Update of the safety checklist for the assessment of in-vehicle information systems: a scoping study

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Update of the Safety Checklist for the Assessment of In-Vehicle Information Systems

A Scoping Study

by S Cynk and D Basacik (TRL)

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(Adrian Burrows)

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Executive summary

A safety checklist for the assessment of In-Vehicle Information Systems (IVIS) (Stevens et al., 1999) was developed by TRL for the Department of the Environment, Transport and the Regions (DETR) in the late 1990s. The checklist was based upon codes of practice and international standards that were relevant at the time of development. Since the checklist’s publication, there have been several advances in technology along with developments in the field of ergonomics and road safety. It is important for the checklist to remain up-to-date to ensure that users are assessing the safety and ergonomics of their systems against current standards.

Much research on the ergonomics of IVIS has been conducted since the publication of the checklist. Many new technologies have also emerged: touchscreens are now widely used, with head-up displays (HUDs) and device integration expected to become a more prevalent aspect of IVIS. As a result of these new technologies, new standards and guidance on the ergonomics and safety of in-vehicle technology have arisen, indicating that the checklist may no longer be current.

One approach for an update of the safety checklist is to base it solely upon the European Statement of Principles on human machine interface for in-vehicle information and communication systems (ESoP, 2008). The ESoP provides guidelines for manufacturers in relation to how IVIS should be designed in order to prevent safety risks from occurring.

Another approach is for the checklist to be broader in scope, as it is currently. In order to determine what the scope of the checklist should be, users of the checklist were surveyed. Whilst arguments were presented for and against the alignment of the checklist with the ESoP (2008), general consensus was that the checklist should take on a broader scope to remain robust for the assessment of IVIS.

In addition, respondents expressed a preference for an electronic system with an option to print the checklist if needed. Finally, most survey respondents stated that they would like to work with TRL on a project to update the checklist, particularly if national or international funding were available. The most appropriate route suggested in the survey was COST.
1 Introduction

A Safety Checklist for the Assessment of In-Vehicle Information Systems (IVIS) (Stevens et al., 1999) was developed by TRL on behalf of the Department of the Environment, Transport and the Regions (DETR) the late 1990s. The checklist drew upon codes of practice and international standards which existed or were emerging at the time of its development. The In-Vehicle Information System (IVIS) User Manual Usability and Safety Checklist was also developed by TRL (Brook-Carter, 2004). These checklists take a similar approach to assessing whether the use of an in-vehicle system may compromise safety.

In advance of this current study, there was anecdotal evidence that the checklist is being used both in industrial and academic settings; however, there have been advances in technology and developments in the fields of ergonomics and road safety since its publication. The DfT, as sponsors of the checklist, are in a position to ensure that the checklist remains up-to-date, thus ensuring that users of the checklist are assessing the safety and ergonomics of their systems against appropriate and up-to-date standards and guidance.

The study described within this document was commissioned to investigate whether an update of the checklist is necessary, and if so, to consider the scope of such an update. To this end, the following tasks were undertaken:

- A broad review of IVIS technology, ergonomics and safety issues associated with the technology, and available literature and guidance on these issues, including other checklists
- An investigation of potential presentation options for an assessment spreadsheet or tool
- A survey of users and potential users of the Checklist
- An investigation of potential avenues and partners for international collaboration, should the DfT wish to pursue an update of the Checklist.

The following sections summarise the findings of the study.
2 Advances in ergonomics

There have been significant scientific and technological advances in the field of In-Vehicle Information Systems over the last decade. One consideration of this study was whether these technological changes have ergonomics implications which could be addressed within the Checklist.

The following references are standards and guidelines relevant to ergonomics and IVIS which have emerged or been updated since the publication of the Checklist:

- Federal Motor Vehicle Safety Standards (NHTSA, 2008)
- Federal Motor Vehicle Safety Standards (NHTSA, 2008)
- Statement of Principles on Human Machine Interface (HMI) for In-Vehicle Information and Communication Systems (Commission of the European Communities, 2006)
- SAE Recommended Practice Calculation of the Time to Complete In-Vehicle Navigation and Route Guidance Tasks (SAE J2365), (Society of Automotive Engineers, 2002)
- ISO 3958 Road vehicles – Passenger car driver hand control reach
- ISO 4040 (2001) Road vehicles - passenger cars - location of hand controls, indicators and tell-tales
- ISO 7000 (2004) – Graphical symbols for use on equipment - Index and synopsis
- ISO (DIS) 11429 Ergonomics – System danger and non-danger signals with sounds and lights
- ISO FDIS 16673 Road vehicles – Ergonomic aspects of transport information and control systems - Occlusion method to assess visual distraction

These key references were not available when the Checklist was published, and future revisions need to reflect the best practice outlined within these documents.

