Draft Working Paper on

Human Machine Interface

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Summary

The High Level Group (HLG) has identified the Human Machine, Interface (HMI) as one of four short-term priority areas requiring attention as part of the Community action plan for the deployment of road transport telematics in Europe.

A concern has been raised that introducing information inside the vehicle might have an impact on traffic safety. This paper summarises the current situation concerning HMI, identifies the main issues for consideration by the HLG and provides a number of recommendations.

The current situation can be likened to a jigsaw:-

> In some areas information and consensus exists: For example, a set of Principles concerning HMI design and operation have been agreed by the European Conference of Ministers of Transport. Also, research knowledge is available in textbooks and, more recently, in guidelines derived from EC research projects.
>
> In other areas work is in hand: For example, manufacturers are involved in an active programme of standardisation of aspects of HMI design and performance. In the UK, the Department of Transport has sponsored the development of an HMI checklist and has a licensing regime in place for driver information systems.
>
> However, there are also areas in which pieces are missing: There is a lack of agreement concerning methodologies and criteria for evaluating HMI systems, and smaller manufacturers (particularly after-market suppliers) are sometimes unaware of current best-practice in design.

Options available to the HLG, which are discussed in the paper, include:

1. No specific action beyond information dissemination
2. Voluntary codes of practice
3. Standards
4. Legislation

Given that standards are a relatively long time-scale solution, the real choice for immediate action is between legislation and voluntary codes.

One approach to developing a voluntary code and evaluation process, based on the Statements of Principle agreed by the European Conference of Ministers of Transport and involving participation of European manufacturers, is outlined.

Some longer term recommendations for information dissemination, standards development and research are also given.

1. Current Situation

1.1 Introduction

Advances in vehicle instrumentation are driven by customer demand, the desire of manufacturers to add value, and by technology which offers increasingly sophisticated and cost effective options. The range of information and communications equipment available to the motorist has grown considerably over the past five years. Trip computers and RDS radio/cassette recorders are now standard on many models and the use of m-vehicle telephones has also increased. Throughout Europe, dynamic route guidance systems have been demonstrated and a number of other driver information products are on the market. In Germany, France, Japan and the USA screen based navigation systems are available as options on selected vehicles.

Any new item of equipment has potential implications for safety because it will alter the existing relationship between the driver, his vehicle and the road environment.

1.2 Actors and interests

From the public interest point of view, it is important that assurances can be given concerning in-vehicle telematic systems in the areas of'

> Safety - Public interest includes the safety of drivers using systems, their passengers and other road users. Ideally there would be agreed methodologies and criteria for evaluating systems. Type-approval and licensing provisions exist which cover safety-critical aspects of vehicles (such as brakes and lighting).
>
> Access and Introduction - Driving tests ensure minimum capabilities and 'driving standards (and additional provision is made for helping disabled drivers with mobility). There would be concern if HMI design made certain vehicles unsuitable for particular driver groups (e.g. elderly drivers) or restricted accessibility by requiring special training and/or testing.
>
> Market issues - There is public interest in promoting a fair and orderly market for telematic systems. HMI should not be used as a pretext for unfairly excluding products (e.g. from after-market suppliers). Within a suitable framework, European industry can exploit its strengths in product innovation and design to sell world-wide and this will encourage widespread use of beneficial products and economies of scale.

From the industry point of view, there is also a strong commitment to ensure driver comfort and safety. Vehicle manufacturers are aware that the automotive market is conservative and that long-term damage can be done unless new systems are introduced progressively and are accepted by their customers. There is, perhaps, a difference in emphasis between original equipment manufacturers and after-market suppliers. However, they both agree that uncertainty over procedures for approval and different procedures in different Member States hinder market development. They also wish to see a minimum of constraints on the development and implementation of future innovative products.

Vehicle manufacturers take an active part in HMI standardisation activity. They expect standards to provide minimum performance specifications and not to impinge on individual "look and feel" designs. Adopting standards is then a preferred route to minimising business risk.

