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Road vehicles — Ergonomic aspects of transport information and control systems — Occlusion method to assess visual demand due to the use of in-vehicle systems

Véhicules routiers — Aspects ergonomiques des systèmes d'information et de contrôle du transport — Méthode par occlusion pour évaluer la distraction visuelle due à l'utilisation des systèmes embarqués

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Contents

Page

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 39, *Ergonomics*.

This second edition cancels and replaces the first edition (ISO 16673:2007), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the accessibility has been changed from “unrestrained driver” to “buckled driver” in 3.1;

— the following paragraph has been added in 4.1: “Written instructions should not be visible to the participants during task performance or they should be visible to the participants during the whole task performance, i.e. also during occluded intervals”;

— Annex B has been added.

Introduction

A wide range of information and communication devices and advanced driver assistance systems are being introduced into motor vehicles. These include navigation aids, emergency messaging systems and wireless communication including email and internet access, which are all accessible to the driver of a motor vehicle. Many of these features have associated visual information that can potentially both inform and distract. To help ensure that the use of such devices and features that are meant to be used by the driver while driving do not result in excessive visual demand, a consistent, verifiable and repeatable method to determine the visual demand imposed by such in-vehicle systems is needed.

Developing precise mathematical predictions of the risk of a crash due to driver distraction from using a particular driver interface is difficult. However, it can be reasonably stated that if drivers are not looking at the road (e.g. looking inside the vehicle to operate a control or read a display), then the probability of a crash is increased[5].

This document is not intended to preclude direct measurement of eye glances as a method to assess visual demand. Direct measurement of eye glances is always desirable. However, direct measurements of eyes-off-the-road times, i.e. glance time measurements, are typically difficult and very costly to measure. The occlusion method estimates visual demand, including resumability, of a task using a means for intermittent viewing of the in-vehicle system. Evaluation by occlusion identifies driver interfaces that are likely to take the driver's eyes away from the road for excessively long durations. Additional data collected without occlusion can be combined with occlusion data to calculate *R*, a measure believed to identify whether or not tasks can be easily resumed after the driver interrupts the task to look back at the road. This procedure does not require extensive resources and can be applied if a functioning prototype of the driver interface exists.

Road vehicles — Ergonomic aspects of transport information and control systems — Occlusion method to assess visual demand due to the use of in-vehicle systems

1 Scope

This document provides a procedure for measuring visual demand due to the use of visual or visual-manual interfaces accessible to the driver while the vehicle is in motion. It applies to both original equipment manufacturer (OEM) and after-market in-vehicle systems. It applies to both permanently installed and portable systems. It applies to any means of visual occlusion and is not dependent on one specific physical implementation.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
driver accessible
interface controls necessary to complete the *task* (3.11) that are within the reach of the buckled driver and the interface display is visible with a head movement, and the system is operable by the driver

Note 1 to entry: See ISO 3958[1] for the driver reach of the restrained driver, and SAE J1050[3] for the head movement.

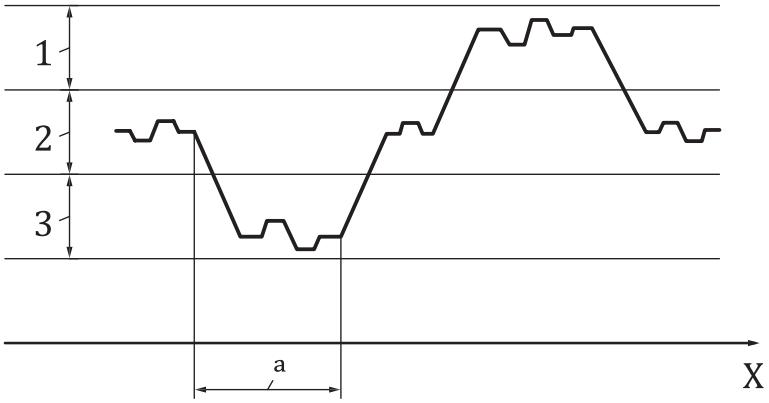
Note 2 to entry: The driver interface includes the visual display and any relevant controls.

EXAMPLE A nomadic or portable device such as a PDA outside of the reach of a restrained driver is still considered driver accessible if within the reach envelope of a buckled driver.

3.2
glance duration
time from the moment at which the direction of gaze moves towards a target (e.g. the interface display) to the moment it moves away from the target

Note 1 to entry: This includes the transition time to that target as shown in Figure 1, simplified from ISO 15007-1:2014, Figure A.2[2].

