

The Driver - Vehicle - Environment Model

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Summary



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AIDE final workshop and exhibition April 15-16, 2008, Gothenburg

- Overview on Joint Driver Vehicle Environment models (DVE)
- Global and Embedded DVE
- Review of existing Joint DVE
- Selection of the most suitable for AIDE requirements
- AIDE Global DVE model (G_DVE)
- AIDE Embedded DVE model (E_DVE)
 - Driver model
 - Vehicle model
 - Environment model
- Computational numeric simulation of the DVE



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Joint Driver Vehicle Environment (DVE) model: overview



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The model is based on the concept of a **“joint” cognitive system**:

- The dynamic interactions between Driver, Vehicle and Environment are represented in a harmonized and integrated manner
- The interactions between Driver-Vehicle-Environment are presented in a simplified way to enable fast computing
- Essential correlations between the independent variables
- Driver behavior prediction in dynamic and rapidly changing conditions



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Global and Embedded DVE



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- **G_DVE (Global DVE):** will support designers to predict the behaviour of the joint DVE system. It represents the theoretical generalization of the DVE model.
- **E_DVE (Embedded DVE):** it will be part of the computerized numerical simulation of the DVE (the SSDrive system).



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Review of existing Joint Driver Vehicle Environment models



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- Selection from the literature of the most suitable candidate Joint DVE model from a list of 21.
- **Model requirements for AIDE's Global and Embedded DVE:**
 - the model should be able to predict driver performance;
 - the model should be able to account for multiple, simultaneous activities;
 - the model should be recursive and capable of describing one or more of the interactions between driver, vehicle and environment, or between all three.



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DVE model candidate list

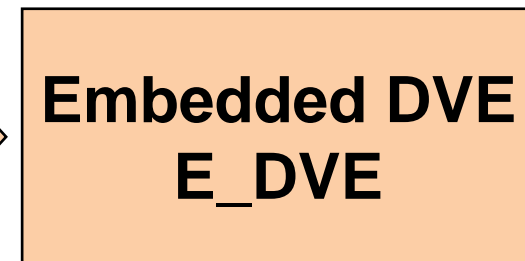


Selected Joint models for Global and Embedded DVE

- **COCOM/ECOM (Contextual Control Model / Extended Control Model):** a qualitative model for Driver-in-Control (DiC) based on the principles of cognitive systems engineering.



- **IVIS DEMANd:** In-Vehicle Information System Design Evaluation and Model of Attentional Demand.

