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User-centered development of a driving simulator for training of emergency vehicle drivers and development of Emergency Vehicle Approaching messaging: A simulator study

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Abstract

There is a large risk of accidents in connection with emergency driving and the need for both better possibilities to train emergency vehicle driving and for systems guiding other road users to the right behavior is apparent. The aim of this study was (1) to initiate user-centered development of a driving simulator for training of emergency vehicle drivers and (2) to collect information about how to best communicate EVA messages. The method used is user-involved, iterative development of both the driving scenario and the driving simulator. 104 participants have tried the simulator and responded to a questionnaire. Most difficult for emergency vehicle drivers are vehicles in front suddenly braking and failure in other drivers noticing them. Desired behaviour in other road users is to yield to the right and brake smoothly. The attitude towards communication of EV driving is positive, regarding both pre-alerting drivers who are approaching an incident scene and sending out EVA-messages.

Keywords: driving simulators; emergency vehicle driving; traffic safety; emergency vehicle driver training; C-ITS

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1. Introduction

The risk of accidents in connection with emergency driving is increasing (Burke, Salas, & Kincaid, 2001; Wilbur, 1997; Lundälv, Philipson, & Sarre, 2010). Despite the obligation for other road users to yield to and provide free passage for emergency vehicles (Svea Trafikutbildning AB, 2019), incidents often occur and unfortunately also serious accidents.

A quantitative illustration of the problem is shown in Table 1, where costs for vehicle damage, incurred within the Swedish police are presented. (Dahlström, 2018). They are substantial, and increasing, even if some of the explanation for the latter could stem from the recent introduction of so-called PIT manoeuvres (pursuit intervention technique) also in the Swedish Police force arsenal.

Table 1. Costs for vehicle damage, incurred within the Swedish police.

| Police vehicle damage (Sweden, SEK) | 2013 | 2014 | 2015 | 2016 | 2017 |
|--|-------------|-------------|-------------|-------------|-------------|
| PIT* manoeuvres | 196 | 276 | 314 | 316 | 345 |
| Cost (PIT) | 8 425 166 | 10 291 811 | 12 606 430 | 12 984 906 | 15 576 793 |
| # damages | 4771 | 4819 | 4904 | 4931 | 5105 |
| Damage cost | 57 902 774 | 56 027 009 | 62 981 290 | 59 229 373 | 61 500 611 |

The warning systems that are available are still primarily siren and emergency vehicle lighting, both of which have limited reach and detectability. This is sometimes supplemented with broadcast calls over radio. One well established such technology is the Traffic Announcement (TA) features of the European RDS system. However, only very few recipients of such broadcast warnings are actually affected, and, as a consequence, radio stations are reluctant to interrupt regular programming, and tend to select only the most critical cases (Sveriges Radio, 2013). Recently, cellular mobile communication technology and so-called collaborative intelligent transport services (C-ITS) begin to enable new ways of conveying traffic-related messages. Such messages can be adapted to the situation, traffic flow and individually directed only to those road users who are at risk of interfering with an emergency vehicle's route. Such services are developed and demonstrated in the EU project Nordic Way 2 (<https://www.nordicway.net/>), within which protocols and standards are developed for messages, issuing warnings for "Emergency Vehicle Approaching" (EVA). Both self-driving vehicles and manually operated are target groups. VTI's task in Nordic Way 2 is to investigate through driving simulator studies how such a system should be designed for optimal effect.

