

Distr.: General
19 September 2018

English only

Economic Commission for Europe

Inland Transport Committee

Global Forum for Road Traffic Safety

Seventy-seventh session

Geneva, 18-21 September 2018

Item 3 (c) (i) of the provisional agenda

Convention on Road Traffic (1968)

Automated driving

Vehicles with automated driving systems: The concept of activities other than driving

**Submitted by Professor O. Carsten, European Transport Safety
Council.**

This document, submitted by professor O. Carsten, provides a literature review on the impact of task activity on takeover from automated driving.

Literature Review on the Impact of Task Activity on Takeover from Automated Driving

Method

Two bibliographic databases were searched, TRID and PsycINFO.

The TRID database of transport-related literature (<https://trid.trb.org/>) was searched as follows:

Keywords: automated and driving and takeover

Subject areas: "Safety and human factors"

Language: English

Fourteen items were identified by this search of which six examined the effects of task activity.

PsycINFO, a database of peer-reviewed literature in psychology from the American Psychological Association (<http://www.apa.org/pubs/databases/psycinfo/index.aspx>), was accessed through the University of Leeds library. It was searched for "automated and driving and takeover" and "automation and driving and takeover" in any of title, abstract, heading word, table of contents, key concepts, original title or tests and measures in English. This identified 19 items of which 2 were spurious. Many of the items overlapped with those found through the TRID stage, so that in reality this second search uncovered two additional items.

A third source was papers known to the reviewer as well as references cited in the items identified from the databases. Finally one highly relevant review, available as a prepublication draft was found, the meta-analysis on takeover times of Zhang et al. (2018 — <https://tinyurl.com/yb8anx3k>). This last identified 93 studies, of which 91 were conducted on driving simulators and two on test tracks. Of the 93 studies, up to 35 compared takeover performance with a non-driving task to takeover performance without a non-driving task (it is not possible from the article to determine the exact number of studies making that overall comparison).

Two themes emerged from reading the identified studies:

1. The impact of task activity on takeover time
2. The impact of task activity on takeover quality

Impact on takeover time

Ko and Ji (2018) found that tasks that were rated by the participants as inducing high "flow" (i.e. intense engagement) induced longer responses to takeover requests. The time to fixation of eyes on the road, time to hands on the wheel, and time to completion of takeover were all longest under high flow. The effect was to increase response time by approximately 0.25 sec.

The study of Wandtner et al. (2018) examined how takeover time was affected by a variety of non-driving tasks. Both time to hands on the wheel and time to initiation of braking were affected by task type. An

auditory-vocal task increased mean time to hands on the wheel by approximately 0.1 sec., a visual-vocal task increased the time by roughly 0.25 sec, visual-manual interaction with a mounted device increased time by roughly 0.2 sec., and visual-manual interaction with a handheld device increased time by 0.7 sec. Time to initiation of braking was similarly affected, although here performance following visual-manual interaction with a mounted device was substantially worse than in the case of following a visual-vocal task, i.e. all visual-manual interaction had the worst impact.

The meta-analysis of Zhang et al. (2018) modelled the numerical results from the identified studies. The analysis of the findings across 12 studies showed that performing a non-driving task on a handheld device substantially increased mean takeover time with an estimated increase of 0.65 sec over the mean time of 2.27 sec without such a task. Other non-driving tasks — visual on a mounted device, auditory, visual-manual and cognitive — also increased mean takeover time, but to a lesser extent.

Impact on takeover quality

Gold et al. (2013) found that drivers who were engaged with a task on a tablet computer and who were then required to take over with a comparatively short notification period of 5 seconds had problems in vehicle handling in response to an emergency situation. A longer notification period of 7 seconds reduced this effect but by no means eliminated it: performance was still worse than in manual driving,

Merat et al. (2014) found that, when performing a cognitive task under high automation (SAE Level 2), drivers responded more poorly to a critical incident compared to when they were performing the same tasks under manual driving. The dependent variable here was reduction in vehicle speed.

Radelmayr et al. (2014) found that both a visual task and a cognitive task performed prior to a takeover request had detrimental effects on takeover quality as measured by ability to perform a manoeuvre to avoid a collision. This effect was observed in high density traffic, but not in medium or low density traffic.

Zeeb et al. (2016) examined how takeover quality from a Level 2 type system was affected by three different tasks — writing an email, reading a news item and watching a video clip. In a wind gust situation, deviation from lane centre increased by approximately 8 to 9 cm for drivers who were reading a news item or watching video. Interestingly, the email task did not affect performance to the same extent, although the drivers rated it as the most distracting, suggesting perhaps that, because they were aware of its impact, drivers took more care to compensate.

The study of Wandtner et al. (2018) examined how the takeover performance from a Level 2 type system was affected by a variety of non-driving tasks. Three measures were used to assess performance — avoidance of a collision with a broken-down vehicle and with other traffic, minimum time-to-collision and maximum deceleration in avoiding a collision. On the first two measures, a visual-manual task degraded takeover performance the most, while performance with an auditory-vocal task was similar to that with no task.

Implications

The studies are conclusive in pointing to an impact of non-driving task activity on both takeover time and takeover quality. Some types of task have a worse impact than others, with interaction with a handheld device at the time of a takeover request being particularly problematic. However, virtually every type of task has been shown to have a negative impact.

These findings point to a variety of policy and design considerations:

1. When there is the potential for a handover to manual driving, whether from Level 2 or Level 3 or Level 4, the use of handheld devices by human drivers should not be permitted.
2. Careful consideration should be given to which tasks are permissible in Level 3 driving, since all kinds of non-driving tasks have been shown to have negative impacts on takeovers.
3. For Level 4 systems which have the possibility of handover to manual driving, the permitted activities should be performed via the vehicle interface and the vehicle should regulate when they are permitted. Activities should cease well before the vehicle reaches the limit of its Operational Design Domain.

Oliver Carsten
ETSC
September 2018