

TRIAL AND EVALUATION OF INTEGRATED IN-CAR ITS TECHNOLOGIES: REPORT ON AN AUSTRALIAN RESEARCH PROGRAM

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SUMMARY

In Melbourne, Australia, a major research project is currently underway with the aim of stimulating the demand by fleet owners for in-vehicle ITS technologies which have significant potential safety benefits. A fleet of cars is being equipped with an integrated suite of eight in-vehicle intelligent transport systems. Fleet drivers will operate these vehicles for about 12 months. During this period driver attitudes towards, and acceptance of, these technologies will be assessed, and the effects of the selected technologies on driving performance and safety will be evaluated on the road and in an advanced driving simulator. Under normal conditions drivers will be unaware that they driving an ITS-equipped vehicle: it is only when they intentionally or inadvertently operate the vehicle in an unsafe manner that they will be warned and calibrated in an integrated manner by the various ITS technologies.

INTRODUCTION

During the past 30 years the road accident fatality rate in Australia has been reduced from being one of the highest among motorised countries to one of the lowest. It has dropped from 8.1 deaths per 10,000 registered vehicles in 1970, to around 1.5 in 1999. Nevertheless, road crashes continue to account for over 90 per cent of the total cost of transport-related accidents across all modes in Australia [2]. Each year, over 1700 people die on Australian roads and over 60,000 are injured. Although the various strategies implemented in Australia to date have largely been successful in cutting the road toll significantly since the 1970s, the rate of improvement is starting to plateau. It is recognised in Australia that Intelligent Transport System (ITS) applications have the potential to yield a new wave of road safety and other benefits. To this end a national ITS strategy known as "E-Transport" [1] was launched in December 1999 by the

Australian government. The strategy brings a strategic and coordinated focus to the planning, application and assessment of ITS technologies in this country. Whilst Australia has been progressive in developing and deploying Intelligent Transport Systems, to date there have been no demonstration and research projects here concerned with establishing the potential road safety and human performance benefits of in-vehicle ITS technologies.

Around the world, suppliers and manufacturers have generally found it difficult to stimulate consumer demand for in-vehicle ITS systems. A major reason for this is that, at their current level of technical maturity, most in-vehicle systems are considerably more expensive than other active safety systems and are generally perceived to be beyond the reach of the average consumer. Another reason is that the average driver around the world does not know what actually exists in the way of ITS systems and has never experienced what it is like to drive a vehicle equipped with ITS technologies. If consumers do not know what they want, they will not demand to have it. Finally, for many in-vehicle systems which are currently available or emerging, little or nothing is known about their effects on safety and human performance in the short, medium and long term. At this early stage in the evolution of ITS technologies, there is simply not enough field research data available to convince vehicle manufacturers of the potential safety benefits of some of the more promising technologies.

In Australia, the major vehicle manufacturers sell about 65 percent of their new vehicles to fleets. This is important information. It suggests that, if we are going to stimulate societal demand for in-vehicle systems that enhance safety, then an important first step is to stimulate demand for these systems by fleet owners. Also, fleet owners might be expected choose vehicle technologies on a more national basis than ordinary consumers. To achieve this, it is necessary to make fleet owners thoroughly familiar and comfortable with ITS technologies and it is necessary to demonstrate to them the positive benefits of the technologies in reducing crash costs, fuel costs, environmental impact and, above all, in protecting their greatest asset – their employees.

The process for achieving this overall aim is a four-phase research and demonstration project which is being funded by the Transport Accident Commission (TAC) and is being strongly supported (see below) by the Ford Motor Company of Australia. The TAC has commissioned the Monash University Accident Research Centre (MUARC) to conduct the research. MUARC is Australia's largest injury prevention research centre and is recognised internationally for its research on a wide range of road safety and human factors-related issues. The project is described below.

THE PROJECT

AIMS

In June 1999 the TAC commissioned MUARC to undertake what has become known locally as the "TAC Intelligent Car Research and Demonstration Project". The aims of the project are:

- to, in conjunction with the Australian automotive industry, initiate a process that stimulates demand, initially by fleet owners and in the longer term by others in society, for in-vehicle ITS technologies which have significant potential road safety benefits;

- to trial and assess the technical operation of several currently available in-vehicle ITS technologies;
- to assess driver attitudes towards, and acceptance of, these technologies; and
- to evaluate the effects of the selected technologies on driving performance and safety on the road and in an advanced driving simulator.

APPROACH

The project is being conducted in 4 principal phases. These are described below.