Emergency driving is further complicated by the fact that traffic intensity varies considerably depending on where the accident or incident occurred, where the emergency vehicle is in relation to the accident site but also because on actions taken by other road users, e.g. their reactions as they notice the warning lights and sirens (Vägverket, 2008). From literature, from previous projects such as AstaZeroSim (Skoglund, Bolling, Åsberg, & Reichenberg, 2015; Burke, Salas, & Kincaid, 2001; Lundälv, Philipson, & Sarre, 2010), and from meetings and interviews over recent years with a number of professional emergency vehicle drivers, it is apparent that there are several problems with education and training of emergency vehicle driving that a simulator-based method can solve:

Emergency vehicle driver training has been suggested as one of the most effective approaches to reduce emergency service vehicle incidents (Bui, et al., 2018) and specifically recurring training also for established drivers has been requested (Jansson & Strandberg, 2006). Even though there are stated goals of competence for emergency vehicle drivers (Vägverket, 2008; Myndigheten för samhällsskydd och beredskap, 2017), practicing emergency driving on the road is not permitted in many countries and a simulator-based method would enable risk-free training that otherwise is not possible. Such training could for instance be focused on increased risk awareness and improved self-perception, or on training of unforeseen traffic events. Examples of such events are erratic or even blocking behaviour from fellow road users, such as suddenly slowing down, not being attentive, not yielding, etc. Also, suitable speed- and distance-keeping, attention to other traffic and to vulnerable road users, are skills that could be trained in a simulated environment but would be difficult to train in real life. A key advantage of simulator-based training is risk-free learning allowing for mistakes, but also the possibility for self-paced exercises and limitless repetition, and ample opportunity for reflection and feedback. This contributes to increased self-awareness and risk awareness, which should enable drivers (and fellow co-riders) of emergency vehicles to arrive at an incident

scene without jeopardizing their own or other road users' safety. Another important aspect is that they would do so with enough cognitive forces left to solve their primary task at the destination. A key factor for such training to be effective is that skills, behaviour or self-awareness learned in a simulated environment must transfer to the real on-road environment. This has been shown to be the case in several studies, both in general (Underwood, Crundall, & Chapman, 2011; Andrieu & Saint Pierre, 2012), and also specifically in the case of emergency vehicle driving training (Bui, et al., 2018). The use of driving simulators specifically designed for education and training of emergency vehicle driving is being investigated in a project led by VTI and co-funded by the Swedish Transport Administration, the Swedish Police and with contributions from several Swedish national ambulance and fire brigade organizations.

Both for investigating the impact of C-ITS-based warning systems, such as the EVA message system, and to enable simulator-based emergency vehicle driving training, relevant driving scenarios and a realistic simulator environment needs to be developed. User involvement is used in this contribution to investigate demands and expectations on a driving simulator set-up and to further develop both the simulator rig, driving scenarios and the methodology.

2. Aim

One aim of the study was to initiate user-centered development of a driving simulator for training of emergency vehicle drivers. A second aim was to collect information about how to best communicate EVA messages. A further technical goal was to develop a new simulator rig and simulator scenarios that could be used in present and future projects supporting both aims above. A set of four research questions (I – IV) were developed, all with the purpose of finding out more about the need for scaled-down driving simulators within “blue light” organizations:

- I - Which difficulties do emergency vehicle drivers encounter under EV driving?
- II - Which behaviour is desirable in other road users?
- III - How should simulator-based training best be developed?
- IV - How and when should warnings regarding EV driving be communicated to other road users?

3. Method

The method used was **user-involved, iterative development** of both the driving scenario and the driving simulator rig, conforming to the agile style of development (Agile Alliance, 2018). For the present type of project, an agile way of working was judged to be particularly suitable. In contrast to the traditional plan-based or “waterfall” way of managing projects, the agile methodology is more suitable when the requirements are not all well-defined beforehand, and when creativity and innovation and maximizing the value of the resulting software is top priority. A prerequisite is that work must be possible to organize into iterative, short development cycles, each resulting in step-wise deliverables, that can be successively evaluated and further developed. The agile approach benefits from maintaining close contact with highly involved, professionally engaged end-users, and the approach has over the past several years successfully been applied to a similar type of development of VTI's driving simulators for train driver traffic safety education and training (Thorslund, Rosberg, Lindström, & Peters, 2019). This paper describes two cycles of such user-centered development, where, as a mid-term result, a new simulator rig was built with modifications based on input from the first cycle. A simulator study with user questionnaires was performed in conjunction with each cycle, resulting in two sub-sets of data being collected.