Note 2 to entry: A single glance duration may also be referred to as a glance.



Key

X time
1 target B (e.g. the interior mirror)
2 target A (e.g. the roadway)
3 target C (e.g. in-vehicle display)
a Glance duration.

Figure 1 — Chronological relationship of driver visual allocation between target regions

3.3
goal
system end state sought by the driver and which is meaningful in the context of a driver's use of an in-vehicle system

EXAMPLE Obtaining guidance to a particular destination, magnifying a map display, or cancelling route guidance.

3.4
integrated system
two or more in-vehicle devices which provide information to, or receive output from, the driver of a motor vehicle whose input and/or output have been combined or harmonized

EXAMPLE 1 An in-vehicle entertainment system and route guidance system which use the same visual and manual input portals and visual and auditory output portals.

EXAMPLE 2 An in-vehicle entertainment system whose auditory output mutes when a mobile phone call is made or received.

3.5
occlusion interval
time during which the driver interface is not visible when using an occlusion procedure

3.6
outlier
observation that lies outside the overall pattern of the sample data distribution[6]

3.7
portable system
device, which provides information to, or receives output from the driver of a motor vehicle, that can be used within the vehicle without installation or can be rapidly and easily installed in and removed from a vehicle

3.8
resumability
ease with which a dialogue can be continued after it is interrupted

Note 1 to entry: A dialogue is considered resumable if task performance continues without a significant degradation after an interruption.

3.9
resumability ratio
R
ratio of the duration of the total shutter open time (*TSOT*) to the total task time unoccluded (TTT_{Unoccl}), i.e. $TSOT/TTT_{Unoccl}$

3.10
system response delay
SRD
interval during which the driver has to wait for an interface to respond or update in order to continue a task

EXAMPLE Waiting for an off-board computer to be queried or waiting for a voice message to be generated.

3.11
task
process of achieving a specific and measurable goal using a prescribed method

Note 1 to entry: Ultimately, it is for the users of this document to determine tasks that are meaningful in the context of a driver's use of a system.

EXAMPLE 1 Obtaining guidance by entering a street address using the scrolling list method, continuing until route guidance is initiated (visual-manual task).

EXAMPLE 2 Determining where to turn based on a turn-by-turn guidance screen (visual task).

3.12
total shutter open time
TSOT
total time that vision is not occluded when using an *occlusion procedure* (3.19)

Note 1 to entry: *TSOT* is the sum of *vision intervals* (3.17) required for the *task* (3.11) of interest.

3.13
total task time occluded
TTT_{Occl}
total time to complete the *task* (3.11) of interest, including both unoccluded and occluded intervals, while using a *visual occlusion procedure* (3.19)

3.14
total task time unoccluded
TTT_{Unoccl}
total time required to complete the *task* (3.11) of interest without using a *visual occlusion procedure* (3.19) and without any concurrent task

3.15
trial
investigation of one participant undertaking one repetition of one *task* (3.11)

3.16
vehicle in motion
vehicle whose speed relative to its supporting surface is "nonzero"

Note 1 to entry: Practical limitations on existing vehicle sensors may cause small velocities (typically not more than 5 km/h) to be registered as zero.

3.17
vision interval
discrete time during which the driver interface is visible when using an occlusion procedure

Note 1 to entry: Vision interval is also the shutter open time (*SOT*).

3.18
visual demand
amount of visual activity required to extract information from an interface of an in-vehicle system to perform a specific *task* (3.11)

Note 1 to entry: In general, visual demand depends on the quantity of information to be extracted and the ease with which information extraction can be resumed following any interruption.

3.19
visual occlusion procedure
measurement method involving periodic obstruction of the participant's vision or the obscuration of visual information under investigation

4 Measurement procedures

4.1 Set-up

Intermittent viewing of an interface can be provided by various means. The occlusion procedure approximates the driver looking back and forth between the forward driving scene and an in-vehicle interface, looking at each for a brief period of time. In addition to the commonly used goggles[8], occlusion can be achieved using blanking of the visual display or a shutter in front of the interface. Display blanking can be done by electronically turning the visual display on and off in accordance with the timing in 4.2. A shutter shall be opaque during the occlusion interval. This could be done electronically with a variable transmittance lens, such as that used in the occlusion goggles, or it could be done using a system of one or more mechanical shutters. In the latter case, the shutters should not interfere with operation of the manual controls. Whether using electronic or mechanical means, the switching process and restoration of the active screen display at the end of an occlusion interval shall occur in less than 20 ms. Early studies involving occlusion in the primary driving task (forward field of view) used a head mounted mechanical shutter[17].

