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Road vehicles — Ergonomic aspects of transport information and control systems — Simulated lane change test to assess in-vehicle secondary task demand

Véhicules routiers — Aspects ergonomiques des systèmes de commande et d'information du transport — Essai du changement de voie simulé pour évaluer la demande de tâche secondaire à bord du véhicule

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 26022 was prepared by Technical Committee ISO/TC 22, *Road Vehicles*, Subcommittee SC 13, *Ergonomics applicable to road vehicles*.

Introduction

Many advances are being made in introducing a wide range of information, communication, entertainment and driver assistance systems in motor vehicles. Navigation aids, emergency messaging systems and wireless communication, including e-mail and internet access, are all possible. Since many of these features require the driver's attention it is important to recognise that, on one hand, these systems provide information and assistance but, on the other hand, have the potential to distract the driver as well.

The lane change test (LCT) described in this International Standard, is a dual-task method that is intended to estimate secondary task demand on the driver resulting from the operation of an in-vehicle device in a laboratory setting. The method is simple and inexpensive so that it can be used by vehicle manufacturers, in-vehicle device manufacturers, and other organizations.

The driver behaviour and attentional demand principles embodied in the LCT only apply to the operation of a typical passenger car, as the vehicle dynamics model, driver eye height, and lane change dimensions and geometries are scaled for such vehicles.

The test procedure specified in this International Standard uses software to set up the LCT task on a computer, and to calculate the primary task performance measures. Appropriate software is available from the ISO Central Secretariat.

Road vehicles — Ergonomic aspects of transport information and control systems — Simulated lane change test to assess in-vehicle secondary task demand

1 Scope

This International Standard describes a dynamic dual-task method that quantitatively measures human performance degradation on a primary driving-like task while a secondary task is being performed. The result is an estimate of secondary task demand.

The method is laboratory based, and this International Standard defines the method, the minimum requirements for equipment to support the method, and procedures for collecting and analyzing data derived from the method.

The method is applicable to all types of interactions with in-vehicle information, communication, entertainment and control systems; manual, visual, haptic and auditory, and combinations thereof. Secondary tasks requiring speed variations to be performed cannot be tested with this method. It applies to both Original Equipment Manufacturer (OEM) and aftermarket in-vehicle systems. It also applies to systems either portable or integrated into the vehicle. The driver behaviour principles, the specific task procedures and driving task correspond only to the operation of a passenger car.

2 Terms and definitions

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

2.1
adaptive model
reference path trajectory adapted to each participant

2.2
baseline
test condition with the primary task only

2.3
basic model
nominal reference path trajectory is the same for all participants

2.4
calibration task
type of reference task used for the purpose of comparing different tests or test results between sites, or over time at a given site

2.5
course
path along which the simulated vehicle actually travels

2.6
dual task
two tasks concurrently performed, primary task plus a secondary task

2.7
environment
physical surroundings in which data are captured

2.8
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; magnification of a map display; or cancelling route guidance.

2.9
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, manual and auditory interface.

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

2.10
lane change
lateral displacement of a vehicle from current lane to another lane, including crossing one or two lanes

2.11
lane change task
series of prescribed lane change manoeuvres that are the main component of the primary task in the lane change test

2.12
outlier
an observation that lies outside the overall pattern of a distribution

2.13
manufacturer
organisation or person designing, developing, producing, integrating and/or supplying in-vehicle equipment

2.14
path deviation measure
mdev
difference between a reference path trajectory and an actual driven course

2.15
portable system
nomadic device
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 the vehicle

2.16
primary task
course following and manoeuvring control activity which a participant performs throughout the duration of a test (simulated substitute for driving)

2.17
reference task
a standardized secondary task which can be used to compare different levels of performance degradation

2.18
run
driving used to collect LCT data, typically consisting of 18 lane changes accomplished over a 3 minute period in either single task or dual task conditions

2.19
secondary task
interaction with an in-vehicle information, communication, entertainment, or control system, carried out concurrently with the primary task

2.20
secondary task demand
sum of perceptual, cognitive and motoric activity required by a secondary task

2.21
single task
one task (primary or secondary task) without additional activity (as opposed to dual task)

2.22
task
process of achieving a specific and measurable goal using a prescribed method

NOTE Ultimately, it is for the users of this International Standard to determine tasks that are meaningful in the context of a driver's use of an in-vehicle device.