An **emergency vehicle driving scenario** from a previous project was used as a starting point (Skoglund, Bolling, Åsberg, & Reichenberg, 2015). The entire scenario consists of approximately 20 minutes of driving in a sequence of highway, rural road, and urban road environments. Regardless of environment, the surrounding road users act very irrational and it is a challenge to get through. The scenario handling software allows the subjects to begin driving at any pre-defined starting point, and three different such entry points were devised in this case, beginning either on a highway, a rural road or in the urban setting. An initial scenario sequence was developed, where the vehicle type and the impending rescue mission is presented, along with information on how to operate the simulator

rig and select entry point. The rescue mission and practical details on how to operate the simulator was described to each participant using “splash screens” as shown in Fig. 1.



Fig. 1 “Splash screens” (in Swedish), presented to each participant at the initial stage of simulator driving, explaining the situation, vehicle type and emergency/rescue mission, and how to operate the scenario selection in the simulator before beginning to drive

The scenario is populated with a naturalistic density of scripted and ego-vehicle-adaptive road users including trucks, buses, cars, and pedestrians. Both oncoming traffic and vehicles travelling in the subject’s own direction are part of the scenario, as well as vehicles entering from a perpendicular access road, and crossing the subject’s street in down-town intersections (both signalized and non-signalized). The behaviour of other road users had been pre-programmed, and designed to reflect naturally occurring behavioural patterns, based on literature and information from pre-study interviews with ambulance, police, and fire brigade staff. Consequently, some of the other road users in the scenario yield and provide free passage to the subject’s emergency vehicle, whereas others exhibit common, but less helpful, behaviour, such as not yielding, or suddenly braking, as the emergency vehicle approaches from behind.

The initial development cycle was performed using a **scaled-down simulator rig (Rig 1)** from a previous VTI project, which was equipped with the emergency driving scenario, see Fig. 2. This rig was modified with certain add-ons, specifically designed to provide a sense of realism, and with the purpose of inducing cognitive load, similar to that under real emergency vehicle driving. To this end, the rig was equipped with communication and information devices. Some of these were mock-ups: among these were a control panel from the Rakel system provided by the Swedish Civil Contingencies Agency (MSB) and used within nearly all Swedish emergency vehicles. A fully working communication system based on walkie-talkies was also installed. A second screen was also fitted over the centre console. This was implemented using an Android smartpad which alternated between showing “fake” drone photos from the accident scene, a map and (non-interactive) navigation info.

As the method used is user-centric, iterative development, a second development cycle was carried out approximately halfway through the period, based on the questionnaire results and other feed-back from users. As a result, a **second simulator rig (Rig 2)** was built, with several improvements and alterations, see Fig. 2. The main alterations were: adding of side monitors to form a complete three-monitor visual system; replacing a simpler seat, pedal gear and steering wheel with authentic car parts; adding fully controllable blue lights, dual siren sounds and working indicator controls.

A three-page **questionnaire** in Swedish with 16 questions was developed to cover several areas related to emergency driving, new technology, and traffic safety, including the four research questions listed in section 2 (Aim) above. Some basic demographic data was also covered, and subjects could at will provide their contact info, if they wished to be kept informed or would want to participate in further studies. The questionnaire was designed to be used by several different professional categories, with questions 6 – 10 intended to be answered only by professionals who regularly drive or ride in emergency vehicles as crew. An English translation of eight of the items from the questionnaire is provided in Table 2, which also shows the coupling between the research questions and specific questionnaire items.

