

INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME



AIDE IST-1-507674-IP

DVE Model – Results of validation of model predictions vs Driving Simulator tests

Deliverable No.		D1.3.3	
SubProject No.	SP1	SubProject Title	Behavioural Effects and Driver-Vehicle-Environment Modelling
Workpackage No.	WP3	Workpackage Title	Driver-Vehicle-Environment Simulation and Validation (DVE-SV)
Activity No.	A1	Activity Title	Identification and validation of a reference model of DVE
Authors		P.C. Cacciabue (JRC), E. Carusi, G. Munaretto (KITE)	
Status (D: draft, in progress, S: Submitted to EC, F: Final accepted by EC)		S	
File Name:		AIDE D1.3.3-v6.doc	
Project start date and duration		01 March 2004, 48 Months	

Executive Summary

The objective of this study is to validate the DVE model developed in AIDE-SP1, and in particular of the Driver component, against the performance of real subjects in a virtual driving simulator.

This Deliverable follows the analysis of the experiments carried out in the simulator of VTI, and published in a previously released Deliverable (D1.3.2), and contains the comparison of the predictions of the DVE simulation tool with the observed behaviours of drivers. A set of specified scenarios with predetermined events were produced in the VTI driving simulator: in total 36 drivers drove in the simulator. Driver experience was varied between three types of drivers, namely novices, average drivers and professional/experienced drivers. Similarly, three levels of distraction (no distraction, medium and high level of distraction) were induced by a simulated IVIS and were varied within drivers.

The set of outputs utilised to carry out the qualitative and quantitative analysis is very rich and many different comparisons can be performed from the data collected in the VTI simulator and analysed in Deliverable 1.3.2. However, in order to keep the assessment of the computerised simulation (called SSDRIVE, for Simple Simulation of Driver Performance) sufficiently simple and clear, only certain behavioural aspects have been taken into consideration. In particular, the simulation outcome has been evaluated with respect to the coherence and effectiveness of steering and speed behaviour, in relation to a number of the model *parameters*. In this way, it has been possible to:

- Confront the result of experiments and simulations of different types of drivers; and to
- Discuss the possibility and assess the ability of the simulation to describe on the one side different behaviours, and, on the other side, consistency of the model when attempting to emulate extreme conditions such as very unruly or very cautious drivers.

The document is divided into two main parts:

1. Review and description of main model assumptions, equations, and simulation algorithms; and
2. The application of the SSDRIVE simulation to the VTI simulator and comparison of results of SSDRIVE runs with observed behaviour from virtual reality simulator sessions.

Part 1 (Chapter 2 and 3) focuses on the description of the model and implementation algorithms primarily of the Driver cognitive and behavioural performances. The other two components of the joint DVE system, i.e., Environment and Vehicle, are dealt with relatively simple and well known correlations and equations which are not reported in detail. The overall model has been referred to as E-DVE, for Electronic or Embedded DVE Model, which characterises the fact that the model focuses on a simple simulation of human performances and must be embedded in a computerised and fast running numerical simulation. This model is a simplified version of the so called G-DVE model, for Global or Generic DVE Model that is more theoretical and includes detailed account of the higher level mental processes that govern behaviour. The implementation of the overall DVE model into a computerised and fast running simulation has been called SSDRIVE, which enables to perform a variety of calculations associated with possible behaviours of different types of drivers.

In particular, the following characteristics of the theoretical model and the overall SSDRIVE simulations are described:

- The theoretical architecture of the Driver model.
In particular, the paradigm of reference, called Information Processing System (IPS), is revised and the basic approach for simulating specific driver behaviour is discussed, based on five main *parameters*, namely *Attitudes/personality (ATT)*, *Experience/competence (EXP)*, *Task Demand (TD)*, *Driver State (DS)*, and *Situation Awareness/Alertness (SA)*. These *parameters* enable the consideration of dynamic behaviour and interaction between the three components of the DVE system, as well as the simulation of the error making process.
- The implementation algorithms.
These algorithms enable to carry out the dynamic evaluation of steering, acceleration, and braking behaviour, associated to intended speed levels. In particular, a number of functions and correlations associated with instinctive and typical driver routine responses, also called “skill based” behaviour according to the well known Rasmussen model (Rasmussen, 1983, 1986), are implemented. These correlations are essential in transforming the theoretical model assumptions and equations into algorithms for emulating driver dynamic activity and interaction with the control system of the vehicle.
- The overall DVE model and simulation architecture.
The time evolution and the interactions between different components, or *modules*, are discussed. In particular, the “Manager” of the simulation is revised. This component governs the following activities:
 - a. The time step and consistency of the calculations of the three modules;
 - b. The evaluation of human error and decision making (speed and activities).

Part 2 of the deliverable (Chapter 4) is dedicated to the actual validation process.

The first step of validation concerns the *steering* task. In order to enable the simulation to carry out several tests and to avoid having to filter or perform data screening on the output of the SSDRIVE, the simulation has been performed at a constant speed. In this way, the Driver of SSDRIVE aims at maintaining a constant speed throughout the whole track. This simplification condition has to be adequately considered in the validation process. In particular, the variables used to carry out the validation of the steering task have been: Steering angle; Lateral distance from the centre-line of the carriageway; and Lateral acceleration. As a conclusion of this first validation assessment, the following points have been made:

1. The values of inclination of the steering, the lateral distance from the lane centre-line and the values of lateral acceleration are reasonably predicted by the simulation tool;
2. Their mean values are found to be well within the distribution of variance of the values observed from the experiments carried out in the VTI virtual driving simulator.; and
3. The simulation conditions and numerical algorithms adopted to describe in analytical terms the DVE theoretical model turn out reasonable and correct.

The second step of validation concerns the task *speed and acceleration*. The Driver of SSDRIVE varies speed throughout the whole track according to the decision making, associated to the model *parameters*, and modulated by the road and traffic conditions. In particular, different types of drivers have been simulated by varying the input *parameters* of the simulation, primarily *Attitude (ATT)* and *Experience (EXP)*. As a conclusion of the assessment of speed behaviour, the simulation has shown to be able to describe driver behaviour reasonably well and with sufficient consistency. As in for the case of steering, it is important to stress that the validation focused on these aspects rather than on the accuracy of results with respect to the VTI simulator outcome.

The overall results of the comparison discussed in this Deliverable demonstrate that the model and SSDRIVE simulation are able to describe driver diverse behaviour and that they fit reasonably well within the observed data from the VTI simulator. Even if a lot of work remains to be performed in the direction of driver simulation and consideration of behavioural adaptation and attitudes before a consolidated and generally accepted model is developed, this important first step of validation of the SSDRIVE approach can be considered achieved.