HIRAOKA LAB.

[Design Methodology of Human-Centered Systems]

Vehicle Dynamic Control and Strategy of Automated Driving

Human-Machine Systems

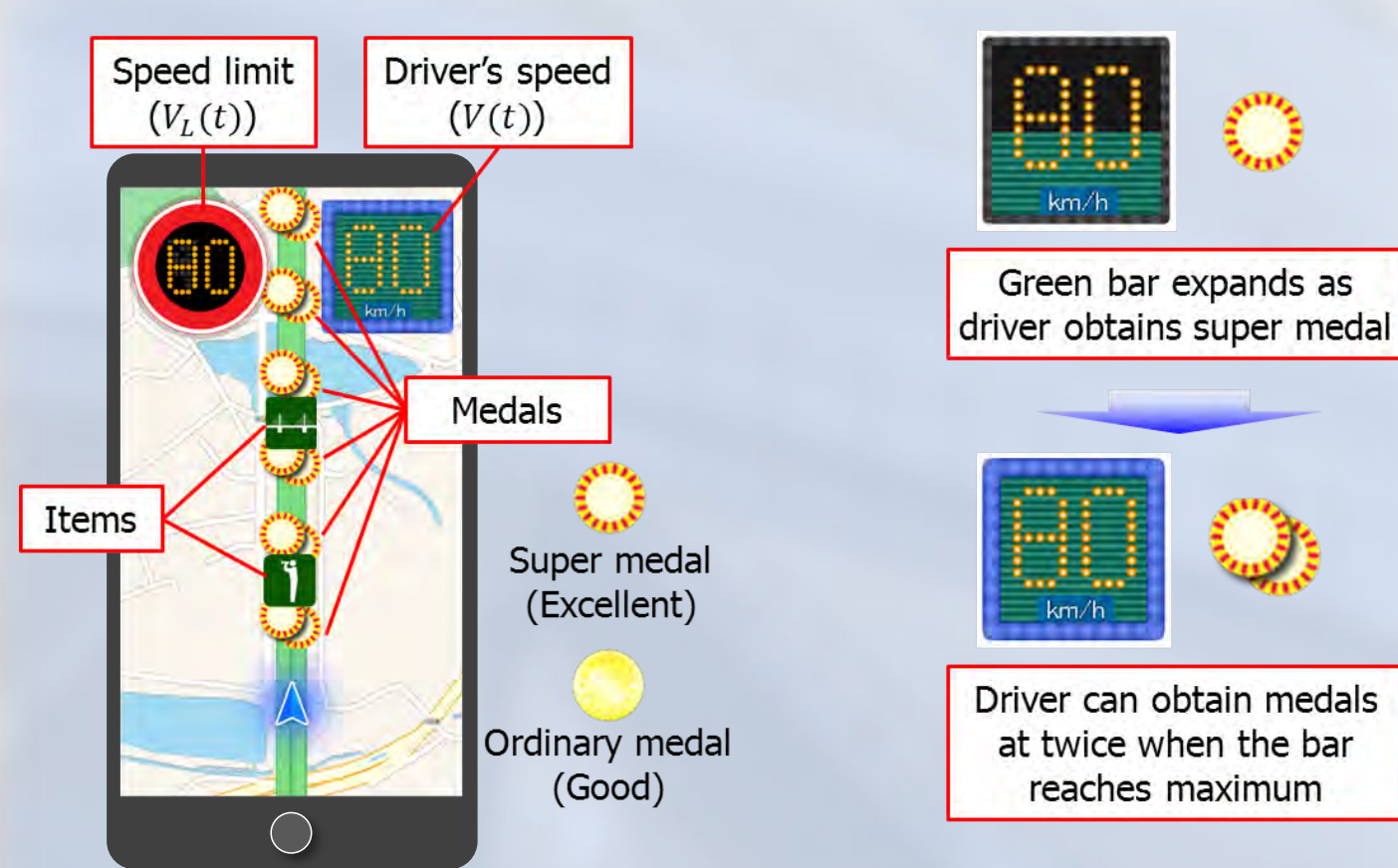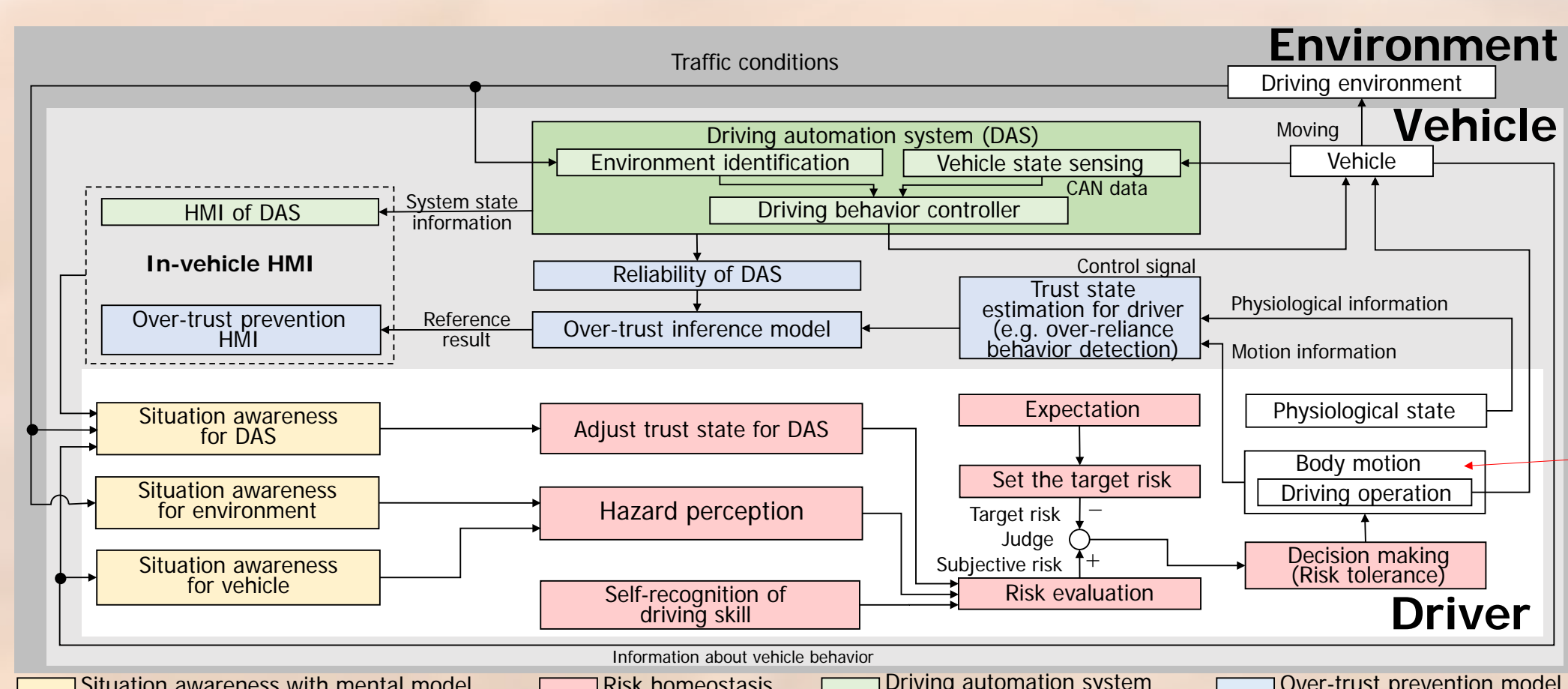Department of Mechanical and Biofunctional Systems

