Intelligent Vehicle Safety Systems

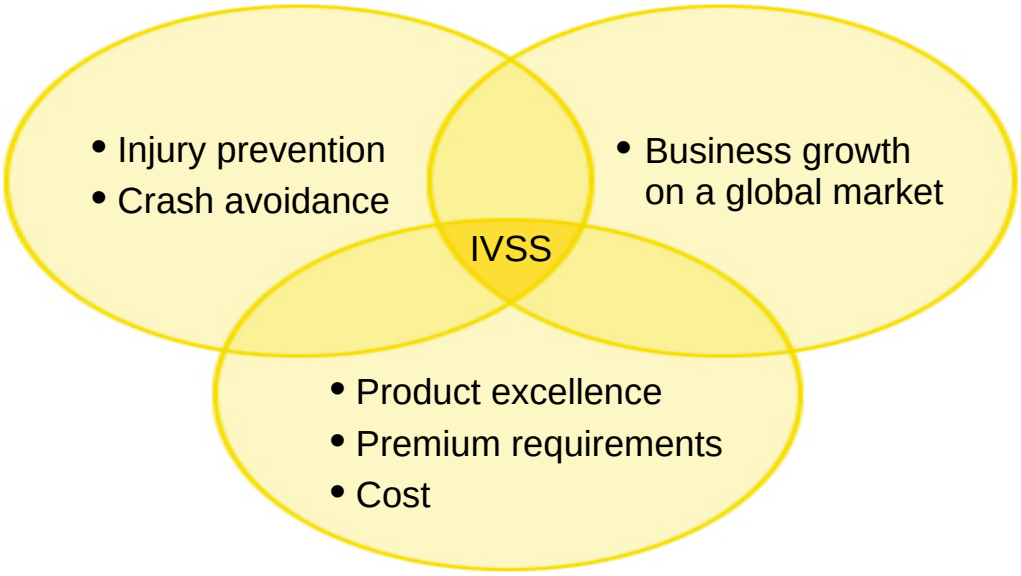
IVSS Driver Impairment Cluster
Report I

IVSS Project Report

The IVSS Programme

The IVSS programme was set up to stimulate research and development for the road safety of the future. The end result will probably be new, smart technologies and new IT systems that will help reduce the number of traffic-related fatalities and serious injuries.

IVSS projects shall meet the following three criteria: road safety, economic growth and commercially marketable technical systems.



Three interacting components - for better safety, growth and competitiveness:

The human being

Preventive solutions based on the vehicle's most important component.

The road

Intelligent systems designed to increase security for all road users.

The vehicle

Active safety through pro-active technology.

Title of the report: IVSS Driver Impairment Cluster, Report I

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Reference number:

Publication date: 2007-02-01

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1. Introduction

There are several projects within the IVSS Program which aim at developing detection and warning systems for different types of driver impairment (DI). Therefore an analysis of possibilities/options for interactions between projects in the IVSS DI cluster was included as a task in the DROWSI project. SRA is responsible for this task.

2. Method

IVSS projects addressing DI issues were identified in consultation with Ruggero Ceci, SRA and Anders Haggård, IVSS. The following IVSS projects were included in the analysis:

▪ **Drowsiness Intervention (DROWSI)** Trötthetspredicering och motåtgärder i fordon *Contact: Peter Kronberg,* Volvo Technology
▪ **Driver Attention – Dealing with Drowsiness and Distraction (Driver Attention)** Förarens uppmärksamhet – Hantering av sömnighet och distraktion *Contact: Arne Nåbo,* Saab Automobile
▪ **Workload Estimation & Dialog Management (Dialog Management)** Beräkning av förarbelastning & Dialoghantering *Contact: Arne Nåbo,* Saab Automobile
▪ **Optimized System Integration for Safe Interaction in Vehicles (OPTIVe)** Optimerad systemintegration för säker interaction i fordon *Contact: Patrik Palo, Robert Broström,* Volvo Car Corporation
▪ **Sensor Fusion for Safety Systems (SEFS)** *Contact: Malte Ahrholdt,* Volvo Technology
▪ **KAIA II** Förar- och fordonskompatibel alkoholsensor med inbyggd absolutmätning *Contact: Håkan Pettersson,* Autoliv Research
▪ **Driver Apprehension of Vehicle Response (Driver Apprehension)** Föraruppfattning av fordonsrespons *Contact: Boris Thorvald,* Scania CV
▪ **Development of an Eye Control Test for Real-time In-vehicle Detection System for Alcohol and Drug-related Driving Impairment (EYECON)*** Test av perceptuell kapacitet i trafiken *Contact: Per-Olov Boström,* AB Volvo, *Trent Victor,* Volvo Technology

*Not approved IVSS project.

