

The Idea of “Driver in the Loop” in Advanced Driver Assistance Systems

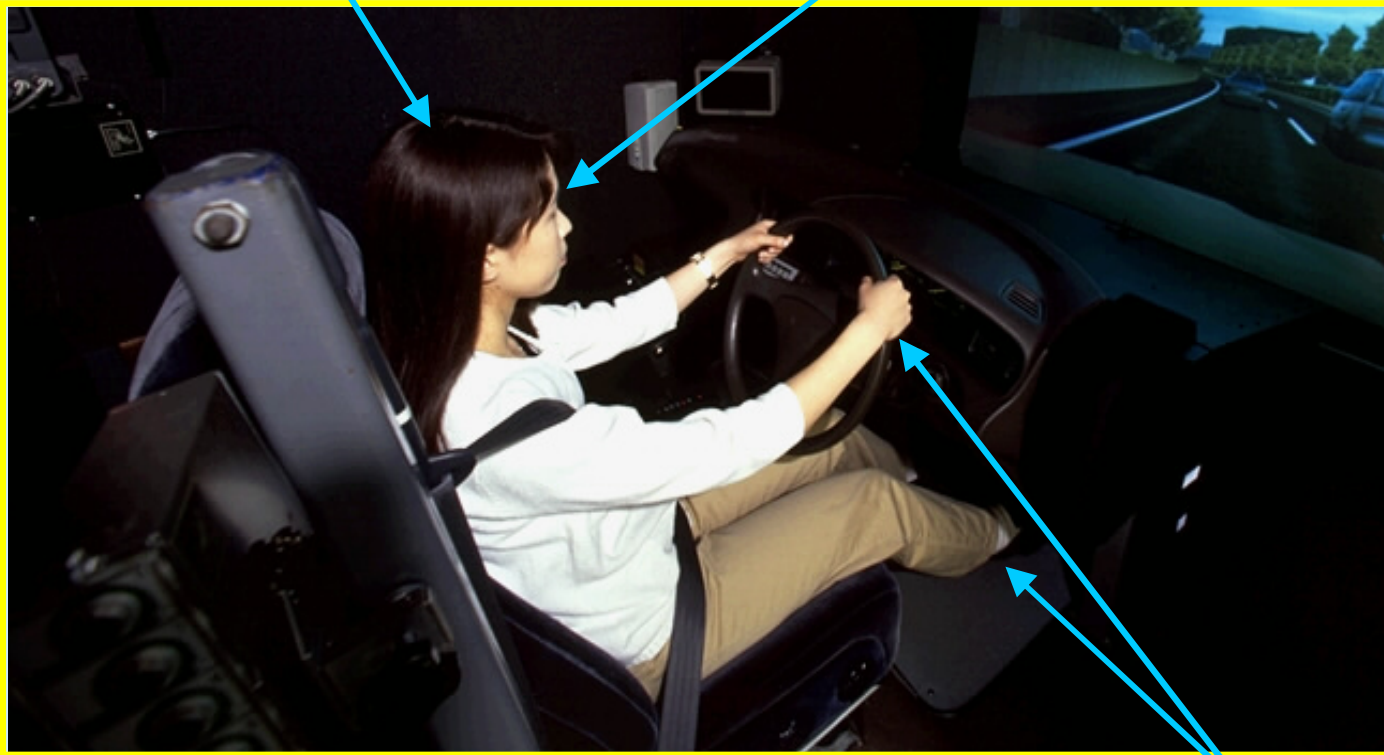
**UNECE/WP29/ITS Informal Group
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Driver Behavior in Car Driving

