DEVELOPMENT OF SAFETY PRINCIPLES FOR IN-VEHICLE INFORMATION AND COMMUNICATION SYSTEMS

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SUMMARY

This paper describes the development of safety principles for in-vehicle information and communication systems. From the early 1990s, the UK Department of Transport (DoT) recognised that the development of internationally agreed tests to limit the distraction potential of in-vehicle systems would take many years. They therefore initiated the development of recommendations that could be applied in the interim. The UK work resulted in a "Code" which was also taken up by the European Conference of Ministers of Transport (ECMT). Subsequently the European Commission (EC) sponsored the development of a set of principles that cover many of the same issues.

Meanwhile, although some progress in research and international standards has taken place, there remains the issue of how to assess in-vehicle safety or even the extent to which a specific in-vehicle information system supports the safety and effectiveness principles of the EC. One approach to assessment, using a Checklist, is described in this paper. It allows experts to make a rapid and structured assessment of the key features of an in-vehicle system and highlights where specific driver distraction studies would be most beneficial.

INTRODUCTION

With the number of commercially developed in-vehicle information systems (IVIS) expected to increase rapidly in the next few years, there is a need for assurance that any particular system can be used safely and that human machine interaction (HMI) is not a barrier to deployment.

The potential for distraction from the driver's principal task of safely negotiating the vehicle through a complex traffic environment, is graphically illustrated in Figure 1, taken from an early investigation into the "Traffic*master*" driver information system (1). White bars represent time spent looking within the vehicle and black bars externally. In vehicle tasks represented are:

PL Tape = inserting and playing a casette tape
RW Tape = rewinding a casette tape
SPEEDO = reading the speedometer
RADIO = tuning the radio to a specific frequency
TM = reading congestion information from the in-vehicle screen

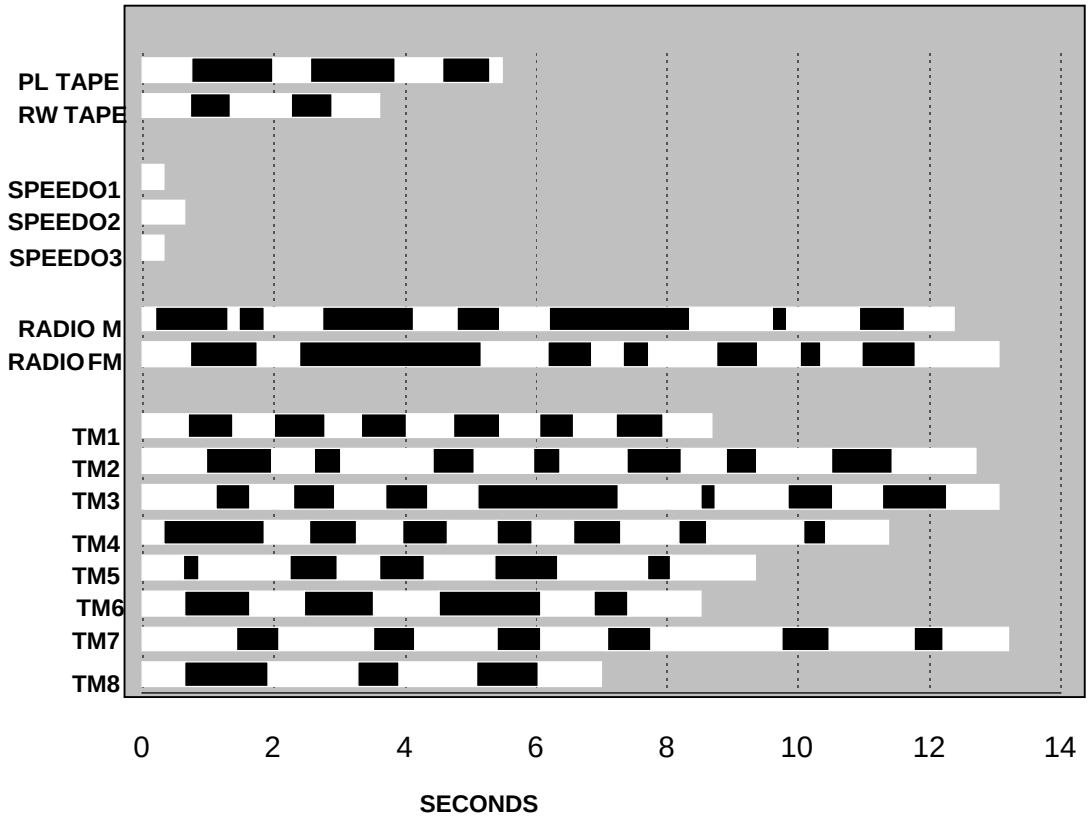

Figure 1. Representation of driver's direction of gaze when interacting with in-vehicle devices

DEVELOPMENT OF EUROPEAN HMI RECOMMENDATIONS

From the early 1990s, the UK Department of Transport recognised that the development of internationally agreed tests to limit the distraction potential of in-vehicle systems would take many years and therefore initiated the development of recommendations that could be applied in the interim. Figure 2 displays the main events in the European development of HMI Recommendations over the last ten years.