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).

2.23
track
three-lane, straight, simulated roadway

2.24
trial
investigation of one participant undertaking one repetition of one secondary task

3 Lane change test (LCT)

3.1 Principle and overview

The lane change test (LCT) is a simple laboratory dynamic dual task method that quantitatively measures performance degradation in a primary driving task while a secondary task is being performed. The primary task in the LCT is a simulated driving task which resembles the visual, cognitive and motor demands of driving.

In the LCT, a test participant is required to do a primary task consisting of driving at a constant, system-limited speed of 60 km/h along a simulated straight three-lane road containing a series of lane changes defined by signs displayed on a screen. Simulated vehicle position is controlled by means of a steering wheel. Participants are instructed in which of the lanes to drive by signs that appear at approximately regular intervals on both sides of the track. The LCT is performed by participants according to pre-test instructions contained in this International Standard (see Annex A). The method may be implemented in a laboratory, in a driving simulator, in a mock-up or in a real vehicle.

There is no limitation to the definition of a secondary task according to this International Standard as long as the secondary task is compatible with the LCT procedure.

EXAMPLE Secondary tasks requiring speed variations to be performed are not accommodated.

3.1.1 Application of the LCT

In a typical application of the LCT, the primary task performance degradation resulting from a certain secondary task can be compared to the performance degradation resulting from a reference task (see Annex B). A reference task is a standardized secondary task which can be used to compare different levels of performance degradation. Such standardized reference task can also be employed to compare different test sites or to verify consistency in repeated testing.

For product development purposes, the LCT can also be used to compare alternative HMI candidates or solutions rather than comparing each of these solutions to a reference task (see Annex C).

3.2 Participants

Participants shall be licensed drivers having a similar level of familiarity with the secondary task under investigation. Other relevant characteristics of the participants shall be recorded (gender, age, driving experience and previous experience with the LCT). At least 16 participants shall take part in the evaluation of a single secondary task or in the comparison of two or more secondary tasks for a within-subject design.

3.3 Equipment

3.3.1 Display of visual driving scene

The LCT visual driving scene shall be realised with a monitor or projector with a net refresh rate of at least 50 Hz. A minimum resolution of 1024×768 pixels with a colour depth of 24 bit (also called True Color) is required. The size of the display device must meet the requirements defined in 3.4.3.

3.3.2 Testing environment

The illumination level in the testing environment shall be appropriate to the secondary task. Simulated engine sound is optional and, if used, shall be adjusted to a low level.

Participants shall be comfortably seated directly in front of the primary task visual display while performing each test. The seat shall not swivel or rock. A seat belt shall be used if it is assumed that the use of a seat belt might influence the test results (e.g. restrictions in posture and reach).

3.3.3 Steering wheel and simulation characteristics

For the lateral control of the simulated vehicle, a computer game steering wheel can be used for a laboratory/monitor setup. For seating buck or real vehicle testing, movement of the steering wheel shall provide signals to replicate movements of the game steering wheel. The steering wheel force displacement characteristics shall be approximately linear, and the tangential force at the rim to turn the steering wheel shall be no more than 20 N. A centering (breakout) force, which is optional, shall be no more than 12 N. Adapting LCT to a real vehicle is discussed in Annex D.

The overall transport delay between an initial steering input and a visual display response shall be < 120 ms (not including the simulated vehicle model delay).

The steering wheel sensor shall have a resolution less than 1,5 degrees.

With the steering wheel turned 90 degrees from the straight ahead position, the simulated vehicle shall, at a constant speed of 60 km/h, complete a 360 degree turn in between 13 s and 17 s, corresponding to a turning circle of 70 m to 90 m in diameter.

3.3.4 Vehicle dynamics

The simulated vehicle shall be programmed to respond approximately like a typical passenger car in terms of its size and inertial properties. Yaw rate to steer angle characteristics shall be represented by a first order lag with an equivalent time constant of approximately 0,15 s (±0,03 s), including vehicle mathematical model response and other simulation transport delays (see 3.3.3).