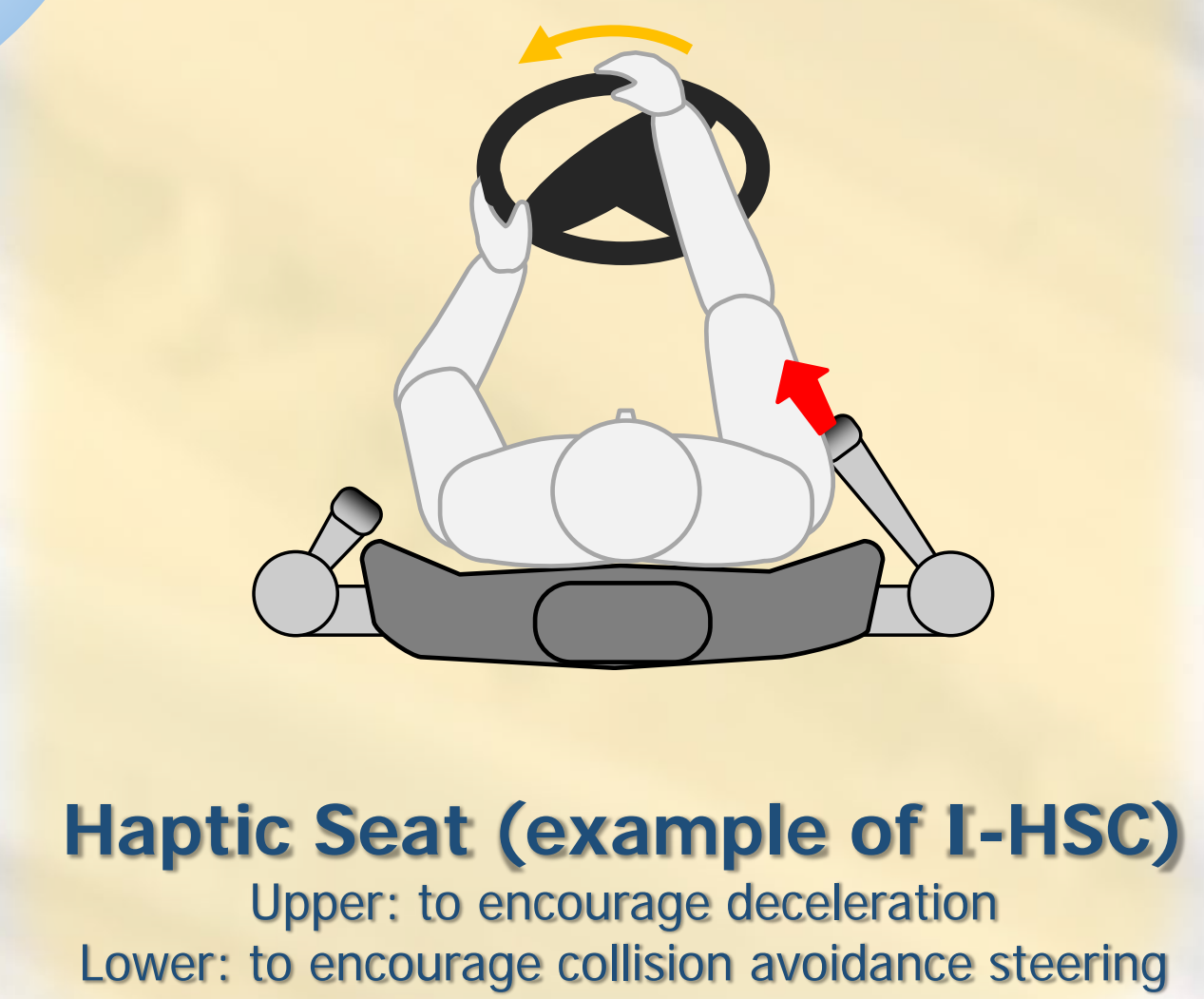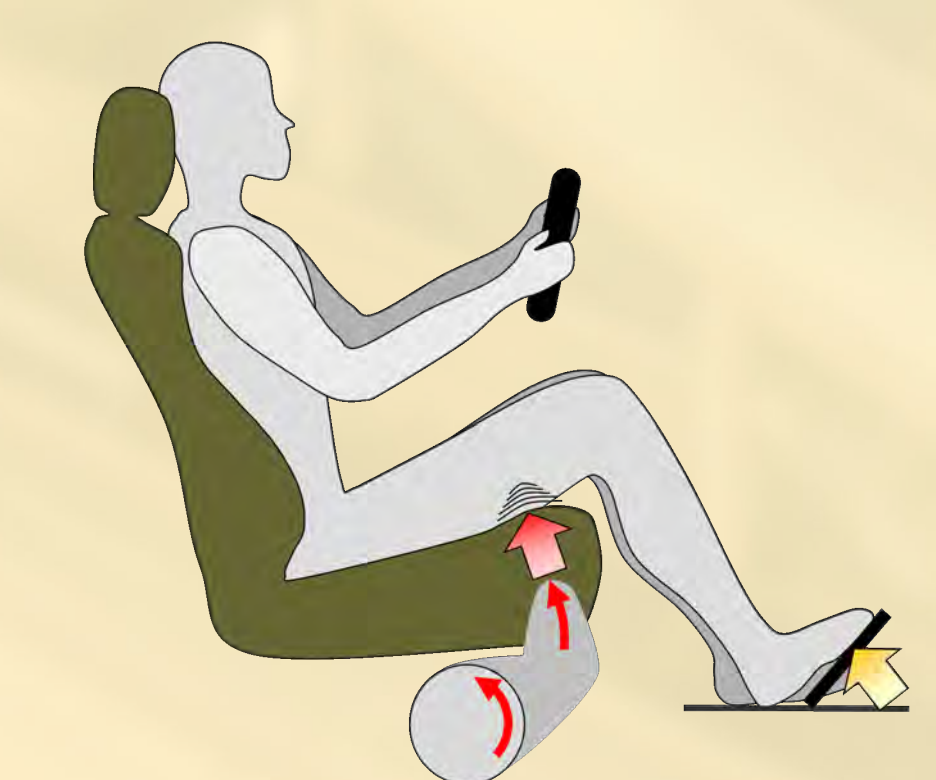