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# Autonomous Driving Intelligence for Future Innovation

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**President**
**Japan Automobile Research Institute**

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2. S-Innovation project outline

3. ADAS: Adaptive Driver Assistance System

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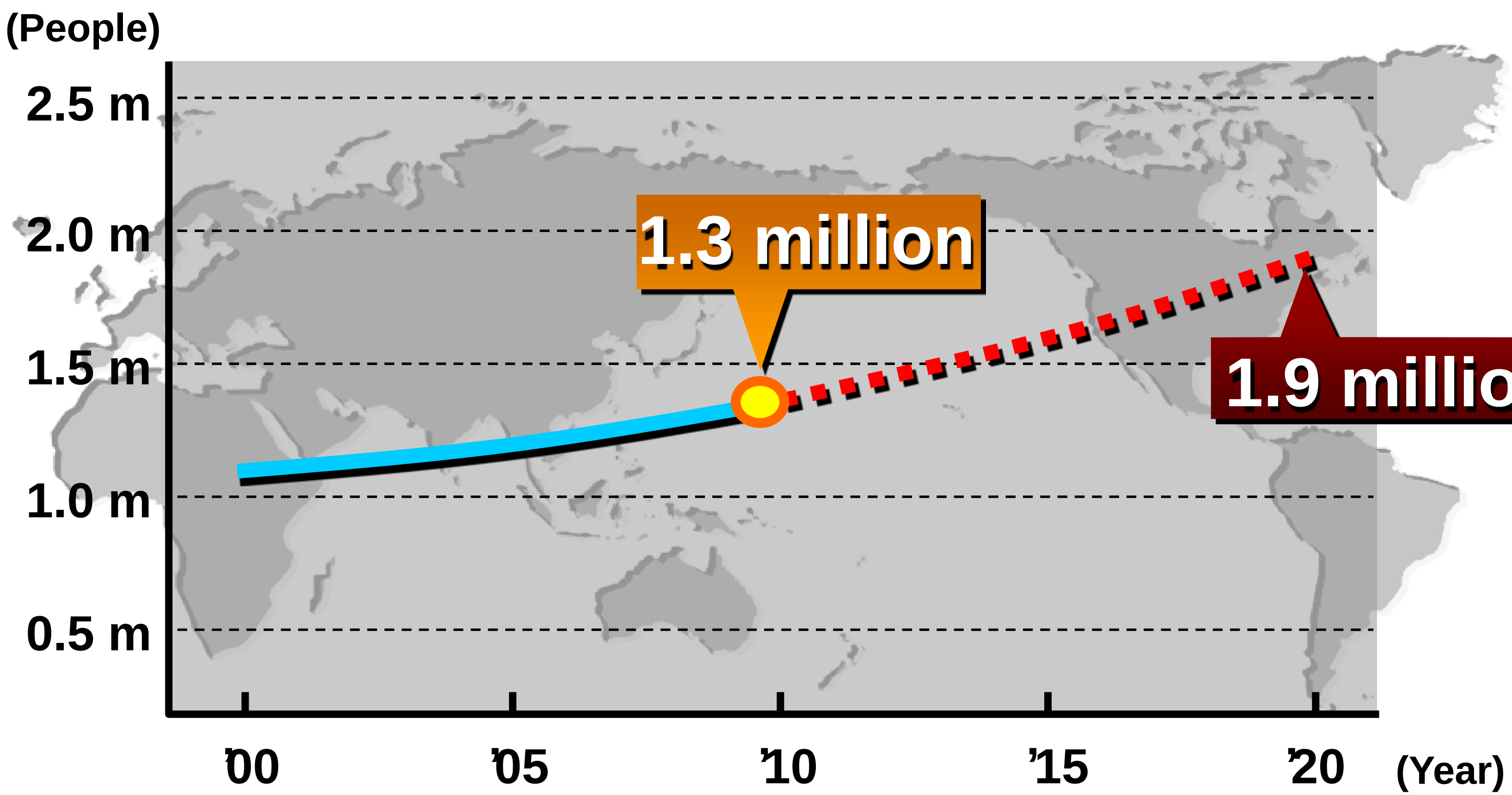
Furthermore ...

SIP: Strategic Innovation Promotion program for ADS (Automated Driving Systems)