In addition to the more general references listed above, there have been specific technological advances over the last decade such as the introduction of head-up displays and touchscreens. Furthermore, issues on device integration and non-critical warnings have continued to be investigated. The following subsections highlight work which has been done in these areas over the last decade.

2.1 Head-up displays

Head-up displays (HUD) project data to a position within the user’s field of view and allow the driver of a vehicle to view visual information without looking away from the road ahead. Currently, HUDs are fitted to high specification vehicles but are expected to become more prevalent in mainstream models over time as costs reduce (Techwatch, 2008). Although it is conceivable that some principles of information display on head-down displays (HDD) may apply to IVIS which utilise HUDs, the current safety checklist does not specifically cater for such designs. With the potential for HUDs to become more popular, it is important that any additional HMI safety issues can be assessed.

The following table presents some key ergonomics references in relation to HUDs.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Horrey et al., 2003</td>
<td>When compared with head-down displays (HDD), the use of HUDs increased the driver's performance on secondary tasks with slowed response times to hazard events.</td>
</tr>
<tr>
<td>Kiefer, 1998</td>
<td>HUDs improved forward scene visibility for older drivers who detected pedestrians more readily than those using HDD.</td>
</tr>
<tr>
<td>Hada, 1994</td>
<td>Drivers are able to look at a HUD for 180 ms longer than HDD without driving performance being affected.</td>
</tr>
<tr>
<td>Liu and Wen, 2004</td>
<td>Drivers are able to respond to information presented on a HUD almost 1 second faster than when presented on a HDD.</td>
</tr>
<tr>
<td>Dingus et al., 2005</td>
<td>Driving performance may deteriorate as a result of HUDs which impose a secondary task as drivers monitor the images as they are driving and become distracted.</td>
</tr>
<tr>
<td>Gish and Staplin, 1995</td>
<td>Projecting symbology onto the forward driving scene will mask external objects and have a negative affect on driving performance. This will become more of a problem in cluttered environments as more external elements are added to the HUD.</td>
</tr>
</tbody>
</table>

The references above highlight that during the design of displays, there may be some fundamental decisions to make in terms of whether a HUD or HDD is preferable. Furthermore, if a HUD is chosen as the preferred design, there has been some scientific research highlighting design considerations specific to this mode of display. As the Checklist currently does not incorporate this knowledge, it is possible to argue that it is not suitable for the assessment of in-vehicle systems which use HUDs.
2.2 Touchscreens

The use of touchscreen technology is becoming a common feature of IVIS. One reason for this may be that they enable an overall reduction in the size of the device. This has the benefit of minimising the obstruction to the driver’s vision.

Navigation and route guidance systems are one of the more prevalent IVIS that utilise touchscreens. They give drivers step-by-step instructions on which route to follow to get to their destination, allowing users to focus on their driving. Satellite navigation systems are now very common due to their relatively low price, and an increasing number of cars have factory fitted systems (Techwatch, 2008). While some navigation systems do not use touchscreen technology, it is likely that the popularity of navigation systems has led to a significant increase in the use of touchscreen technology within vehicles.

Table 2 summarises the results of a brief literature search on the benefits and risks of touchscreens.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tsimhoni, Smith &amp; Green, 2004</td>
<td>Touchscreen technology causes greater disturbances to driving performance than IVIS that use speech recognition. More attention and time is required for use of touchscreen IVIS.</td>
</tr>
<tr>
<td>Huang et al., 2007</td>
<td>Results showed that the usability of touch icons was affected by seven factors: touch field, semantics quality, dynamics, hit quality, tactility, color quality, and shape quality. Among these, touch field was rated as being the most important. Finally, the results of correlation analyses indicated that the user experience affected the importance ratings for usability.</td>
</tr>
<tr>
<td>Woods et al., 2003</td>
<td>An assessment of non-keyboard input devices (NKID) was conducted to identify factors for good design in relation to operation, performance and comfort.</td>
</tr>
<tr>
<td>Salvucci et al, 2007</td>
<td>Devices which have greater tactile feedback in their buttons and controls facilitate ‘blind’ operation and are easier to use while driving.</td>
</tr>
</tbody>
</table>

The table above illustrates that there has been research on design considerations for touchscreens over the last decade. Given the increase in the prevalence of touchscreens within the vehicle, it is important to ensure that any safety considerations can be assessed using the safety checklist.

2.3 Integration issues

In addition to the issue of new varieties of control and display technologies, the issue of device integration has been raised as a significant research area in literature on driver distraction (e.g. Basacik and Stevens, 2008).

Integration can occur in a variety of ways. One example is the packaging of various IVIS functions into a single device, such as the integration of speed, congestion and accident warning systems with navigation systems. Although simple broadcast alerts of accidents and congestion have been available for many years, it is becoming more common for digital messages to be transmitted to, for example, navigation systems, to alert the driver to information that they can then act on. Some satellite navigation systems are able to automatically re-route based on traffic information. Thus, a number of functions are being integrated into a single device.