3.3.5 Measurement recording

All vehicle parameters (i.e. position on track, steer angle, heading angle, heading (yaw) rate, etc.) are recorded at a sampling rate of at least 10 Hz. Additional parameters and information such as a unique time stamp, track number and markers for tasks (typically set manually by the experimenter) shall also be recorded. The LCT simulation shall have a minimum update rate of 100 Hz. In addition, secondary task performance shall be recorded (see 3.7.3). These data are needed to ensure the participant's compliance with the instructions (see Annex A).

3.4 Scenario design

3.4.1 Simulated roadway and surroundings

The simulated roadway (see Figure 1) consists of a straight, three-lane track. A series of lane changes are defined by roadside signs placed at approximately regular intervals. The road is located on a plain green field. Figure 2 shows the dimensions of the lanes and the markers (delineators). The road surface is grey (like a typical paved road). Lane markings are white.

The simulated roadway shall be displayed as if viewed from an eye point 120 cm ± 10 cm over the road surface. This is consistent with that of a typical passenger car.

NOTE 1 The roadway and lane change geometries and the vehicle dynamics are not scaled to correspond to a truck or other large commercial vehicle.

Minimum track length shall be 3 000 m corresponding to 3 min of driving at 60 km/h. This is sufficient in length to collect 2 min of LCT data.

NOTE 2 According to the signs in Figure 1, the participant has to change from the current (middle lane) to the right lane.

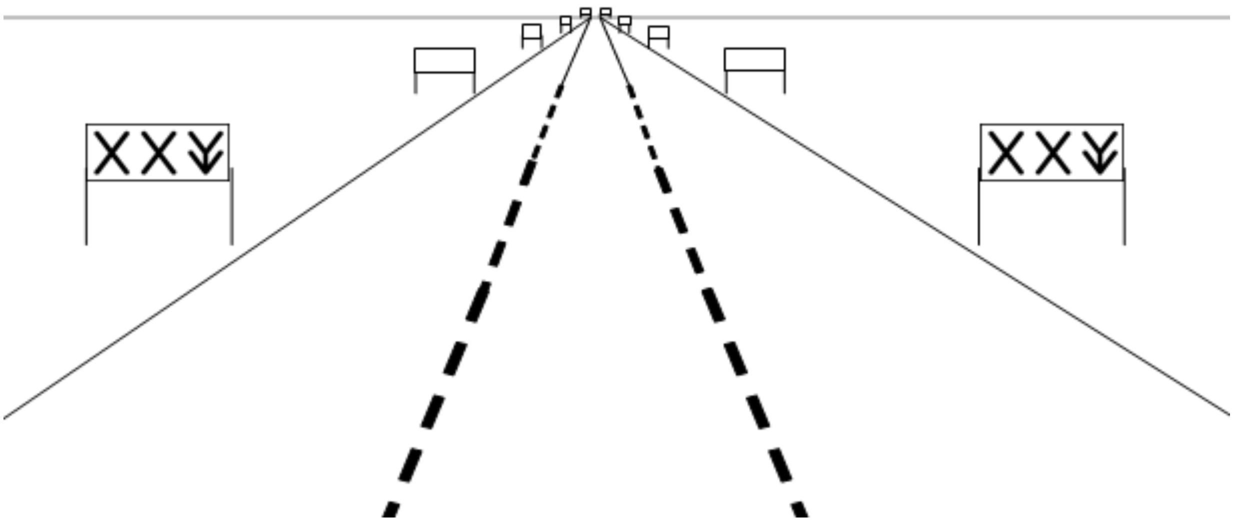
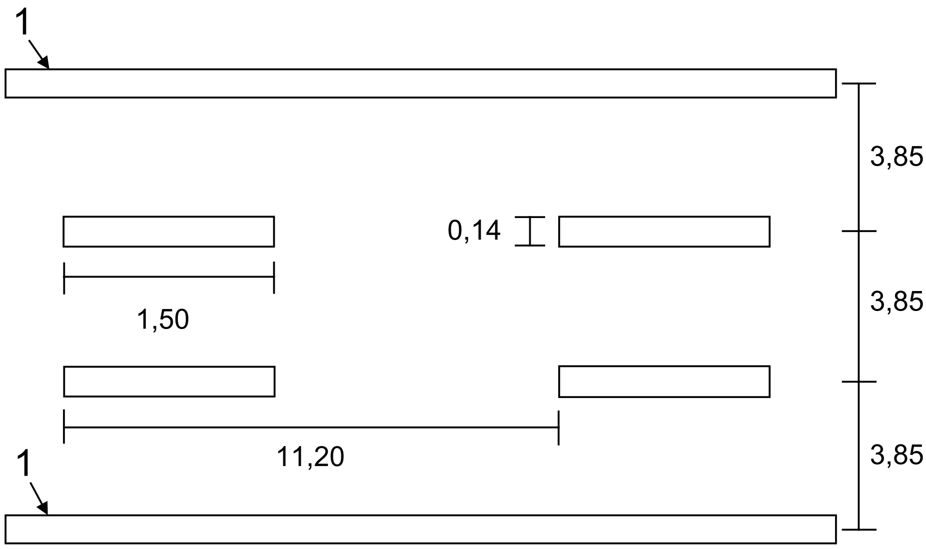