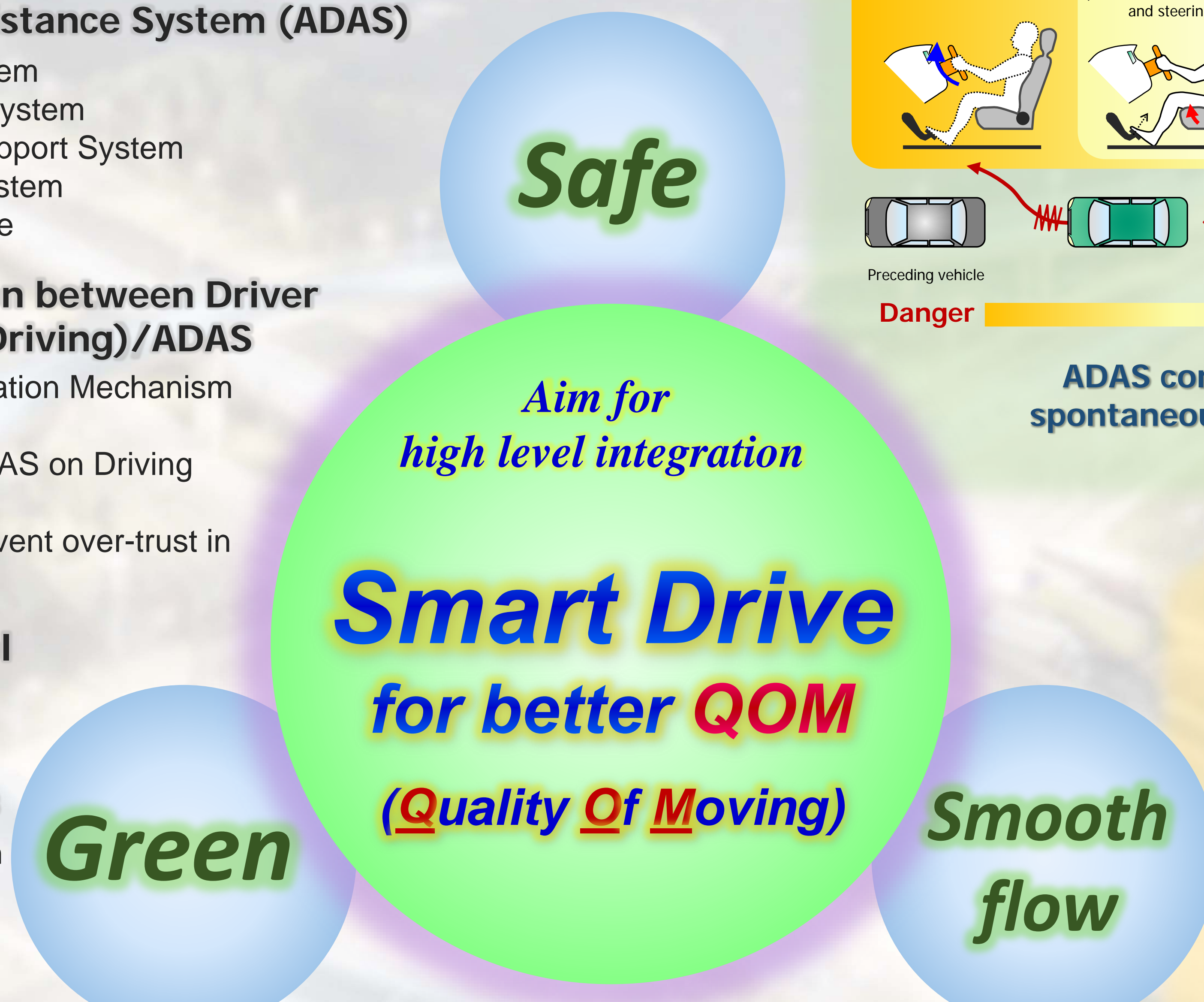