# Traffic accident fatalities in the world

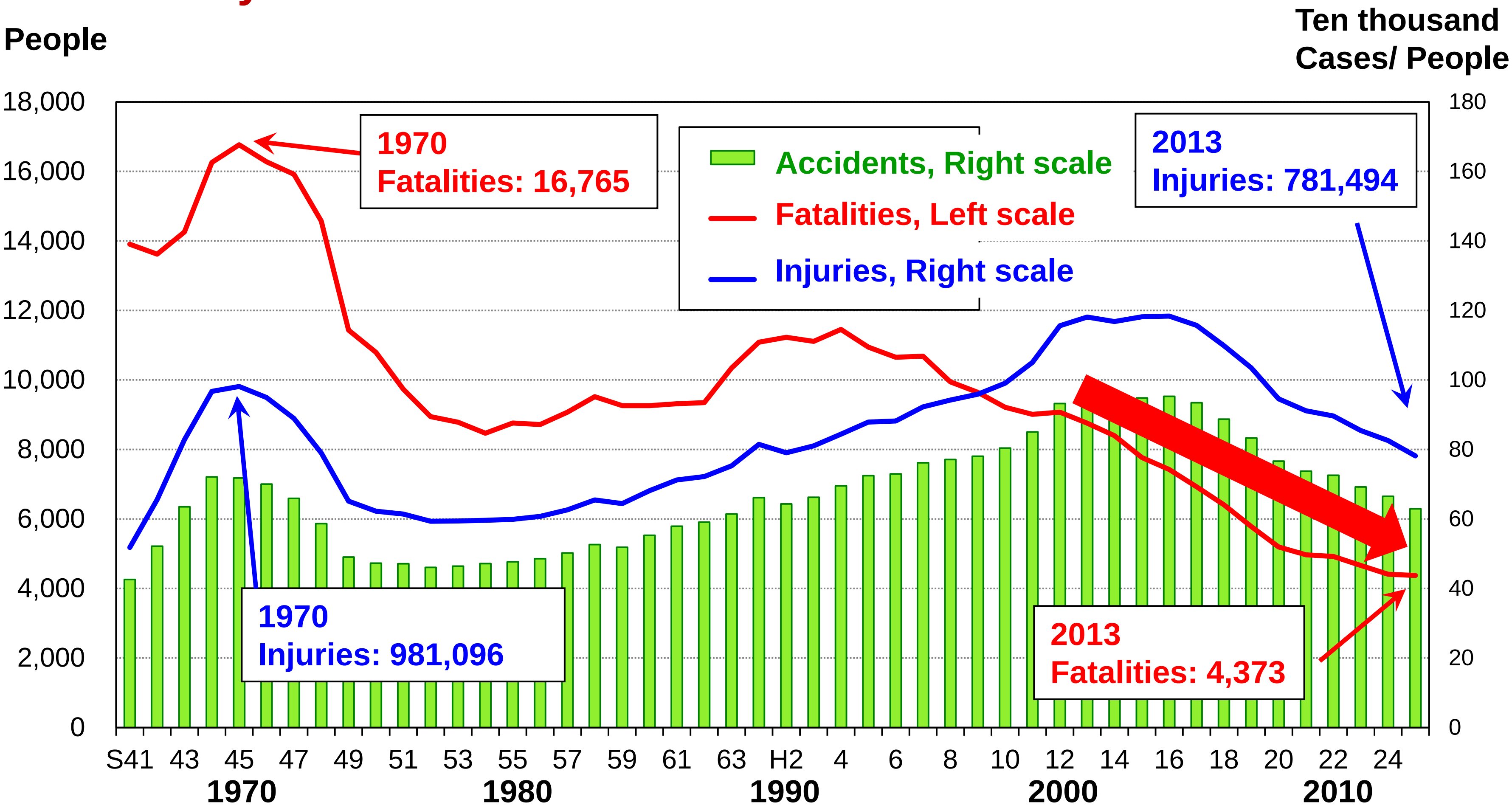
**The number of fatalities in the world has been increasing and it is estimated it will reach 1.9 million in 2020.**




**Source: Guria, J. for Commission for Global Road Safety (2009)**

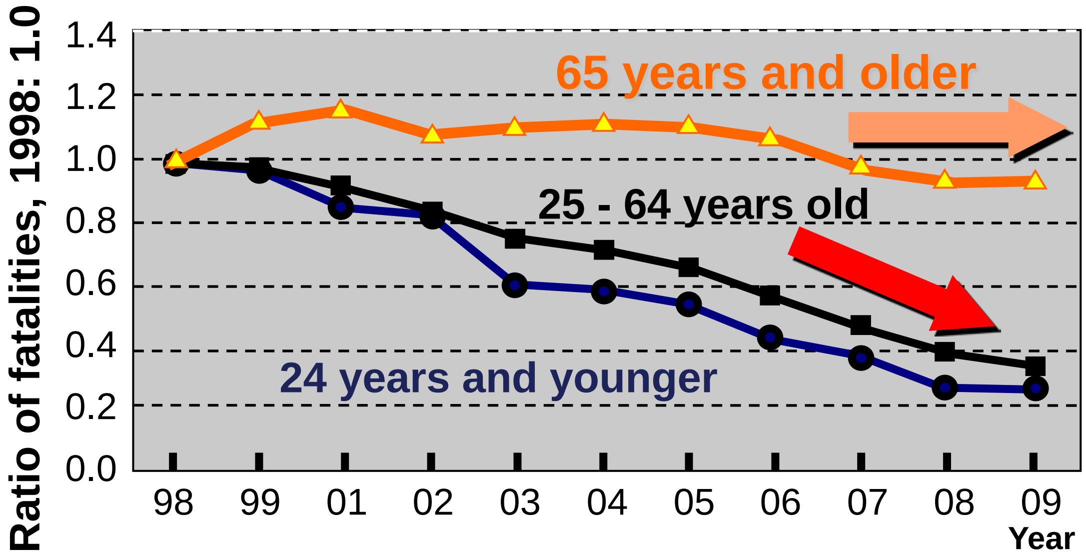
# Annual transition of traffic accidents in Japan

**The number of accidents, fatalities and injuries has been decreasing in recent years.**

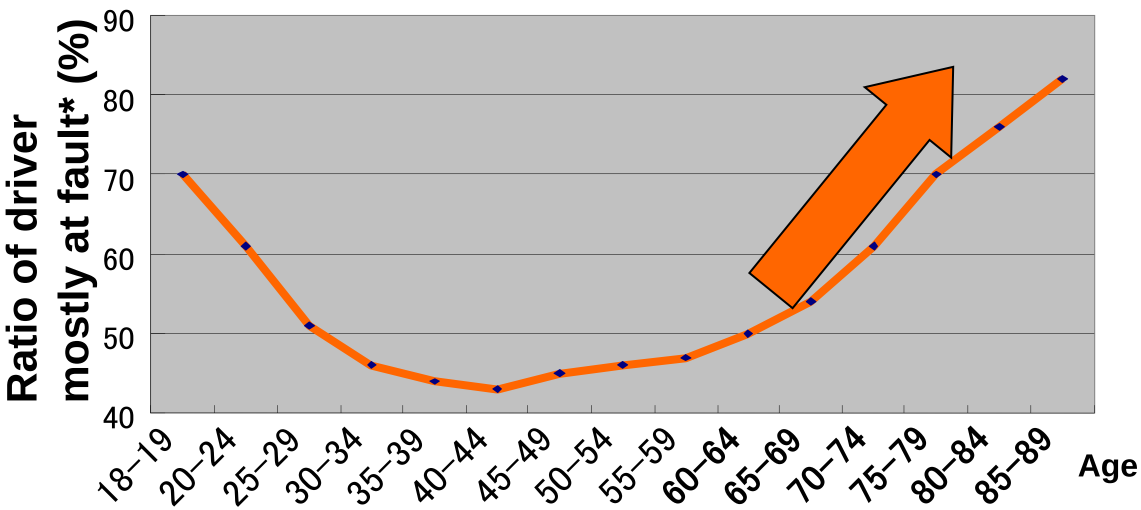



**Source: National Police Agency**

# Accidents in Japan: age-specific analysis




The number of accidents involving aged people is stable, while that involving younger people has decreased.




