Defining HMI and UX Test Environments for Automated Logistics

Peter Fröhlich[1], Klemens Schwieger[2], Philippe Nitsche[2], Martin Reinthaler[2], Manfred Gruber[3], Manfred Tscheligi[1]
Austrian Institute of Technology
Center for Technology Experience[1]
Center for Mobility Systems[2]
Center for Automation, Vision and Control[3]

Giefinggasse 2, 1210 Wien, Austria
firstname.lastname@ait.ac.at

Matthias Neubauer, Andreas Pell
Logistikum – Department of Logistics at the University of Applied Sciences Upper Austria
Wehrgrabengasse 1-3
4400 Steyr/Austria
firstname.lastname@fh-steyr.at

Abstract

Automated vehicles are starting to be introduced in logistics processes, and high efficiency gains are expected. However, there is still insufficient knowledge about the critical success factors of automated logistics solutions, and this is especially true for acceptance and safety of human users (e.g., drivers, workers at the loading ramp, or operators). This paper presents the requirements for a test environment that investigates acceptance and user experience (UX) aspects of the Human-Machine Interface (HMI) of partially and fully automated vehicles in the freight and logistics domain.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Automated and connected driving offers a high potential and diverse opportunities for future transport. This applies, among other areas, to the topic of multi-modal transport logistics for the mobility of goods. Therefore, providing industry and research companies as well as government organizations with a test environment to safely evaluate these new shifts in mobility is paramount.

Table 1: Use cases

Index	Application scenario
1	Automated short-distance traffic
2	Automated long-distance traffic
3	Multimodal transport & cargo handling
4	Automated maneuvering
5	City logistics
6	Communal logistics

Such a test environment should be located in a region where there is high interest and a lively ecosystem of industrial players. The region of Northern Austria, spanned by the Austrian cities of Linz, Wels and Steyr, with its many industrial and logistics-based enterprises, provides optimal conditions in this regard. Infrastructure- and service-operators along with partners of the Connected Mobility Initiative will develop a test region to evaluate and validate new approaches of automated driving.

The exploratory project DigiTrans [8] aimed at deriving the requirements for establishing a test region for automated driving in multi-modal transport logistics. This paper outlines the main findings, research issues and methodology defined within this exploratory project in relation to the user experience aspects of automated mobility solutions for logistics. The following section provides an introduction into the current state of the art and open issues. Then, the key building blocks necessary for a test environment for the holistic consideration of automated mobility solutions for logistics are presented. Finally, the main components of the environment in relation with acceptance and user experience are proposed.

HMI and User Experience

Autonomous vehicles pose completely new requirements towards handover processes in which the professional driver of a freight vehicle has to be introduced safely into the present driving situation. Thereby, the most appropriate mode, information density and required reaction types are to be considered. A study conducted in the context of the EU-funded project COMPANION [1] resulted in the preference of a maximally reduced interaction with the system, in which important, automatically sensed information is transferred via audio signals and modulated light intensity and font color in the display.

The acceptance of partially and fully autonomous freight vehicles, both from the perspective of passengers and other road users, represents a central factor for their successful introduction. Although in related studies participants [2] reveal openness in principle towards these technologies, acceptance is compromised due to expected loss of control, as well as safety, privacy and ethical concerns [3,4,5,6].Thus, the consideration of these aspects and a close co-ordination with public participation activities within a user-centered design process appears indispensable, in order to smoothly seize insecurities and potential resistance.

General requirements for a test environment

The above description of the current state of HMI and user experience research demonstrates the need for more substantial and systematic testing in the field of logistics solutions. In order to tackle these within a test environment, some foundational features of the test environment are necessary to clarify, and the scope of the addressed application areas need to be defined.