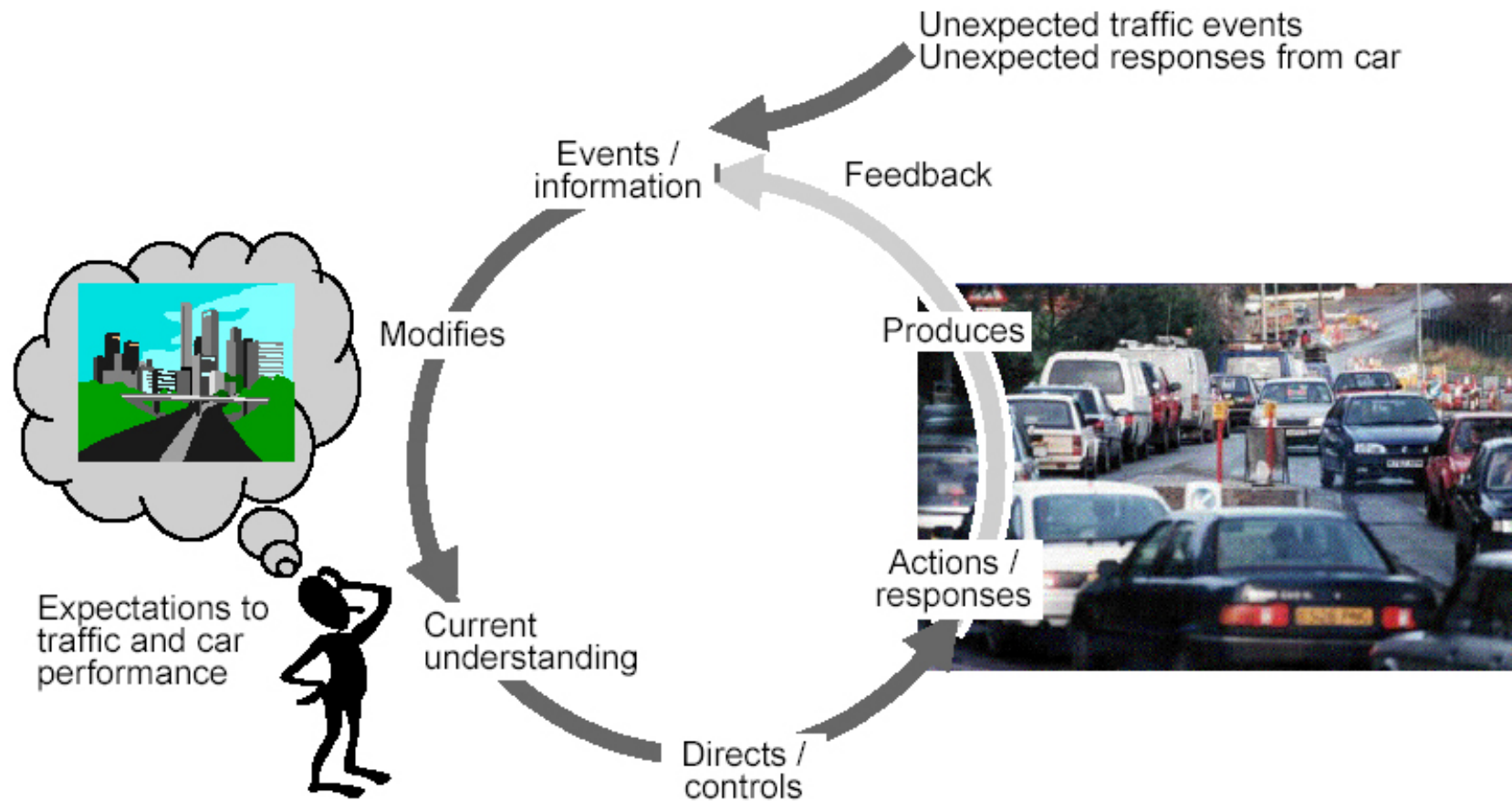


AIDE Global DVE model (G_DVE)



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AIDE Embedded DVE (E_DVE)



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Driver Model

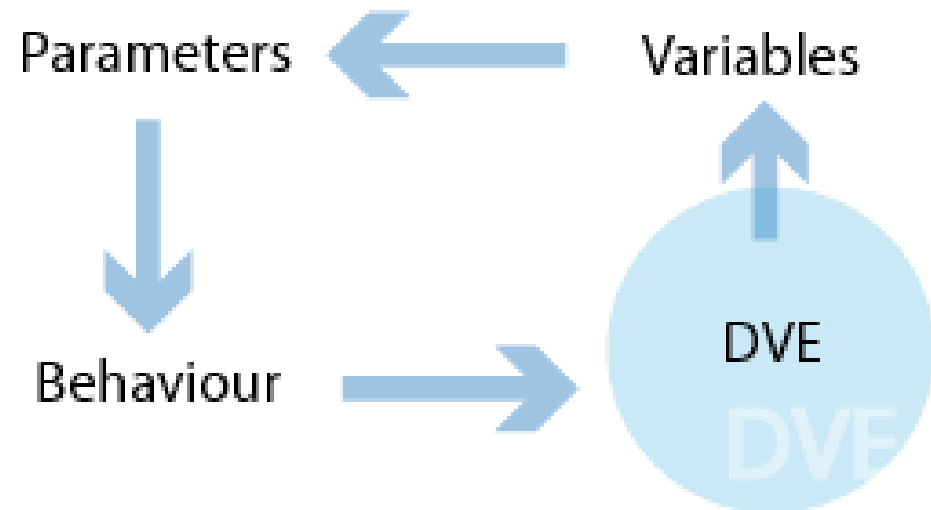
- Tasks
- Parameters and fuzzy correlations
- Simple Model of Joint Cognitive System

Environment

- Road characteristics
- Presence of other vehicles
- Other vehicle, pedestrians, etc.

