



Measures for assessing on-board units for electronic toll collection — Parts 1 and 2

**Prepared for Tolled Roads and Crossings Division, Department
of the Environment, Transport and the Regions**

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Executive Summary

As part of their policy to find new ways to fund road building and maintenance, the Department of Transport (now the Department of the Environment, Transport and the Regions (DETR)) is investigating the possibility of tolling drivers for their use of the motorway system. Part of this investigation involves inviting several consortia to produce Electronic Toll Collection (ETC) systems for testing and evaluation. Testing of the ETC systems is scheduled to begin during 1996.

TRL was asked to develop methodologies for the assessment of ETC on-board units (OBUs). This was undertaken in the absence of any detailed information about the OBUs or their supporting systems belonging to the various consortia involved in the trials.

In the first instance an assessment of the user preferences and expectations of such a system was undertaken. This involved a theoretical assessment of the potential needs of a system user. This assessment was then used to develop a questionnaire (see Part 1) to elicit user preferences and expectations of an ETC system with regard to the OBU, which was distributed to seventeen people within TRL. It was found that potential users expect a unit to display power and tolling status with LEDs and to provide credit information. The unit is expected to be the same size as a cassette box and use a disposable card system for credit transfer. However it is not possible to draw strong conclusions from the survey owing to the number and type of subjects used.

The main part of the study was to develop an ergonomics based checklist (see also Part 2) to assess ETC OBUs with particular regard to safety and good ergonomics. The checklist was loosely based around both the UK Code of Practice for the ergonomics and safety of in-vehicle information systems and a human machine interface safety checklist for in-vehicle information systems, currently under development for DITM Division of DOT (DETR).

In addition, a questionnaire was created to subjectively assess the safety implications of the use of on-board units for the purpose of motorway tolling. The questionnaire along with the ergonomic checklist will be validated during the track trials at TRL.

Part 1: Main report

1 Introduction

As part of their policy to find new ways to fund road building and maintenance, the Department of Transport (now the Department of the Environment, Transport and the Regions (DETR)) is investigating the possibility of tolling drivers for their use of the motorway system. Part of this investigation involves inviting several consortia to produce Electronic Toll Collection (ETC) systems for testing and evaluation. Testing of the ETC systems is scheduled to begin during 1996.

TRL was asked to develop methodologies for assessing the safety and usability of OBUs. This was undertaken in the absence of any detailed information about the OBUs (or their supporting systems) from the various consortia involved in the trials.

This TRL study was divided into three parts in order to examine the safety issues of the human machine interface and to provide a broader understanding of user preferences concerning the OBU. The three parts of the study are shown below:

- User preferences
- Ergonomics checklist (see also Part 2)
- Driver safety

2 Assessment of user preferences

2.1 Questionnaire design

In order to assess the preferences of potential users of an ETC OBU a questionnaire was developed for internal use at TRL. The questionnaire (see Appendix A) was designed to elicit information about the potential user preferences of ETC OBU users. The questionnaire contains questions concerned with the type of information displayed by the unit, the mode of display, and the appearance of the unit. Questions relating to the method of toll payment, the use of card systems, and other information which could be provided by the tolling unit. The questionnaire was distributed to seventeen staff at TRL.

2.2 Results of user preference questionnaire

2.2.1 Demographic information

Of the seventeen TRL employees questioned, three were in the age group 17-24, three in the age group 25-34, nine in the 35-49 age group and two in the 50-64 age group. Ten of those surveyed were female and seven were male. Seven of the group wore glasses for driving.

2.2.2 Information provided by the unit

The questions focused on the information provided by the unit and the display method used. When questioned as to whether they would like the status of the system to be displayed to them, (e.g. on/off, toll/no toll), fifteen respondents stated that they did want this information displayed to them, whilst two did not.

When asked how they would like the power status of the unit to be displayed to them (if it had to be displayed), fifteen respondents stated they would like this done using a Light Emitting Diode (LED), and two respondents answered that they would like this information displayed on a screen.

When the respondents were asked how they would like the tolling status of the unit displayed, eleven stated they would like this done using an LED and six preferred the information to be displayed textually on a screen. The respondents were more divided on when they would like their tolling credit status displayed to them. Nine respondents wanted their current credit status to be displayed continuously, six only wanted credit information when their credit was low, and two did not want their credit status to be displayed at all.

2.2.3 The on-board unit

When questioned about the size they would expect the OBU to be, seven respondents expected the unit to be smaller than an audio cassette box, nine the same size as an audio cassette box, with one respondent answering 'don't know'.

The questionnaire also included a question about the preferred appearance of the OBU. Twelve respondents stated that they wanted the appearance of the OBU to be discrete and unnoticeable and four wanted it to enhance the interior décor of the vehicle in some way. One respondent answered 'don't know'.

2.2.4 Method of toll payment

When asked how they would like to pay their motorway tolls, eight respondents wanted to pay using rechargeable smart cards, four wanted a direct debit smart card, four wanted direct billing (post use), with one don't know.

If a card based system were to be used, fifteen of those questioned said they would prefer the system to use disposable toll cards, one would prefer smart card technology, and one respondent didn't know.

In the event of a smartcard system being used, thirteen respondents were against a payment system that could debit their bank account directly, three were in favour of this method, with one 'don't know'. Eleven were against the smart card replacing the driving licence, while five respondents were in favour of this.

2.2.5 Other comments

Other types of information that respondents suggested could be displayed by the OBU included the level of tolls, the distance between tolls, road conditions, details of road works and possible delays.

Two of those questioned expressed concern about the possibility of fraud or error if a direct debit payment system was used.

2.3 Discussion of user preferences

The results suggest that potential users may prefer OBUs for ETC to display information about both their power and tolling status using LEDs. The unit would also be expected to provide credit information, though the ability to have

this displayed only when credit was low would be useful. The OBU is expected to be the same size or smaller than an audio cassette box, with most respondents preferring the unit to be discrete and unnoticeable. Payment is preferred via disposable toll card.

Since only a small sample of drivers were taken and this sample was clearly unrepresentative of the driving population, results cannot be generalised. Nonetheless, this small survey has produced interesting data concerning user preferences and it has highlighted possible areas where the design of the questionnaire could be improved (e.g. it might be useful to allow respondents to give more than one answer to some questions, or rank responses in order of preference).

3 Ergonomics checklist

3.1 Introduction

As a suitable tool for assessing the usability and safety of the OBUs was not in existence, a new ergonomics based checklist was developed for this purpose. The checklist is an adaptation of the Human-Machine Interaction checklist for In-Vehicle Information Systems (IVIS) under development for DITM Division of DOT (DETR) and is based on the UK Code of Practice. The Code of Practice takes a very general approach to in-vehicle systems and is primarily concerned with safety issues. The HMI checklist for IVIS was not appropriate for evaluating ETC OBUs as it covers areas which are not applicable to the tolling units and there are certain features of OBUs which are not covered by the IVIS checklist.

The OBU checklist (part II of this report) incorporates the most relevant sections of both the Code of Practice and the HMI checklist for IVIS, as well as including new sections specifically related to evaluating tolling units.

3.2 Scope and purpose

Tolling systems can be classified in a number of ways (e.g. by the technology they use). A previous TRL study proposed that OBUs should be classified by the complexity of their construction according to the following scheme:

Class	Description
0	No device suggested in proposal.
1	Vague alternatives suggested in proposal.
2	Simple OBU This has no display, keypad, or any external features. It is simply fitted to the inside of the windscreen.
3	OBU with display This has the same characteristics as the 'simple OBU' above, but also has a display on the unit (for example, to show the remaining credit).
4	OBU with display and button This has a display and a single button (used e.g. as an on/off switch or to scroll around displayed information).

5 **OBU with display and keypad**
This has a display and number of buttons or controls (to implement several functions including indicating a trailer).

6 **Demonstration OBU sub-system**
These are often based on a portable PC and have high functionality but are clearly not saleable as production units.