Table 2. Mapping of research questions I – IV to questionnaire items

| Research question | Questionnaire item(s) |
|---|--|
| I. Which difficulties do emergency vehicle drivers encounter under EV driving? | 6. To what extent do the following factors constitute difficulties during emergency vehicle driving to an accident or incident scene? Rate the difficulty on a scale from 1 (little difficulty) to 5 (major difficulty). a) queues b) roadworks, re-directions c) other vehicle driver fails to notice us d) other vehicle driver deliberately ignores us |

| | |
|--|---|
| | e) other vehicle driver suddenly brakes f) vulnerable road user fails to notice us g) vulnerable road user deliberately ignores us h) something else, namely |
| | 7. Provided that both sirens and blue lights are used, how early does normally a vehicle driver ahead react to your emergency vehicle in different environments? a) in urban environments (50 km/h) – When we are meters behind b) on a highway (110 km/h) – When we are meters behind c) on a rural road (80 km/h) – When we are meters behind |
| II. Which behaviour is desirable in other road users? | 8. How would you like vehicle drivers to react when your emergency vehicle is approaching from behind? a) in urban environments (50 km/h) b) on a highway (110 km/h) c) on a rural road (80 km/h) |
| III. How should simulator-based training best be developed? | 10. What events or situations would you like to train in a simulator? 12. What did you find to be good about the simulator? 13. What should be improved to begin with? |
| IV. How and when should warnings regarding EV driving be communicated to other road users? | 9. Imagine that an automatic warning is issued from the emergency dispatch centre to all vehicles ahead, saying that your emergency vehicle is approaching. Are there places and/or situations when that is not appropriate, and (if so) which are they? 11. Should vehicle drivers who are approaching an incident or crash scene be pre-alerted? (Yes/No) |

The agile method builds on close involvement with end users, who can provide valuable input and also evaluate and give feedback on the successive results from an iterative development method. It was therefore judged as important to find end users with strong engagement and professional experience, and a willingness to contribute and share knowledge. Unlike many other studies, representativeness is of less importance, why **selection of subjects** could take place entirely **based on convenience**. In this study, we included participants from both ambulance services, fire brigades, the police and sea rescue. A number of such actors were invited to the VTI main office in Linköping to perform test runs in simulator Rig 1. Since both Rig 1 and the later developed Rig 2 were designed for transportability, data was also collected at Skadeplats 2018 in Helsingborg (Fig. 2, left) and Ambulans 2019 in Upplands-Väsby (Fig 2, right).



Fig. 2 To the left: Simulator Rig 1 used in the first development cycle. To the right: Simulator Rig 2 used later.

The **data collection procedure** was as follows: The participants were informed verbally about the purpose of the study and their right to stop and withdraw from the study at any time. The test instructor showed each subject how to adjust the seating, seatbelt, steering and pedals. Mock-up drone imagery information displayed on a second screen was explained, and the splash screen info in Fig. 1 then introduced each subject to the driving mission. After the test drive, each participant was asked to fill out a questionnaire. During fall 2018 and winter 2019, a data collection with professional participants recruited by convenience from different “blue light” actors was performed at several different locations in Sweden. **Descriptive analysis** was used on the quantitative data from this study. Distribution of different answers are presented and, in some cases, also mean values. Qualitative data from open questions was categorized and then analyzed with descriptive statistics like the quantitative data.

4. Results

During the first data collection cycle with Rig 1 during fall 2018, 50 participants were recruited. After the construction of Rig 2, another 56 subjects performed a second cycle of studies in spring 2019. Of the 106 participants, 83 (78%) were men, and 23 (22%) were women. All participants were employed in Sweden, except for two British paramedics.

Questionnaire **item 6, concerning difficulties encountered**, was answered by 78 of the participants in the study. Of these, 48 (61.5%) were paramedics, 27 (34.6%) worked with the fire brigade and 3 (3.9%) were part of the police force. The weighted cumulative answers related to questionnaire items 6a – 6g in Table 1 are shown in Fig. 3. Vehicles in front suddenly braking (average score 3.82) and failure in other vehicle drivers noticing the emergency vehicle (average score 3.79) are at the top of the list, followed by queues (average score 3.23) and VRUs failing to notice the EV (average score 3.18). Roadworks and deliberate acts of ignoring the EV are all below 3 on average.

