External HMI for Autonomous Buses

Results of the IQ Mobility project in preparation for Project Qatar Mobility

FRIDA ERIKSSON, ANGELOS MALIKOUTIS, ADELIINA AHO TARKKA, PONTUS UNGER, PEDRAM NAYERI, ANDERS BÄCKMAN, MARIA KOUGIOUMOUTZI, JULIA SÖDERBERG, KAROLINA INGRE, & STAS, S, KRUPENIA

Scania CV AB

Scania Commercial Vehicles AB has been investigating how people interact with autonomous vehicles for close to a decade. Whereas early research focused on Level 3 (SAE, 2016) automation (Krupenia et al., 2014), current research focuses on level 4/5 automation. Two recent projects were IQ Pilot and IQ Mobility. The former focused on autonomous heavy vehicles for urban transport in general and the later specifically on automated buses. These two projects are key steps for Scania to deliver to Project Qatar Mobility (Volkswagen, 2019)—an initiative to develop autonomous transport solutions for the 2022 FIFA World Cup. Here we present key insights into external HMI for autonomous buses acquired from IQ Pilot and IQ Mobility.

CCS CONCEPTS • Autonomous Bus • External HMI • Interaction Design

Additional Keywords and Phrases: Autonomous bus, External HMI, Interaction Design, Guidelines

ACM Reference Format:

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 INTRODUCTION

In December 2019, Volkswagen Group announced "Project Qatar Mobility", a project that seeks to further develop Doha's local public transport sector's self-driving capability. The project will deliver several key autonomous-transport related products and services in time for the country's hosting of the FIFA World Cup in 2022 . Included in this project are several initiatives that will result in the introduction of various vehicle platforms. One vehicle platform will be a Scania Bus (Volkswagen, 2019).

The development of autonomous buses has been, and continues to be, an active research area for Scania. For example, at the UITP 2019 Global Public Transport Summit, Scania presented it's NXT autonomous bus concept (Scania, 2019). The NXT concept included several features intended to support how passengers interact with a driverless bus. For example, lights in the ceiling informed passengers about stop and start driving actions, a disembarking warning system alerted passengers to unsafe oncoming traffic, and information about connecting traffic information was continuously shown. In addition to these interior interaction technologies, NXT included a range of external interaction technologies. For example, people in the vicinity of the vehicle are alerted to its approach via LED lighting on the front, side, and rear. There was also an “I see you” feature that confirmed to cyclists and pedestrians, via lights and sounds, that the vehicle was aware of their presence.

In parallel to developing NXT, Scania’s Interaction Design group participated in IQ Pilot and IQ Mobility. IQ Pilot aimed to develop autonomous vehicle research platforms for the ongoing development of autonomous solutions in urban environments. The related project, IQ Mobility, sought to develop a prototype automated urban public transport vehicle. Within IQ Mobility were several tasks associated with facilitating better interaction between people and autonomous buses. In what follows, we present some of IQ Pilot’s methods and findings.

2 EXTERNAL HMI GUIDELINES AND PRODUCT SOLUTIONS

A key part of the interaction design work on IQ Mobility was to investigate (1) what information must autonomous buses communicate, and (2) how should this information be communicated. To complete these tasks, three stages of investigation were completed, User Needs, Product Development, and Testing.

2.1 User Needs

2.1.1 Methods

Identifying user needs was completed via three steps; Literature Review, Observations, and Interviews. The literature review focused on traffic behavior and autonomous vehicle HMI. The observation study investigated interactions between road users and city buses focusing on what actions bus drivers take, and what they need to communicate to road users and passengers. Twelve observation sessions were completed over several days and multiple locations. Locations were selected based on accident data obtained from municipal databases. From these observation sessions, more than fifty interaction points between buses and road users were identified. Additional observations were undertaken to investigate how people interact with operational automated pods such as the Nobina/SL autonomous pod in Barkarby (Nobina 2018), and the Navya pod in Gothenburg (Gothenburg City, 2019). Data collected via the literature review and observations were analyzed by the research team in preparation for driver interviews. Small group interviews were performed with fifteen professional bus drivers. The drivers provided multiple insights and explanations for the observation data.