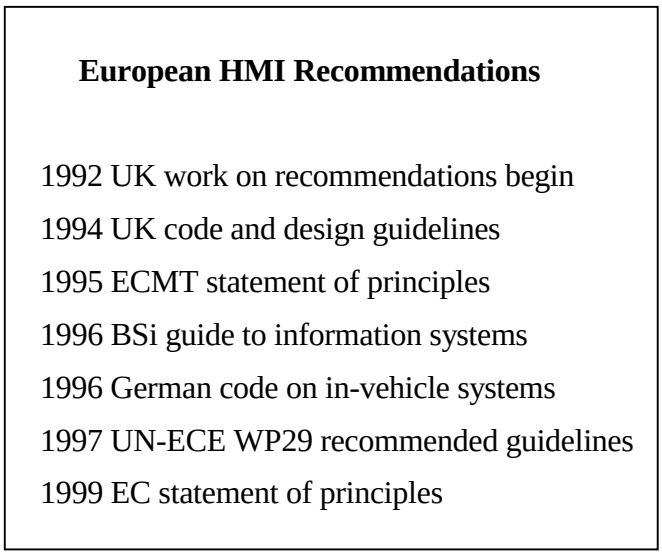

Figure 2. Historical development of European HMI recommendations

In 1992 the Department of Transport commissioned the development of a Code of Practice and Design Guidelines for in-vehicle information systems. The aim was to ensure that such devices could be operated at the highest levels of safety and comfort. A team of consultants summarised relevant ergonomic information (and this became known as the ICE Design Guidelines). At the same time, through a committee and consensus forming process, a list of principles (called the Code of Practice) was developed. These principles highlighted the main safety related factors to be taken into account when designing, installing or using in-vehicle equipment.

Shortly after work began in the UK, the European Committee of Ministers of Transport (ECMT) discussed adopting the UK Code of Practice in lieu of international standards that were several years away. Again, a consensus forming process was undertaken involving representatives from a number of European governments and vehicle manufacturers. The resulting ECMT "statement of principles" is based on the original UK Code (2).

The DoT then asked the British Standards Institute (BSi) to formally publish the Code and Design Guidelines as a public "Draft for Development" (3). To avoid confusion, the ECMT wording was adopted in the BSi document. DD235:1996 contains two parts: the first reproduces the ECMT Statements; the second is the original UK guidelines.

In Germany, as in the UK, there were discussions as to how the ECMT Statements should be applied in practice. In 1996 this resulted in a German code that was a re-interpretation of the ECMT version as a result of agreement between the German ministry and the German industry. It has one section on requirements and another on recommendations in an attempt to highlight the most important aspects of HMI design. The title and text suggest that information systems are the primary focus although some of the statements have a wider application. As with the ECMT statements, there remains the issue that the statements, particularly those relating to driver distraction, are difficult to quantify and test.

The United Nations Economic Commission for Europe is responsible for Type Approval concerning motor vehicles. It too felt that HMI was increasingly becoming an issue and in 1997

the Working Party on the construction of vehicles (WP29) re-published basically the German code. This again has the status of a recommendation and has been distributed widely within the vehicle industry (4).

In 1997 the European Community Strategy Document (5) was issued and one of the 5 areas identified for initial action was HMI. The Proposed action was the development of a Code of Practice and methods for safety evaluation of driver information and communication systems. An EC Task Force was set up in January 1998 reporting to the Member States High Level Groups on Transport Telematics and on Road Safety. There was wide consultation including open workshops. The result was a "statement of principles" which set out the key issues to be considered for IVIS to be used safely and effectively (6).

As well as the principles, the Task Force developed a first step towards assessment of systems with regard to the principles. A number of the principles are rather general in nature and the Task Force concluded that an in-vehicle system could not be directly assessed against them. The principles can, however, be arranged in a form of hierarchy such that the most general ones are at the top of a tree, and assessment against the general principles can be achieved by assessment of their "daughter" principles in the hierarchy.