1.3 Legislation

Manufacturers of automotive products already accept a wide ranging legal liability for their products. Manufacturers have a duty of care towards the users of their products 'and purchasers can also call on contract law to demand that goods are fit for purpose and of satisfactory quality. European Product Liability directives impose strict liability on manufacturers where defects in a product cause death, personal injury or loss or damage to property. In practice, manufacturers protect themselves by making use of "state-of-the-art" knowledge (including regulations, standards, codes of practice and, guidelines) and can argue that all reasonable skill and care was exercised in producing the product.

Surveys of national legislation (e.g. the Joint ECMT-ERTICO project, and within the DRIVE2 HARDIE project) show that different approaches have been taken by Member States in the area of in-vehicle systems and HMI. The situation is complicated by a number of factors including:

- The status of regulation (e.g. pertaining to criminal law, civil law, Codes)
- The degree to which regulations are enforced (which may vary between and within countries)
- The application and interpretation of non-specific regulations to new technology

Each European country has its own type approval system regarding construction of vehicles with mutual re'cognition provisions based on EC directives but there are few specific instances of regulations relating to in-vehicle telematic equipment. Examples include:

- Regulations in Spain concerning the use of hand-held telephones whilst driving.
- German regulation requiring good visibility through the windscreen.
- The UK Road Traffic (Driver Licensing and Information Systems) Act which requires certain types of driver information system to be licensed from the Department of Transport enabling the entire system to be evaluated where necessary, before commercial operation can begin.

1.4 Codes of Practice and related approaches

Based on preliminary work sponsored by the UK Department of Transport, the European Conference of Ministers of Transport has identified those factors - from the design stage of a system through to its actual use - that need to be considered in order to achieve safety and effectiveness of any particular system in practice. It has codified these factors in a Statement of Principles of Good Practice. These Principles are concerned with *what* needs to be achieved. The principles, along with some design guidelines from the original UK work have also been published as a "Draft for Development" by the British Standards Institute.

The Statements of Principle have been derived following a wide consultation and consensus-building process with Authority bodies and manufacturers. They are designed to prevent clearly unsafe products and it seems unlikely that the Principles would provide an insurmountable barrier to responsible manufacturers of in-vehicle equipment. Hence, the Principles provide a good basis for development following a co-operative approach.

1.5 Research and Guidelines

Research, implementation, and evaluation of in-vehicle systems has taken place both at a national and European level, through programmes such as DRIVE and the PROMETHEUS project.

Within the recent "DRIVE 2" programme, Area 5 and, more particularly, Topic Group 4 covered the human factors and driver interaction area. A CORD Task-force tackled evaluation (in its broad sense). The HOPES project provided support for evaluation of traffic system and HMI safety. Many projects (e.g. EMMIS,

EDDIT, ARIADNE, TESCO, ROSES, GEM) used specific methods for specific evaluation purposes and these have been summarised in Topic Group 4 deliverables. The CODE project is providing co-ordination in, this area under the Fourth Framework Programme (FP4).

Some EC funded projects have produced specific HMI guidelines based on research work and trials. HARDIE has published guidelines for HMI design for the general population in the following areas:

- Road and traffic information
- Navigation and route guidance
- Collision avoidance
- Adaptive cruise control

Other guidelines work has been published derived from the TELAID project for the mobility/perceptually impaired population, and from the EDDlT project for the elderly population. A significant body of work has also taken place at the University of Michigan Transport Research Institute and by Transport Canada. Additionally, a number of major books in the area of human factors for ATT systems have been produced in the past four years. Some sources are included as a bibliography in Appendix 1.

These books and reports contain a plethora of human factors data relevant to ATT systems, but often this is not in a form which is easily accessible to designers.

1.6 HMI Standards

In the EC, standards are increasingly being used to provide the essential technical requirements that in the past would have been included in national legislation or regulation. The use of standards in this way helps reduce technical barriers within the Community and promote wide acceptance of ATT systems.

A second trend is the increasing influence of International rather than European groups. Following their architecture initiative, the US have identified standardisation priorities and appear to have the funding to pursue them through ISO. Without a CEN standard in a particular area (e.g. because the different National European interests are unable to agree), the ISO standard would have to be adopted and, through GATT rules and procurement directives, could become effectively mandatory. The excellent organisation and funding of Japanese standards efforts can also be observed.