2.1.2 Results

The User Needs methods described above provided significant insights to guide product development. First, data suggests that External HMI’s should only be used in necessary or critical situations. This was to avoid information overload and reduce visual clutter in a typically stimulus-rich driving environment. Second, information should be communicated multimodally, typically with redundant or complimentary audio and visual signals. Third, there appears to be a unique culture associated with bus drivers that deserves additional investigation. Bus drivers have an internal language that represents the ‘street culture’. The driver must adapt to, but at the same time, influence, the surrounding traffic attitude or culture. Similarly, the automated vehicle needs to be adapted to the local culture. Fourth, it was seen that people respect people-driven vehicles more than automated vehicles. Furthermore, it was noted that some people try and test or even abuse the behavior of the automated vehicle. Fifth and finally, we observed that road users might bend or break traffic rules in order to promote safety. For example, a bus driver might delay turning due to an uncertainty that a nearby cyclist has not seen or understood the bus driver's intentions. Alternatively, the bus driver might avoid entering an intersection to avoid creating a traffic jam. Lastly, it was also observed that drivers had to nudge the buses into the adjacent lane even though other vehicles were already there, or were approaching this space (in other words, other vehicle drivers were ignoring the turn indication lights of the bus).

2.2 Product Development

To develop a product, the user needs were broken down into general design guidelines and specific automated bus solutions. Three key guidelines were developed. First, don't tell other road users what to do. In other words, always communicate the ergo vehicles intent. In doing so, trust can be established towards the automated bus. Second, don't create a new language. The design solutions should be based on communication principals we use today. Additionally, communication should be minimal (as simple as possible), direct (delivered to the appropriate target recipient, not everyone), and understandable (presented in a universal format to be understandable by as wide an audience as possible). Third and final, present one 'bit' of information at a time, and only that information relevant for the current situation.

Using the general guidelines and specific design needs, product ideation and concept development commenced. The methodology for ideation followed a four-step workshop approach. Each workshop contained several interaction designers that had been contributing to the user needs investigation. The four workshops covered (1) what does the bus communicate, (2) how does the bus communicate, (3) technology position/perception mapping, and (4) converging of concepts and expert review.

A key early outcome of these workshops was the identification of what information must be communicated. Here there were three key messages; "I am slowing down" (e.g. at a pedestrian crossing), "I need space" (e.g. when leaving a bus stop), and "I am standing still" (e.g. at a bus stop with an intention to not move).

After multiple rounds of ideation, three potential concepts were created. Each concept was consistent with the general and specific design guidelines, but utilized slightly varying external HMI hardware in different ways. Only key differences between the concepts will be presented.

Concept 1 made significant use of augmented lights and a short LED strip, the use of the movement to communicate intent, and spatial (external) audio. Concept 2 made use of large front and rear displays (covering the full width of the vehicle, including around to the sides), as well as spatial (external) audio. Concept 3 included an LED strip that circumnavigated the vehicle, flashing lights, and spatial (external) audio.

2.3 Testing

User testing was conducted to evaluate how well the different modalities communicate specific messages and intentions. Specifically, the test investigated (1) which modalities are best suited for the different messages in terms of supporting user-comprehension of the intended message, and (2) which concept facilitated better trust.

2.3.1 Method

Thirty participants recruited from an external design agency voluntarily participated in this study. Participants were required to have experience with travelling via bus, cycling, and driving in traffic. Participants and a member of the research team were co-located with an observer in an adjacent room. Participants watched a series of animated vignettes showing a bus concept in five situations. In this between-subject study, each bus concept was viewed by ten people. Vignettes were counterbalanced using a Latin square design to minimize order bias. Of interest were Understandability and Trust associated with the different concepts in different situations. Understandability was measured via semi-structured interviews conducted immediately after viewing the vignettes. Trust was assessed using a modified version of the Trust in Automation Scale (Jian, Bisantz, & Drury, 2000). Here, participants answered six questions such as “I am confident in the vehicle”, and “ I can trust the vehicle” using a seven point Likert scale. The trust questionnaire was provided three times coupled to the vignettes where the following was being communicated via the automated bus; I am slowing down, I am standing still, I need space.