Vehicle

- Simple model
- ADAS and IVIS simple description



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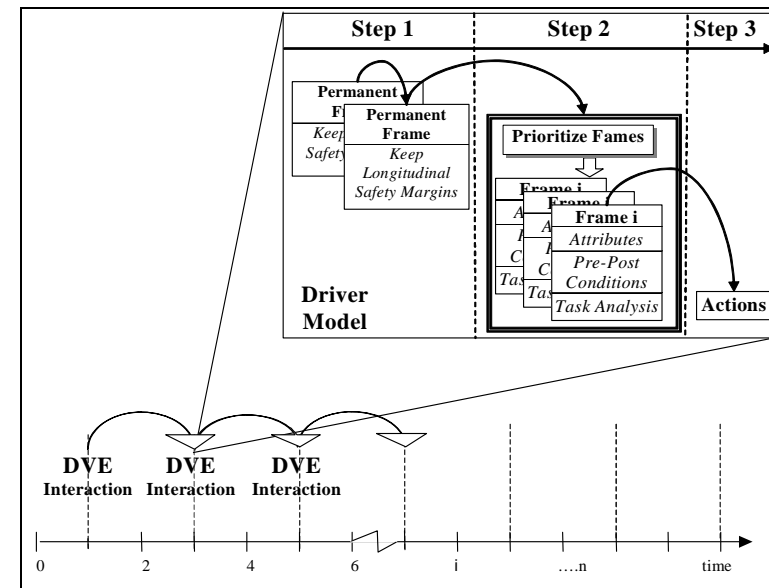
Driver model 1/3



Based on the IPS (*Information Processing System*) approach.

Each instant, drivers follow these tasks (drivers' decision making):

- Attain higher speed, attain lower speed, stop vehicle, turn left, turn right, change lane, overtake, maintain speed
- Permanent tasks: keep lateral safety margins, keep longitudinal safety margins
- Normative and descriptive driver behaviour.



Driver model 2/3



Main parameters describing the Driver model:

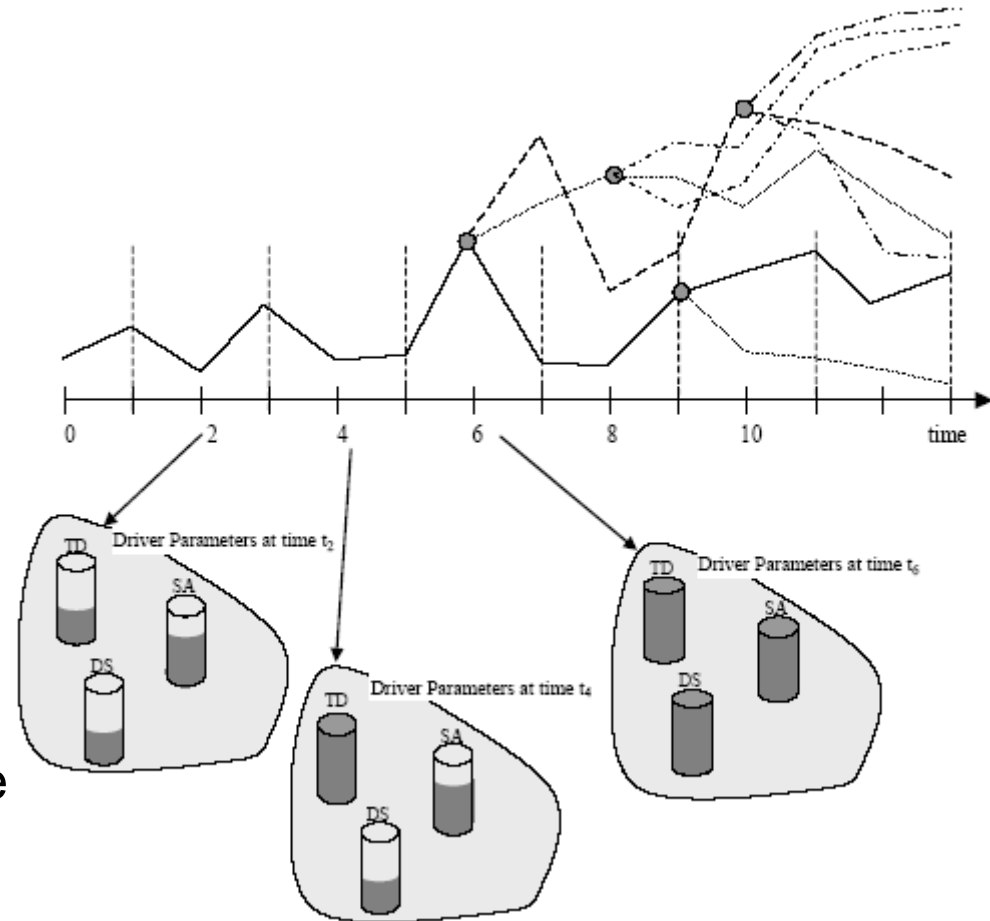
- **Experience:** accumulation of knowledge or skills that result from direct participation in the driving activity
- **Attitude:** a complex mental state involving beliefs and feelings and values and dispositions to act in certain ways.
- **Task Demand (TD):** parameter describing drivers' cognitive effort spent during the driving task.
- **Driver State (DS):** driver physical and mental ability to drive.
- **Situation Awareness/Alertness (SA):** perception of the elements in the environment within a volume of time and space the comprehension of their meaning and the projection of their status in the near future.