Standards for HMl are rather different from those concerning communications or databases, as they involve the interaction of drivers with in-vehicle equipment. Although standardisation of certain symbols is relatively straightforward it is by no means clear what a standard for the presentation of traffic or advanced vehicle control information should be like. However, there is an increasingly wide consensus that standards should, ideally, be of a "performance" nature (i.e. specifying what has to be achieved rather than the exact design that should be used).

Standards often take a considerable time to develop. Identifying requirement can be difficult, and agreeing requirements even more so. The resource-intensive nature of the standards process puts large manufacturers at a relative advantage (to smaller manufacturers and, perhaps, Authority bodies).

From a European perspective, the main HMl standardisation activity is that initiated by TC 278 WG10 which transferred to ISO TC 22 SC13 WG 8 with the same chairman and workplan and had its first meeting in November 1994. It has active members from UK, Germany, France, Italy, Sweden, USA and Japan but has also had attendees from Denmark and Canada. First Committee Drafts are emerging during 1996 as follows:

- visual information (some basic design and performance criteria)
- auditory information (some basic design information)

- visual measurement (definition of one method of measuring and recording eye movement data)
- dialogue management (general principles)

A summary of relevant HMI standardisation activity is provided in Appendix 2.

1.7 Evaluation

Evaluations of acceptable and unacceptable performance are made all the time concerning HMI by authorities, by manufacturers and by customers. Three examples illustrate the point:

- Spanish Authorities decided that the use of hand-held telephones while driving would be illegal.
- Bosch withdrew their original Travelpilot design and have since produced a new model.
- Customers in the UK declined to buy (or disabled) the speech output of Rover's "Maestro" car, produced in the 1970s.

An approach to HMI evaluation, sponsored by the UK DOT, builds on the ECMT Principles by defining a "Checklist" method to determine the extent-to which any particular in-vehicle system satisfies the Principles.

The method recognises that different aspects of HMI do not have the same implications for safety. For example, the statement "instructions should be durable" is of less safety concern than "use should not result in the vehicle becoming unsafe to drive". Therefore, a pragmatic approach has been developed which takes account of the importance of each principle *as* well *as* the extent to which a system complies with it. Failure to satisfy one or more critical safety criteria means that the system should be regarded as unsafe. Careful judgement needs to be exercised over less safety-critical elements. The importance of expert judgement has therefore not been excluded, but has been cast in a formal framework which is more open to inspection.

2. Problem areas

2.1 Scope of the HLG Initiative

A number of 'dimensions" of the HMI initiative require clarification:

- Inside and outside EU: As far as equipment being manufactured inside Europe is concerned, the requirement must be to ensure a fair and level market. However, there is also an issue concerning the safety of all equipment being used in Europe, irrespective of its country of design and manufacture.

- Original Equipment Manufacturers and after-market: The commercial approach of suppliers and characteristics of equipment from these can be quite different and hence different approaches towards solutions could be required.

- HMI and "system" view: Good HMI design does not guarantee a safe system. This is discussed further in the section below on safety.

- Applications covered: Although applications are evolving; some broad categorisation may be helpful e.g. conventional vehicle controls and displays, in-vehicle information systems, external information systems (e.g. VMS), vehicle control applications (such as ACC).

2.2 Safety

In 1991, the DRIVE Safety Task Force identified the need to consider the overall safety in terms of System Safety (i.e. problems caused by design faults or system malfunctions) and Traffic Safety (which involves all components of the traffic system and involves driving behaviour) as well as HMI Safety. As indicated above, there is a question of scope to be considered. Good HMI design does not guarantee a safe system although poor HMI design will generally make matters worse.

Safety can be evaluated, in the long term, by the number of accidents per unit distance travelled but, since accidents are such rare events, more immediately measurable alternative are often sought and it is tempting to extend a "safety pyramid" from accidents, through conflicts to indirect or "surrogate" measures of safety. Possible measures of driver performance related to HMI include glance frequencies and durations, and lateral vehicle control. Differences in such indirect measures can certainly be detected with different in-vehicle HMI, and appear to correspond well with perceived driver comfort, but their relationship to safety is unproven. Clearly, "safe" and "unsafe" are ends of a continuum between which real devices occur.