Phase 1

In Phase 1, which was completed in January 2000, we identified a range of currently available in-vehicle ITS technologies which have the potential to significantly enhance the safety of Victorian drivers. Phase 1 activities included: a review of the literature on the availability and potential benefits of in-vehicle ITS technologies [5]; a review of Victorian crash data which culminated in the development and application of an analytical model for estimating the potential safety benefits of introducing various ITS technologies in Victoria [3]; extensive consultations with local and overseas ITS experts and academics [4], suppliers, and manufacturers; a workshop involving ITS Australia representatives and other key stakeholders; and evaluation of the various candidate ITS systems identified during Phase 1 against a number of criteria including availability, potential safety benefit, cost, and so on. This process culminated in the identification of several in-vehicle ITS technologies deemed suitable for incorporation into Phase 2 activities (see below).

Phase 2

During Phase 2, which began in February 2000, two “demonstration” vehicles will be equipped with the ITS technologies identified in Phase 1. At the time this paper was being prepared, the project team was finalizing negotiations with local and international suppliers for the provision of individual systems and components for these vehicles. Phase 2 activities will be completed in December 2000.

The involvement of the Ford Motor Company of Australia as a key project partner has, and will continue to be, crucial to the success of the project. Ford has actively contributed to all aspects of Phase 1 and 2 activities completed to date. Ford has played an important role in sourcing, selecting, and supporting the development and installation locally of several technologies, and is making available two Ford Fairmont Ghia vehicles which will serve as the demonstration vehicles. These will be equipped with the selected ITS systems described below. Phase 2 activities will include: development of the two demonstration vehicles; the establishment of operating procedures and, where appropriate, training requirements for drivers of these vehicles; assessment of initial driver interactions with the demonstration vehicles; pilot testing in readiness for Phases 3 and 4; programming of the advanced driving simulator located at MUARC to simulate selected ITS systems equipped to the demonstration vehicles; and design of the Phase 4 research program (see below).

Phase 3

The third phase of the project will commence during the latter half of 2000 and will conclude in early to mid 2001. During this phase between 10 and 20 fleet vehicles with the same (or a similar) mix of ITS technologies as the demonstration vehicles will be developed in readiness for the Phase 4 research activities (see below). At the time this paper was being prepared, issues such as the appropriate number of fleet vehicles to be equipped, the identification of candidate corporate fleet owners, and the final configuration of systems to be incorporated into the vehicles were being considered. Progress in relation to these deliberations, which are contingent on the outcomes of Phase 2 activities, will be discussed in Turin.

Phase 4

The final phase of the ITS Research and Demonstration project will involve the conduct and evaluation of a major research study involving the fleet vehicles equipped with ITS technologies in Phase 3. During the study data will be collected, both on-the road and in an advanced driving simulator located at MUARC, to assess the technical operation of the chosen ITS technologies, to assess societal attitudes to and acceptance of the technologies, and to obtain data on the effects of the technologies on driving performance and safety. Planning for this activity is currently underway. The overall design of the research study is yet to be determined. At this stage, it is envisaged that Phase 4 will take the form of an extended on road study in which drivers are allowed to adapt to the characteristics of the fleet vehicles over an extended period of regular driving and in which they drive along their usual routes. Before, during and after comparisons will look at changes in driving performance and behaviour over the trial period, which is expected to be about 12 months in duration.

SYSTEM DESCRIPTIONS

The functional characteristics of the various systems currently being fitted to the two prototype vehicles are summarised below. Functional and human machine interface (HMI) specifications were developed for all of the ITS systems. These were prepared by a multi-disciplinary design team that included representatives from MUARC, Ford and the Transport Accident Commission. Systems purchased “off-the shelf” were assessed for suitability against these specifications and systems configured locally were developed to these specifications. Detailed descriptions of these systems will be presented in Turin.

Intelligent Speed Adaptation

This system is designed to warn the driver when he or she is travelling, intentionally or inadvertently, over the posted speed limit. The system comprises a Global Positioning System (GPS), a digital map of the road system and a digital record of the speed limits applicable to various parts of the road system. A computer program analyses from the GPS data where the vehicle is being driven and compares the speed limit for that location with digitized speedometer input. This system has been developed locally to support the research program. Two variants of the ISA system have been developed – an “informative” and an “actively supporting” system. For international consistency, these terms are the same as those used to describe comparable systems currently being trailed in Sweden. At the touch of a switch, the ISA system can be switched to operate as either an informative or an actively supporting system. The relative effectiveness of

these two variants of ISA in reducing vehicle speeds during and after human adaptation will be evaluated during the Phase 4 trial.