Questionnaire **item 7, concerning detectability** using ordinary blue lights and sirens in different road environments, was answered by 77 participants. Their average estimated detection distance is shown in Table 3, along with standard deviations, and a conversion to detection time at the respective nominal speeds. At the given, nominal, speeds (50, 110 and 80 km/h), the average detection distances are estimated to be 55, 109, and 86 metres, respectively. The standard deviations are large, of the same magnitude as the estimated distances. The equivalent average detection times are approximately the same for all road environments (3.9, 3.6, and 3.9 s, respectively).

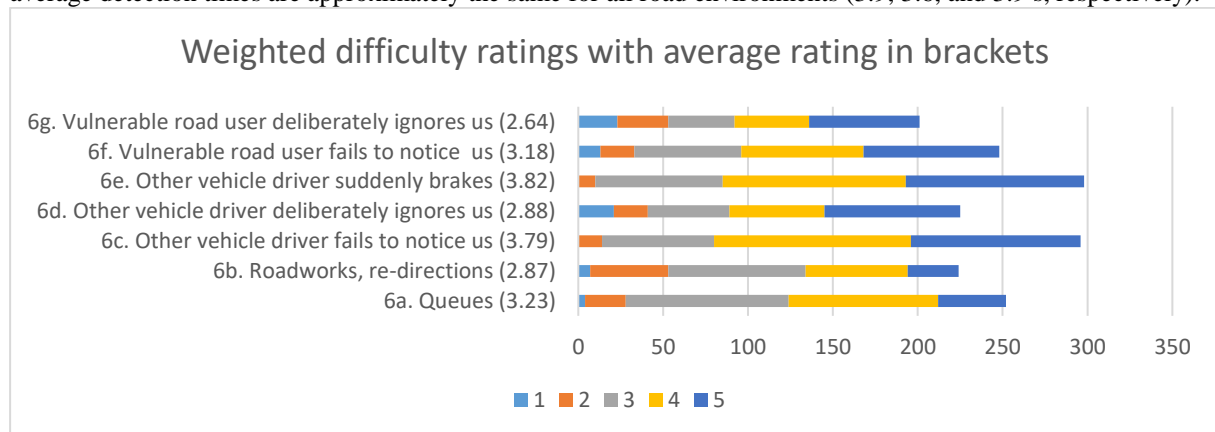


Fig. 3 Answers provided by 78 subjects to the questionnaire items 6a – 6g in Table 1. Average ratings on a scale from 1 – 5 (where 5 represents highest difficulty) are shown in brackets after each item. The bars show weighted cumulative difficulty, where the differently coloured subsections of each bar are proportional to the number of ratings times the nominal difficulty. Nominal difficulties are colour-coded for “1”, “2”, “3”, “4”, and “5”, respectively. For clarity, the combined cumulative scale ranges from 1 x 78 (= 78) to 5 x 78 (= 390)

Table 3. Detectability range in different road environments, estimated by professional drivers, for an emergency vehicle using blue lights and sirens approaching other vehicles from behind.

| Road environment | Nominal environment speed (km/h) | Average estimated detection distance (m) | Std. dev. | Corresponding detection time (s) at nominal environment speed |
|-------------------|----------------------------------|--|-----------|---|
| Urban environment | 50 | 55 | 43 | 3.9 |
| Highway | 110 | 109 | 102 | 3.6 |
| Rural road | 80 | 86 | 69 | 3.9 |