This ratio increases rapidly in line with aging.

* = (No. of driver mostly at fault/ No. of driver mostly at fault + other driver) x 100

Source: ITARDA Information No. 81

# S-Innovation project supported by JST*

**"Autonomous Driving Intelligence to enhance a safe and secured traffic society for elderly drivers" was started in 2010 and will continue until 2019 with the following 3 stages:**

- ✓ **Stage 1: Development of autonomous driving intelligence systems**
- ✓ **Stage 2: System improvement and assessment by field operational tests**
- ✓ **Stage 3: Standardization and commercialization**

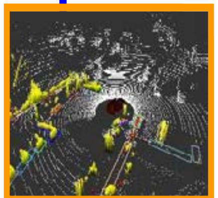
| | |
|---|---|
| **Project Manager:** | **Mr. Hideo Inoue, Toyota Motor Corporation** |
| **Research Leader:** | **Prof. Masao Nagai, JARI** |
| **Project Partners:** | **Toyota Motor Corporation** |
| | **Toyota Central R&D Labs, Inc.** |
| | **The University of Tokyo** |
| | **Tokyo University of Agriculture and Technology** |

***: Japan Science and Technology Agency**

# S-Innovation project: 3 stages' overview

## Stage 1, 2010-2013

**1. Sensing Technology**



Laser scanner and camera (Hardware development) and enhancing classification

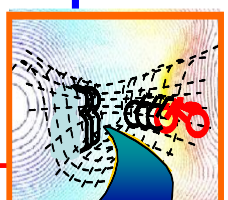
Wide range and rich detail

**2. Environmental perception**

Classification of environmental objects and motion prediction

Situational Risk Assessment

**3. Driver Model**



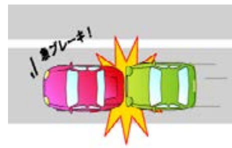
Hazard anticipation, Risk potential estimation

Contour of collision risk

**4. Collision Avoidance Algorithm**

Collision avoidance path generation

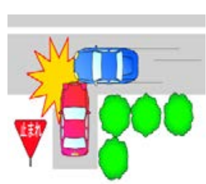
**Functionalities of Low-speed autonomous collision avoidance (up to 30 km/h)**



Rear-end collision avoidance

Pedestrian/bicycle protection

Lane departure prevention



Head-on collisions

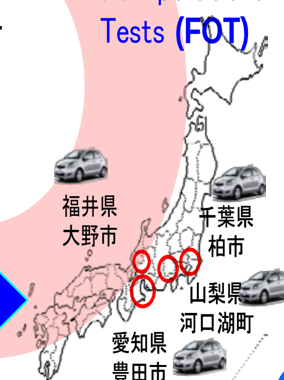
Global Standard Development

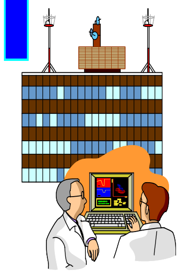
Frontier research for enhancing intelligence

## Stage 3, 2017-2019

Driving simulator exp.

Field Operational Tests (FOT)