The projects address drowsiness and/or distraction, alcohol and drug use and/or focus on sensor fusion (Table 1). All projects have similar objectives with regard to developing detection and warning systems.

In order to identify interactions between the different projects they were divided into six work areas (Table 1):

1. *Driver condition* (studies of driver condition and behaviour as a result of drowsiness, distraction, and drug use),
2. *Prediction and observation techniques* (development of sensors and/or sensor systems for detection of driver condition and behaviour, vehicle regulators, activities in nomad systems, and of the traffic environment)
3. *Countermeasures* (development and design of reaction systems),
4. *Prototype development*,
5. *Field test*, and
6. *Industrial prospective*.

Table 1. Overview of focus of the IVSS projects included in the analyses. The first three columns show type of driver impairment and the last six show project work areas. Yellow columns represent the work areas that were considered of main interest for analyses of prospects for interactions and coordination. *Not approved IVSS project.

PROJECT	*Drowsiness*	*Distraction*	*Drugs/Alcohol*	**1. Driver condition**	**2. Prediction and observation techniques**	**3. Counter-measures**	**4. Prototype implementation**	**5. Field test**	**6. Industrial prospective**
DROWSI	X	-	-	X	X	X	X	X	-
Driver Attention	X	X	-	X	X	X	X	X	X
Dialog Management	-	X	-	X	X	X	X	-	-
OPTIVe	-	X	-	-	X	X	X	-	-
SEFS	-	-	-	-	X	-	X	-	-
KAIA II	-	-	X	-	X	X	X	X	X
Driver Apprehension	-	X	-	X	X		-	-	-
EYECON*	-	-	X	X	X	X	X	X	-

An overview of the prospect for interactions and coordination between the projects was done for work areas 1, 2, and 3, i.e. Driver condition, Prediction and observation techniques and Countermeasures. The analyses were based on available project plans and telephone interviews with contacts for the projects (see above). Please note, however, that the information about the identified projects compiled in this report may not be complete with regard to the issues covered.

3. Project objectives

3.1. Overview

In total, eight IVSS projects with potentials for coordination and cooperation were identified. Two of the identified projects address drowsiness, four address distraction, and two focuses on drug and alcohol use (Table 1). All eight projects use and/or develop one or several prediction and observation techniques and all but one project aim at developing countermeasures for driver impairment.

Five of the projects also aim at compiling knowledge and/or developing the knowledge about DI.

Almost all of the projects aim at developing prototypes, and at least two projects plan to develop industrial prospectives.

Below, work areas 1, 2, and 3, i.e. Driver condition, Prediction and observation techniques, and Countermeasures, are analysed in some more detail (Table 2).

Table 2. Overview of types of sensors (Prediction and observation techniques) and countermeasures used and/or developed in the different projects. Data fusion denotes data handling systems.

PROJECT	Sensors				Data fusion	Countermeasures		
	Driver	Vehicle	Nomadic devices	External		Information	Warning	Intervention
DROWSI	X	X	-	X	X	X	X	X
Driver Attention	X	-	-	-	X	X	X	X
Dialog Management	X	X	X	X	X	X	X	X
SEFS	-	X	-	X	X	-	-	-
OPTIVe	X	X	X	X	X	X	-	-
KAIA II	X	-	-	-	-	(X)	(X)	X
Driver Apprehension	(X)	X	-	-	-	-	-	-
EYECON*	X	-	-	-	X	X	X	X

*Not approved IVSS project.

3.2. Analyses of driver condition

Reviews and/or experimental studies of driver condition, reactions and behavioural effects caused by drowsiness and/or distraction are carried out in DROWSI, Driver Attention and Dialog Management. Also robustness and sensitivity of different observables, as well as the usefulness of mathematical models for prediction of the driver's condition, are analysed in these projects. A literature review of effects of drugs and alcohol was suggested in EYECON (not accepted).