2.3.2 Results

A large amount of data was collected that included information about design features that were or were not understood as intended, or were/were not facilitating trust. A brief summary of some key results are presented here. To communicate “I am slowing down”, the front display from Concept 2 was preferred. To communicate “I am standing still” the rear light solution from Concept 1 was preferred. To communicate “I need space”, the results were mixed, with a combination of the animated arrows on the vehicle displays (concept 2) together with the headlights and sounds were preferred.

3 CONCLUSIONS

The IQ Mobility project has contributed to a significant knowledge gain related to automated bus design. By identifying the general design guidelines, together with the key information to communicate, a concept exterior HMI was created and tested. Although currently limited to video-based testing, the Project Qatar Mobility opens up new opportunities for iterative testing and development in an operational environment.

ACKNOWLEDGMENTS

This work was supported by FFI (project numbers 2016-02547 and 2016-02554).

REFERENCES

Gothenburg City (2019). Test med sjölvkörande bussar på Lindholmen [Test with self-driving buses at Lindholmen]. Press release from 24th April, 2019. Retrieved 23rd September, 2020 from https://stadsutveckling.goteborg.se/hallbart-resande-och-transporter/nyheter/test-med-sjalvkorande-bussar-pa-lindholmen/.

Jian, J., Bisantz, A., Drury, C. (2000). Foundations for an empirically determined scale of trust in automated systems. International Journal of Cognitive Ergonomics, 4(1), 53–71.

Krupenia, S., Selmarker, A., Fagerlönn, J., Delsing, K., Jansson, A., Sandblad, B., & Grane, C. (2014). The ‘Methods for Designing Future Autonomous Systems’ (MODAS) project: Developing the cab for a highly autonomous truck. In T. Ahram., W. Karowski., & T. Marek. (Eds.). Proceedings of the 5th International Conference on Applied Human Factors and Ergonomics and Affiliated Conferences (AHFE2014), Krakow, Poland, 19-23 July, 2014.

Nobina (2018). Första självkörande bussarna I reguljär linkjetrafik I Barkarbystaden [First self-driving buses in regular line traffic in Barkarby city], Press Release. Retrieved 23rd September, 2020 from https://www.nobina.com/sv/sverige/nyheter/Forsta-sjalvkorande-bussarna-i-linjetrafik/#

SAE (2016) Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles (Surface Vehicle Recommended Practice: Superseding J3016 Jan 2014), SAE International, September 2016.

Scania (2019). Taking urban transport to the NXT level – a new concept from Scania. Press release from 10th June, 2019. Retrieved 23rd September, 2019 from https://www.scania.com/group/en/home/newsroom/news/2019/taking-urban-transport-to-the-nxt-level-a-new-concept-from-scania.html

Volkswagen (2019). ‘Project Qatar Mobility’: Self-driving shuttles set to take Doha’s local public transport to the next level in 2022. Press Release from 14th December, 2019. Retrieved 23rd September, 2020 from https://www.volkswagen-newsroom.com/en/press-releases/project-qatar-mobility-self-driving-shuttles-set-to-take-dohas-local-public-transport-to-the-next-level-in-2022-5679/download.

External HMI for Autonomous Buses

Results of the IQ Mobility project in preparation for Project Qatar Mobility

FRIDA ERIKSSON, ANGELOS MALIKOUTIS, ADELIINA AHO TARKKA, PONTUS UNGER, PEDRAM NAYERI, ANDERS BÄCKMAN, MARIA KOUGIOUMOUTZI, JULIA SÖDERBERG, KAROLINA INGRE, & STAS, S, KRUPENIA

Scania CV AB

VIDEO SUBMISSION

https://www.youtube.com/watch?v=HeL2dSbg8t4

From 46:20 to 1:00:00