In addition, drivers are increasingly using nomadic devices within their vehicle. These devices can be used alongside other in-vehicle devices. It is important to consider the
combined demand that the combination of systems could put on the driver, particularly in safety-critical situations. This suggests that it is insufficient to consider the design of a single system when assessing safety, but rather the design of systems in the context of other IVIS.

Table 3 contains some references to human factors considerations related to device integration.

**Table 3. Effects of integrating devices for human machine interface**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Notes</th>
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<tbody>
<tr>
<td>Sanders and McCormick, 1992</td>
<td>With multiple channels of information, people tend to sample channels in which the signals occur frequently rather than those in which signals do not occur often. A driver may miss an important warning if it does not occur as frequently as some others.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Warnings of multiple devices must be managed and prioritised as drivers can become confused if messages are presented simultaneously.</td>
</tr>
<tr>
<td>EC AIDE Project</td>
<td>The result of sub project 3 will be the design, development and validation of three prototype road vehicles, one city car, one luxury car and one heavy truck, for the safe integration of multiple IVIS and ADAS functions, including nomad devices</td>
</tr>
</tbody>
</table>

A further aspect of integration relates to system controls. For example, the BMW iDrive incorporates many different technologies that are accessible and adjustable by a single control. The iDrive is currently available on three models of BMW cars. The integration of controls has been investigated in relation to, for example, the joystick controls of fighter jets (Sanders and McCormick, 1992). However, there appears to be a relative scarcity of research in this field.

The integration of nomadic devices and original equipment, and the integration of system controls are emerging areas of research. While literature may currently be sparse, it is also important to consider including some general questions or remarks within the Checklist, to ensure that this issue is considered during any assessment.

### 2.4 Warning messages

There has been considerable research in the field of in-vehicle warnings over the last decade. Arguably, a safety checklist may not be an appropriate method of assessing drivers’ likely responses to critical warnings; however, a number of devices also emit non-critical warnings which may be more appropriate for inclusion within the scope of the checklist. Non-critical warning systems give the driver information which is useful in accomplishing the driving task, but that does not require an immediate response to be of benefit.

Common in-vehicle warnings include seat belt reminders that alert the driver when the seat belt is not engaged correctly. Drivers are encouraged to utilise these restraints, either by way of a visual cue or an audible alarm indicating that the seat belt is not inserted into the socket. Tyre pressure monitoring systems also use a warning to inform the driver when a tyre has deflated below the recommended pressure. In the USA, this type of IVIS has been a mandatory requirement for all light motor vehicles sold after 1st September 2007. Since the USA is a major distributor, increasing numbers of vehicles in Europe are now fitted with tyre-pressure monitoring systems.

Weather warning systems warn the user of potential adverse weather conditions that may have an effect on their driving performance. Typical systems include traffic broadcasts, SMS and webcam updates. Simple traffic broadcasts have been used for...
many years to alert the driver to rain, fog, ice, snow, etc, whilst more involved systems, such as SMS alerts and webcams, are being developed.

On-board diagnostic systems inform the driver of any defects by monitoring the status of other in-vehicle systems. Since 2001, new vehicles have been required to have approved diagnostic systems. Early on-board diagnostic systems simply illuminated a malfunction indicator light if a problem was detected. However, modern on-board diagnostic systems use a digital communications port to identify and remedy vehicle malfunctions.

Additionally, satellite navigation and route guidance systems can give verbal instructions which are usually supplemented by visual displays.

Many of the warning systems mentioned above use either a visual or auditory indicator, or both, to make the driver aware of a non-critical occurrence. If designed incorrectly, it is possible that these warnings could distract the user from the primary driving task.

The table below summarises the results of a broad literature search on non-critical warnings.
Table 4. Ergonomics of warning systems

