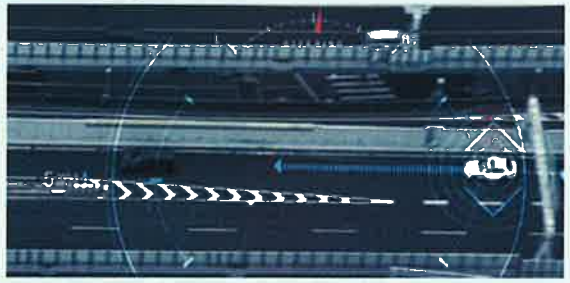
➢ Localization

Double deck (GPS reception issues)

Multiple lane markings
(white lines detection issues)

➢ Object detection & Planner

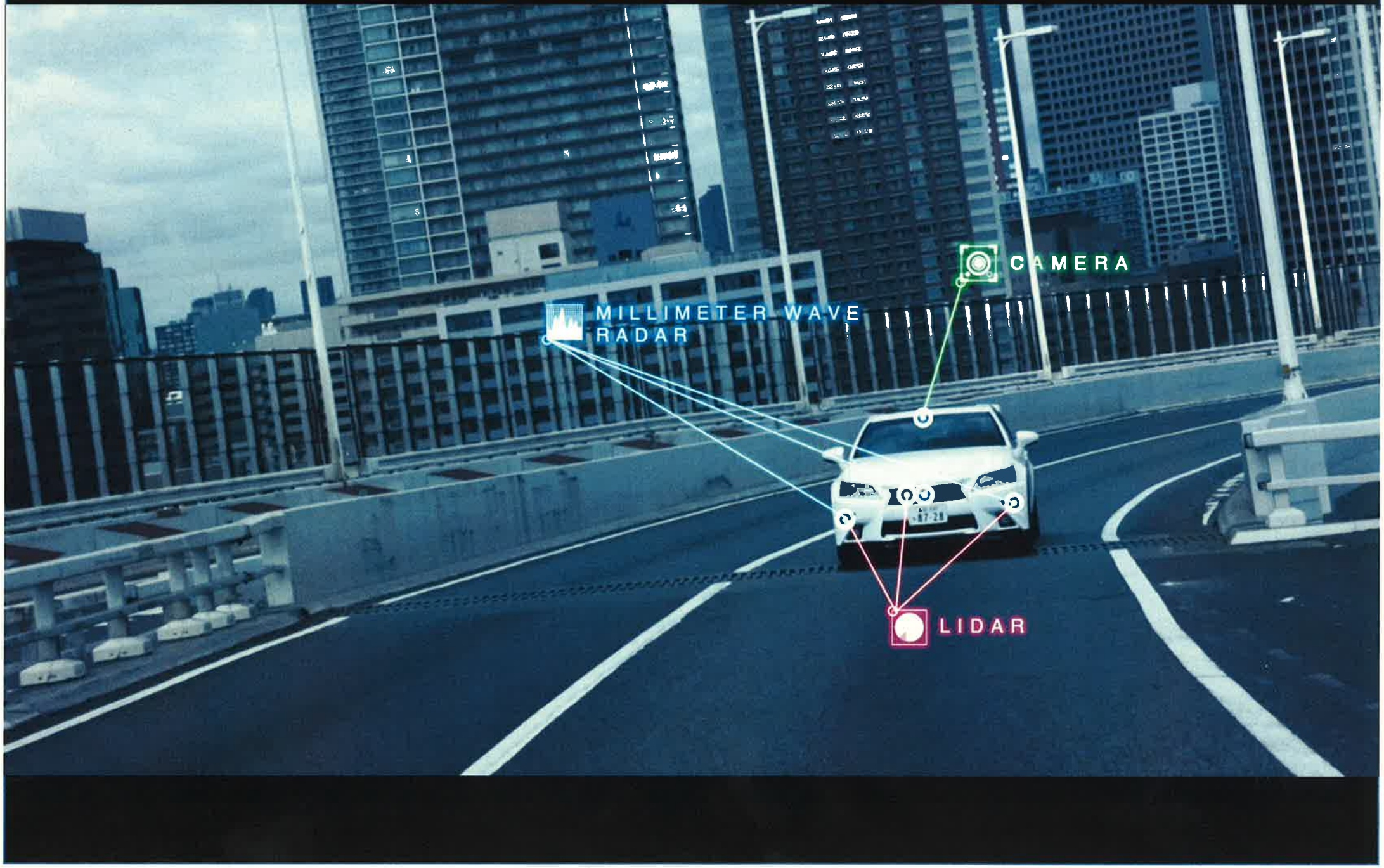
Merge



Diverge

Level-up by evaluating in public road tests

Highway Teammate



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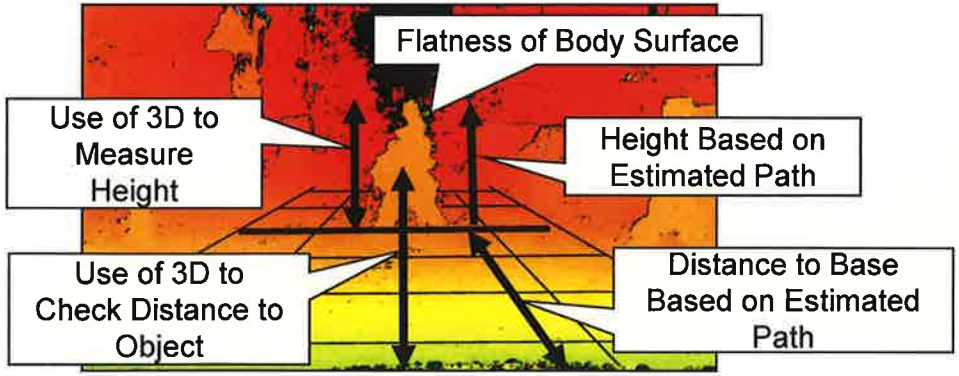
4. **Technology Development for Automated Driving on Surface Roads**

Recognition Technology using Camera

■ Challenging Conditions; Recognition Difficulty