The OBU checklist was designed for the assessment of devices ranging from simple units (class 2) to OBUs with display and keypad (class 5). It was anticipated that some of these units would be capable of providing auditory and textual information. Highly advanced systems (e.g. those which use speech output, or provide functions not related to tolling) need also to be assessed using the full Human Machine Interface safety checklist for In-Vehicle Information Systems. The nature of the questions in the OBU checklist is limited to questions which a competent person could answer equipped solely with the checklist and a vehicle equipped with the OBU. More sophisticated objective assessments may be called for if the assessor feels that difficulties exist in answering questions, or that a function is on the borderline between acceptability and unacceptability.

The checklist is aimed at assessors with a background knowledge related to ergonomic design of Human Machine Interfaces and road vehicle safety. The checklist is intended to be used in conjunction with other assessment tools dealing with non-ergonomic aspects of the OBU.

The OBU checklist is designed to provide a structured subjective assessment tool for the evaluation of safety related ergonomic features of an ETC OBU system. In addition it gives a systematic method of allocating a 'score' to the ETC system/OBU which indicates the extent to which it can be considered ergonomic and may be useful to compare different OBU designs.

3.3 Description of checklist

The checklist contains:

- Introduction - Background information and instructions for completing the checklist.
- The Checklist - Working checklist to be used when assessing ETC OBUs scoring system.

The checklist itself is split into five sections, each containing closely related questions.

- Section 1 - Questions relating to Physical Interface
- Section 2 - Questions relating to the Human Machine Interface
- Section 3 - Questions relating to Information Presentation
- Section 4 - Questions relating to Toll Payment
- Section 5 - Questions relating to Documentation of the System

The scoring system employed in this document is based upon a scoring system derived at TRL for the ergonomic aspects of the UK Code of Practice (CoP) and developed

further in the HMI checklist for in-vehicle information systems. The CoP scoring was derived from a series of paired comparisons of every question, ordering and ranking the importance of each question and allotting a fractional score. For the OBU checklist, the weighting score allotted to each question within a sub-section (of which there are 13) was allocated in a similar way to the CoP, and reflects the perceived importance of that question in terms of safety and useability when compared with the other questions *in the same sub-section*. Each question has its own scoring bar e.g.

-2	-1	0	+1	+2
Some critical abbreviations have problems	Some abbreviations have problems	Not applicable, there are no text displays	The use of abbreviations is adequate	The use of abbreviations is excellent

The scoring allows different OBUs from each consortia to be compared within each of the thirteen sub-sections of the checklist. (However, because some whole sub-sections may be applicable to some OBUs but not others, the scoring system does not allow a total score for the OBUs to be calculated with which they can be compared). The following table has been devised to record and allow easy comparisons between the scores of each of the different OBUs for each of the checklist sub-sections.

ETC System	Section												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1													
2													
3													
4													
:													
n													

3.4 Discussion

The absence of OBUs in the development process of the checklist may mean that it is not comprehensive and it is recommended that development work continues when the ETC track trials begin at TRL. It is possible that the OBU checklist will eventually be amalgamated with the IVIS checklist. This will ensure that any checklist evaluation of ETC OBUs can be conducted comprehensively across all aspects of their man-machine interface.

At a later date it may be decided to produce a supportive text to accompany the tolling checklist. If this is the case then this document would provide detailed instructions for completing the checklist in addition to a discussion of the weightings applied to questions.

4 Subjective assessment of driver safety

4.1 Scope

A questionnaire has been created to subjectively assess whether OBUs pose a hazard for road users by concentrating on whether the units distract the driver from the task of vehicle control. It is anticipated that questionnaire piloting will be undertaken on the TRL test track during 1996 during testing of tolling systems.

At the initial stage the sampling frame will consist of drivers using the test track at TRL.

4.2 Questionnaire design

The questionnaire is designed primarily to assess the distraction effects of the OBU, but acceptance and understanding of the unit is also taken into consideration. The questionnaire is divided into five parts. The first part asks general questions about the user's driving habits. The following section concentrates on the human machine interface of the OBU. Part three examines the user's understanding of information provided by the unit by considering a number of tolling scenarios, (e.g. when the vehicle passes through a toll), and checks whether the user has understood the feedback from the unit. In addition this part of the questionnaire examines safety issues not covered in the previous section. The following section asks questions about difficulties the user may have encountered when using the unit. It also covers the important topic of system failure. The last section is included to obtain more general information from the user.

4.3 Piloting the questionnaire

At the present time only one OBU is available for study. As the unit does not function independently from its supporting tolling system, it is unable to provide any feedback. Thus the questionnaire can only be piloted once a tolling system is in place, or alternatively when a mock-up unit is created to mimic a working OBU. Once the piloting stage has been completed any necessary modifications will be made to the questionnaire.

5 Discussion and conclusions

The study has developed methodologies for assessing OBUs for ETC, as well as developing subjective methodologies for assessing user preferences and expectations. It will be necessary to validate both the ergonomics checklist and the driver safety questionnaire using a working version of an ETC system with its associated OBUs. In addition it would be advantageous to distribute the user preferences questionnaire to a wider group of subjects at a later date.

It is important that user preferences and expectations are taken into consideration when designing new systems and their interfaces as this will not only make them easier (and often safer) to use but will also improve the chances of the new system being accepted by the users.

The authors consider that further development work should be carried out on the ergonomics checklist and the

safety questionnaire. This can be started once track testing begins and OBUs in their supportive ETC environments become available. Further development work on the user preferences questionnaire would also be valuable.

6 Acknowledgements

The study described in this report forms part of the research programme undertaken for the Department of Transport (now Department of the Environment, Transport and the Regions). The advice of Dr A Stevens, Mr A Quimby and Mr B Stoneman is gratefully acknowledged.

7 References

Department of Transport (1994). *The design of in-vehicle information systems Code of Practice and Design Guidelines, revision D.*

European Conference of Ministers of Transport (ECMT) (1995). *New information technologies in the road transport sector - Policy Issues, Ergonomics and Safety.* London, HMSO.

Appendix A: User response questionnaire

USER RESPONSE QUESTIONNAIRE

Date

No.

The purpose of this questionnaire is to assess the safety aspects of the various motorway tolling systems which are being tested on the TRL track. Your answers will be treated in the strictest confidence.

Part 1: General questions about you and your driving habits

1. What is your age? (please tick box)

17-24 25-34 35-49 50-64 65+

2. What is your sex? male female

3. What is your occupation?

4. Do you wear glasses for driving? Yes No

5. Approximately how many miles do you drive per year?

6. Approximately how many miles do you drive per year on motorways?

Part 2: Questions about the display and the interface of the on-board unit (OBU)

7. Could you see the OBU when driving the vehicle without having to avert your gaze from the road? Yes No

8. Did you find the presence of the OBU distracting? Yes No

9. If there is a display on the OBU, how easy was it to read information from the display while the vehicle was in motion? (please circle number)

v. easy 1 2 3 4 5 6 7 v. difficult

10. Did you have any problems reading the display in daylight?

Yes No Not applicable

11. Did you have any problems reading the display in the dark?

Yes No Not applicable

12. How easy was it to locate and operate the buttons/controls of the OBU while the vehicle was in motion? (if applicable, please circle number)

v. easy 1 2 3 4 5 6 7 v. difficult

13. How did you find volume of the unit?
(if applicable, please circle number)

too quiet 1 2 3 4 5 6 7 too loud

14. Did you find any of the messages from OBU annoying?

Yes No Not applicable

Part 3: Questions about using the on-board unit (OBU)

15. When the vehicle passed through a toll, what did the unit do?

Don't know
 Not applicable

16. Were you able to read the credit balance while the vehicle was in motion?

Yes - Was it awkward/difficult to display the credit balance ? Yes No
- Did you have any difficulty reading the credit balance? Yes No
 No, Don't know Not applicable

17. How did you know when credits were deducted from the unit?

Don't know
 Not applicable

18. How did you know when credits were low on the unit?

Don't know
 Not applicable

19. How did you know when there were no credits left on the unit?

Don't know
 Not applicable

20. How did you know when the battery was low?

Don't know
 Not applicable

Part 4: Questions about any difficulties you may have had with the OBU

21. Please describe any difficulties you have had with the OBU.

None

22. Did the system fail?

Yes

When did it fail?