<table>
<thead>
<tr>
<th>Reference</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN ISO 15006:2004</td>
<td>Road vehicles. Ergonomic aspects of transport information and control systems. Specifications and compliance procedures for in-vehicle auditory presentation</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Simple tones have been shown to produce faster reaction times than speech warnings when used in conjunction with a visual display.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Familiar environmental sounds intuitively convey information about the object or action they represent, e.g. Car horn or skidding tyres.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Auditory icons produce significantly faster response times compared with tone and speech, but with more inappropriate responses such as braking in non-collision situations.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Auditory warnings can startle the driver so should be avoided for advisory warnings.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Simple warning tones may confuse the driver and produce an unnecessary response if they do not know what the tone indicates.</td>
</tr>
<tr>
<td>Grönlund, 2008</td>
<td>Auditory warning chimes can confuse a driver if they do not sound often enough for the driver to learn their meanings.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Drivers with auditory impairments do not benefit from auditory warnings.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Drivers may be listening to the stereo or having a conversation with passengers which can mask auditory warnings.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Female synthesised voices may require greater intensity to achieve the same level of effectiveness that a male voice elicits. Female voices are perceived to be quieter and less effective than male voices.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Visual displays that appear abruptly, flash, and are conspicuous in colour (red/amber) catch the driver’s attention.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Visual warnings provide the driver with situation specific information but they are not very good at capturing the user’s attention as they must be placed in the driver’s line of sight.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>The visual display should be at least twice as bright as the background.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Older drivers wear glasses more often which may interfere with the visual display of warnings, leading to slower reaction times.</td>
</tr>
<tr>
<td>Campbell et al., 2007</td>
<td>Visual warnings that are similar in colour and close to other symbols may confuse the driver.</td>
</tr>
<tr>
<td>Brown, 2005</td>
<td>Multimodal warnings are more effective at warning drivers than single mode warnings. A hearing impaired user would benefit from the visual display for example.</td>
</tr>
</tbody>
</table>

2.5 Commentary

The sections above show that there has been a significant research effort on the ergonomics of in-vehicle information systems since the publication of the Checklist. Touchscreens are now in widespread use, and there are suggestions that HUDs will be used in mainstream vehicle models as the cost of the technology decreases. A broad
literature search has identified design considerations in relation to HUDs, touchscreens and in-vehicle warnings. In addition, there has been some research on device integration; however, this area of research is perhaps not as well-developed.

In addition to scientific research, the last decade has also seen a significant number of new standards and guidance on the ergonomics of in-vehicle technology.

These findings suggest that current users of the Checklist may not be assessing the safety of their devices against the most current and up-to-date best practice guidance. Checklist users would benefit from an updated version which caters for new technologies and includes the scientific progress, a brief summary of which has been outlined within this section.
3 A comparison of the latest ESoP and the Safety Checklist

3.1 ESoP on human machine interface for in-vehicle information and communication systems

The European Statement of Principles on human machine interface for in-vehicle information and communication systems (ESoP, 2008) is a document which summarises safety considerations regarding the interactions between drivers and in-vehicle information and communication systems. This statement of principles aims to deal with issues relating to all information and communications systems that are used by drivers during the driving task, with the exception of voice controlled systems or warning systems that require immediate driver action. Specifications are given relating to class M and N vehicles, including passenger cars, trucks, and buses but not motorcycles and other vehicles. Its main approach is to provide manufacturers with some design guidelines for information and communication systems and to prevent safety risks from occurring. The main points covered are:

- How to design and locate information and communication systems so that their use does not compromise the driving task,
- How to present information in a way that does not impair the driver’s vision of the road,
- How to design system interaction such that the driver maintains safe control of the vehicle, feels comfortable and confident with the system, and is ready to respond to unexpected occurrences.

The principles cover six topic areas that specify the requirements for the design and manufacture of in-vehicle information and communication systems. Each principle is followed by an explanation, good and bad examples, which systems it applies to, verification of whether a system is in accordance with a principle and references which provide additional information relevant to the principle.

First, factors regarding the overall design of the system are highlighted, particularly focusing on the importance of the system not posing a risk to the driver. Then, guidance is given on installation and location of the system.

A number of suggestions are also made for the presentation of information to ensure that the system does not create hazards for the driver.

Comprehensive instructions are given regarding the interaction between the driver and the display and controls. Guidance for auditory information and the system’s responses is presented.

Aspects of system behaviour are covered and the principles advise that components that are dangerous to interact with when driving should be disabled when the vehicle is in use.

The next set of principles describes how information about the system should be presented and what the content of this should be.

Recommendations for safe use are also outlined to support drivers in the safe operation of in-vehicle systems while driving.
Finally, advice for the implementation of the ESoP (2008) and recommendations for safe use is provided for the attention of industry providers and services, with particular emphasis on nomadic devices.

Although the principles that are outlined in this paper are aimed to be used for any type of IVIS and to be resilient to technological developments, revision of the principles may be necessary to accommodate integration of functions and systems.

### 3.2 The safety checklist for assessment of IVIS

Design guidelines for safety of in-vehicle information systems were developed by Stevens et al. in 2002 to provide manufacturers with a summarised review of the factors that need to be considered in the design process. A safety checklist (Stevens et al., 1999) was developed as a supplement to these guidelines; this presented manufacturers with a structured tool to assess whether existing or planned IVIS systems comply with safety guidelines and best-practice. Several experts are able to use the checklist to identify and discuss safety concerns before making recommendations for improvements if necessary.

The checklist is split into six sections: Documentation, Installation, Controls, Auditory, Visual and Dialogue & Safety. The issues are addressed through a series of specific questions that can be used to identify relevant features. These include:

- **Documentation and user instructions**: Questions are based around compliance with standards, regulations and recommendations, packaging information and instructions, and training for the user.