Judgment

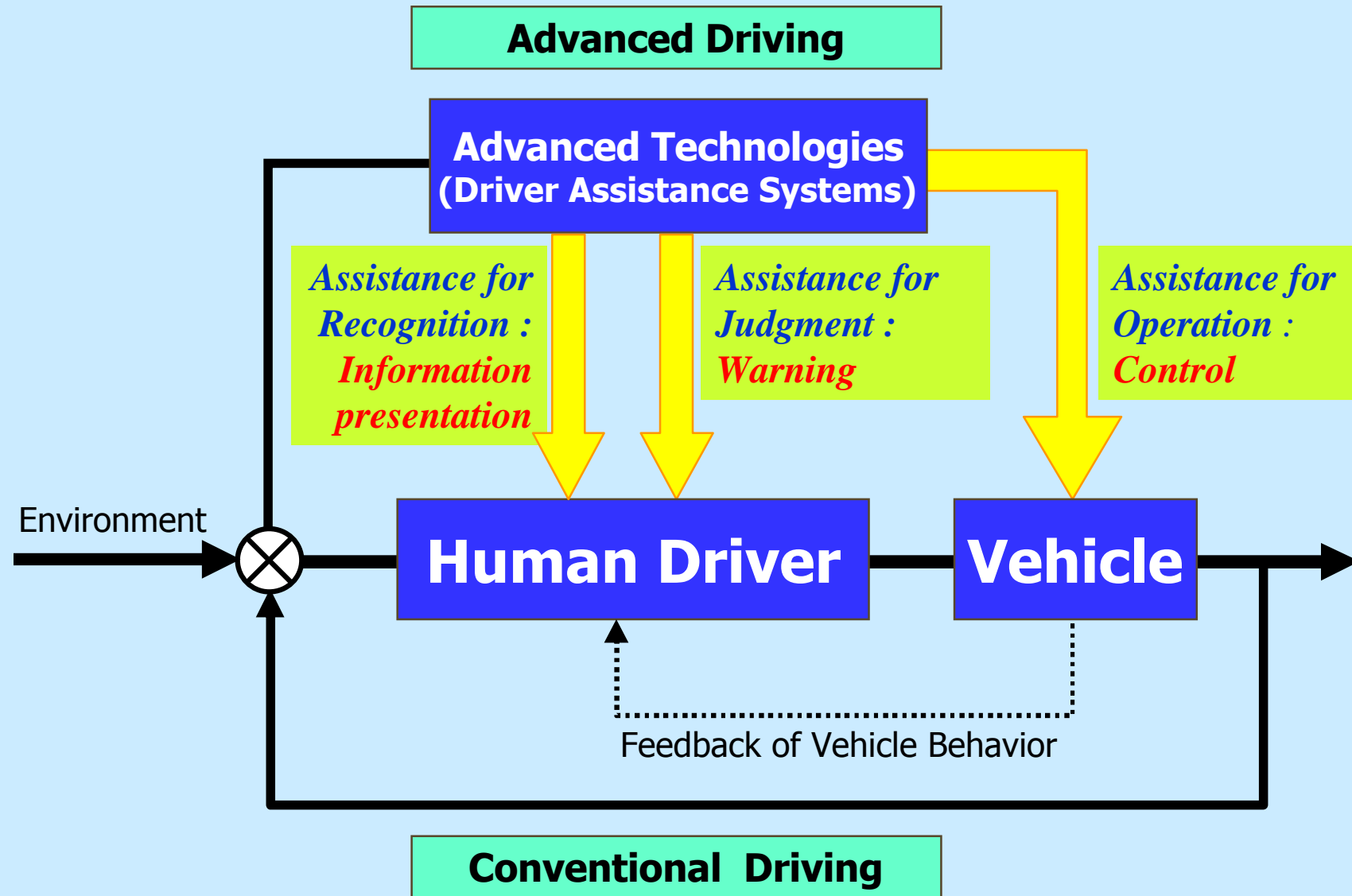
Recognition



Operation

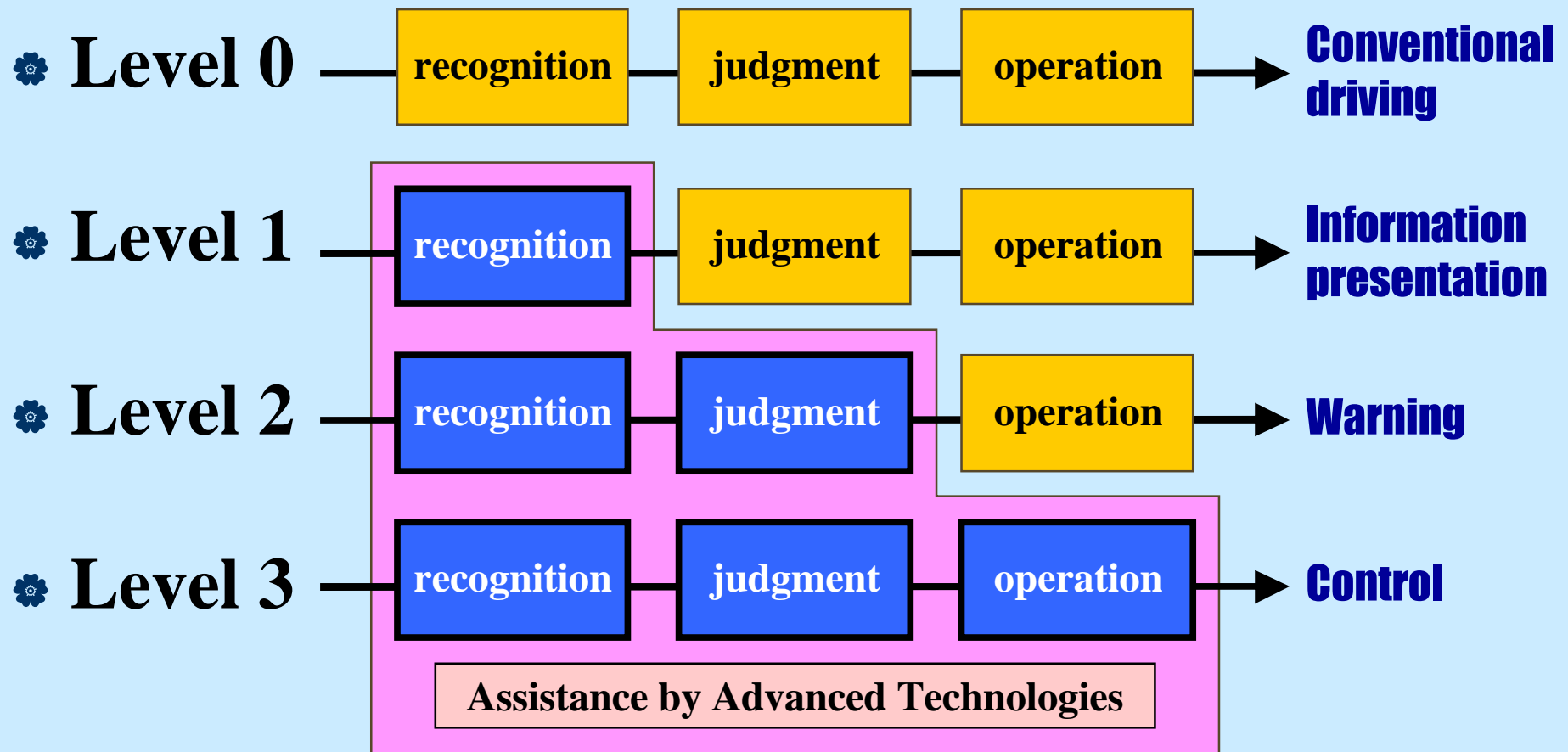
It is widely recognized that human errors are contributing factors to traffic crash.