The two systems are similar in most respects. Whilst the vehicle is being driven at or below the posted speed limit nothing is seen or heard, although the driver has the option of viewing the posted limit on a visual display by depressing a control button. If the speed limit is exceeded for more than a minimum specified period of time, however, the system commences to present to the driver a series of graded warnings. The informative system presents a 4-stage series of visual and auditory warnings ranging in severity from least intrusive to most intrusive depending on how long the speed limit has been exceeded. Visual and auditory warnings occur concurrently at Stages 3 and 4. The actively supporting system warnings are identical to those for the informative system at Stages 1 and 2. However, in this system there are no auditory warnings. Rather, the Stage 3 and 4 auditory warnings are replaced by a “haptic” warning in the form of a pressure inducing device under the accelerator pedal which provides a feeling of light resistance. This resistance is designed to remind the driver that he or she is currently exceeding the posted speed limit. This pressure device permits the driver to overcome the resistance in order to accelerate should driving conditions require it. This haptic feedback device has been developed locally to support the research program.

Forward Collision Warning System

The Forward Collision Warning (FCW) system is designed to warn the driver if he or she is likely to collide with an object in front by activating visual and audible alerts. This system has been chosen for use in this study as a means of calibrating the driver to adopt larger headway distances to vehicles in front rather than as a system to be relied on to prevent rear-end crashes. A commercially available system, the Eaton Vorad EVT-300, has been fitted to the two prototype vehicles. The system uses transmitted and received radar signals to determine the distance and relative speed between the host vehicle and objects in front. The system issues visual alerts when objects are within 350 feet in front of the vehicle and auditory alerts when the vehicle is within one-half second, 1 second, and 2 seconds following interval. The system provides warnings for both stationary and slow moving objects. Physically, the system is comprised of four components: the antenna assembly, a central processing unit, the driver display unit, and the interconnecting harness.

Breath Alcohol Detection and Advisory System

The Breath Alcohol Detection and Advisory System is designed to deter people from driving a vehicle if they have been drinking alcohol. The system is currently being developed by a company in Sweden in accordance with a locally produced functional specification. The system consists of four main components: electronics; a passive “Sniffer”; an active breath alcohol testing device; and a visual text display.

Unlike alcohol ignition interlock systems, which are designed primarily for recidivist drink drivers, the BADA is a quality assurance system designed specifically to deter fleet drivers from driving while under the influence of alcohol. The system is designed to be more acceptable to drivers than conventional interlock systems. The passive “Sniffer” sub-system of the BADA automatically detects the presence of alcohol in the air inside the cabin of the car and, if alcohol

is detected, issues an advisory message to the driver to blow into a mouthpiece (the “active” sub-system) to test his or her breath alcohol concentration. (If no alcohol is detected, the system is silent and the driver is unaware of it.) If the driver’s BAC is greater than the pre-defined legal or corporate BAC limit, the driver is advised to stop the vehicle within 2 minutes. If the driver elects not to do so, an electronic message (“registration”) is sent automatically to the fleet manager advising him/her that the driver is currently exceeding the acceptable BAC limit. If the driver’s BAC is greater than zero but less than the pre-defined legal or corporate BAC limit, the driver is required to undertake a new blow test every 15 minutes until such time that his/her BAC is less than the previous reading. If the driver elects at any stage not to undertake a blow test when advised to take one, the driver is advised to stop the vehicle within 2 minutes or incur a registration. Drivers can elect to take a breath test up front rather than be passively monitored by the Sniffer sub-system.

Seat Belt Reminder System

The Seat Belt Reminder System is designed to remind the driver to fasten his or her seat belt. This system is being developed locally to a functional specification developed by the project team, but is similar functionally to a prototype system already developed in Sweden. Physically, the system is comprised primarily of three sensors: a sensor attached to the seat belt buckle to detect whether the belt has been properly buckled; a sensor attached to the webbing retractor system to detect whether the seat belt has been extracted to an extent indicating that it is wrapped around the person; and pressure sensors under the seat fabric to detect whether a person is sitting in one of the driver or passenger seats. If all occupants in the vehicle fasten their seat belt, no warnings are issued and the occupants are unaware that the system exists. However, if any person (driver or passenger) sits in the vehicle and does not fasten his/her seat belt, a visual “unbuckled” icon illuminates until the vehicle speed reaches 15 km/hour. Between 15 and 24 km/hr, the "unbuckled" icon flashes and a single audio chime is heard. Between 25 and 49 km/hr, the chime sounds repeatedly at the same rate that the visual icon flashes. When the vehicle travels at 50 km/hr or higher, the audio chime and the "unbuckled" icon sound/flash even faster. The system cannot be circumvented while the vehicle is in motion.