Drive recorder
Logging data analysis

Urban test sites

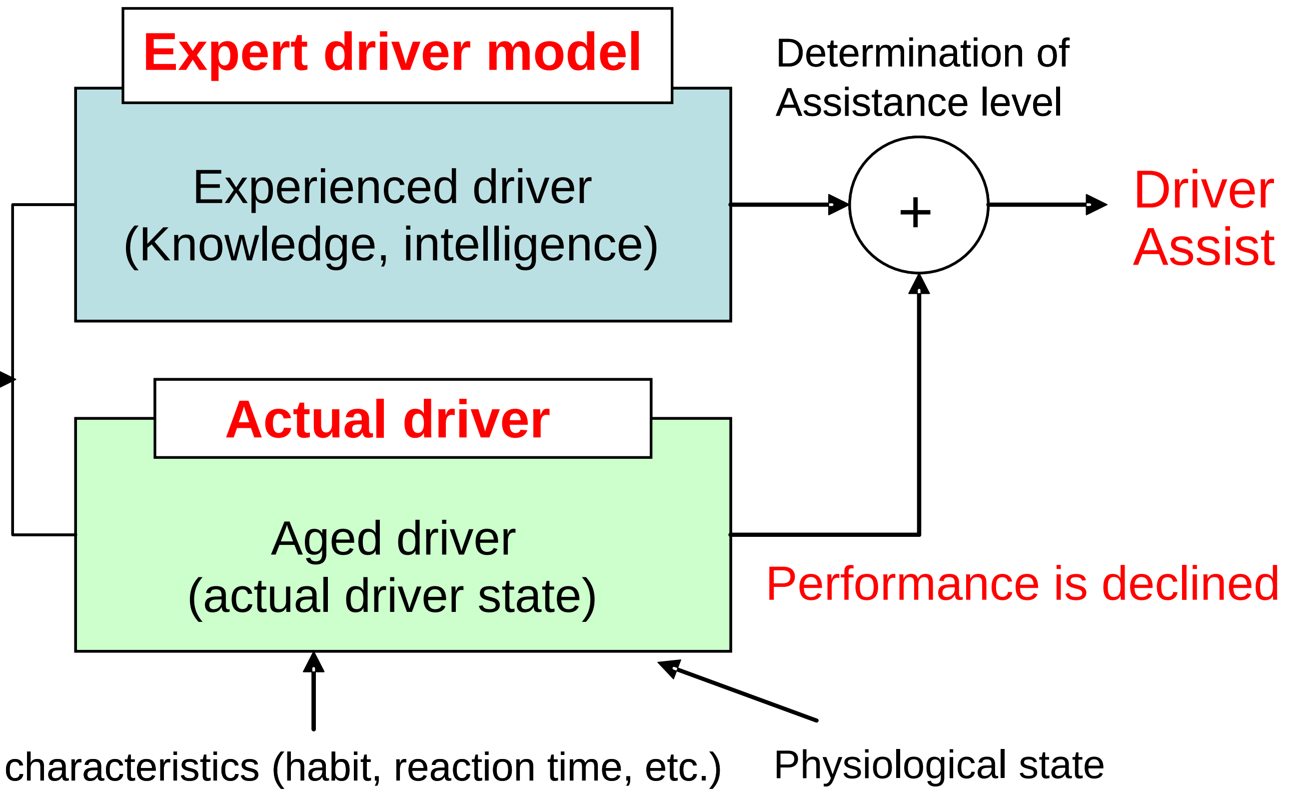
## Stage 2, 2014-2016

- Acceptance study
- Effectiveness estimation

**Emerging Intelligent mobility technology and commercializing for protect aged drivers**

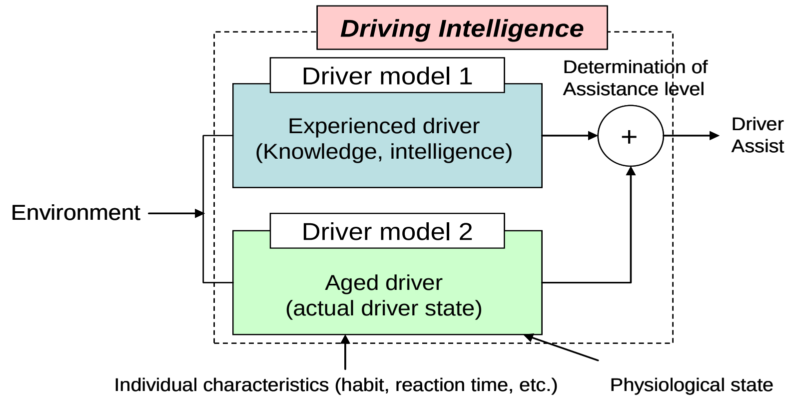
Adaptive Driver Assistance System

# ADAS Concept
# with autonomous driving intelligence


**Shared control between an expert driver model and actual driver**

# ADAS Concept
# with autonomous driving intelligence

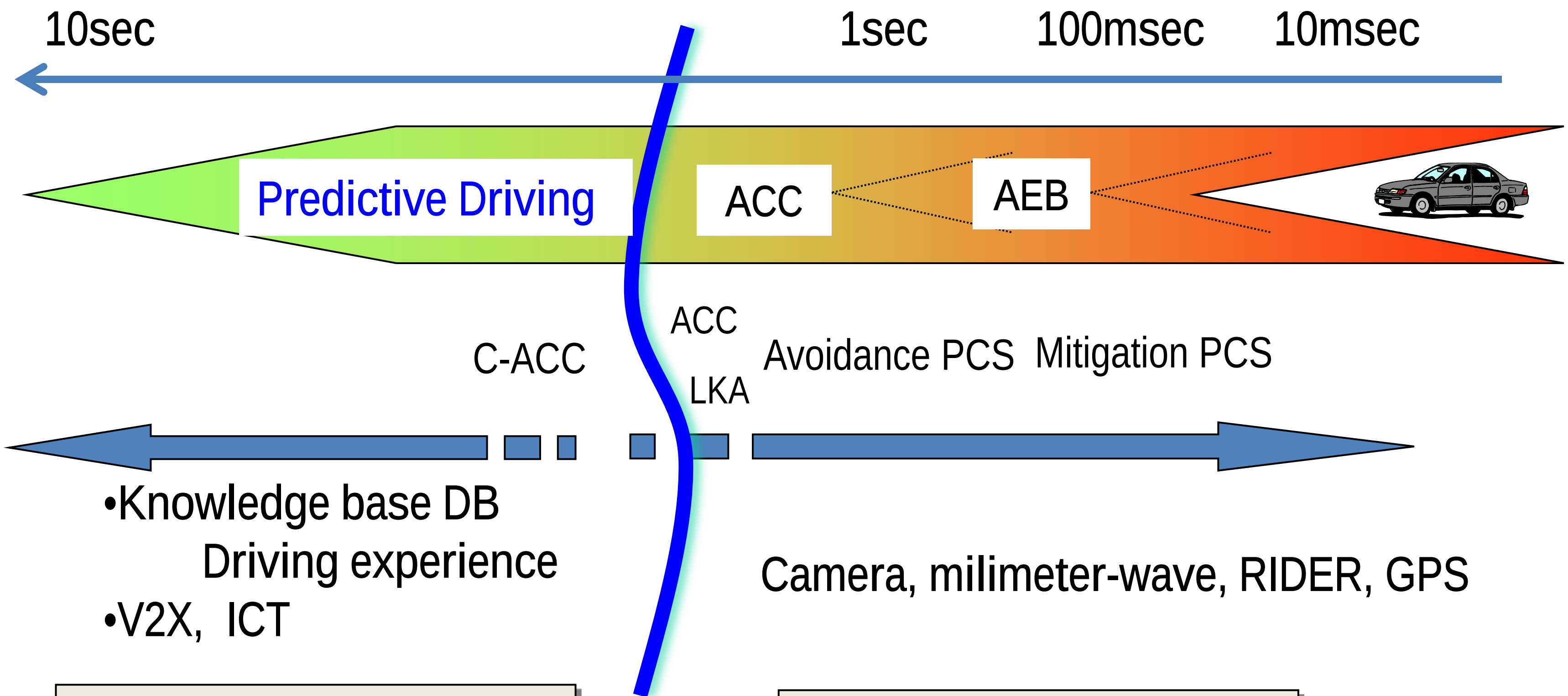



**ADAS: Adaptive Driver Assistance System is proposed to prevent traffic accidents caused by a decline in elderly drivers' performance.**