Block Diagram for Conventional and Advanced Driving



Behavioral Model of a Driver and Level of Driver Assistance

Behavioral Model of a Driver

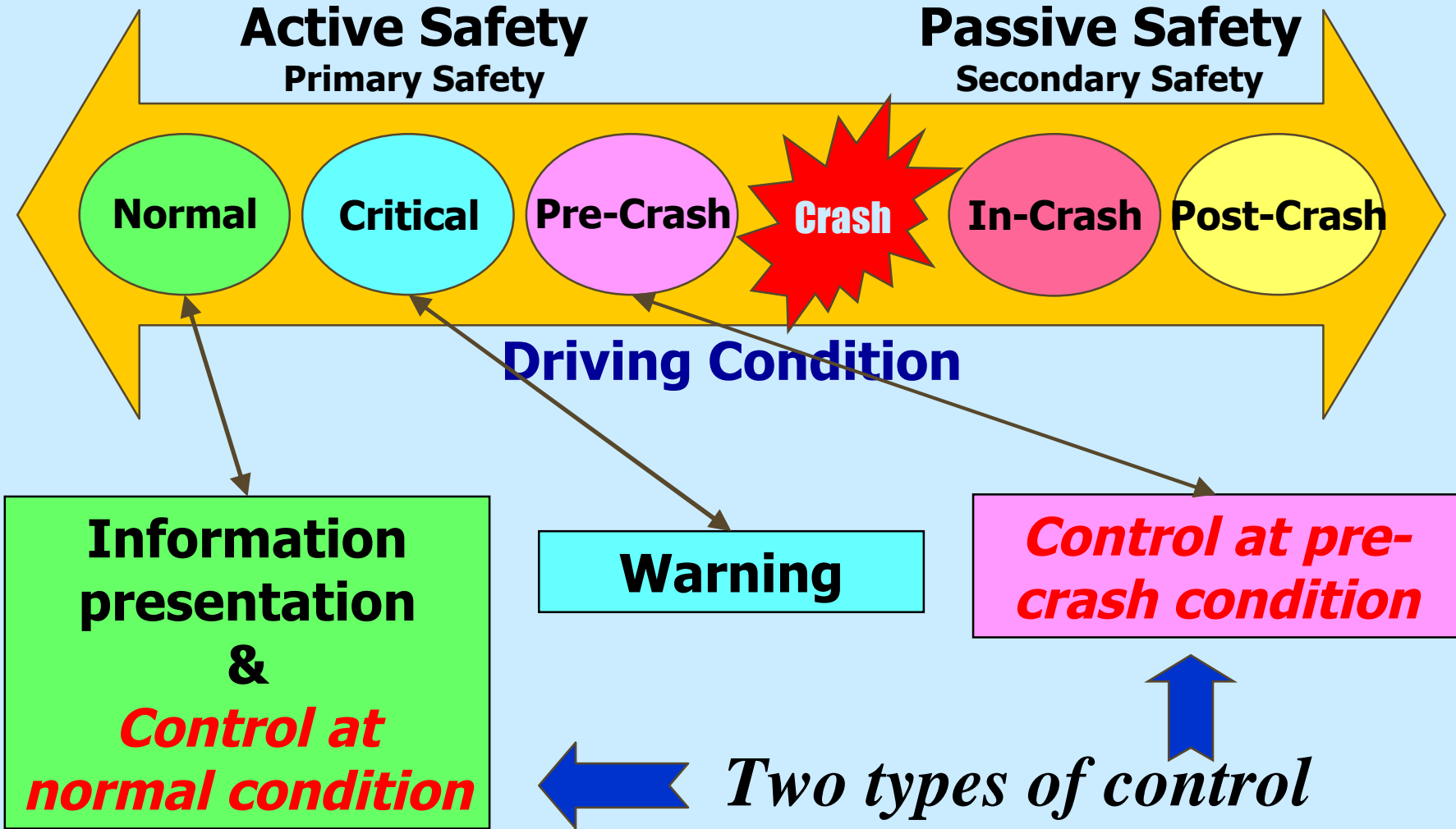


Description of Driver Assistance

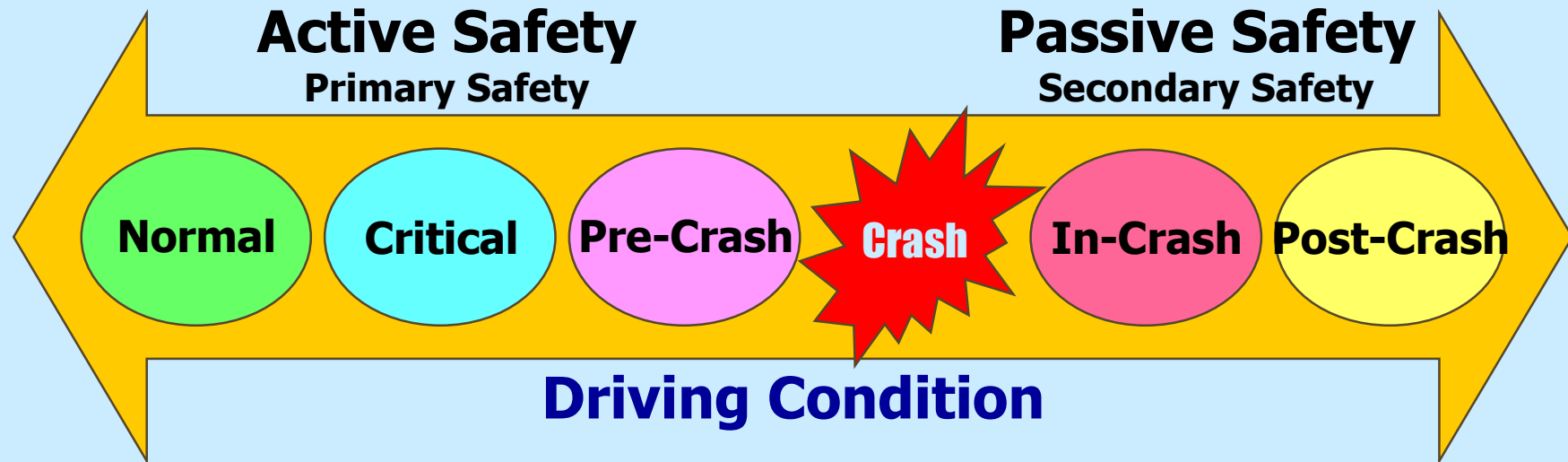
- ◆ ***Information Presentation*** : Providing information using symbols, text, etc.
⇒ ***Navigation System etc.***
- ◆ ***Warning*** : Providing timely information so as to avoid critical situation ⇒ ***Forward Collision Warning etc.***
- ◆ ***Control*** : Applying active braking, accelerating and/or steering to improve convenience and to reduce crash severity
⇒ ***ACC, Forward Collision Damage Mitigation Braking System etc.***



Driver Assistance according to Sequence of Driving Condition



Characterization of Control



- 1. Control for normal driving condition** : For example running in express way for a long time, control for convenience improvement (load optimization) is effective.
- 2. Control for pre-crash driving condition** : For example rear-end collision to forward vehicle, and if there is no driver evasive action, control for severity reduction (crash mitigation) becomes crucial.

Features of Two Types of Control

1. Convenience improvement (load optimization)

- The idea of “**driver in the loop**” means a driver must be involved in car driving.
- This implies the responsibility of car driving attributes to a human driver.
- Because of driver’s involvement in car driving, a driver will not be overly dependent on system.

2. Severity reduction (crash mitigation)

- Warning is given, but a driver misses it and there is no driver evasive action.
- **At this final moment**, system will activate to mitigate crash severity, i.e. mitigation braking etc.
- Because of its final moment activation, there would not cause driver overly dependence to system.

Driver in the Loop

Points to be addressed

◆ Driver involvement in car driving

- A driver shall be involved in car driving. When there is no driver operation for a certain length of time or so on, advanced assistance system shall be released and **control mode shall get back to conventional driving.**