In Driver Apprehension the aim is to develop the knowledge about how vibrations affect driver performance.

3.3. Prediction and observation techniques

Prediction and observation techniques used and/or developed in the different projects include:

- Internal sensors for observation of the driver, e.g. cameras and physiological sensors.
- Vehicle sensors for observation of vehicle regulators and controls.
- Sensors for observation of nomadic devices.
- External sensors for observation of lane position and scenarios, e.g. optic and radar cameras.

Data fusion algorithms / mathematical models are used for integrating data and information provided from different sets of sensors into a relevant feed-back action. Information may be a result of sensor input to the system and/or input from external information sources.

3.3.1. Observations of the driver (driver behaviour and condition)

Five projects (DROWSI, Driver attention, Dialog Management, OPTIVe, and EYECON) use internal cameras for observing the condition of the driver. Many of the observed variables are related to the eyes, but also e.g. head movement and body posture are included as variables.

The information collected is used for analysing drowsiness (DROWSI, Driver Attention), level of distraction (Driver Attention, Dialog Management, OPTIVe), and alcohol/drug use (EYECON).

Two of these projects focus only on driver variables, i.e. Driver Attention (drowsiness and distraction) and EYECON (alcohol/drugs). DROWSI (drowsiness), Dialog Management (distraction), and OPTIVe (distraction) use a combination of driver, vehicle, and external variables.

KAIA II aims at developing an internal IR-optic sensor for detection of gaseous alcohol and CO_2 concentration in the internal atmosphere of the vehicle.

3.3.2. Observations of the vehicle

In DROWSI, Dialog Management, and OPTIVe a combination of driver, vehicle, and external variables are used for evaluating the driver's status. Vehicle observations include e.g. steering wheel indicators, speed, acceleration, retardation, flash indicators, and gyro.

3.3.3. Observations of nomadic devices

In two projects, i.e. Dialog management and OPTIVe, also nomadic devices such as mobile phones, etc. are included in the supervision system

3.3.4. Observations of the traffic environment

As mentioned above, three projects, i.e. DROWSI (drowsiness), Dialog Management (distraction), and OPTIVe (distraction) use a combination of driver, vehicle, and external variables for evaluating the driver's status. External sensors include external cameras for surveying lane position and deviation as well as the traffic environment.

In OPTIVe and Dialog Management also information from external sources is evaluated, e.g. information from safety systems and gps.

In SEFS external sensors (optic and radar cameras) are used for detection of lane position and objects. The project aims at developing a consistent perception of the environment and has a more pronounced focus on developing the systems for data fusion.

3.3.5. Sensor data fusion

In order to develop a safety system that reacts to certain observations or sets of observation in a consistent and relevant manner models or algorithms for sensor data fusion need to be developed.

The objective of SEFS is to develop methods and algorithms for sensor data fusion of information from external sensors, i.e. optic cameras and radar systems for surveying lane position and scenario. The goal of SEFS is to provide a more consistent perception of the environment.

Also DROWSI, Dialog Management, and OPTIVe include development of sensor data fusion algorithms or models. The latter projects, however, aim at developing a perception of the driver's status based on information from internal, vehicle and external sensors.

EYECON (not accepted) and Driver Attention aims at developing an index of perceptual suitability of the driver based on camera observations of the driver.

3.4. Countermeasures

Countermeasures denote (re)actions from the data fusion system as a response to input from different sets of sensors (feed-back) or from external information sources. The purpose of the actions is e.g. to reduce or prevent drowsiness and distraction and to prevent the use of drug and/or alcohol during driving.

All of the projects included in this study (except Driver Apprehension and SEFS) include the development of countermeasures (Table 2). The types of countermeasures used/to be used are, however, only partly specified for some of the projects. OPTIVe, for instance, aim at developing multifunction control and display strategies, e,g, for head-up displays, and KAIA II and EYECON (not approved) focus on ignition interlock functions, but may also include other countermeasures.

4. Conclusions

From this brief project overview it is clear that there are many possibilities/options for interactions between projects in the IVSS DI cluster, e.g. within the following areas:

- Studies of driver condition, reactions, and behaviour.
- Prediction and observation techniques / Sensors.
- Development of sensor data fusion algorithms and models.
- Development and design of countermeasures.

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