**ADAS's realizes "Driver-in-the-loop Autonomous Driving" which means shared driving between an expert driver model and actual driver.**

**How to model an expert driver's anticipatory information gathering is one of the most important points to design ADAS.**

# Expert drivers' anticipatory information gathering




**Anticipatory Driving Information**

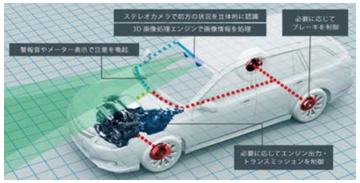
**In-vehicle sensor Information**

**Experienced drivers gather information through both in-vehicle sensors and their driving experience.**

# Performance limitation of AEB

**Current AEB: Autonomous Emergency Braking system is activated after detection of pedestrians with in-vehicle sensors, then braking is not enough to avoid a crash in some situations.**

## Current AEB

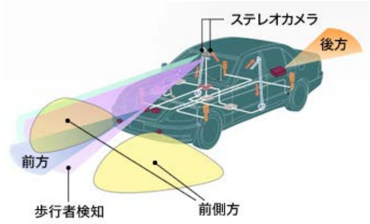


**SUBARU**

**Eyesight ver.2.0**

**VOLVO**

**HUMAN SAFETY**

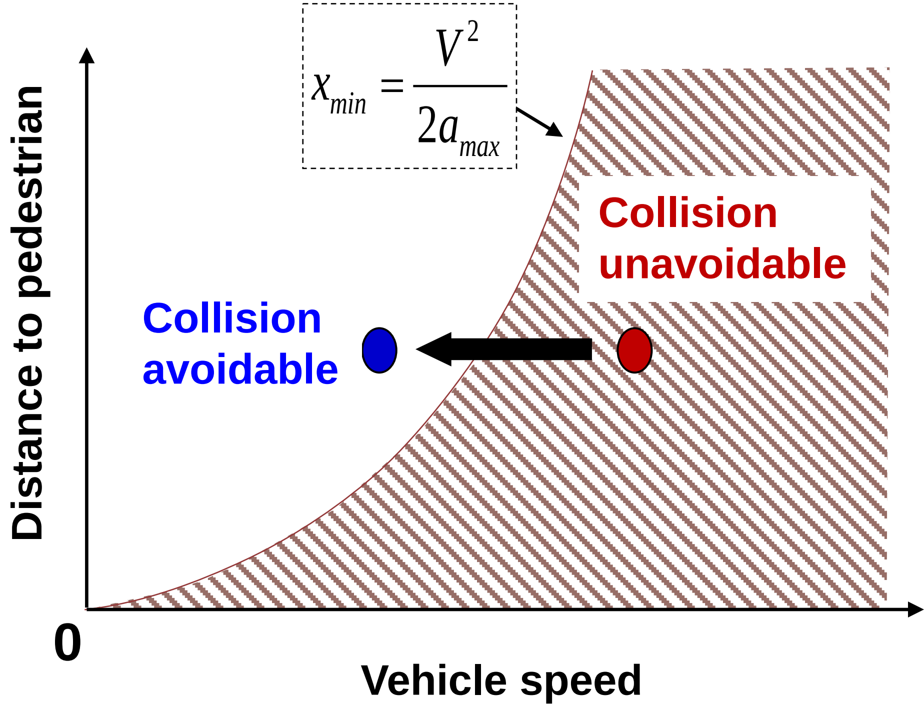



**TOYOTA**

**re-Crash Safety**

**Daimler**

**6D-Vision**



# Autonomous Emergency Braking without hazard anticipation

# Autonomous Emergency Braking
# with hazard anticipation

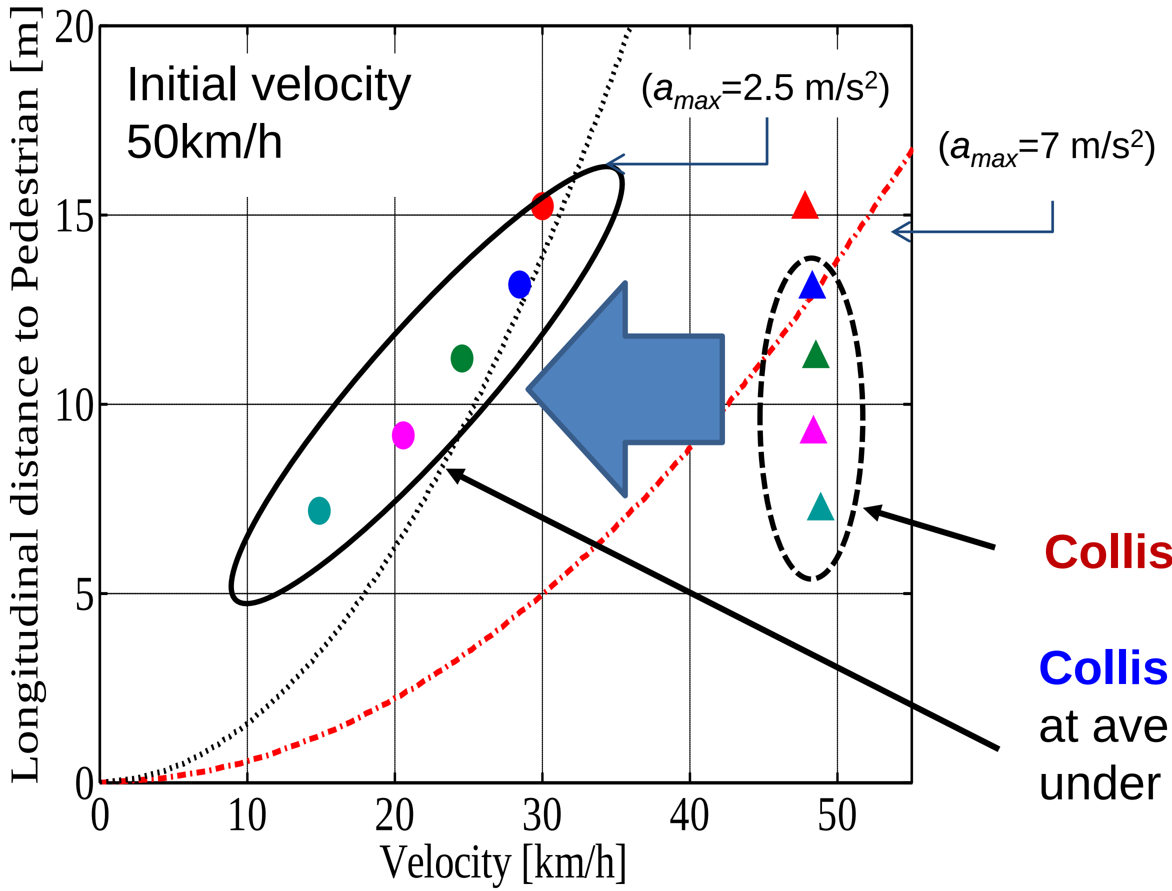
# Collision avoidance performance evaluation*