General Testing Services

We came up with the insight that a test environments for automated mobility in logistics should provide a large range of services: test design, data collection, equipment installation, operation and support, and evaluation. Several test levels should be offered in a comprehensive test environment, that is, early tests of virtual prototypes should be enabled through simulation, while first observations of functional systems prototypes should be done within versatile and

Table 2: Automated vehicle types, use cases and user groups

Automated vehicle type	Use case	User group
Multifunctional delivery car	5	Driver, Co-driver, Other road user
Truck	1, 2, 3	Driver, co-driver, other road user, loader
Tractor truck	1, 2, 3, 4	Driver, co-driver, co-driver, other road user, loader
Loading robot	1	Operator, loader
Pallet transporter	1	Operator, loader
Maneuvering vehicle for trailers	1, 4	Operator, loader
Container conveyor train	3	Operator
Gantry crane	3	Operator
Reach Stacker	3	Operator
Multifunctional vehicle for communal cleaning and maintenance services	6	(Driver), Operator, Road user

standardizable laboratory conditions. In order to further contextualize the testing process, tests in real-contexts, either at factory premises or public roads should be facilitated.

Use cases
Table 1 provides an overview of the use cases identified within the DigiTrans project. These include freight transport over long distance using the motorway as well as short-distance transport (e.g. between different parts of a factory that are connected through communal roads). Furthermore, logistics processes during multimodal transport & cargo handling (as well as maneuvering are investigated as to the efficiency and acceptability of automation. Furthermore, the use of automated vehicles for delivery within urban areas (see scenario 5, city logistics) and communal services (street and snow clearing on roads and walkways) is also promising and thus should be investigated.

Vehicle types and user groups
Table 2 suggests that there is a large diversity of partially and fully autonomous vehicles used throughout the different defined logistics use cases. These range from "classical" truck and delivery cars, which in the next years will often be managed by a driver, while control will be handed to the car on highways and larger streets. An extension of classical cars are communal service vehicles, which are designed to drive along walkways and which feature special mountings for cleaning and maintenance. However, there are also be less-"car like" automated systems automated vehicles, such as specific vehicles for factory premises or large logistics terminals. Given the complexity, heterogeneity, and different possible levels of automation, there are also different types and qualities of human involvement. In several cases, such as truck driving, vehicles will be manned within the foreseeable future, but the handover from manual to automated driving will be of increasing importance. There will thus also be the role of passive "co-driving", either when the driver changes to self-driving mode, or when the driver is accompanied by another passenger.

Another important user group are loaders or dischargers, who interact with autonomous delivery cars or trucks from outside at the loading ramp. Especially with full automation, operators within factory premises or cargo stations will gain increasing importance as they will have to survey potentially large numbers of automated vehicles using specialized networked software. Of course, the safety or everyday routines of other people who are actually not involved in the investigated automated logistics processes may get compromised.

HMI and User Experience Testing Scope

The following services and activities are foreseen for the testing of HMI and user experience aspects in the test environment:

1. *Early development of scenarios, methods and criteria*, to support companies in the preparation of their tests
2. *Test instrumentation for vehicles*, enabling exact positioning, audio and video recording, as well as driving data capture from the CAN-Bus
3. *Test instrumentation for the vehicular environment*, including videos of the overall usage situation, location and activity sensors, in order to evaluate driving behavior and interaction with other traffic participants

4. *Test instrumentation for monitoring and control* would entail a comprehensive tracking of the operator's actions and the monitored processes in the factory premises or cargo stations (by video and data logging)
5. *Tools for inquiry* should enable the capture of experience in different usage situations and contexts, such as in the truck and the loading ramp.
6. *Tools for user observation* need to be used that can assess driver distraction, cognitive load, task performance and situation awareness
7. *Tools for the creation of experience* should be provided, such as prototyping kits, driving simulators, as well as mobile AR and VR for the simulation of usage situations in the factory or at the ramp.
8. *Tools for the prediction of experience*, based on technology acceptance models and machine learning methods should enable the foresight of usage behaviors, which could then be used to improve the technology under development.

Conclusions

The requirements presented in this paper are based on a systematic stakeholder dialog process, and we are confident to set up the envisaged test environment in the near future. The deep empirical grounding of this aspired test bed will increase the likelihood that automated driving solutions are successful within for the promising application field of logistics.

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