L3Pilot project findings: Driver response process to take-over requests in real traffic

Linda Pipkorn, PhD Student | Crash analysis and prevention | March 11th, 2022

Background

- **The L3Pilot project:** European project aiming to *test the viability of automated driving (AD) as a safe and efficient means of transportation*.
- Several studies conducted within L3Pilot to investigate the effects of increasing vehicle automation on:

  - User behavior: e.g., how do users of automation respond when required to resume manual driving?

  - Traffic environment & Traffic safety (safety benefit estimation)

	ADEST study	L3Pilot Test track study	Traffic Jam Pilot study	L3Pilot Wizard of oz pilot	Intoxication study
Test environment	Test track	Test track	Test track	Public road	Test track
System type	Assistance	ACC and AD	Manual and AD	AD	Manual, Assistance and AD
Conflict scenario	Lead-vehicle cut-out + stationary object	Lead-vehicle cut-out + stationary object	Road-work zone	None	None
Conditions	Hands on wheel requirement (yes/no)	Take-over request timings (9 s/18 s time-to-collision)	Automation duration (4 min/14 min)	Repeated exposure to take-over requests	Intoxicated (yes/no)
Analysis	Response process to conflict	Take-over performance	Take-over performance	Take-over performance + visual attention	Visual attention
Publications (published or submitted)	Driver conflict response during supervised automation: Do hands on wheel matter? (2021, TRF)	It's about time! Early take-over request in automated driving enables safe response to conflicts (2022, TRF)	Automation Aftereffects: The Influence of Automation Duration, Test Track and Timings. (2021, IEEE ITS)	Two publications: one submitted to *Human Factors* and one manuscript to be submitted.	The influence of alcohol, automation, and non-driving related tasks on driver visual behavior on test track (2021, in prep.)

Methods

- Public road study to investigate drivers' response process to take-over requests in **real traffic**. Manual baseline included.
- Wizard of OZ approach to simulate AD
- Take-over request: audio + visual information
- Evaluating user behavior: video coding of driver actions and gaze behavior when responding to take-over requests

Findings

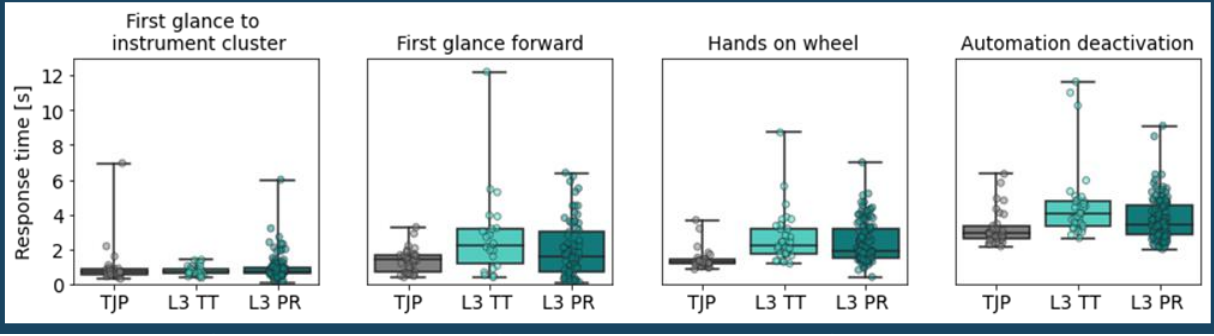
Responding to take-over requests in automated driving consists a process of actions that requires time and may include a noticeable number of off-road glances.

- Participants managed to deactivate automation in response to all take-over requests [1].
- In real traffic, participants looked on (38%) or off path (mainly towards non-driving related task items) when the take-over request was issued [1].
- Participants typically started their response by looking to the instrument cluster (72%) or forward (25%) before placing hands on wheel, deactivating automation and putting the foot on the accelerator pedal [1].
- Few participants put their foot over the brake pedal in response to the take-over request & some drivers deactivated automation before they looked to the forward road the first time [1].

[1] *Pipkorn, L., Tivesten, E., Flannagan, C., & Dozza, M. (2022). Driver response to take-over requests in real traffic. [Manuscript in prep.].*

Findings

Responding to take-over requests in automated driving consists a process of actions that requires time and may include a noticeable number of off-road glances.



	First glance to IC [s]			First glance forward [s]			Hands on wheel [s]			Foot on accelerator [s]			Automation deactivated [s]		
Study	**TJP**	**TT**	**PR**	**TJP**	**TT**	**PR**	**TJP**	**TT**	**PR**	**TJP**	**TT**	**PR**	**TJP**	**TT**	**PR**
Median	0.7	0.7	0.7	1.4	2.2	1.6	1.2	2.2	1.6	N/A	N/A	3.9	2.9	4.1	3.4
90%ile	1.0	1.2	1.5	2.0	5.1	4.5	1.8	3.8	3.8	N/A	N/A	6.0	4.7	5.8	5.3
Max	7.0	1.4	6.0	3.3	12.2	6.4	3.7	8.7	6.6	N/A	N/A	10.1	6.3	11.6	9.1