Driver Model 3/3



- Basic Indicators of Driver Operational Navigation (BIDON Model): mechanism that used to describe driver's error and behaviour in relation to the basic parameters.
- Drivers' Error Making : the error generation process is essentially associated to a single parameter called Drive Error Propensity (DEP)



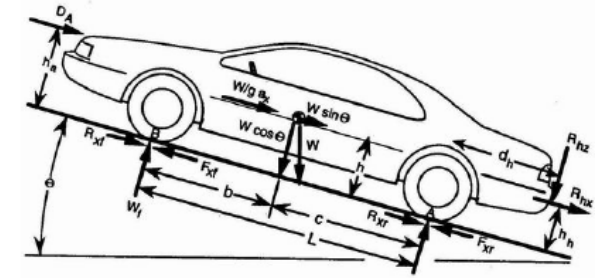
Vehicle model



Main signals describing the dynamic and interaction of the vehicle model.

- ▣ **Primary task signals:** Speed, Steering angle, Yaw-rate, Number of Brakes, Accelerator pedal position (or throttle information), etc.

- ▣ **Signals from external sensors and secondary tasks:** Lateral position and number of Line Crossing, Headway, Time-To-Collision, GSM Module, Vocal module, Navigation system, etc.



$$m \cdot a_x = F_x - R_x - D_A - F_{brake} - W \cdot \sin \vartheta$$

Longitudinal vehicle model equation

$$\begin{bmatrix} \dot{v}_y \\ \dot{\psi} \end{bmatrix} = \begin{bmatrix} -\frac{C_f + C_r}{mV} & -\left(\frac{C_f l_f + C_r l_r}{mV} + V\right) \\ \frac{C_f l_f - C_r l_r}{J_z V} & -\frac{C_f l_f^2 + C_r l_r^2}{J_z V} \end{bmatrix} \cdot \begin{bmatrix} v_y \\ \psi \end{bmatrix} + \begin{bmatrix} \frac{C_f}{m} \\ \frac{C_f l_f}{J_z} \end{bmatrix} \cdot \frac{\delta_{sv}}{N}$$

Lateral vehicle model equation

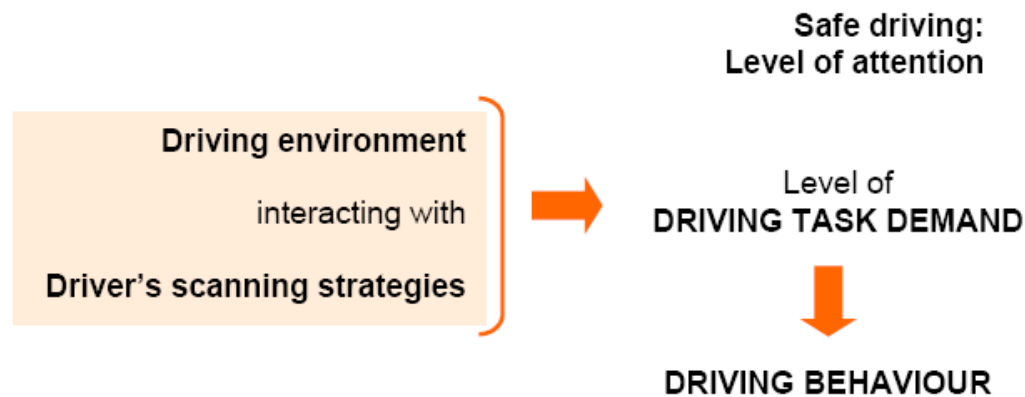
Environment model



Environment model comprises:

- Road characteristics
- Presence of other vehicles and other obstacles (pedestrians, etc.)
- Weather conditions (visibility)

Driving environment is strictly related to driving Task Demand variation.