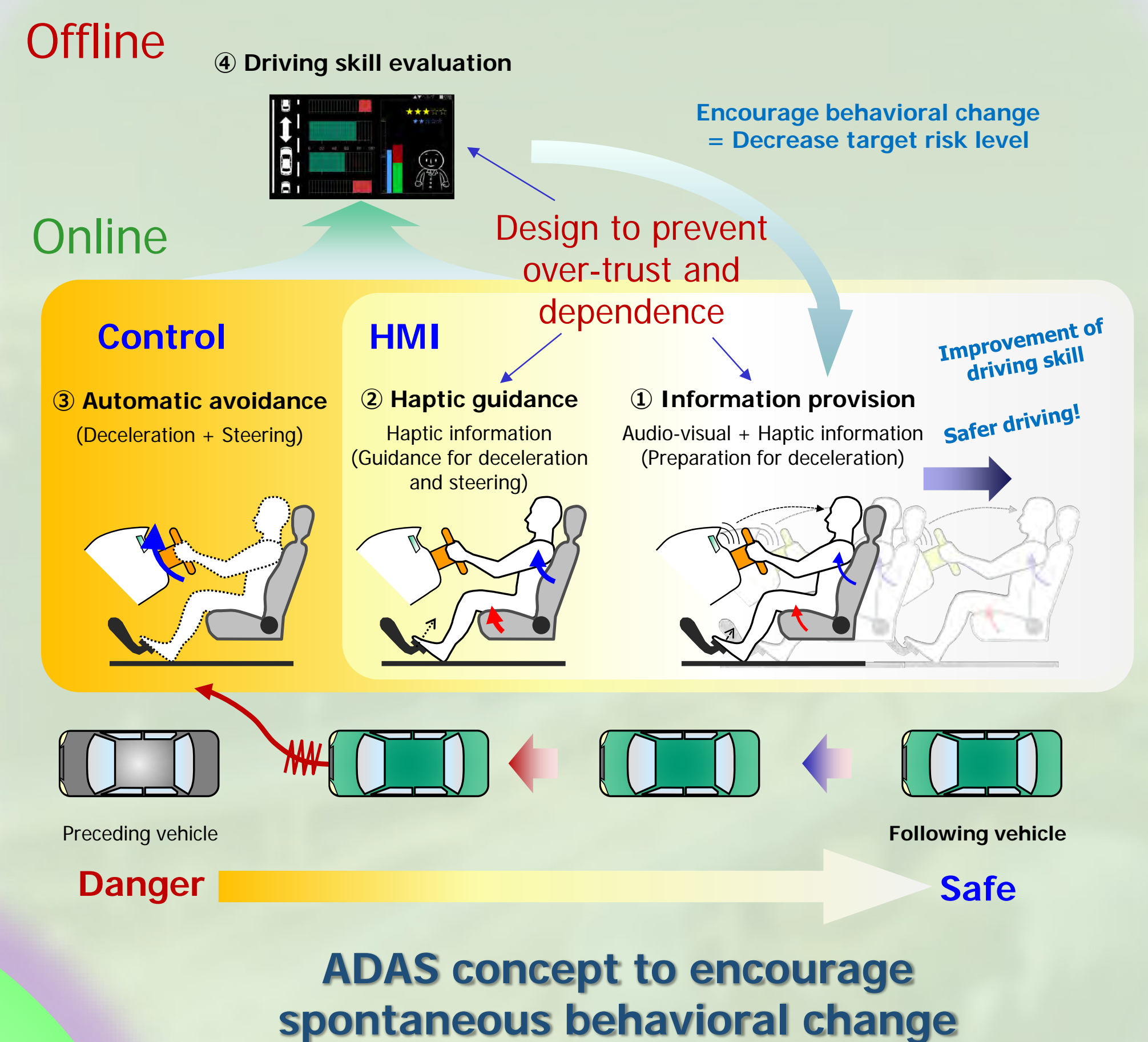https://sites.google.com/site/toshihirohiraoka/