***: with a driving simulator in 'Tokyo University of Agriculture and Technology'**

## Varying the timing of pedestrian appearance:

●: $x_{ped}$ = 15m, ●: $x_{ped}$ = 13m, ●: $x_{ped}$ = 11m, ●: $x_{ped}$ = 9m, ●: $x_{ped}$ = 7m

● : Predictive Braking Assistance（PBA） ▲ : Automatic Emergency Braking（AEB）



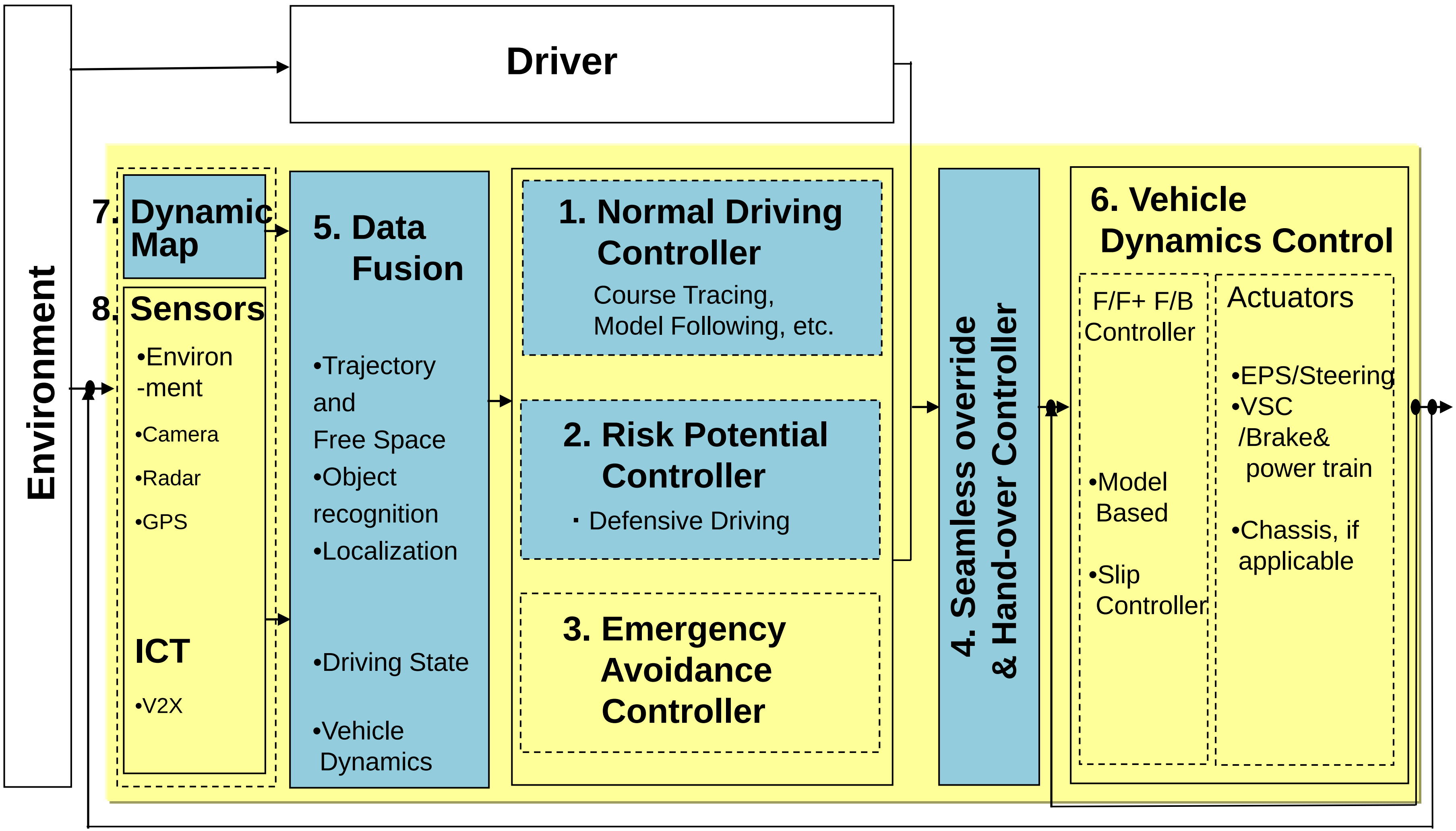

**Theoretical braking distance:**

$$x_{min} = \frac{V^2}{2a_{max}}$$

**Collision Unavoidable**

**Collision can be avoided** at average deceleration under 2.5m/s$^2$

# ADAS Control Structure in S-Innovation Project



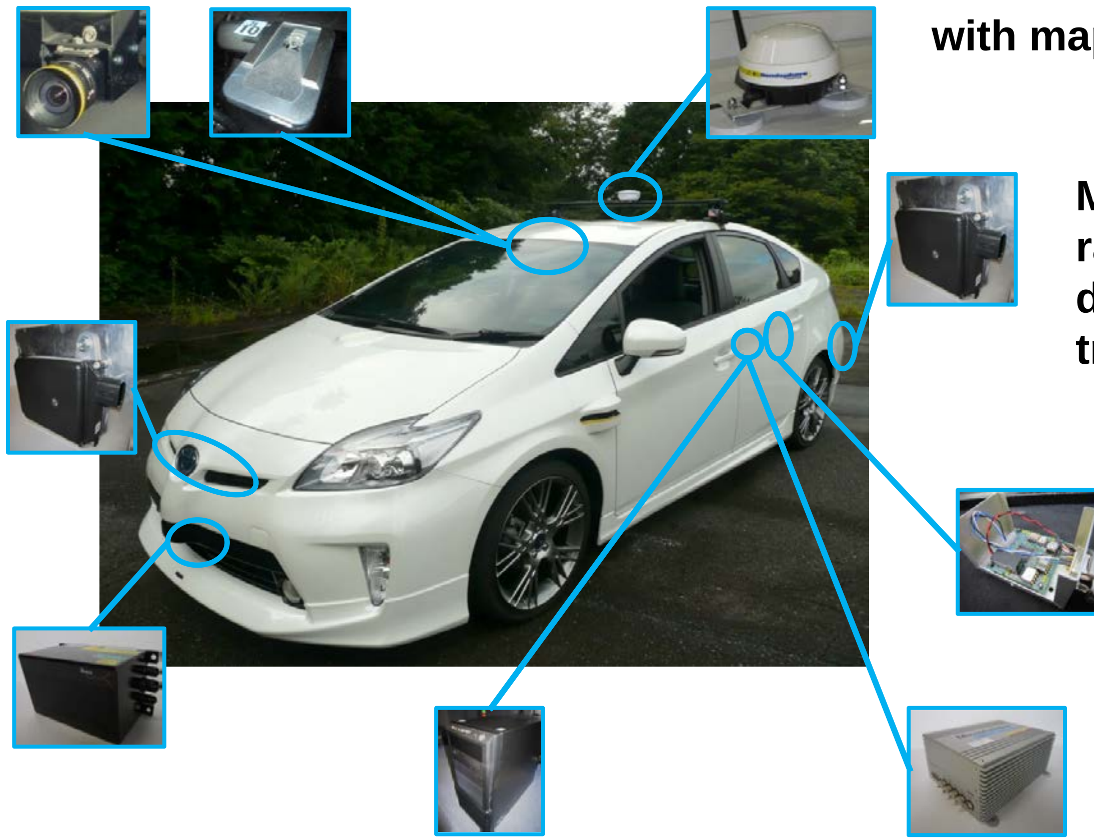

: new sections which need to be developed

# Experimental vehicle for FOT in Stage 2

Camera for detecting traffic lane

Monocular camera for identifying traffic participants and/or stop lines

DGPS for connecting with map information



Millimeter-wave radar for detecting traffic lane

Millimeter-wave radar for intersections with poor visibility

IMU for measuring vehicle behavior

Radar for detecting objects in twilight and/or at night

ROS system for integration of sensor information

DSP for controlling vehicle

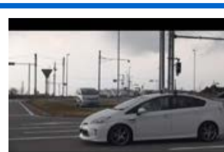
# FOTs of autonomous driving intelligence

## DS / Urban Test Sites for system validation

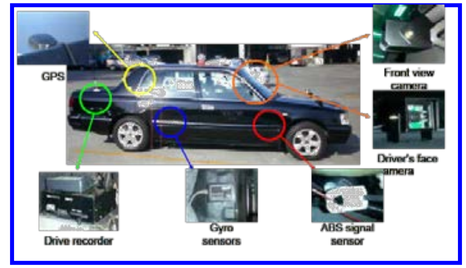
**Safety check on public roadways**
- **Crash-relevant scenario simulation in test sites**

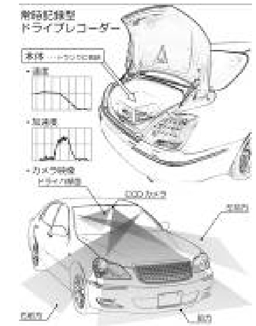
**Safety impact assessment in certain circumstances**

**Driving simulator study**
- **Driver acceptance study**