Any human performance based HMl evaluation method needs to consider the choice of subjects and the variability and subtleties of human responses including behaviour modification. Drivers may only interact with an in-vehicle system when they feel safe to do so, and for a time that they are comfortable with.

2.3 HMI standards

Despite considerable efforts, the HMI standards (emerging from ISO TC22 SC13 WG8) can only approach the "performance" standard ideal in a small number of (relatively uncontroversial) areas, and gaps remain. For example, the issue of map displays is explicitly excluded from the visual standard. Although text on a display is assured to be visible, guidance about how much text should be presented or when, or what message it should convey is limited.

The standard will also describe a method (i.e. one possible method) for measuring visual behaviour and presenting results. This should better enable research work to be compared in the future, but no explicit link can be supported from metrics of glance duration and frequency to acceptable/unacceptable performance.

Standards are very specific instruments and need to be based on widely-agreed evidence A standard cannot specify *all the* necessary requirements to produce a "safe" system nor identify *all the* things that should be avoided to guarantee safety. So, although the standard *may* make a contribution to better design (and hence improved safety conformance to the standard gives no guarantee about the safety of a given device.

2.4 Evaluation

In commonusage, "HMI evaluation" has come to mean an investigation of the overall merit of an interface taking account of driver comfort and safety. Such evaluations are often based on implicit and poorly defined criteria since there are no widespread agreements about which evaluation methods are appropriate or what constitutes an "acceptable levels of performance". Note that in the context of standards "evaluation" does not mean an investigation of the overall *merit* of an interface but its *conformance,* i.e. the extent to which a given device meets the provisions of the standard (and a specification of equipment and procedures necessary to determine this). In the IS0 group referred to above, the topic of evaluation has yet to be addressed.

3. Possible Solutions

First it is necessary to decide on scope and objectives. Although the principle of increasing driver comfort and safety will be readily agreed by Authority bodies and Manufacturers, the preferred methods to achieve and ensure this are likely to be more diverse.

Four basic approaches can be identified, and can be used in combination:

1. No specific action (leaving the issue to ongoing research, and customer and market forces)
2. Voluntary codes of practice
3. standards
4. Legislation

The identification of Human Machine Interface as a strategic issue to be addressed in the short-term by the HLG implies that Member. States regard this as an area for attention and action. At a minimum, there seems to be a need for publicity and dissemination of good practice throughout the industry and, particularly, to smaller after-market suppliers. A wealth of informal (often scientifically "unsupported") knowledge exists as well as more recent research findings and design guidelines.

Current standards work is limited, as described above and can be protracted Standards bodies have to make use of existing information rather than carring out original work and standards need to be based on research evidence and a broad consensus. If Member States wish to go beyond the sort of document that the current standard process is likely to produce (for example to specify pass/fail criteria for safety related features), then such objectives may have to be pursued in a forum other than standards.

Again because of the dearth of scientific evidence, *restrictive* legislation to supplement existing product liability regulations could be difficult to write. Even relatively simple laws such as banning non hands-free communications equipment, or equipment which requires both hands to be used, requires careful definition of terms and could potentially be rendered obsolete by improvements and innovations in technology. An approach of *permissive* legislation allows Authorities to become aware of systems with potential safety implication and involves an evaluation process which is not tightly specified. To date, this appears'to have worked well within a generally permissive regime(UK), but the approach may not transfer as well to other Member States.

An approach using a voluntary code provides a basis on which new research Wings and advances in technology can be incorporated. It also provides a basis on which an evaluation process and series of benchmarks can be built (if required).