Reverse Collision Warning System

The Reverse Collision Warning (RCW) system is designed to warn the driver if he or she is likely to collide with an object behind the vehicle by activating audible alerts. The system fitted to the 2 prototype vehicles is a commercially available product produced by Bosch called the Bosch Parkpilot. This has been included as a comfort system to assist drivers to reverse park rather than as a safety system. Physically, this system is comprised of 4 ultrasonic sensors which operate as transmitter and receiver on the basis of the pulse-echo principle. These are attached to the rear bumper in 4 positions across the width of the vehicle. The device is capable of detecting stationary and slow moving objects up to a distance of 1.5 metres from the reversing vehicle, but issues audible warnings with increasing intensity at and below a distance of 1 metre.

Emergency Notification and Response System

The emergency notification and response system is designed primarily to provide rapid notification to emergency services of vehicle location in the event of a crash or medical

emergency. The system fitted to the two prototype vehicles is an off-the-shelf product developed locally by the company Intellimatics. It consists of a covert antenna, mobile phone communications (GSM), satellite positioning (GPS) units, speaker, microphone and button console. The button console is the human-machine interface. It contains four buttons: an SOS button which when depressed initiates a call to a national emergency response centre, a road-side assistance button, a telephone button, and an information button which provides access to a range of services such as navigation assistance, remote vehicle immobilisation and so on.

Daytime Running Lights

The two prototype vehicles have been equipped with daytime running lights. The car headlights will come on automatically on low beam (in daytime running light mode) when the engine is started and go off automatically when the engine is turned off. In DRL mode, the headlights will (a) operate at 80% of their normal low beam luminance to conserve power and (b) operate without interior lights or other exterior lights which would normally operate when the headlights are activated. Normal vehicle lighting operation will be resumed whenever the headlight switch is moved from the off position.

Route Navigation System

The two prototype vehicles will contain a voice guided, turn-by-turn, route navigation system, incorporating signals from GPS navigation satellites, a gyroscope and the vehicle speedometer. The system is an adaptation of a commercially available system supplied to Ford Australia by VDO which is provided as an optional inclusion on the Ford Fairmont Ghia vehicles being used as prototype vehicles. At this point in time, a decision has not been made as to whether the system will be used in the study and formally evaluated as a representative navigation system from a human factors/safety perspective. Consideration is being given to use of the system display to present some other (non-urgent) information from other systems under evaluation in the program.

Data Logging System

During the Phase 4 fleet evaluation, a wide range of driver/vehicle performance data will need to be logged before, during and after drivers adapt to the various ITS technologies. The data logging system will utilize re-useable flash memory type computer devices to record relevant data. These devices are being selected with an accent on robustness so as to withstand the temperature and vibration conditions that could be expected to occur if they are located in the trunk (boot) of the prototype and fleet vehicles.

System Integration Issues

Although the various systems described above are being installed as separate systems in the two prototype vehicles, some integration of the system displays is being attempted in these vehicles in order to optimise the design of the human machine interface and to conserve display space on the vehicle dashboard. We are currently investigating use of a miniature TV screen to integrate the display of some visual information from certain systems and consideration is also being given to

use of the route navigation display screen to display some non-urgent messages. The precise location of the TV screen has not yet been determined.

CONCLUSION

In-vehicle ITS technologies have several important roles to play in society: to calibrate drivers to use the road transport system within its limits; to reduce undesirable driver behaviours which are impossible to handle within a safe system; and to make safe driving easier and more comfortable. It is our view that under normal conditions drivers should not be aware that they driving an ITS-equipped vehicle - it is only when the driver intentionally or inadvertently operates the vehicle outside the design criteria of the traffic management system that he or she will be warned or calibrated. This design philosophy has been central in guiding the choice and design of ITS systems to be fitted to the vehicles in this project. The calibrating approach contrasts with the design of some ITS solutions which may have the effect of encouraging the driver to drive to the limit imposed by the ITS system.

Several features of the present study distinguish it from other research and demonstration projects around the world: the focus of the field trial is on fleet vehicles, as these represent about 65 percent of the new car market in Australia and will drive societal demand for in-vehicle ITS systems; the project has the support and involvement of a major vehicle manufacturer, the Ford Motor Company of Australia; the vehicles to be trialed and evaluated will contain a relatively large number of integrated ITS systems which will allow us to examine the *interactive* effects of these systems on human behaviour over an extended period of time; the choice of ITS systems has been guided by the central design philosophy noted above; and the study will involve the concurrent collection, in the simulator and on the road, of human factors data for the same ITS systems which will yield important data on the validity of simulator studies of ITS applications.

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