- **Installation of IVIS**: The physical and visual access to driver controls and displays are considered along with compatibility with other systems.

- **Ergonomic issues of how the driver interacts with the controls**: This includes layout and design, visual displays (location and legibility), and attributes of auditory information such as volume and frequency.

- **The interaction between drivers and systems**: The display of information, menu facilities, as well as simplicity and quantity are assessed.

- **Safety issues related to IVIS**: Consideration is given to driver distraction, system fault and input error warnings, the potential for driver behavioural adaptation and the provision of accurate information.

The guidelines (Stevens et al., 2002) and checklist (Stevens et al., 1999) primarily deal with IVIS that provide the driver with information about his journey, but may also be transferable to in-vehicle entertainment systems. However, it may not be appropriate to assess a number of systems, such as head-up displays, iDrive and similar controls, device integration, touchscreens, and warning messages, using the checklist which was published before these technologies were deployed.

### 3.3 In-vehicle information system (IVIS) user manual usability and safety checklist

This checklist (Brook-Carter, 2004) was developed to assess IVIS User Manuals against established ergonomics custom and practice. Its primary approach is to provide a structured aid to an expert who wishes to assess the usability of IVIS user manuals and...
the effective provision of safety information within them. This is regarded as the first step for identifying potential problems which may then be investigated further to come to a solution.

According to Brook-Carter (2004), the evaluation of IVIS User Manuals involves three stages. During the first of these, details about the assessment scenario are recorded. The assessor must note down information about the IVIS and User Manual that they are reviewing, including details of the product and the nature of the assessment.

The second stage involves conducting the checklist assessment. A series of questions and response boxes allows the assessors to reach a qualitative evaluation of the IVIS User Manual. Elements of the manual are reviewed in turn. The assessor uses the checklist to establish the quality of the user manual, whether the information included is simple and accurate, whether instructions are clearly explained, whether the diagrams used are clear and appropriate, how easy navigation of the user manual is, whether the User manual is appropriate for its prospective users, and whether the safety issues that may occur are clear.

Supportive information is provided alongside the checklist to clarify what each element of the IVIS User Manual should include. Examples of good and bad practices are also included as a further aid.

The final stage in the evaluation of IVIS User Manuals is to complete the assessment summary report. The assessors note both the good and bad features of the user manuals; this structured approach then enables them to suggest recommendations to overcome any concerns.

This checklist was developed as a tool to establish the effectiveness and usability of IVIS User Manuals. As it does not focus on safety implications of the in-vehicle technology itself, this checklist appears to be resilient to changes in technology. However, the IVIS User Manual Usability and Safety Checklist (Brook-Carter, 2004) does not refer to legal requirements. These may directly affect the use of IVIS by drivers and the current checklist regarding user manuals does not consider this.

3.4 Commentary

The checklists described above are used to assess the safety of IVIS and the usability of IVIS user manuals. They both take a similar approach to communicating best practice guidance. Both are divided into sections and present the reviewer with a number of questions relating to specific elements of the system or manual. The main difference is the subject matter of each checklist, with one focussing on the design of a device and the other assessing the clarity and precision of information provided about the system within a user manual.

While the overall aims of the ESoP (2008) and Safety Checklist for the Assessment of IVIS (Stevens et al., 1999) are similar, each hold particular value at different stages of the product lifecycle. Although the ESoP could be used at any stage throughout the design and manufacturing process, it is especially useful during the initial stages of design. The ESoP does not provide specific criteria to assess whether the design goal has been achieved for a finished product. This is where the safety checklist becomes an effective tool, as it is designed to assess the safety of a prototype or finished product at the end of manufacture.

For example, one of the ESoP (2008) principles in relation to the visual display of information states that:

“Visually displayed information presented at any one time by the system should be designed such that the driver is able to
assimilate the relevant information with a few glances which are brief enough not to adversely affect driving”.

This statement is elaborated upon to explain that if the driver is required to glance at information regularly in order to detect the visually displayed information, then the risk of encountering dangerous traffic situations while glancing away from the road is increased. The ESoP then provides examples of good and bad practice in relation to the principle, to provide further support to the reader. The good example given for the principle above is as follows:

“Easily legible and well structured graphics on a well positioned visual display which allows identification of the relevant menu item with one single glance of 1 second”.

The bad example given is:

“A navigation system which only offers support by a visual display rich in detail, which needs full and lengthy attention of the driver to identify a target on a moving map”.

Finally, references that are relevant to the principle are given.