When the principles were published Member States were asked to monitor the dissemination and use of the principles by industry and report on their effectiveness in reducing the potential problems associated with in-vehicle distraction and other possible negative consequences of poor interface design. Further work on assessment will be undertaken through EC sponsored research projects under the Fifth Framework programme (FP5).

TECHNICAL CONTENT OF RECOMMENDATIONS

The EC statement of principles applies to driver information and communication systems used by the driver while driving. The 35 principles cover six areas:

- **Overall Design** - These principles make the important point about supporting rather than distracting the driver.
- **Installation** - This refers to appropriate location of systems according to regulations and standards, not obstructing the line of sight and avoiding glare and reflections.
- **Information Presentation** - This is concerned with clear and simple forms of presentation which should be appropriate accurate and timely.
- **Interaction with Displays and Controls** - These principles require the driver to be in control and still able to attend to the main driving task. They also make important more specific point about speech based communications systems providing a hands-free facility.
- **System Behaviour** - This is concerned with what should and should not be accessible while driving and with appropriate system performance in different circumstances.
- **Information about the system** - These principles refer to all the information driver has access to including advertising, packaging, written instructions, diagrams, in-built instructions and help functions.

Example statements are presented in Figure 3.

> 4.3 The system should be designed so as not to distract or visually entertain the driver.
>
> 6.1 Visually displayed information should be such that the driver can assimilate it with a few glances which are brief enough not to adversely affect driving.
>
> 8.1 Visual information not related to driving that is likely to distract the driver significantly (e.g. TV, video and automatically scrolling images and text) should be disabled or should only be presented in such a way that the driver cannot see it while the vehicle is in motion.

Figure 3. Example EC Statements related to driver distraction

The BSi Code is similarly focussed on information and communication systems and is also structured into sections:

- General
- Driver/System interaction
- System instructions
- Responsibilities of the supplier
- Responsibilities of the installer
- Responsibilities of an employer
- Responsibilities of vehicle hire companies
- Responsibilities of the driver

The first three contain much of the same material as the EC statement of principles. The last 6 are different and are concerned with the responsibility of different Actors. Some examples from these sections are reproduced in Figure 4.

> 2.4.2 (Supplier) Suppliers should be sufficiently familiar with equipment offered in order to assist buyers at the time of purchase and to provide after-sales support.
> 2.6.3 (Employer) Adequate training should be provided on all systems that drivers are required to use. A record of training should be retained and methods of assessing the effectiveness of the training should be considered.
> 2.7.1 (Hirer) Vehicle hire companies should inform drivers of the purpose of all information systems installed in the vehicle and should offer instructions in their safe use.

Figure 4. Example BSi Statements concerning responsibilities

ASSESSMENT OF IN-VEHICLE SYSTEMS

Even when quantitative measurements of a driver's visual performance are made (as for Figure 1), there remains the question as to the level of visual distraction that is acceptable in terms of safety. In undertaking an assessment of safety it is important to also appreciate the potential benefits that information and communication systems may provide. For example, a navigation system may encourage the driver to direct brief glances away from the road, but may be preferable to using a conventional map.

Accepting therefore that quantitative measurements are not sufficient, the DETR and TRL have developed a Checklist for assessors with background knowledge related to ergonomic design of human-machine interfaces and road vehicle safety. It is intended for use in conjunction with other assessment tools.

The Checklist was developed taking account of established ergonomic principles and practice, emerging international standards and previous codes of practice and safety checklists (7). It was widely distributed for comment and a workshop was held during 1999 after which the final version was produced (8).

The checklist itself is split into sections, each containing closely related issues that are addressed through a series of specific questions. There are forms for recording the assessment scenario, detailed results and a summary of findings. The forms are accompanied by Supportive Information providing further explanation and including examples of good and bad design, technical references and a glossary of terms and abbreviations.

The checklist is particularly detailed in the area of driver and workload (principally visual distraction). Since a complete assessment of this important aspect of driver performance would require field trials, the checklist, instead, makes detailed enquiries of various components that are likely to contribute to distraction when interacting with controls and visual displays.

The checklist has been applied to a number of systems (9) and has been found to provide a structured approach to safety assessment. It can be completed in a few hours and is useful in identifying areas (specific IVIS functions or design features) which need to be studied further using in-depth and more quantitative assessment techniques. It also provides a cost-effective primary assessment of an IVIS with respect to the EC statement of principles. For a fuller and more comprehensive assessment, the Checklist would need to be supplemented with:

- Subjective assessment using a panel of drivers
- Specific technical investigations of failure modes
- Quantitative measurements of visual workload.

Acknowledgements

This paper was produced under a contract placed by the Department of Environment, Transport and the Regions. Any views expressed in it are not necessarily those of the Department.

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