◆ Driver override

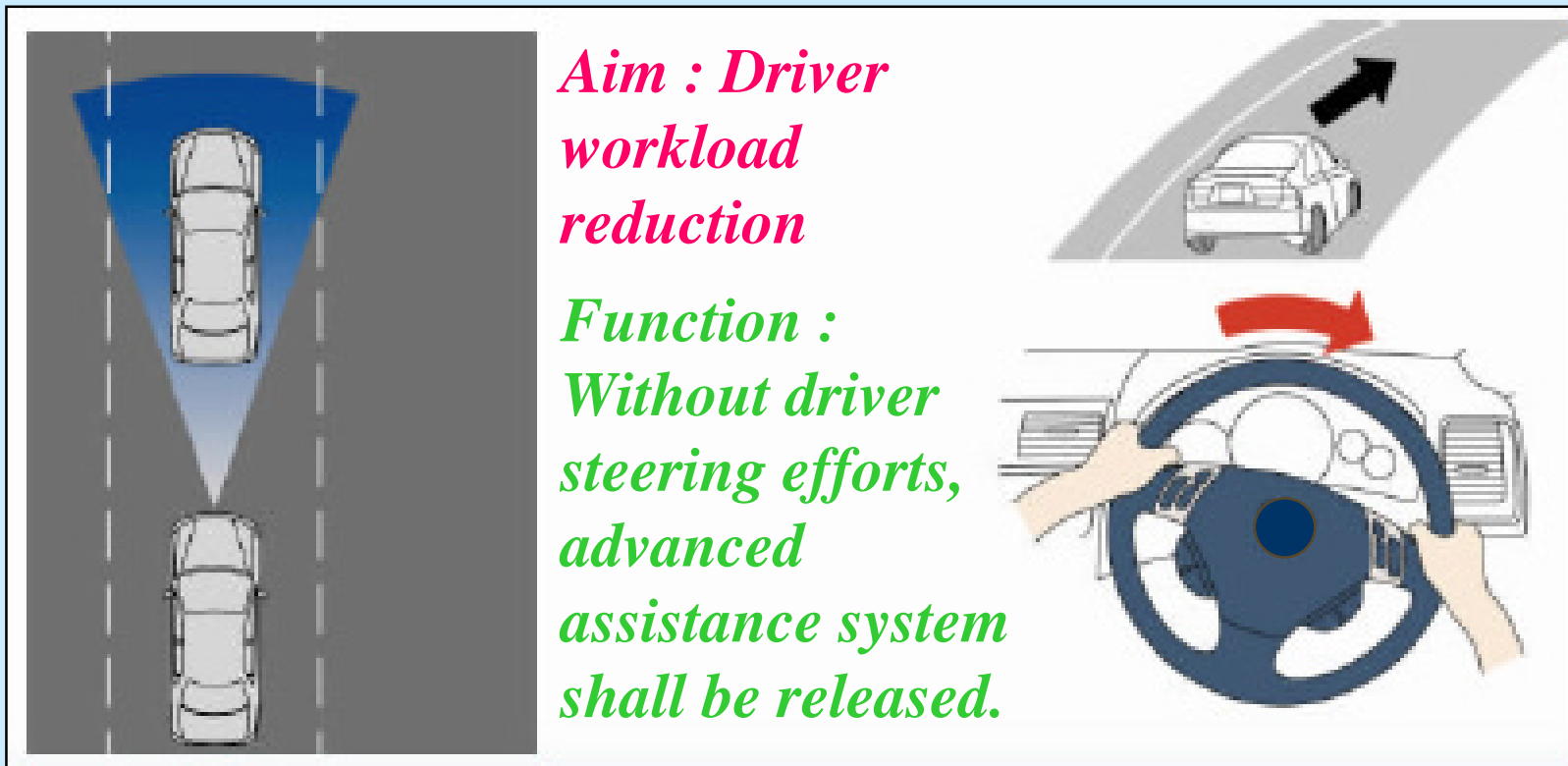
- Even if active braking, accelerating and/or steering are activated, once a driver moves into willing action to control a vehicle, **advanced assistance system shall be overridden by a driver at any time.**

Driver in the Loop

Example

Adaptive Cruise Control system + Lane Keep Assist System

A. Iihoshi, WP29/ITS RT, Feb. 2004



ACC : Controlling vehicle speed & headway distance

LKAS : Steering assistance to keep vehicle in the center of its lane

Concluding Remarks

- ◆ Advanced technologies could be effective to improve driving convenience, reduce crash risk and mitigate crash severity. These technologies are generically called as “**Driver Assistance Systems**”.
- ◆ Driver assistance systems can be classified into three levels such as “**Information Presentation**”, “**Warning**” and “**Control**”, being compatible with human driver behavior.
- ◆ Rules and/or guidelines on information presentation are established and used among the regions voluntarily as **self-commitment**. On the other hand, there are **no specific rules on warnings** at the moment.
- ◆ On control, there could be two approaches; one is control for mitigating crash severity **at pre-crash driving condition**, and the other is control for improving convenience **at normal driving condition** where the idea of “**Driver in the Loop**” becomes important.

Next Step : Driver in the Loop

A goal of IHRA-ITS WG : To develop test procedures to assess driver-vehicle interaction as a means for determining the safety potential of ITS crash avoidance and driving enhancement for in-vehicle systems

Items to be clarified

- ◆ **Presence (or absence) of driver operation in car driving ⇒ Long term**
- ◆ **Transition of control behavior from system to human driver once system is released or fails ⇒ Short term**
- ◆ **Driver override ⇒ Short term**