The safety checklist (Stevens et al., 1999), however, asks a series of questions to determine whether a system is likely to compromise safety. In relation to visual displays, for example, the checklist asks a number of questions to establish whether the presentation of visual information is appropriate for use within vehicles. Questions asked about the visual display of information include:

1. “Does information presented on the IVIS display appear legible?”
2. “Can the IVIS internal illumination be used without washout of the display in any conditions?”
3. “Are colours used effectively in the design and presentation of visual images?”

The reviewer is asked to select one of four responses:

- “none” – there are no safety concerns,
- “minor” – there are minor safety concerns in relation to the questions,
- “serious” – there are serious safety risks associated with the question, or
- “NA”.

Many of the questions are broken down further to assess specific parameters of the system with respect to the question asked. Question 1 (does information presented on the IVIS display appear legible?), for example, is divided into a set specific statements, which may, in turn be broken down into specific parameters to be assessed. For example:

- Legibility is not compromised by: size of image, contrast, brightness, illumination, image stability, resolution, and colour.
- The use of capitals is limited, for example, first letter only.
- Graphics/representational features are clearly the same when highlighted or reversed out.
- Horizontal and vertical spacing of words and sentences is consistent.

The assessor notes their level of agreement with the statement as true, false or NA, for each parameter.

The examples above demonstrate the different approaches taken within the Checklist (Stevens et al., 1999) and ESoP (2008). It is clear that the ESoP offers general guidelines for manufacturers in relation to the design of IVIS to prevent safety risks from
occurring. The safety checklists, however, are more rigorous and specific in terms of identifying safety concerns.

The sections above summarise two separate checklists: one for the assessment of the system itself, and a further checklist for the assessment of the user manual. A sensible approach would be to combine the two checklists, so that a single tool could be used to assess the IVIS ‘package’ which the driver receives. An update of the Safety Checklist would be an ideal opportunity to facilitate this.
4 Questionnaire Survey of Users

In addition to the broad review of literature, this scoping study also conducted a questionnaire survey to obtain opinions on the Safety Checklist for the Assessment of In-Vehicle Information Systems (Stevens et al., 1999).

Participants were questioned on the methods which they use to assess the safety of IVIS, whether they use the TRL/DETR IVIS checklist and how often they use this tool. The questionnaire also asked participants whether they think the checklist needed to be updated, and what the scope of this should be. In particular, the questionnaire aimed to identify whether the Safety Checklist for the Assessment of In-Vehicle Information Systems (IVIS) should be solely based on the European Statement of Principles (ESoP, 2008) or whether it should remain broader. Finally, the questionnaire included questions regarding presentation options for the checklist, and potential sources of funding for checklist development. A copy of the questionnaire can be found in Appendix A.

4.1 Participants

97 individuals from universities, manufacturers and road safety research companies were contacted by email and asked to comment, by filling in a questionnaire, on the Safety Checklist for the Assessment of In-Vehicle Information Systems. Contacts were located in several different European countries, USA, Canada, Japan and Australia. Of the 97 people that were contacted, 12 responded.

4.2 Method

The questionnaire was developed based on the research questions of the study. It was piloted with an expert in driver distraction, and revised based on comments. The final version of the questionnaire was sent to all participants with a covering email outlining the aims of the study. The email contained a hyperlink to the checklist, in case any of the participants needed to refresh their memory about its content. A reminder email was then sent approximately three weeks after the initial email.

4.3 Results

In total, twelve people responded to the questionnaire, although only 9 questionnaires were returned. A review of the questionnaire responses shows that the TRL/DETR IVIS checklist is used by 6 of the respondents. Of the remainder, three of the respondents do not use a checklist at all, whereas two have created their own checklist and one uses the SaTTE checklist. One person indicated that as well as using the TRL/DETR IVIS checklist, they use an adapted version of it which incorporates revisions to certain terms and rephrased questions to make the checklist more suitable for assessing IVIS in the early stages of design.

Of the respondents who use the TRL/DETR IVIS checklist and responded to the question, three stated that they have used it within the last two years. One respondent had used it between 1 and 5 years ago and a further respondent, more than 5 years ago. A further respondent indicated that the Checklist was being used to develop a similar tool to assess information systems used by motorcyclists.

Seven people responded the question on whether the TRL/DETR IVIS checklist needs to be updated, all of whom reported that an update is required. In terms of the scope of the checklist, two of the nine who responded, thought that safety checklists for assessing IVIS should be based solely on the ESoP as they are the accepted standard. However, the majority expressed an opinion that the ESoP are underdeveloped and too restrictive.
for assessing the safety of IVIS. They suggested that the domain of application should be extended to include other relevant principles and EU country specific habits. One respondent noted that the appeal of the current checklist is that it is broader in scope than the ESoP, and that basing it on a wider set of principles would help to ensure its value outside of the EU.