- **HMI investigation**
- **System parameter study**



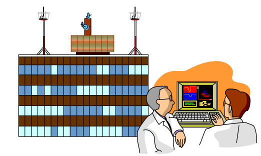
## Drive Recorder



## Field Operational Tests in Japan


**Test car driving data collection**



## Incident Data Base

- **Biometric data**
- **Fault diagnosis/Negative check**
- **Accident prevention effectiveness**
- **Hazard map construction**

## Conclusions:

✓ADAS with Autonomous Driving Intelligence has been studied to enhance safe and secured driving especially for elderly drivers in the aging society.

✓Proposed control structure is based on an expert driver model, consisting of normal driving, risk-predictive anticipatory driving, and emergency driving.

✓Prototype test vehicles are evaluated by DS (Driving Simulator) and urban test sites to avoid pedestrian collisions.

## Outlook:

✓FOT will be conducted on public roads to collect naturalistic driving behaviors, and environmental data to improve ADAS and HMI, by incident analysis.

# Contents

## Furthermore...

## SIP: Strategic Innovation Promotion program for ADS (Automated Driving Systems)

# SIP: Strategic Innovation Promotion program for ADS (Automated Driving Systems)

## Growing interest for automated cars in Japan

- June 2013: Japan's New IT Strategy published.
  - Requested to plan road maps across ministries
- Oct. 2013: ITS World Conference @ Tokyo
  - Japan's automakers disclosed their development plans.
- Nov. 2013: First testing on public roads
  - Prime Minister Abe was in the car.