What happened?

No

Part 5: General questions about the OBU

23. Please describe any of the OBU's features which you find awkward/don't like.
(if applicable)

24. Which features (if any) would you like to see improved?

25. Which features (if any) do you find unnecessary?

26. Would you like to see any additional features incorporated into the unit?

27. Please give any other comments you have about the OBU.

THANK YOU FOR YOUR HELP

Appendix B: User preferences questionnaire — Private car

USER PREFERENCES QUESTIONNAIRE - Private car

Date

No.

The purpose of this questionnaire is to assess the user needs and expectations of electronic motorway tolling systems, with particular emphasis on on-board units (OBUs) and the information they provide. Your answers will be treated in the strictest confidence.

Have you already participated in the TRL motorway tolling trials? Yes No

Part 1: Personal details

1. What is your age? (please tick box)

17-24 25-34 35-49 50-64 65+

2. What is your sex? male female

3. What is your occupation?

4. Do you wear glasses for driving? Yes No

5. How many miles do you drive a year?

6. How many miles do you drive on motorways?

Part 2: Information provided by the unit

7. Would you like the status of the system (ie. what it is doing at any given time eg. on/off, toll/no toll) to be displayed to you?

Yes No Don't Know

8. How would you like the power status displayed?

- By an LED/light
- By text on a screen
- By an auditory tone (beep/noise) when unit is switched on
- Don't know

14. Would you like the appearance of the OBU to

- Be discrete and unnoticeable
- Enhance the overall appearance of your car
- Other (please state)
- Don't know / don't mind

Part 4: Method of toll payment

15. How would you like to pay your motorway tolls?

- Using a rechargeable smart card
- Direct billing to your bank
- Post use billing (eg. quarterly toll bills)
- Don't know / don't mind
- Other (please state)

16. If a card system were used, would you prefer the system to use

- Disposable toll cards (e.g. phone card)
- Rechargeable toll cards
- Don't know / don't mind

Part 5: Other Comments

17. If you have any other comments to make about what you might want from an electronic toll collection system, please write them in the space below.

THANK YOU FOR YOUR HELP

Appendix C: User preferences questionnaire — Motorcyclist

USER PREFERENCES QUESTIONNAIRE - Motorcyclist

Date

No.

The purpose of this questionnaire is to assess the user needs and expectations of electronic motorway tolling systems, with particular emphasis on on-board units (OBUs) and the information they provide. Your answers will be treated in the strictest confidence.

Part 1: Personal details

1. What is your age? (please tick box)

17-24 25-34 35-49 50-64 65+

2. What is your sex? male female

3. What is your occupation?

4. Do you wear glasses for driving? Yes No

5. How many miles do you ride a year?

6. How many miles do you ride on motorways?

Part 2: Information provided by the unit

7. Would you like the status of the system (ie. what it is doing at any given time eg. on/off, toll/no toll) to be displayed to you?

Yes

No

Don't Know

8. How would you like the power status displayed?

By an LED/light

By text on a screen

By an auditory tone (beep/noise) when the unit is switched on

Don't know

9. How would you like the tolling status displayed?

- By an LED/light
- By text on a screen
- By an auditory tone (beep/noise)
- Don't know / don't mind

10. Would you like a display to inform you of your credit remaining in the unit?

- Yes No Only when credit
is low Don't Know

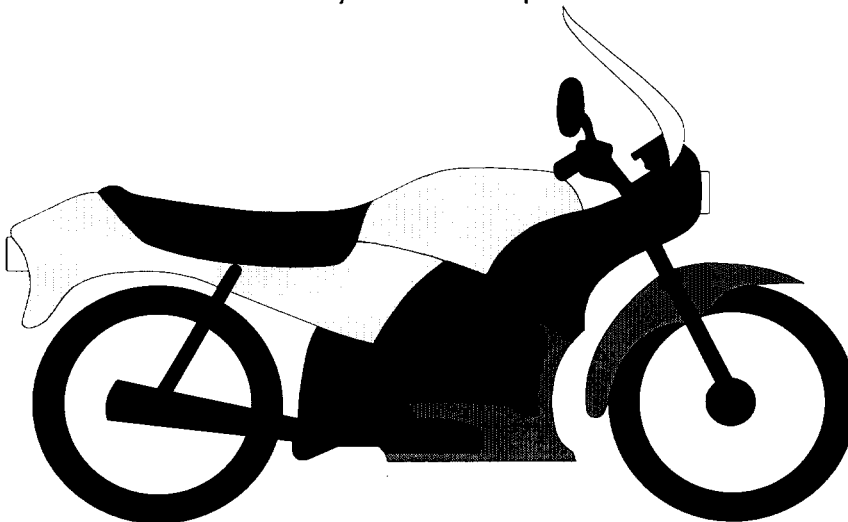
11. Is there any other information you would like the unit to display to you?

Part 3: The in-vehicle unit

12. What size would you expect/like the OBU to be?

- Smaller than a audio cassette box
- The same size as an audio cassette box
- Larger than an audio cassette box
- Don't know

13. Please mark where on the bike you would expect/like the OBU to be attached ?



14. Would you like the appearance of the OBU to

- Be discrete and unnoticeable
- Enhance the overall appearance of your bike
- Other (please state)
- Don't know / don't mind

Part 4: Method of toll payment

15. How would you like to pay your motorway tolls?

- Using a rechargeable smart card
- Direct billing to your bank
- Post use billing (eg. quarterly toll bills)
- Don't know / don't mind
- Other (please state)

16. If a card system were used, would you prefer the system to use

- Disposable toll cards (e.g. phone card)
- Rechargeable toll cards
- Don't know / don't mind

Part 5: Other Comments

17. If you have any other comments to make about what you might want from an electronic toll collection system, please write them in the space below.

THANK YOU FOR YOUR HELP

Appendix D: User preferences questionnaire — HGV

USER PREFERENCES QUESTIONNAIRE - HGV

Date

No.

The purpose of this questionnaire is to assess the user needs and expectations of electronic motorway tolling systems, with particular emphasis on on-board units (OBUs) and the information they provide. Your answers will be treated in the strictest confidence.

Have you already participated in the TRL motorway tolling trials? Yes No

Part 1: Personal details

1. What is your age? (please tick box)

17-24 25-34 35-49 50-64 65+

2. What is your sex? male female

3. What is your occupation?

4. Do you wear glasses for driving? Yes No

5. How many miles do you drive a year?

6. How many miles do you drive on motorways?

Part 2: Information provided by the unit

7. Would you like the status of the system (ie. what it is doing at any given time eg. on/off, toll/no toll) to be displayed to you?