Nevertheless, there were some suggestions for improvement including ratings for traffic safety impact, a broader range of problem field areas, a total numerical score and minimisation of the number of true/false items. Particular subject areas recommended for inclusion were the quality of auditory information, non-physical input controls such as voice recognition and a section on the interaction between IVIS. Finally, it was suggested that further revisions should:

- avoid human factors jargon,
- allow the assessor to justify their responses,
- make the checklist a suitable tool for assessing IVIS at all stages of the design process,
- create versions in other languages for use in the EU, and
- accommodate features at all levels (e.g. to assess each display separately when there are multiple displays in a vehicle).

Half of the respondents believed that a hand-held PC based system for input and analysis would be the most suitable format for an updated checklist. One person thought that the updated checklist should be presented on a hand-held PC based system with an option to print the checklist for field.

### 4.4 Commentary

The questionnaire results are an important part of this study, because they reflect the opinions of well respected individuals working in the area of intelligent transport systems and road safety, who are users and potential users of a safety checklist. Although the response rate was not high, there is evidence that the Checklist is being used, and a consensus that an update is required to reflect scientific and technological progress.

On the subject of its scope, only two out of nine respondents indicated that they would prefer to see the Checklist and the ESoP (2008) aligned. The majority opinion was that the broader scope of the Checklist was appealing and useful in carrying out assessments. In fact, it was suggested that the scope of the Checklist should be such that it is also applicable outside of the EU. It is possible for the Checklist to be both based on the ESoP and support a broader assessment if electronic recording and filtering is used.

In terms of presentation, there was a general agreement that an electronic version of the checklist would be beneficial, although there were also suggestions that the Checklist should be printable if necessary. The main options for an electronic system would be to write bespoke software, or use spreadsheet programmes such as Microsoft Excel, which are known to be accessible to most potential users. The latter could be seen as a more cost-effective option, which also overcomes the need for potential users to download additional software onto their computers. However, any software used for the checklist would most likely require regular maintenance.
5 Potential partners for international collaboration

The questionnaire survey outlined in section 3 asked respondents for suggestions of national and international organisations which might be appropriate for funding a project to update the TRL/DETR Safety Checklist for the Assessment of IVIS. Respondents named COST, International Transport Safety Association, the European Commission, OEMs and tier 1 suppliers, ERA-NET transport, FP7 and eSafety as being worth further investigation.

5.1 COST

COST is the European Cooperation in the field of Scientific and Technical Research. It is one of the longest-running European instruments supporting cooperation among scientists and researchers across Europe. COST is also the first and widest European intergovernmental network for coordination of nationally funded research activities. COST’s mission is to strengthen Europe in scientific and technical research through the support of European cooperation and interaction between European Researchers. It also aims to maximise European Synergy and added value in non-competitive and pre-normative research. COST enables scientists to collaborate in a wide spectrum of activities grouped under nine key scientific domains. Although COST does not provide funding for research in itself, it provides financial support for cooperation efforts of scientific groups across Europe and the coordination of these research networks called “Actions”. Funds will cover the costs of networking activities such as meetings, conferences, workshops, short term scientific exchanges and dissemination activities.

Two of the specific key domains that COST covers are information and communications technology and transport and urban development, both of which could possibly include an update of the safety checklist.

5.2 ERA-NET Transport

ERA-NET Transport develops and supports a wide range of research programmes in the area of transport research policy. ERA-NET Transport specifically look at the economic benefits, efficiency improvements, environmental improvements and safety factors involved in transportation. Driver support systems with an interface between the driver and the vehicle and the vehicle and the road are some outputs from their workshops so it is possible that ERA-NET Transport could be approached to provide funding for a safety checklist update.

5.3 European Commision / FP7

The commission awards money in the form of grants to implement projects or activities in relation to European Union policies. In the area of transport, funding is provided for projects in the field of transport safety.

Framework Programmes (FPs) are a main financial tool used by the European Union to support all scientific disciplines. FP7 identifies 7 challenge areas and 2 other areas in an attempt to address sustainable development. The relevant topics that are covered for transportation in the FP7 focus on improving road safety by use of in-vehicle systems and improving energy efficiency of all modes of transport. In particular, the ICT for road safety area centres on advanced in-vehicle safety systems which aim to improve systems supporting autonomous driving, systems which improve vehicle performance and reduce costs, and collision avoidance systems.
Considering the specifications of the FP7, this type of funding is probably not applicable for an update of the TRL/DETR safety checklist for the Assessment of IVIS would more than likely fall outside of the scope of the call for research.

5.4 **International Transport Safety Association**

The International Transport Safety Association (ITSA) aims to improve the safety of all modes of transport and transport systems across many different countries. Despite their interest in improving transport safety, it is unlikely that the ITSA will be interested in funding an update of the safety checklist as their main focus is on accident investigation.
6 Discussion and Conclusions

This study aimed to investigate whether there is a need for the Safety Checklist for the Assessment of IVIS (Stevens et al., 1999) to be updated, and if so, what its scope should be. To this end, a survey of users of the Checklist was conducted alongside desk research.