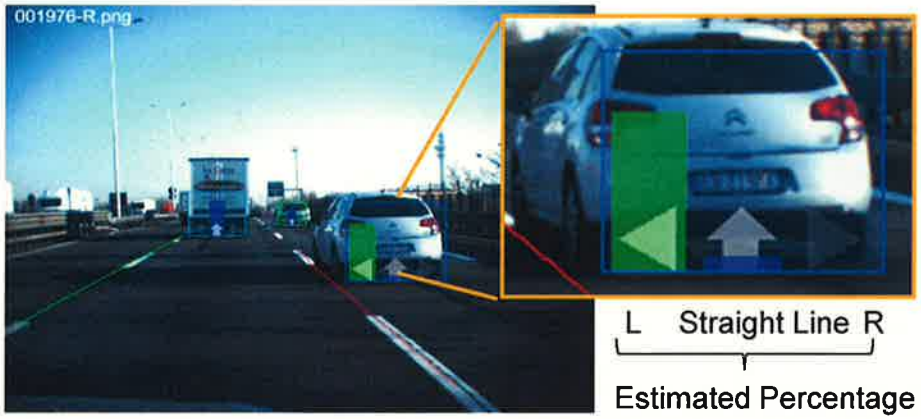
B. Schiele@Max Planck Inst.

e.g. Recognition of Partially Visible Pedestrians



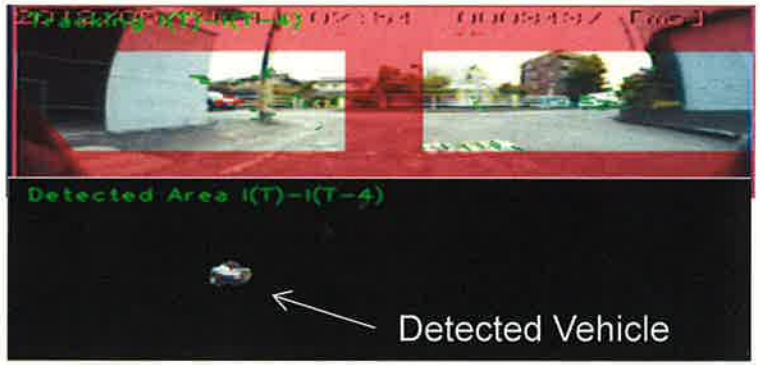
e.g. Recognition Based on Multiple Clues

■ Future Prediction



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

Estimated Percentage Chance of Future Drive Path



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

Planning: Driving Intelligence for Surface Roads

Various rules and designs. Poorly maintained.

Many types of mobility. Move to various directions.

Decisions for complicated situations are required.