Yes

No

Don't Know

8. How would you like the power status displayed?

By an LED/light

By text on a screen

By an auditory tone (beep/noise) when the unit is switched on

Don't know

9. How would you like the tolling status* displayed? (* whether you are being tolled or not)

- By an LED/light
- By text on a screen
- By an auditory tone (beep/noise)
- Don't know

10. Would you like a display to inform you of your credit remaining in the unit?

- Yes No Only when credit is low Don't Know

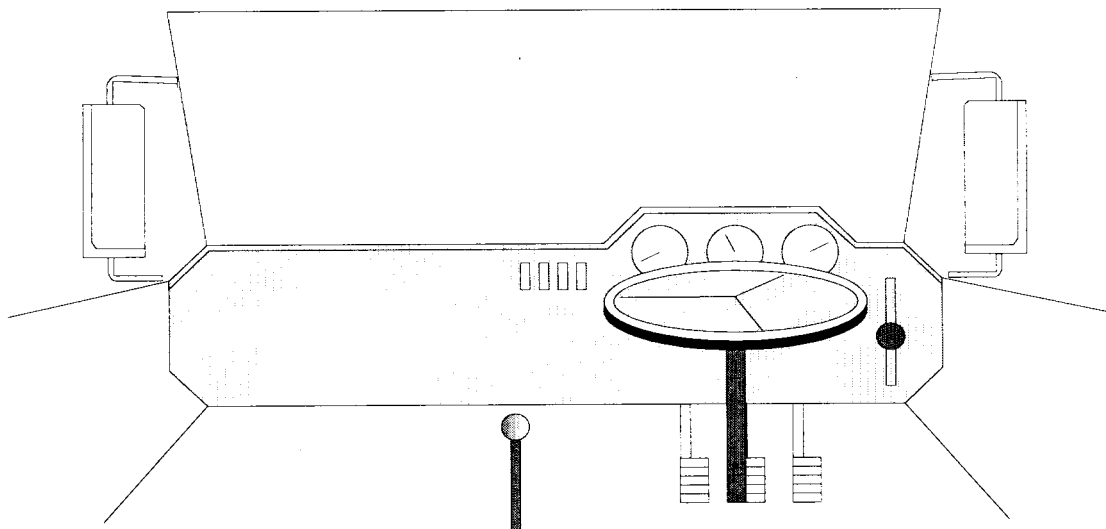
11. Is there any other information you would like the unit to display to you?

Part 3: The in-vehicle unit

12. What size would you expect/like the OBU to be?

- Smaller than a audio cassette box
- The same size as an audio cassette box
- Larger than an audio cassette box
- Don't know / don't mind

13. Where on the windscreen would you like the OBU to be attached ?



14. Would you like the appearance of the OBU to

- Be discrete and unnoticeable
- Enhance the overall appearance of your HGV
- Other (please state)
- Don't know / don't mind

Part 4: Method of toll payment

15. How would you like your company to pay for motorway tolls?

- Using a rechargeable smart card
- Direct billing to their bank
- Post use billing (eg. quarterly toll bills)
- Don't know / don't mind
- Other (please state)

16. If a card system were used, would you prefer the system to use

- Disposable toll cards (e.g. phone card)
- Rechargeable toll cards
- Don't know / don't mind

Part 5: Other Comments

17. If you have any other comments to make about what you might want from an electronic toll collection system, please write them in the space below.

THANK YOU FOR YOUR HELP

Part 2: Safety checklist

1 Introduction

1.1 Scope

This document contains an ergonomics based ‘Safety Checklist’ for evaluating on-board units (OBU) designed for Electronic Toll Collection (ETC) against well established ergonomic custom and practice. The checklist is designed for the evaluation of ETC OBUs which are capable of providing auditory and written visual information using some form of screen. Highly advanced systems, (e.g. systems which provide information other than just for tolling, or ones using speech output), should also be assessed using the full Human Machine Interface safety checklist for in-vehicle information systems. The nature of the questions is limited to those which a competent person could conduct equipped solely with the checklist and a vehicle equipped with the OBU. More sophisticated objective assessments may be called for if the assessor feels that difficulties exist in answering questions or that a function is on the borderline between acceptability and unacceptability.

The checklist is intended for assessors with background knowledge related to ergonomic design of Human Machine Interfaces (HMI) and road vehicle safety. The checklist is intended to be used in conjunction with other assessment tools dealing with non ergonomic aspects of the OBU.

1.2 Function

The function of the document is to provide both a structured subjective assessment tool for the evaluation of safety related ergonomic features of an ETC OBU system and systematic method of allocating a ‘score’ to parts of the ETC system/OBU which indicates the extent to which it can be considered ergonomic.

1.3 Structure

The checklist itself is split into five sections, each containing closely related questions. The sections are:

- 1 Questions relating to Physical Interface
- 2 Questions relating to the Human Machine Interface
- 3 Questions relating to Information Presentation
- 4 Questions relating to Toll Payment
- 5 Questions relating to Documentation of the System

2 Instructions for completing the checklist

The checklist is for subjective assessment only and should not require sophisticated measuring instruments. Where the assessor feels that the evaluation can only conclude by adopting an objective method, this needs to be indicated in the report.

The majority of the questions require the OBU to be correctly installed to the manufacturer’s or supplier’s specification in a motor vehicle of a type the device is designed to be used in.

The questions are divided into five sections and thirteen subsections. This is for ease of use of the checklist as closely related questions requiring similar evaluation conditions are grouped together. Where questions dealing with related topic areas are not in the same subsection, they are cross referenced so that the assessor can identify interactions between ergonomic features of the system.

Many of the questions have a short list of statements which can be applied to the OBU in order to identify some of the more subtle aspects of the system. Each of these statements can be answered True, False or Not Applicable. True statements mean the OBU is adhering to good ergonomic practice and is likely therefore not to cause problems in operation. False indicates a deficiency in the ergonomic design of the OBU and this may identify a potential safety hazard. Not applicable is suitable when the device does not have a feature relevant to the statement.

The scoring system employed in this document is based upon a scoring system derived at TRL for the ergonomic aspects of the UK Code of Practice (CoP) and developed further in the HMI checklist for in vehicle information systems. The scoring for the latter was derived from a series of paired comparisons of every question, ordering and ranking the importance of each question and allotting a fractional score. For the tolling checklist, the weighting score allotted to each question within a sub-section (of which there are 13) was allocated in a similar way to the code of practice, and reflects the perceived importance of that question in terms of safety and useability when compared with the other questions in the same sub-section.

In this checklist, each question has its own scoring bar e.g.

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	Control location is adequate	The use of abbreviations is excellent

Only one score should be given in response to each question.

Whilst conducting the evaluation, notes should be gathered to describe good features and the problems that were identified to assist in compiling the report.

Question 13 is slightly different in its format as it directs the assessor to review the documentation that the manufacturer or designer supplies with the OBU. This is because there are a significant number of ergonomic design features that are already covered by standards. Manufacturers or designers should be able to provide documentation demonstrating the use of the standards and guidelines, or justifying deviation from them. Question 13 also includes questions of a complex technical nature that cannot readily be assessed by a ‘pen and paper’ checklist, but which should be documented by the supplier as part of the design.

Having completed the checklist, the assessor should transfer the scores for each question into the scoring

system where the appropriate weighting for each question can be applied to give overall scores for each section.

For overall scoring of sub-sections, -10 would indicate the lowest possible score for the OBU when assessed with all questions in that sub-section, and that the unit may pose a serious hazard. Scores of 5+ *when assessed using all questions within a subsection* would indicate a generally good OBU design with regard to safety and good ergonomics. Assessors should take careful note of features which are rated -2 in individual questions as this will indicate specific problem areas that will need to be discussed with the manufacturers, irrespective of the scores for the various subsections.

It is recommended that wherever possible two people should conduct the evaluation. At night, the second assessor should take care not to cause disruption to the vehicle interior illumination whilst completing the checklist.