One of the most representative human-machine systems in daily life is a driver-vehicle system. To achieve a safer, more comfortable, and more efficient traffic environment, we have to optimize the whole system including driver-vehicle-road in addition to improving vehicle performance. Consequently, my current research goal is to **establish a design methodology of the driver-vehicle system to improve QOM (Quality Of Moving)**.

Vehicle Dynamic Control

- **Control System Design Robust to Disturbances and Modeling Errors**
  - Automatic Path Tracking Control for Four-Wheel Steering Vehicle
  - Active Four-Wheel Steering Control

HMS (Human-Machine System)

- **Advanced Driver-Assistance System (ADAS)**
  - Eco-Driving Support System
  - Safe Driving Evaluation System
  - Wakefulness-Keeping Support System
  - Smooth Driving Assist System
  - Expressway Driving Game

- **Analysis of Interaction between Driver and AD (Automated Driving)/ADAS**
  - Modeling of Trust Generation Mechanism for AD/ADAS
  - Impact of Trust in AD/ADAS on Driving Behavior
  - Countermeasures to prevent over-trust in AD/ADAS

- **Haptic Shared Control**
  - Direct HSC (D-HSC)
  - Indirect HSC (I-HSC)

- **Collision Risk Indices**
  - Deceleration for Collision Avoidance (DCA)
  - Lateral Acceleration for Collision (LACA)

Safe

Aim for high level integration

Smart Drive
for better QOM
(Quality Of Moving)

Green

Smooth flow

Offline
④ Driving skill evaluation

Online

Encourage behavioral change = Decrease target risk level

Design to prevent over-trust and dependence

Control	HMI		Improvement of driving skill
③ Automatic avoidance (Deceleration + Steering)	② Haptic guidance Haptic information (Guidance for deceleration and steering)	① Information provision Audio-visual + Haptic information (Preparation for deceleration)	Safer driving!

Preceding vehicle — Following vehicle

Danger → **Safe**

ADAS concept to encourage spontaneous behavioral change

Trust generation mechanism model for AD/ADAS

Traffic conditions

Environment
Driving environment

Driving automation system (DAS)
Environment identification
Vehicle state sensing
Driving behavior controller
CAN data

Vehicle
Moving
Vehicle

HMI of DAS
System state information
Reliability of DAS

In-vehicle HMI
Over-trust prevention HMI
Reference result
Over-trust inference model

Control signal
Trust state estimation for driver (e.g. over-reliance behavior detection)

Physiological information
Motion information

Situation awareness for DAS
Adjust trust state for DAS
Expectation

Situation awareness for environment
Hazard perception
Set the target risk

Situation awareness for vehicle
Self-recognition of driving skill
Target risk
Judge
Subjective risk
Decision making (Risk tolerance)
Risk evaluation

Physiological state
Body motion
Driving operation

Driver

Information about vehicle behavior

Situation awareness with mental model | Risk homeostasis | Driving automation system | Over-trust prevention model

Expressway Driving Game

Speed limit $(V_L(t))$
Driver's speed $(V(t))$

Medals

Green bar expands as driver obtains super medal

Items

Super medal (Excellent)

Ordinary medal (Good)

Driver can obtain medals at twice when the bar reaches maximum

Haptic Seat (example of I-HSC)
Upper: to encourage deceleration
Lower: to encourage collision avoidance steering

Background Photo was Designed by fanjianhua / Freepik