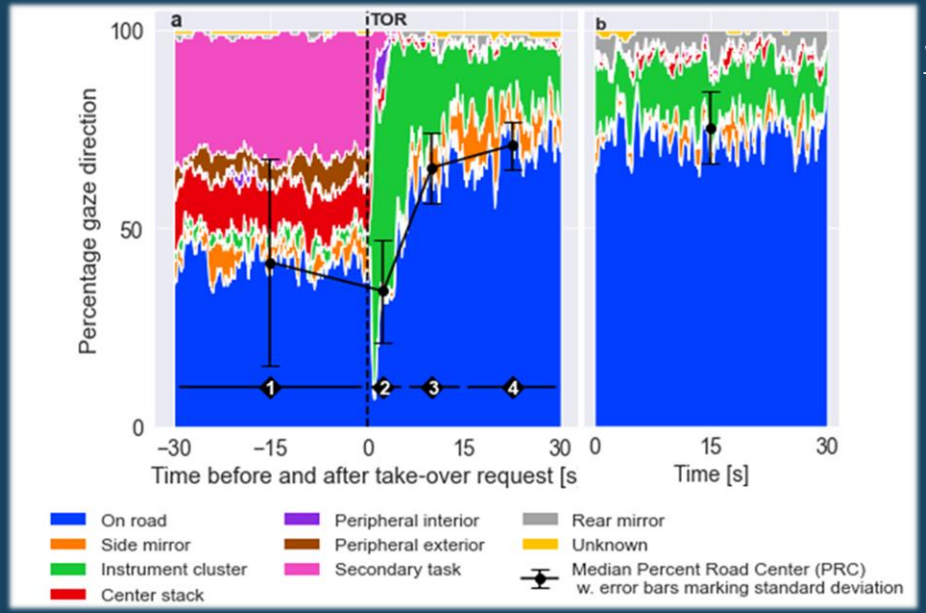
[1] *Pipkorn, L., Tivesten, E., & Dozza, M. (In press). It's about time! Early take-over request in conditional automation enables safe response to a lead-vehicle cut-out scenario. Transportation research part F: traffic psychology and behaviour.*
[2] *Pipkorn, L., Victor, T., Dozza, M., & Tivesten, E. (2021). Automation Aftereffects: The Influence of Automation Duration, Test Track and Timings. IEEE Transactions on Intelligent Transportation Systems.*
[3] *Pipkorn, L., Tivesten, E., Flannagan, C., & Dozza, M. (2022). Driver response to take-over requests in real traffic. [Manuscript in prep.].*

Findings

Responding to take-over requests in automated driving consists a process of actions that requires time and may include a noticeable number of off-road glances.

- Reduced visual attention to the forward road during automation, compared to manual [1].
- 1 s after a take-over request only 8% of gaze are on road [1].
- Levels of visual attention towards the forward road did not return to the levels observed during manual driving until after 15 s had passed [1].

a) A take-over request in automation **b)** Manual driving baseline



Work awarded with The Honda Student Paper Award *2021 Driving Assessment Conference*

[1] Pipkorn, L., Dozza, M., & Tivesten, E. (In press). Driver visual attention before and after take-over requests during automated driving on public roads. *Human factors*.

Conclusions

Several studies were conducted as part of the four-year L3Pilot project. One of these studies investigated drivers' response to take-over requests on public road:

- In real traffic, drivers can transition control from automated to manual driving in response to a take-over request.
- The transition should be considered as a process of actions (look to instrument cluster, hands on wheel, deactivate automation) that requires a certain amount of time.
- Before and shortly after, receiving a take-over request, drivers look less to the forward road than in manual driving. In fact, a take-over request may trigger drivers to look off road rather than on road. Thus, drivers may not be aware of the driving environment when taking back control and may therefore miss safety-critical events.

Publication list

- Pipkorn, L., Victor, T. W., Dozza, M., & Tivesten, E. (2021). Driver conflict response during supervised automation: Do hands on wheel matter?. *Transportation Research Part F: Traffic Psychology and Behaviour*, 76, 14-25. https://doi.org/10.1016/j.trf.2020.10.001

- Pipkorn, L., Victor, T., Dozza, M., & Tivesten, E. (2021). Automation Aftereffects: The Influence of Automation Duration, Test Track and Timings. *IEEE Transactions on Intelligent Transportation Systems*. Doi: 10.1109/TITS.2020.3048355

- Pipkorn, L., Tivesten, E., & Dozza, M. (2022). It's about time! Earlier take-over requests in automated driving enable safer responses to conflicts. *Transportation Research Part F: Traffic Psychology and Behaviour*, 86, 196–209. https://doi.org/10.1016/J.TRF.2022.02.014

- Pipkorn, L., Dozza, M., & Tivesten, E. (In press). Driver visual attention before and after take-over requests during automated driving on public roads. *Human factors*.

- Pipkorn, L., Tivesten, E., Flannagan, C., & Dozza, M. (2022). Driver response to take-over requests in real traffic. [Manuscript submitted for publication].

- Tivesten, E., Broo, V, Ljung Aust, M. (2021). The influence of alcohol, automation, and non-driving related tasks on driver visual behavior on test track. Manuscript in prep.

Project deliverables

- All deliverables can be downloaded here: L3Pilot: Downloads
- User & Traffic Evaluation:

D7.2 Microsoft Word - L3Pilot-SP7-D7.2-L3-L4_long-term_study_about_user_experiences_v2.0-for_website.docx

D7.3 L3Pilot-SP7-D7.3-Pilot_Evaluation_Results-v1.1-for_website.pdf

- Safety Impact Evaluation:

D7.4 Microsoft Word - L3Pilot-SP7-D7.4-Impact_Evaluation_Results-v1.0-for_website.docx

CHALMERS

Contact: linda.pipkorn@chalmers.se, lindapipkorn.com
Marco Dozza, Emma Tivesten, Thomas Streubel, Jonas Bärgman, Pierluigi Olleja, Jordanka Kovaceva