3 Safety checklist

Section 1 Questions relating to the physical design of the OBU

1 In-vehicle installation of the OBU

1.1 Are the OBU controls easily reached by the driver?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	Control location is adequate	Control location is excellent

All controls vital when driving can be reached from the normal driving position. TRUE/FALSE/NA

Stretching or leaning are not required. TRUE/FALSE/NA

Awkward arm or body positions are not required. TRUE/FALSE/NA

1.2 Is physical or visual access to other driver devices not obstructed by the OBU or its mounting?

-2	-1	0	+1	+2
The use of critical controls or displays is obstructed	The use of non critical controls or displays is obstructed	Not applicable	Access to other controls and displays is adequate	Access to other controls and displays is excellent

The OBU does not interfere with normal leg, hand and arm movements. TRUE/FALSE/NA

The OBU does not interfere with the view out of the window. TRUE/FALSE/NA

No controls vital to safe driving are obstructed. TRUE/FALSE/NA

No displays vital to safe driving are obstructed. TRUE/FALSE/NA

Tactile searching for controls (in the dark) will not generate mistaken operation of OBU controls or other vehicle controls. TRUE/FALSE/NA

Information displayed on the OBU will not be confused with other information. TRUE/FALSE/NA

1.3 Is the OBU mounting safe in use?

-2	-1	0	+1	+2
There are likely to be serious problems	Slight problems are evident	Cannot be awarded in this case	The mounting is adequate	The mounting is excellent

The mounting is solid and stable under normal use. TRUE/FALSE/NA

The mounting is sufficiently rigid to prevent movement during control use. TRUE/FALSE/NA

The mounting is sufficiently strong to prevent the device from becoming dislodged. TRUE/FALSE/NA

The OBU and its mounting are free from sharp or hard edges. TRUE/FALSE/NA

1.4 Once positioned is the display stable and free from serious shake?

-2	-1	0	+1	+2
There is serious shake / stability problem	There is some shake under extreme circumstances	Not applicable, there is no visual display	The mounting is adequate	The mounting is excellent

2 Control physical design, operational feedback and use

2.1 Is the control design suitable for safe operation?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	The control layout is adequate	The control layout is excellent

Controls can be easily manipulated. TRUE/FALSE/NA

Control action gives predictable results. TRUE/FALSE/NA

Control designs are suited to their method of operation. TRUE/FALSE/NA

2.2 Is the control layout suitable for safe operation?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	The control layout is adequate	The control layout is excellent

Controls that need to be used whilst the vehicle is in motion are easily reached. TRUE/FALSE/NA

Each control can be used without inadvertently activating another control. TRUE/FALSE/NA

The layout of the controls is conducive to being used 'eyes off'. TRUE/FALSE/NA

2.3 Do the controls adopt safe stereotypical norms for their action and labels?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	The use of stereotypes is adequate	The use of stereotypes is excellent

The controls seem to adopt safe stereotypical norms for action and response. TRUE/FALSE/NA

The controls seem to adopt safe stereotypical norms for labels. TRUE/FALSE/NA

The controls seem to adopt safe stereotypical norms for icons. TRUE/FALSE/NA

The conventions adopted are the same as for the rest of the motor vehicle to which the system is fitted. TRUE/FALSE/NA

The conventions adopted are the same as those used in the national location where the system is to be used. TRUE/FALSE/NA

2.4 Is each control easily discernible by a variety of methods?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable, there are no controls	The distinction between controls is adequate	The distinction between controls is excellent

The OBU controls can be distinguished by means of labels / icons. TRUE/FALSE/NA

The OBU controls can be distinguished by means of colour. TRUE/FALSE/NA

The OBU controls can be distinguished by means of shape. TRUE/FALSE/NA

The OBU controls can be distinguished by touch by means of clearance. TRUE/FALSE/NA

The OBU controls can be distinguished by touch by means of location. TRUE/FALSE/NA

The OBU controls can be distinguished by touch by means of grouping. TRUE/FALSE/NA

The OBU controls can be distinguished by touch by means of shape. TRUE/FALSE/NA

The OBU controls can be distinguished by means of touching the controls. TRUE/FALSE/NA

The OBU controls can be distinguished by auditory feedback. TRUE/FALSE/NA

The OBU controls can be distinguished by their motion and motion feedback. TRUE/FALSE/NA

2.5 Is control operation feedback given to the user?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable	The feedback is adequate	The feedback is excellent

Control activation is indicated by touch feedback. TRUE/FALSE/NA

Control activation is indicated by displacement feedback. TRUE/FALSE/NA

Control activation is indicated by auditory feedback. TRUE/FALSE/NA

2.6 Is control operation feedback given in an appropriate way?

-2	-1	0	+1	+2
Some critical dialogues have problems	Some dialogues have problems	Not applicable	The feedback is adequate	The feedback is excellent

The feedback medium is not the same as the input medium. TRUE/FALSE/NA

The feedback is complementary to the input / state change. TRUE/FALSE/NA

The feedback is appropriate to visual components. TRUE/FALSE/NA

Feedback of speech input is provided. TRUE/FALSE/NA

Audio feedback is audible above background noise levels. TRUE/FALSE/NA

Audio feedback is below the level at which it might startle the driver. TRUE/FALSE/NA

Visual feedback persists long enough to permit vision to the road to be maintained and the feedback not to be lost. TRUE/FALSE/NA

2.7 Does the system react quickly and accurately when controls are operated?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable, there are no controls	The reaction speed is adequate	The reaction speed is excellent

The system responds immediately to control activation. TRUE/FALSE/NA

Each control only performs the action associated with that control. TRUE/FALSE/NA

2.8 Is colour used effectively to aid coding of controls?

-2	-1	0	+1	+2
Some critical controls have problems	Some controls have problems	Not applicable, there are no controls	The colour coding is adequate	The colour coding is excellent

The colours for control coding avoid red/green colour differences. TRUE/FALSE/NA

The colours for control coding avoids blue/yellow colour differences. TRUE/FALSE/NA

Colour coding is not problematic at night. TRUE/FALSE/NA

The colours employed do not generate adverse visual after effects. TRUE/FALSE/NA

The coding has a clear meaning within the context of the OBU. TRUE/FALSE/NA

3 Visual display physical design, operation and use

3.1 Can the display location be adjusted by the user for correct viewing?

-2	-1	0	+1	+2
Some critical displays have viewing problems	Some displays have viewing problems	Not applicable	The display adjustment is adequate	The display adjustment is excellent

Display text and graphics are clear and do not suffer from distortion. TRUE/FALSE/NA

Labels are clear and do not suffer from distortion. TRUE/FALSE/NA

Icons are clear and do not suffer from distortion. TRUE/FALSE/NA

The entire display area is equally visible from one viewing position. TRUE/FALSE/NA

3.2 Is the OBU free from reflections and/or glare under all ambient lighting conditions?

-2	-1	0	+1	+2
There are serious problems	There are minor problems in unusual circumstances	Cannot be awarded in this case	The control of reflections is adequate	The control of reflections is excellent

Natural light will not be reflected into the driver's eyes and act as a dangerous glare source. TRUE/FALSE/NA

External artificial light will not be reflected into the driver's eyes and act as a dangerous glare source. TRUE/FALSE/NA

Artificial light from light sources within the car will not be reflected into the driver's eyes and act as a dangerous glare source. TRUE/FALSE/NA

External light falling on the display will not obscure the legibility of the display. TRUE/FALSE/NA

Artificial light from outside of the vehicle falling on the display will not obscure its legibility. TRUE/FALSE/NA

Artificial light from sources inside the car falling on the display will not obscure its legibility. TRUE/FALSE/NA

3.3 Is the windscreen free from reflections and/or glare caused by the display?

-2	-1	0	+1	+2
There are problems in the main field of view	There are problems away from the main field of view	Not applicable, there are no light sources or reflective items	The control of reflections is adequate	The control of reflections is excellent

Primary reflections of light sources within the OBU do not occur in the driver's normal field of view. TRUE/FALSE/NA

Secondary reflections do not occur in the driver's normal field of view by day or night. TRUE/FALSE/NA

3.4 Are the displays and controls lit at night without unduly affecting vision?

-2	-1	0	+1	+2
The driver's eyes are affected	The OBU is not legible	Not applicable, there are no illuminated displays or controls	The illumination is adequate	The illumination is excellent

The OBU illumination does not cause disability glare. TRUE/FALSE/NA

The OBU illumination does not cause discomfort glare. TRUE/FALSE/NA

The OBU illumination does not prevent the OBU from being clearly legible. TRUE/FALSE/NA

The OBU illumination does not cause visual after effects. TRUE/FALSE/NA

Automatic dimming controls are within an acceptable range. TRUE/FALSE/NA

Manual dimming controls are within an acceptable range. TRUE/FALSE/NA

3.5 Can the OBU internal illumination be used without washout of the display in any conditions?

-2	-1	0	+1	+2
There are serious washout problems	Slight washout occurs	Not applicable, there is no visual display	The illumination is adequate	The illumination is excellent