Rich

Rich recognition

Drive safely, but may struggle in some cases

High grade roads

✓Detect all objects, take safest route

✓Take worst case scenario if there is lack of information, like blind spots

Smart

Prediction

Drive smoothly only in learned area by predicting objects' motion

Major surface roads (can follow humans' directions)

✓Predict objects' motion, take safer route

✓Collect lacking information

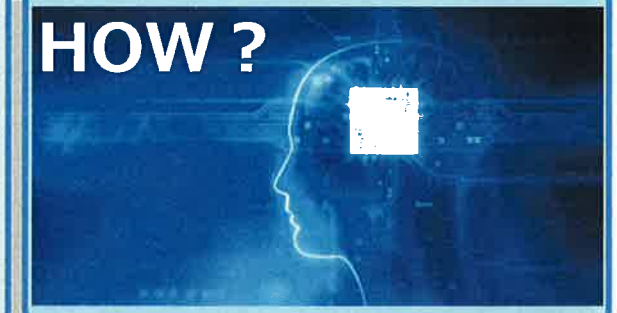
✓Find hidden risks

Emergence

Building up

Cope with new situations correctly and build up knowledge

All roads

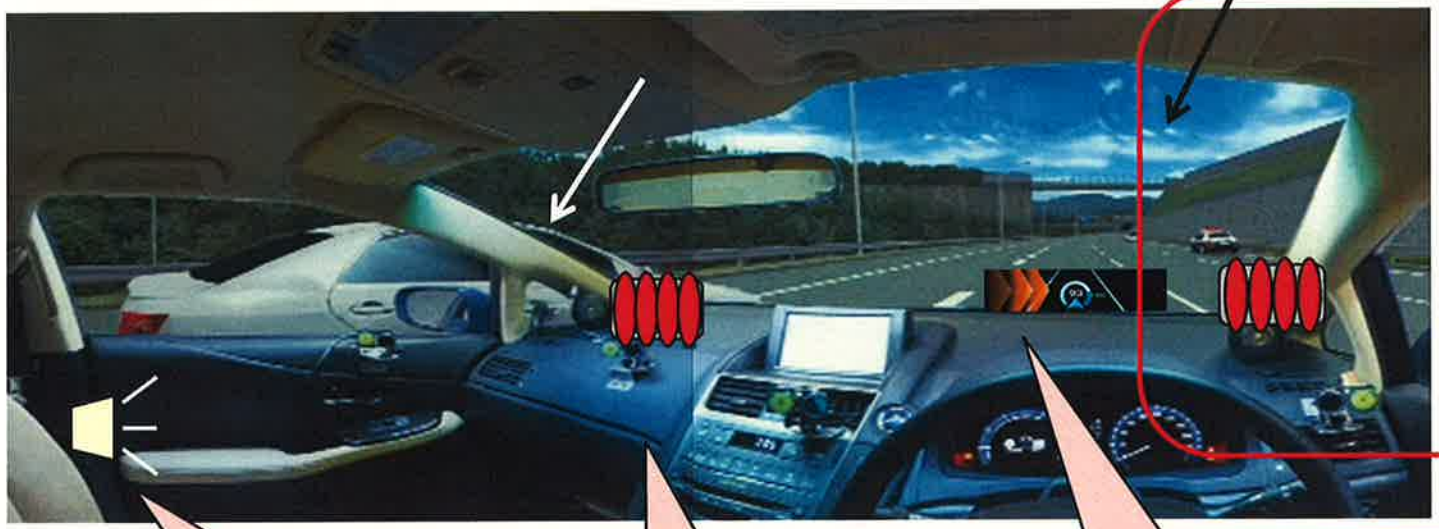


Big jump of technology needed for each step

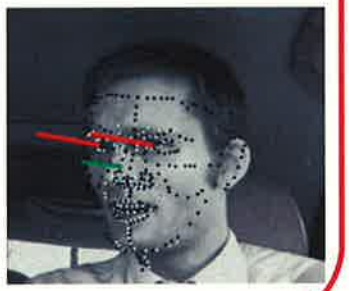
Decision-making Technology

HMI: Evaluation using Driving Simulator

Validating the effectiveness of functions, using the Driving Simulator



Driver Monitoring



Approach to Recognition
Multi-modal approaches

Voice prompt: "Please look out to your left"

Indicator lamps (flash to attract driver)

Head-up Display (Display another vehicle merging in from the left)

Display information

MOBILITY TEAMMATE CONCEPT

Automated Driving Tech.