Figure 1 — Simulated roadway

Dimensions in metres



Key

1 road edge line

Figure 2 — Dimensions of the road markers (not to scale)

3.4.2 Signs

Both “START” signs and “Lane Change” signs appear in pairs on both sides of the simulated roadway (see Figure 1 for example of sign positions). “Lane Change” signs are rectangular and have a thin black border and black symbols on a white background (see Figure 4). The signs are 2,0 m wide and 1,0 m high and the lower border is 1,0 m above the ground. The downwards arrow on the “Lane Change” sign indicates the target lane. In Figure 4, (a), (b), and (c) show the left, middle and right lanes, respectively. Dimensions of the “Start” sign can be the same as the “Lane Change” sign, but the colours shall be different from those of the “Lane Change” signs (see Figure 3). The “START” sign shall appear approximately 150 m before the first “Lane Change” sign.

Figure 3 — “Start” sign

Figure 4 — “Lane Change” signs

3.4.3 Experimental and measurement setup

3.4.3.1 Participant's view of display

The horizontal viewing angle to the display for the road scenery (monitor or screen) shall be between 20° and 55°. The eye-to-display distance shall be no less than 60 cm. The horizon of the visual scene shall be between –5° and +5° from the participant's eye point height.

3.4.3.2 Steering wheel location

The steering wheel shall be located where it does not interfere with the visual scene of the LCT. It shall be capable of being handled comfortably.

3.4.3.3 Standard scenario

The standard scenario for a 3 000 m test track is as follows:

- only the scripted instructions are given to the participants (see Annex A),
- speed is specified and limited to 60 km/h, resulting in a duration of about 180 s per track,
- there are 18 pairs of “Lane Change” signs along a track.

3.4.3.4 Lane change sign spacing

The lane change signs are always visible but blank until the lane indications on the signs appear (i.e. pop-up) at a distance of 40 m before the signs. The mean distance from sign to sign is 150 m (a minimum of 140 m plus an exponentially distributed random variable with a mean of 10 m), so that the mean duration between two lane changes is about 9 s (at a speed of 60 km/h).

3.4.3.5 Ordering the lane change directions

The number of the six possible lane changes (from left lane to middle lane, from left lane to right lane, etc.) shall be balanced within 18 pairs of signs. This balancing also applies if tracks longer than 3 000 m are used. If the total number of pairs of signs on a track is not a multiple of 18, balancing shall be done to the extent possible. The presentation order of lane change signs in tracks used for different runs shall be randomised to avoid learning effects. At least five different orders shall be used randomly for different runs.

3.4.3.6 Secondary task equipment

The equipment for evaluating the secondary task shall be positioned where the participants can properly interact with it. The position depends on the purpose of the test, e.g. systems intended for vehicle use shall be positioned in their intended locations in the vehicle relative to the participant.

3.4.3.7 Document the setup

Because experimental setting effect may have an impact on the results, description of the setup, viewing distance and angle to road scene and type of road scene presentation, testing environment (personal computer, buck or complete car), and type of seat shall be reported.

It has been shown that better lane change trajectories have resulted when using a driving simulator instead of a personal computer [12], presumably due to the increased visual realism in a driving simulator. This emphasises the need to describe precisely each equipment setup before comparing the results of different experimental contexts.