3.6 Is the visual display suitable for the user?

-2	-1	0	+1	+2
Some critical displays have problems	Some displays have problems	Cannot be awarded in this case	The display(s) is adequate	The display(s) is excellent

The visual displays have adequate contrast for the text / graphics on them to be clearly legible. TRUE/FALSE/NA

The visual displays have adequate size for the text / graphics on them to be clearly legible. TRUE/FALSE/NA

The visual displays have adequate colour for the text / graphics on them to be clearly legible. TRUE/FALSE/NA

The visual displays have adequate luminance for the text / graphics on them to be clearly legible. TRUE/FALSE/NA

4 Audio display properties of the OBU system

4.1 Are auditory messages or tones unlikely to cause annoyance to the driver?

-2	-1	0	+1	+2
Some critical signals have problems	Some signals have problems	Not applicable, there are no auditory features	The messages / tones are adequate	The messages/ tones are excellent

Auditory tones or messages do not 'startle' the driver. TRUE/FALSE/NA

Auditory tones or messages do not repeat themselves at unnecessarily short intervals. TRUE/FALSE/NA

Auditory tones or messages do not set the pace of interaction for the driver. TRUE/FALSE/NA

Auditory tones or messages do not have a subjectively irritating or annoying property of any kind. TRUE/FALSE/NA

Auditory tones or messages do not arise frequently in association with 'non information' or appear redundant. TRUE/FALSE/NA

4.2 Is the auditory display suitable for the user?

-2	-1	0	+1	+2
Some critical displays have problems	Some displays have problems	Cannot be awarded in this case	The display(s) is adequate	The display(s) is excellent

Auditory displays can be clearly heard in the vehicle when in motion. TRUE/FALSE/NA

Auditory messages can be clearly understood. TRUE/FALSE/NA

Section 2 Questions relating to the human machine dialogue

5 Dialogue features of the interface

5.1 Is the vocabulary of written messages easy to understand and appropriate to the message?

-2	-1	0	+1	+2
Some critical messages have problems	Some messages have problems	Cannot be awarded in this case	The vocabulary is adequate	The vocabulary is excellent

The words employed in the dialogue are simple and obvious. TRUE/FALSE/NA

The system avoids the use of long messages, jargon and abbreviations. TRUE/FALSE/NA

Explanations are clear and easy to hear or read. TRUE/FALSE/NA

Short words are employed in preference to long ones. TRUE/FALSE/NA

All messages are clear. TRUE/FALSE/NA

The order of wording is natural and logical. TRUE/FALSE/NA

5.2 Are all abbreviations used understandable?

-2	-1	0	+1	+2
Some critical abbreviations have problems	Some abbreviations have problems	Not applicable, there are no text displays	The use of abbreviations is adequate	The use of abbreviations is excellent

All abbreviations used are understandable. TRUE/FALSE/NA

There is a good reason for use of abbreviations. TRUE/FALSE/NA

Abbreviations are used for names only. TRUE/FALSE/NA

No words are abbreviated. TRUE/FALSE/NA

Critical information is not conveyed with abbreviations. TRUE/FALSE/NA

Abbreviations, if present, aid the readability of the messages. TRUE/FALSE/NA

Abbreviations are used consistently. TRUE/FALSE/NA

Entire sentences are never made up from abbreviations. TRUE/FALSE/NA

Abbreviations are well known and understandable. TRUE/FALSE/NA

Abbreviations are translated correctly for the country and language of their use. TRUE/FALSE/NA

5.3 Does textual information make sense?

-2	-1	0	+1	+2
Some critical messages have problems	Some messages have problems	Not applicable, there is no textual information	The text information is adequate	The text information is excellent

The messages are not capable of misinterpretation. TRUE/FALSE/NA

6 Feedback given by the OBU

6.1 Does the system give feedback to the user in response to commands and inputs?

-2	-1	0	+1	+2
Some critical dialogues have problems	Some dialogues have problems	Not applicable, there are no commands or inputs	The feedback is adequate	The feedback is excellent

There is an indication of when the next input is required. TRUE/FALSE/NA

The feedback loop is complete in all interactions. TRUE/FALSE/NA

Feedback relating to the system state is given. TRUE/FALSE/NA

Feedback is an integral part of the system operation. TRUE/FALSE/NA

6.2 Is there no perceptible delay between input from the user and presentation of the response?

-2	-1	0	+1	+2
Some critical delays occur	Some delays occur	Not applicable, there is no user input	The response time is adequate	The response time is excellent

The user can see / hear immediately that the system is responding to their input. TRUE/FALSE/NA

The user can see / hear immediately if they have chosen correctly or have made a mistake. TRUE/FALSE/NA

6.3 Is the user informed if the system is working/busy?

-2	-1	0	+1	+2
No busy indication is given	The busy indication is inadequate	Not applicable, there are no commands or inputs	The feedback is adequate	The feedback is excellent

The user is informed when the system is working/busy. TRUE/FALSE/NA

The system informs the user if input cannot be accepted or processed. TRUE/FALSE/NA

The user is informed of system status at all times. TRUE/FALSE/NA

6.4 Is an indication of unit failure given?

-2	-1	0	+1	+2
No failure indication is given	The failure indication is inadequate	Cannot be awarded in this case	The feedback is adequate	The feedback is excellent

A message appears diagnosing a fault. TRUE/FALSE/NA

The failure indication can be displayed in the event of a complete loss of power. TRUE/FALSE/NA

7 Driver workload design of the interface

7.1 While driving, is interaction with the system limited to minimal keystrokes?

-2	-1	0	+1	+2
Some critical interactions have problems	Some interactions have problems	Not applicable, there are no keys / controls	The keystroke requirement is adequate	The keystroke requirement is excellent

While driving, the user is not required to operate the system more than confirming or accepting a decision. TRUE/FALSE/NA

While driving, interaction with the system needs minimal keystrokes. TRUE/FALSE/NA

When driving, complex inputs are not required. TRUE/FALSE/NA

The functionality of complex systems is automatically reduced when moving. TRUE/FALSE/NA

7.2 For common operations only 1 or 2 keystrokes should be necessary, is this so?

-2	-1	0	+1	+2
Some critical operations have problems	Some common operations have problems	Not applicable, there are no keys / buttons	The number of keystrokes is adequate	The number of keystrokes is excellent

Often repeated and simple tasks need a low number of keystrokes to complete. TRUE/FALSE/NA

The system requires 2 key presses (i.e. confirmation) for interactions where the consequences of initiating the action are unusually high. TRUE/FALSE/NA

7.3 Are input errors easily recoverable?

-2	-1	0	+1	+2
Some critical inputs have problems	Some inputs have problems	Not applicable, there are no inputs	The recoverability of errors is adequate	The recoverability of errors is excellent

The occurrence of an input error is not a major problem. TRUE/FALSE/NA

The user can correct the mistake or return to the previous stage easily and quickly. TRUE/FALSE/NA

The presence of the error is clearly indicated. TRUE/FALSE/NA

The user can backtrack and learn from mistakes. TRUE/FALSE/NA

8 Error messages provided by the OBU

8.1 Error messages provide suitable information to the driver?

-2	-1	0	+1	+2
Some critical messages have problems	Some messages have problems	Not applicable, there are no system error messages	The error messages are adequate	The error messages are excellent

The system presents an understandable written description of which error has occurred. TRUE/FALSE/NA

8.2 Are the error messages relevant to the user?

-2	-1	0	+1	+2
Some critical messages have problems	Some messages have problems	Not applicable, there are no system error messages	The error messages are adequate	The error messages are excellent

The error messages are worded to identify those the user cannot correct. TRUE/FALSE/NA

The error messages are worded to identify those the user can correct. TRUE/FALSE/NA

8.3 Are the error messages relevant to the situations?

-2	-1	0	+1	+2
Some critical messages have problems	Some messages have problems	Not applicable, there are no system error messages	The error messages are adequate	The error messages are excellent