The desk research highlighted a number of key standards and guidelines which have come into existence since the publication of the Checklist in the late 1990s. Furthermore, it showed that technologies such as head-up displays and touchscreens, which were not specifically considered when the Checklist was compiled, are coming into increasing use. In-vehicle warnings, and issues relating to the integration of devices are also becoming more important as vehicle manufacturers integrate IVIS, and drivers bring nomadic devices into the vehicle. Although the literature appears to be somewhat scarcer in relation to device integration, there is a body of ergonomics research not currently reflected within the Checklist. The implications are that current users of the Checklist may not be assessing their systems against the most up-to-date guidance and best-practice.

In terms of scope, it is suggested that the two checklists for assessing the device and its user manual could be merged into a single tool. In addition, there are arguments for and against the alignment of the Checklist with the ESoP (2008). While on one hand the ESoP represent the definitive European guidance on the subject of IVIS design, it is also possible to argue that the broader scope of the checklist, and the depth to which it covers design issues is beneficial from a safety perspective. Indeed, the questionnaire results show that most respondents were against the alignment of the ESoP and Checklist, instead favouring the Checklist remaining a broader and more rigorous tool for the assessment of IVIS.

In terms of format, the survey results suggested an electronic system would be beneficial, as long as there remained an option to print the checklist if needed. The main options would be to write bespoke software, or use spreadsheet programmes such as Microsoft Excel, which are known to be accessible to most potential users. The latter could be seen as a more cost-effective option, which also overcomes the need for potential users to download additional software onto their computers.

A final aim of this project was to investigate potential opportunities for international collaboration. Most survey respondents stated that they would be happy to work with TRL on a project to update the checklist. Of the potential bodies identified by respondents, COST appears to be the most likely as a co-ordinating organisation, although the majority of funding would need to come from national governments.

It is suggested that, should an update be commissioned, opportunities for collaboration are exploited to bring different, even cross-cultural perspectives on IVIS design. Such a process would increase the applicability of the Checklist across Europe and beyond, ensuring a wider application area for the Checklist.
Acknowledgements

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Appendix A  Questionnaire

1. Which checklists have you used to assess the safety of in-vehicle information systems (IVIS)? Please place an ‘x’ next to all that apply.

☐ None

☐ The TRL/DETR Safety Checklist for the Assessment of In-Vehicle Information Systems

☐ Other(s) (please specify):

2. If you have used The TRL/DETR Safety Checklist for the Assessment of In-Vehicle Information Systems (IVIS), please answer the following questions:

a. When did you last use it?

☐ Less than 2 years ago

☐ 2 - 5 years ago (inclusive)

☐ More than 5 years ago

b. Do you think there is a need to update this checklist?

☐ Yes    ☐ No

Please make suggestions for future revisions:

Please make suggestions for future revisions:

c. What format do you think would be most suitable for an updated checklist?

☐ Pen and paper system

☐ Hand-held PC-based system for input only

☐ Hand-held PC based system for input and analysis

☐ Other (please specify):
3. The TRL/DETR Safety Checklist for the Assessment of IVIS is currently broader in scope than the European Statement of Principles (ESoP) on Human Machine Interface for In-Vehicle Information and Communication Systems, and also gives more specific guidance in places.

Do you think safety checklists for assessing In-Vehicle Information Systems should be based solely on the ESoP?

☐ Yes  ☐ No

Please explain why:

4. Can you suggest any national or international organisations which might be interested in funding a project to update The TRL/DETR Safety Checklist for the Assessment of In-Vehicle Information Systems? Please write your suggestions below.

a. If some national or international funding could be identified, would you be willing to work jointly on a new IVIS checklist project?

☐ Yes  ☐ No
Update of the safety checklist for the assessment of in-vehicle information systems: a scoping study

A safety checklist for the assessment of In-Vehicle Information Systems (IVIS) (Stevens et al., 1999) was developed by TRL for the Department of the Environment, Transport and the Regions (DETR) in the late 1990s. The checklist was based upon codes of practice and international standards that were relevant at the time of development. A literature review and a questionnaire survey of experts was conducted to ascertain whether and how the checklist should be updated. Much research on the ergonomics of IVIS has been conducted since the publication of the checklist. Many new technologies have also emerged: touchscreens are now widely used, with head-up displays (HUDs) and device integration expected to become a more prevalent aspect of IVIS. As a result of these new technologies, new standards and guidance on the ergonomics and safety of in-vehicle technology have arisen, indicating that the checklist may no longer be current. The results also suggest that there are arguments for and against the alignment of the checklist with the European Statement of Principles (2008); however, the general consensus was that the checklist should remain broader in scope and depth to remain robust for the assessment of IVIS.

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