## 2014 as a starting year of ADS in Japan

**Source: Ichikawa, ITS World Congress 2013**

# ADS: Automated Driving System nominated in SIP

✓A new cross-ministry Strategic Innovation Promotion (SIP) program in JFY2014 was **launched by the Japanese government**.

✓10 candidate technology fields including "Automated driving system" for accident reduction, mobility and environment improvement, were selected.

✓Total SIP budget in JFY 2014 is **50 billion Japanese yen** (500 million US dollars), and **2.5 billion yen** (25 mil. US dollars) for automated driving system.

# Definition of automation level in SIP

: commercial viability : plan

| | | |
|---|---|---|
| **Full-automated** driving system | Level 4 | Acceleration, steering and braking are conducted except by a driver. **A driver has no involvement**. — Late 2020's |
| **Highly automated** driving system | Level 3 | Acceleration, steering and braking are conducted by a vehicle. **A driver corresponds during an emergency only**. — Early 2020's — Airplane Shinkansen |
| | Level 2 | Acceleration, steering and braking are operated by a vehicle simultaneously. — 2017- |
| Safe driving support system Independent control | Level 1 | AEB, LDW — ACC, LKS |
| No driving supports Warning only | Level 0 | Warning |

# SIP for ADS, R&D items

✓Development & verification of ADS technologies

**“Dynamic Maps (Mapping Data Infrastructure)”, prediction based on IT (cooperative technologies), sensing technologies, drivers’ model (human factors), system securities**

✓Basic technologies

**National DB of traffic accidents, data analysis and simulations technologies, visualization of CO2 emissions**

✓International cooperation

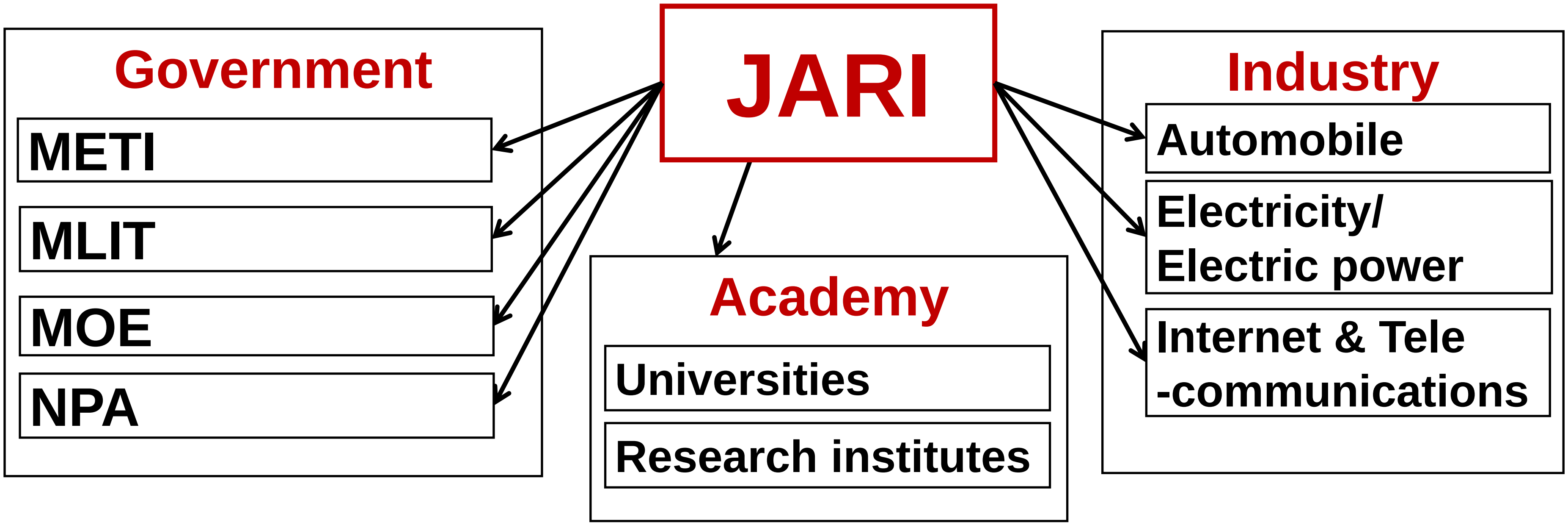
**Open research facilities, social acceptance, package type ITS infrastructures export strategy**

✓Next generation urban transport

**Enhanced local traffic management, next generation transport system (through Tokyo Olympics/Paralympics)**

# JARI's stance in SIP for ADS

**JARI is positioned between the government and industry. Utilizing this unique neutral position, JARI has been contributing to policy making for government and to common problem solutions for industries.**




**METI: Ministry of Economy, Trade and Industry**
**MLIT: Ministry of Land, Infrastructure, Transport and Tourism**
**MOE: Ministry of the Environment**
**NPA: National Police Agency**

## Remaining issues

**Over the past decade, many automated driving systems have been researched and developed. Manufacturers are increasingly focusing on ADAS and Automated Driving Systems in new model cars.**

**However, there are still many technical and non-technical issues, such as legal and public acceptance, etc. to overcome so that harmonization between each sectors and regions are needed.**

# Thank you for your attention.

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**Tel: +81-3-5733-7921**

# System requirements from elderly drivers' interview

| Elderly drivers' characteristics | System functionality requirements |
|---|---|
| When using **only a warning system**, the ratio of elderly drivers who cannot completely avoid collisions increases. | The system needs to **assist by vehicle control intervention**, such as autonomous braking. |
| People older than 65 years have **a narrower effective field of view**, from the recognition ability survey. | The environment perception and recognition function **with wide range and field of view** is requisite. |
| Situations which elderly drivers are not good at, such as **driving in reverse and parking**, increase. | **Emergency assist function for pedal misapplication**, with obstacle detection is necessary. |
| Elderly drivers still have **high motivation to drive**. Their driving ability is good thanks to their experience. | Driverless vehicle technology is not needed, but **shared driving between the driver and the system** must be developed. It is important to assist drivers adapt to their driving states. |