The messages are specific about the type of error that has occurred. TRUE/FALSE/NA

9 Data supplied by the OBU

9.1 Can the user easily understand the information provided?

-2	-1	0	+1	+2
Some critical information has problems	Some information has problems	Cannot be awarded in this case	The information is adequate	The information is excellent

The maps and graphical information are easy to interpret. TRUE/FALSE/NA

The text is comprehensible. TRUE/FALSE/NA

The information is appropriate to the context. TRUE/FALSE/NA

9.2 Is the information given by the system timely?

-2	-1	0	+1	+2
Some critical information has problems	Some information has problems	Cannot be awarded in this case	The timeliness of information is adequate	The timeliness of information is excellent

The information is up to date and relevant to the current, real-time situation. TRUE/FALSE/NA

The driver has time to respond safely to information provided by the system. TRUE/FALSE/NA

9.3 Is the information given by the system relevant?

-2	-1	0	+1	+2
Some critical information has problems	Some information has problems	Cannot be awarded in this case	The relevance of information is adequate	The relevance of information is excellent

The information is up to date and relevant to the current, real-time situation. TRUE/FALSE/NA

The driver has time to respond safely to information provided by the system. TRUE/FALSE/NA

Section 3 Questions relating to information presentation

10 Graphic design of the OBU

10.1 Is the design of visual display images appropriate?

-2	-1	0	+1	+2
Some critical images have problems	Some images have problems	Not applicable, there is no visual display	The display image is adequate	The display image is excellent

The design of the screen image is suitable for use in a vehicle. TRUE/FALSE/NA

The design of the interface text and graphics takes into account viewing distances, lighting environment, motion effects, after images etc. TRUE/FALSE/NA

The design of the displayed image (font, colours used, sizes and shapes) is suitable for the driver to view while driving. TRUE/FALSE/NA

A digital display is employed to display numerical credit information. TRUE/FALSE/NA

10.2 Is the size of the display image appropriate for the user?

-2	-1	0	+1	+2
Some critical images have problems	Some images have problems	Not applicable, there is no visual display	The display image is adequate	The display image is excellent

Text and graphic items can be read clearly from the normal viewing position. TRUE/FALSE/NA

All of the displayed items are clearly visible. TRUE/FALSE/NA

Related information needed when driving is visible on the same screen. TRUE/FALSE/NA

All of the information needed for one decision can be accessed without paging or scrolling. TRUE/FALSE/NA

10.3 Are systems based on colour displays (LED and text/graphics) capable of safe use without full colour vision?

-2	-1	0	+1	+2
Some critical colours have problems	Some colours have problems	Not applicable, there are no colour displays	The use of colour is adequate	The use of colour is excellent

All safety related aspects of a colour based system are capable of operation by persons with colour defective vision. TRUE/FALSE/NA

Where colour coding is the only differentiating factor, the information is not safety critical. TRUE/FALSE/NA

10.4 Are colours used effectively?

-2	-1	0	+1	+2
Some critical colours have problems	Some colours have problems	Not applicable, there are no colour displays	The mounting is adequate use of colour	The mounting is excellent

The choice of colour is good. TRUE/FALSE/NA

Differences in hue are visible where necessary. TRUE/FALSE/NA

Differences in saturation are visible when necessary. TRUE/FALSE/NA

Differences in lightness are visible when necessary. TRUE/FALSE/NA

Colours are limited to clearly differentiated sets. TRUE/FALSE/NA

Colours are equally visible under night time viewing conditions. TRUE/FALSE/NA

Colours are suitable for colour deficient vision. TRUE/FALSE/NA

Red/green and blue/yellow combination coding are avoided. TRUE/FALSE/NA

Problems of simultaneous colour contrast and colour after effects are avoided. TRUE/FALSE/NA

**Section 4 Questions relating to toll payment
11 Credit**

11.1 Does the system inform the driver when they are low on credit?

-2	-1	0	+1	+2
No notification of low credit	Inappropriate notification of low credit	Not applicable, there is no card	Adequate notification of low credit	Excellent notification of low credit

The system gives a visual warning. TRUE/FALSE/NA

The system gives an auditory warning. TRUE/FALSE/NA

11.2 Does the system inform the driver when the driver has run out of credit?

-2	-1	0	+1	+2
No notification of empty card	Inappropriate notification of empty card	Not applicable, there is no card	Adequate notification of empty card	Excellent notification of empty card

The system allows travel on tolled roads. TRUE/FALSE/NA

The system informs the driver that no card is present. TRUE/FALSE/NA

11.3 Is the OBU resistant to theft?

-2	-1	0	+1	+2
There is no theft protection	There is inadequate theft protection	Not applicable	Adequate theft protection is provided	Excellent theft protection is provided

The system is linked to a coded account. TRUE/FALSE/NA

The system is easily removed from view. TRUE/FALSE/NA

The system has a code key. TRUE/FALSE/NA

12 Card based systems

12.1 Does the card slot allow safe card insertion whilst driving?

-2	-1	0	+1	+2
The card is very difficult to insert whilst driving	There are some problems inserting the card	Not applicable, there is no card	The card can be inserted whilst driving	The card is easy to insert whilst driving

The card slot is within easy reach of the driver.

TRUE/FALSE/NA

The card is easy to insert.

TRUE/FALSE/NA

The card cannot be inserted incorrectly.

TRUE/FALSE/NA

The card cannot be inserted until the vehicle is stationary.

TRUE/FALSE/NA

12.2 Does the unit inform the driver when no card is present?

-2	-1	0	+1	+2
No indication is given	Inappropriate indication is given	Not applicable, there is no card	Some indication is given	Excellent indication is given

The system does not cause annoyance to the driver.

TRUE/FALSE/NA

The system informs the driver that no card is present.

TRUE/FALSE/NA

The system gives a visual indication.

TRUE/FALSE/NA

The system gives an auditory indication.

TRUE/FALSE/NA

12.3 Does the system inform the driver when the card is empty?

-2	-1	0	+1	+2
No notification of empty card	Inappropriate notification of empty card	Not applicable, there is no card	Adequate notification of empty card	Excellent notification of empty card

The system gives a visual warning. TRUE/FALSE/NA

The system gives an auditory warning. TRUE/FALSE/NA

12.4 Is the card system resistant to fraud?

-2	-1	0	+1	+2
There is no fraud protection	There is inadequate fraud protection	Not applicable	Adequate fraud protection is provided	Excellent fraud protection is provided

The system only accepts relevant cards. TRUE/FALSE/NA

The cards are tamper proof. TRUE/FALSE/NA

The card is resistant to theft. TRUE/FALSE/NA

12.5 Is the card suitably durable?

-2	-1	0	+1	+2
The card has very little durability	The card can survive some poor handling	Not applicable, there is no card	The card is resistant to reasonable abuse	The card is highly durable

The card can survive being sat on. TRUE/FALSE/NA

The card can survive being folded. TRUE/FALSE/NA

The card is fold resistant. TRUE/FALSE/NA

The card is waterproof to a limited degree. TRUE/FALSE/NA

Section 5 Questions relating to the documentation of the system

13 Questions relating to documentation of the system

-2	-1	0	+1	+2
No documentation has been supplied / unjustifiable claims have been made	No compliance with standards is demonstrated	Cannot be awarded in this case	The documentation is adequate	The documentation is excellent

The manufacturer supplies crash-worthiness certification. TRUE/FALSE/NA

There is evidence that control locations comply with ISO/BS/SAE recommendations. TRUE/FALSE/NA

There is evidence that display locations comply with ISO/BS/SAE recommendations. TRUE/FALSE/NA

There is evidence that colour coding follows standards or conventions for the use of colour. TRUE/FALSE/NA

There is evidence that the audio signals lie in the range of 200 to 8000 Hz. TRUE/FALSE/NA

There is evidence as to how the volume control affects the volume of each frequency band. TRUE/FALSE/NA