During the occlusion interval, neither the interface displays nor controls shall be visible, but operation of the controls shall be permitted (though most input to the interface might occur when vision is available). This protocol simulates drivers looking at the road but continuing to enter information via a manual control.

The system under investigation shall be operational and fitted to a vehicle, simulator buck, or mock-up in a design which duplicates the intended location of the interface in the vehicle (i.e. the viewing angle and control placement relationships shall be maintained). The ocular illumination levels in the vision and occlusion intervals should be comparable so that dark/light adaptation of the participants' eyes is not necessary during the procedure.

The instruction shall be standardized and be presented either orally or in writing. The display and controls of the interface should be visible during instruction. An instruction may be repeated at the request of the participant.

Written instructions should not be visible to the participants during task performance or they should be visible to the participants during the whole task performance, i.e. also during occluded intervals. The latter holds only if the screen is blanked or hidden during the occlusion intervals.

4.2 Vision and occlusion intervals

The vision interval shall be 1,5 s and the occlusion interval shall be 1,5 s. These intervals are consistent with the occlusion literature (see References [4], [9] to [13]).

Periods of vision and occlusion shall automatically occur without interruption until the task is completed or the trial is terminated (see 4.4). Thus the pacing of the occlusion intervals is controlled by the system, rather than the participant.

4.3 Task timing

The total shutter open time (*TSOT*) shall be defined as follows:

— Start: Timing starts with the beginning of the first vision interval;

— End: Timing ends when the instructed task has been completed and the participant says he or she is “done”;

— Duration: Tasks are timed from start to end without interruption, including errors and subtracting occlusion intervals. Individual system response delays greater than 1,5 s are accounted for by the procedure in Annex A. If the task is completed during a vision interval, then only that part of the vision interval that was used for the task should be included in the *TSOT*.

As an alternative, *TSOT* may be approximated by the number of vision intervals needed to complete the task multiplied by the 1,5 second vision interval. Another approximation is provided by (TTT_{Occl}/3,0) × 1,5. Individual system response delays greater than 1,5 s are accounted for by the procedure in Annex A.

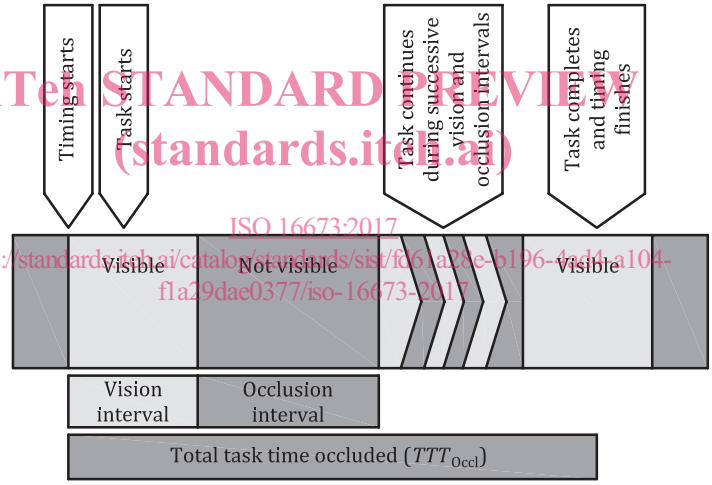


Figure 2 — Measurement of total task time in occluded conditions

The total task time unoccluded (TTT_{Unoccl}) shall be determined as follows:

— Start: timing starts at the end of the task instruction;

— End: timing ends when the instructed task has been completed and the participant says he or she is “done”;

— Duration: tasks are timed from start to end without interruption, including errors. Individual system response delays that are greater than 1,5 s are accounted for by the procedure in Annex A.

The total task time in occluded conditions (TTT_{Occl}) shall be determined as follows (see Figure 2):

— Start: timing starts with the beginning of the first vision interval;

— End: timing ends when the instructed task has been completed and the participant says he or she is “done”;

— Duration: tasks are timed from start to end without interruption, including errors. Individual system response delays that are greater than 1,5 s are accounted for by the procedure in Annex A.