Whether the route of legislation or of a voluntary code is followed, the question of evaluation (conformance to the legislation or code) has still to be addressed. Accepting that assessing complex concepts such as safety will, for the foreseeable future, be a matter of expert judgement, this suggests that a framework should be sought within which those expert judgements can be expressed and communicated. A checklist method offers one approach to this which could detail:

- the criterion to be tested
- a detailed interpretation of exactly what the criterion means
- the rationale for why the question is important and the consequences of not fulfilling the implied requirements
- the method to answer the question, including how to present the data
- specific examples of good and bad design solutions
- references to any related experimental work

The level of detail specified within the checklist would have to be decided (and would, perhaps, be different in different areas). For example, the checklist could:

- make no requirements of the evaluation method
- require the category of method to be specified by the assessor (as in ISO 9241-14)
- specify the category of method to be used
- specify the method and data presentation to be used
- specify the required standard based on the data

4. Recommendations

Authority "bodies of the Member States need to first agree a framework, for future work and clarify the issues of scope, referred to above.

Then, the four options should be considered:

1. No specific action beyond information dissemination
2. Voluntary codes of practice
3. Standards
4. Legislation

Given that standards are a relatively long time-scale solution, the real choice for immediate action is between legislation and voluntary codes. A European rather than National approach is preferable (and perhaps mandatory) so the scope for a workable agreement needs to be explored. Either route implies a common approach to evaluation. One factor which the Member States may wish to consider is the role of manufacturers within the decision-making process. Clearly, legislation could be enacted in isolation from manufacturers but any form of voluntary code is unlikely to be workable without them.

Assuming that a participatory approach to a voluntary code is the preferred solution, the Member States should consider the consultation process that they wish to see between Authorities and Suppliers. The following recommendations are submitted for consideration as one possible way of proceeding:

1. The ECMT Statements of Principle, which are based on wide consultation, should be taken as a starting point.

2. A small group of (up to 6) experts should be established under CEN TC278 WG10 (not ISO) to develop and agree a "Checklist" approach (as described above) based on the Statements of Principle as a framework for making subjective and objective assessment of in-vehicle telematic systems. A strictly limited timescale for reporting should be established of 6 months. Participation should be contingent on a willingness to work towards a pragmatic solution within that timescale. The output should be published and will be available for use by Authority bodies.

3. The Statements of principle and checklist evaluation should be incorporated into a European Voluntary code prepared by Authority bodies with input from manufacturers.

For the longer term, some further recommendations can be given:

4. A dissemination programme should be established to allow "best practice" in HMI design and evaluation to become more accessible. This should involve summarising existing knowledge and guidelines from EC and other international programmes and making them available (e.g. in book form' or intemet pages).

5. The results of (2.) should be submitted to ISO TC22 SC13 WG8 where a new Work Item on Evaluation and Safety should be established. An agreed international standard would be the longer-term goal.

6. The Commission could support research projects, for example, under FP4 2nd call, which can contribute to the knowledge required to write performance standards in the area of HMI.

APPENDIX 1:. BIBLIOGRAPHY SOME SOURCES OF INFORMATION

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APPENDIX 2: SUMMARY OF HMI STANDARDS ACTIVITY

GROUP	WORKING GROUP	NOTES
CEN/TC 278 Road Transport informatics	WG10 Man-Machine Interface	Most activity has now been transferred to ISO/TC22 SC13 WG 8 under the same Chairman. Work on symbols transferred to ISO/TC22 SC13 WG5. TC278 WG10 is now dormant but ready to receive input from ISO groups.
ISO/TC 22 SC 13		This Sub-Committee was re-activated in 1994. (Chair G Rupp)
	WG 3 controls and tell-tales	
	WG 5 Symbols	
	WG 7 Hand Reach and R and H point determination	
	WG 8 Traffic Information Control Systems On-board - Man Machine interface	The activities of WG8 are described in greater detail within the main paper (chair: F Hartemann)
	WG 9 Human Factors and MMI	Duplicate of TC 204 WG 13
ISO/TC 204 Transport Informatics and Control Systems		Broadly speaking, this is the recently formed ISO equivalent of CEN/TC278. Note that CEN/TC278 WG10 did not transfer here.
	WG 13 Human Factors and MMI	WG 13 was originally focused on off-board information presentation (VMS signs etc) but has been re-defined by the participants towards in-vehicle applications. (chair: G Farber)
	WG 14 Obstacle warning systems	This includes front, side, rear, comer warnings, and mayday systems. It also has interest in human factors issue: associated with Adaptive cruise control and Collision warning/avoidance systems.