There is evidence that automatic volume control responds evenly across the ambient spectrum or is a weighted response to ambient noise frequencies. TRUE/FALSE/NA

There is evidence that menu navigation has been carefully thought out and implemented. TRUE/FALSE/NA

There is evidence that the colours used follow recognised standards for motor vehicle displays. TRUE/FALSE/NA

There is evidence that icons follow appropriate standards. TRUE/FALSE/NA

The manufacturer's documentation supports claims to ease of use by elderly or disabled users. TRUE/FALSE/NA

No false claims are made by the manufacturer about using the system. TRUE/FALSE/NA

The documentation demonstrates that the response times are sufficiently rapid for operation. TRUE/FALSE/NA

How quickly the system reacts to input from the control centre? (ms)

How quickly the system reacts to input from on board transducers? (ms)

How frequently does the system update reference to external data (e.g. GPS)? (ms)

How long does it take for the control centre to analyse and distribute new information? (ms)

4 Scoring

Section 1 Questions relating to the physical design of the IVIS

1 In-vehicle installation of the OBU

1.1 Are the OBU controls easily reached by the driver?

Comments	Score	Multiplier	Result
		1.50	

1.2 Is physical or visual access to other driver devices not obstructed by the OBU or its mounting?

Comments	Score	Multiplier	Result
		1.50	

1.3 Is the OBU mounting safe in use?

Comments	Score	Multiplier	Result
		1.10	

1.4 Once positioned is the display stable and free from serious shake?

Comments	Score	Multiplier	Result
		0.90	

Sub-Section 1

Total score

2 Control physical design, operational feedback and use

2.1 Is the control design suitable for safe operation?

Comments	Score	Multiplier	Result
		1.25	

2.2 Is the control layout suitable for safe operation?

Comments	Score	Multiplier	Result
		1.25	

2.3 Do the controls adopt safe stereotypical norms for their action and labels?

Comments	Score	Multiplier	Result
		0.40	

2.4 Is each control easily discernible by a variety of methods?

Comments	Score	Multiplier	Result
		0.40	

2.5 Is control operation feedback given to the user?

Comments	Score	Multiplier	Result
		0.50	

2.6 Is control operation feedback given in an appropriate way?

Comments	Score	Multiplier	Result
		0.40	

2.7 Does the system react quickly and accurately when controls are operated?

Comments	Score	Multiplier	Result
		0.40	

2.8 Is colour used effectively to aid coding of controls?

Comments	Score	Multiplier	Result
		0.40	

Sub-Section 2

Total score

3 Visual display physical design, operation and use

3.1 Can the display location be adjusted by the user for correct viewing?

Comments	Score	Multiplier	Result
		0.90	

3.2 Is the OBU free from reflections and/or glare under all ambient lighting conditions?

Comments	Score	Multiplier	Result
		0.90	

3.3 Is the windscreen free from reflections and/or glare caused by the display?

Comments	Score	Multiplier	Result
		0.90	

3.4 Are the displays and controls lit at night without unduly affecting vision?

Comments	Score	Multiplier	Result
		0.90	

3.5 Can the OBU internal illumination be used without washout of the display in any conditions?

Comments	Score	Multiplier	Result
		0.90	

3.6 Is the visual display suitable for the user?

Comments	Score	Multiplier	Result
		0.50	

Sub-Section 3

Total score

4 Audio display properties of the OBU system

4.1 Are auditory messages or tones unlikely to cause annoyance to the driver?

Comments	Score	Multiplier	Result
		3.00	

4.2 Is the auditory display suitable for the user?

Comments	Score	Multiplier	Result
		2.00	

Sub-Section 4

Total score

Section 2 Questions relating to the human machine dialogue

5 Dialogue features of the interface

5.1 Is the vocabulary of spoken and written messages easy to understand and appropriate to the message?

Comments	Score	Multiplier	Result
		2.00	

5.2 Are all abbreviations used understandable?

Comments	Score	Multiplier	Result
		2.00	

5.3 Does textual information make sense?

Comments	Score	Multiplier	Result
		1.00	

Sub-Section 5

Total score

6 Feedback given by the IVIS

6.1 Does the system give feedback to the user in response to commands and inputs?

Comments	Score	Multiplier	Result
		1.25	

6.2 Is there no perceptible delay between input from the user and presentation of the response?

Comments	Score	Multiplier	Result
		1.25	

6.3 Is the user informed if the system is working/busy?

Comments	Score	Multiplier	Result
		1.25	

6.4 Is an indication of unit failure given?

Comments	Score	Multiplier	Result
		1.25	

Sub-Section 6

Total score

7 Driver workload design of the interface

7.1 While driving, is interaction with the system limited to minimal keystrokes?

Comments	Score	Multiplier	Result
		2.00	

7.2 For common operations only 1 or 2 keystrokes should be necessary, is this so?

Comments	Score	Multiplier	Result
		1.50	

7.3 Are input errors easily recoverable?

Comments	Score	Multiplier	Result
		1.50	

Sub-Section 7

Total score

9.3 Is the information given by the system relevant?

Comments	Score	Multiplier	Result
		1.65	

Sub-Section 9

Total score

8 Error messages provided by the OBU

8.1 Do system error messages provide suitable information to the driver?

Comments	Score	Multiplier	Result
		1.65	

8.2 Are the error messages relevant to the user?

Comments	Score	Multiplier	Result
		1.70	

8.3 Are the error messages relevant to the situation?

Comments	Score	Multiplier	Result
		1.65	

Sub-Section 8

Total score

9 Data supplied by the OBU

9.1 Can the user easily understand the information provided?

Comments	Score	Multiplier	Result
		1.7	

9.2 Is the information given by the system timely?

Comments	Score	Multiplier	Result
		1.65	

Section 3 Questions relating to information presentation

10 Graphic design of the OBU

10.1 Is the design of visual display images appropriate?

Comments	Score	Multiplier	Result
		1.40	

10.2 Is the size of the display image appropriate for the user?

Comments	Score	Multiplier	Result
		1.40	

10.3 Are systems based on colour displays (LED and text/graphics) capable of safe use without full colour vision?

Comments	Score	Multiplier	Result
		1.40	

10.4 Are colours used effectively?

Comments	Score	Multiplier	Result
		0.80	

Sub-Section 10

Total score

Section 4 Questions relating to credit

11 Credit

11.1 Does the system inform the driver when they are low on credit?

Comments	Score	Multiplier	Result
		2.00	

11.2 Does the system work normally when the driver has run out of credit?

Comments	Score	Multiplier	Result
		2.00	

11.3 Is the system resistant to theft?

Comments	Score	Multiplier	Result
		1.00	

Sub-Section 11

Total score

12 Card based systems

12.1 Does the card slot allow safe insertion whilst driving?

Comments	Score	Multiplier	Result
		1.00	

12.2 Does the system inform the driver when no card is present?

Comments	Score	Multiplier	Result
		1.00	

12.3 Does the system inform the driver when the card is empty?

Comments	Score	Multiplier	Result
		1.00	

12.4 Is the card system resistant to fraud?

Comments	Score	Multiplier	Result
		1.00	

12.5 Is the card suitably durable?

Comments	Score	Multiplier	Result
		1.00	

Sub-Section 12

Total score

Section 5 Questions relating to the documentation of the system

13 Questions relating to documentation of the system

Comments	Score	Multiplier	Result
		5.00	

Sub-Section 13

Total score

Overall Total

Sub-section	Score
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

Abstract

TRL was asked to develop a methodology for the assessment of Electronic Toll Collection (ETC). This was undertaken in the absence of any detailed information about the on-board units (OBUs) or their supporting systems from the various consortia involved in the trials. User needs and safety issues were considered to develop a Human-Machine Interaction based checklist (see Part 2) to evaluate ETC OBUs, and a post use questionnaire to subjectively assess system users' opinions of the OBUs. Some information about user preferences and expectations was elicited via a user preferences questionnaire (see Part 1) which was given to selected staff at TRL.