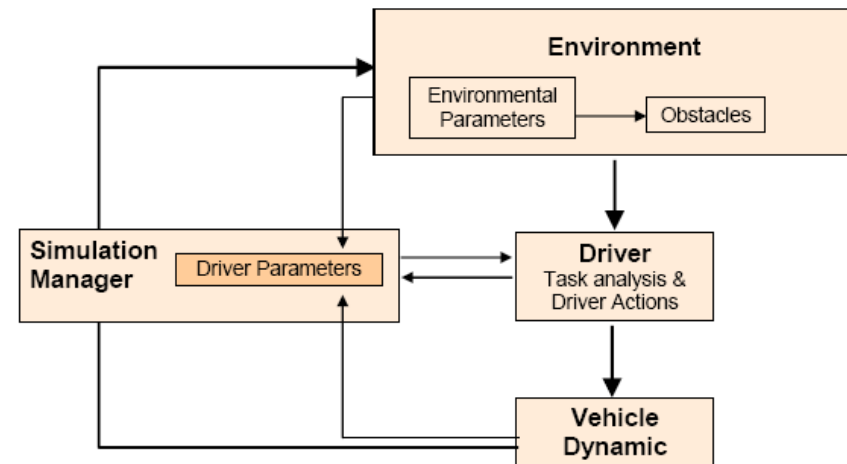
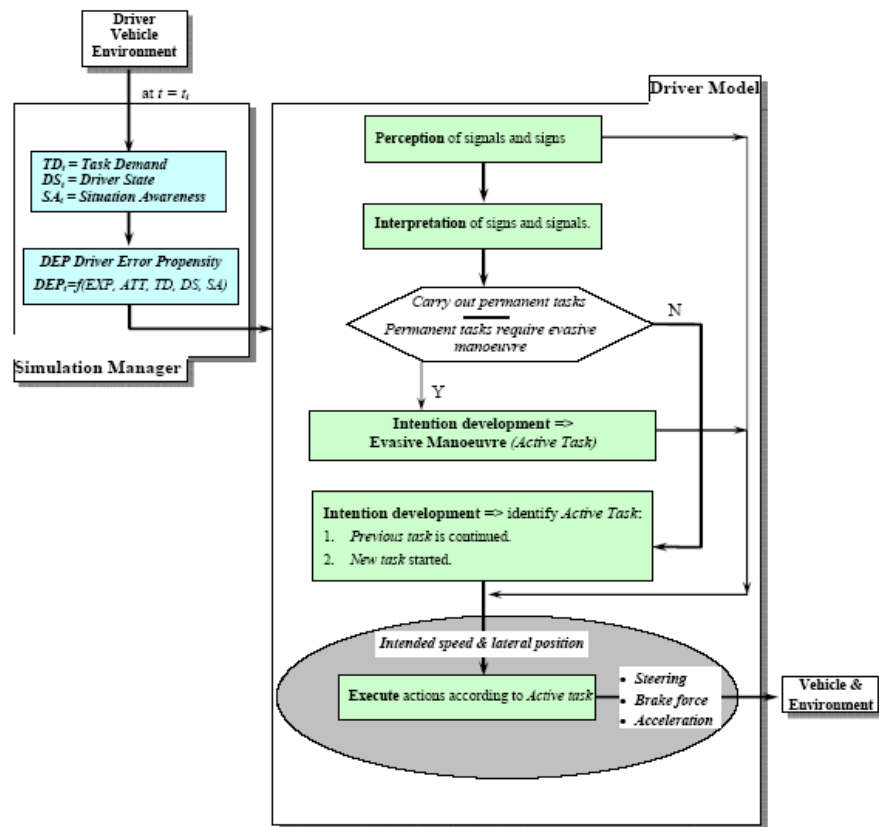
Computational numeric simulation of the DVE



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From the DVE to the SSDrive tool



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A vision of the future



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Cars and trucks will have a real-time DVE model to assist the driver and to manage the interaction of D - IV - E
where IV = Intelligent Vehicle

= concept of intelligent co-driver

Thus the E_DVE will be embedded in the vehicle



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Thank you for your attention!