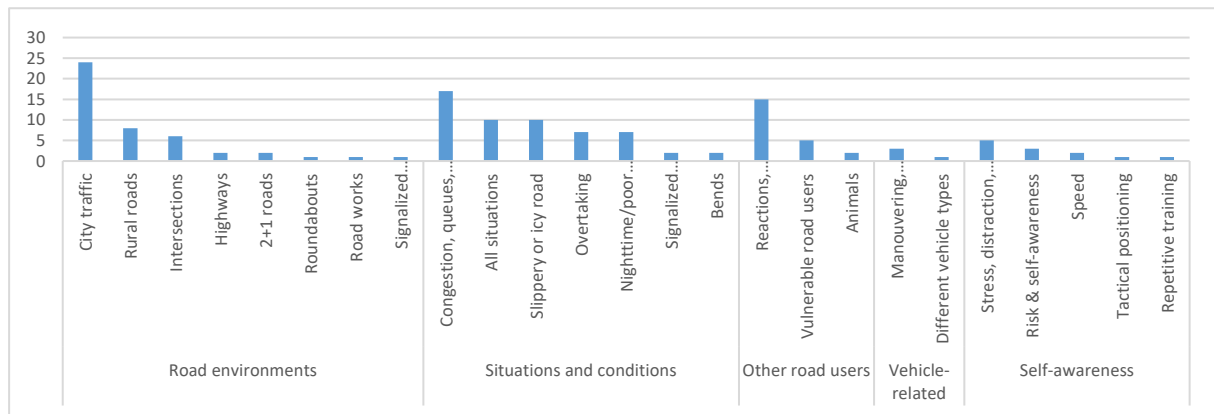
Research question II is answered in part by **item 8** in the questionnaire, which read “How would you like **vehicle drivers to react** when your emergency vehicle is approaching from behind”, with answers given for the three road environments “Urban environment”, “Highway”, and “Rural road”. The number of respondents were 81, and the answers which were in principle unison, can be summarized as follows: keep right or make a gentle maneuver to the right; slow down and don’t brake too fast. A request specific for highway driving was to change to the right lane and for urban traffic there was a rather common appeal to other road users to show that they have seen the emergency vehicle.

4.1. How to develop simulator-based driving training

Three items in the questionnaire address research question III, regarding **how to develop simulator-based driver training**, namely **item 10** “What events or situations would you like to train in a simulator?”, **12** “What did you find to be good about the simulator?”, and **item 13** “What should be improved to begin with?”.

As instructed in the questionnaire, **item 10** was only answered by participants who drive or ride in emergency vehicles. A total of 79 participants provided answers under this open question item regarding what they would like to train in a simulator. Only one of these answered “None”, indicating that this participant thinks simulator-based training is not desired at all. The free-text answers were re-coded into 37 categories, into which a total of 138 suggestions, made by the 79 participants, were grouped. See Fig. 4.

Fig. 4 Answers provided by 79 participants to the questionnaire item 10 in Table 1, “What events or situations would you like to train in a



simulator?”. A total of 138 suggestions are divided into categories and presented in falling rank within each category.

Regarding questionnaire items 12 and 13, since focus was on gathering as much and diverse input as possible, responses from all 107 participants who drove are included. The data was furthermore not split depending on professional driver category, nor on any other demographic variable. Of the 107 participants, 51 used simulator Rig 1, and 56 used Rig 2, which included several changes based on input from the first iteration using Rig 1. The data are therefore presented here separated on the two rigs, corresponding to the two development iterations. The distribution of answers to items 12 and 13 are shown in Table 4.

Table 4. Distribution of answers to questionnaire items 12 and 13 regarding what was good about the simulator and what could be improved, respectively. Answers are split across the two Rigs (1 and 2) that correspond to the two successive cycles of development

| Condition | Rig 1 | | Rig 2 | |
|-----------------------------|-----------|--------------|-----------|--------------|
| Drivers (N = 107) | 51 | | 56 | |
| Question | 12 “Good” | 13 “Improve” | 12 “Good” | 13 “Improve” |
| Drivers who answered | 39 | 44 | 43 | 36 |
| Number of answers (N = 307) | 65 | 108 | 57 | 77 |
| Share who answered | 76% | 86% | 77% | 64% |
| Suggestions per person | 1.67 | 2.45 | 1.33 | 2.14 |

From Table 4 it can be seen that the share of participants who answered with suggestions for improvements was higher (86%) for the first rig than for the second (64%). The average number of suggestions for improvement per person was also higher for Rig 1 (2.45) than for Rig 2 (2.14).

The free-text answers to questionnaire **items 12 and 13** were quantified into individual items and grouped into main categories, namely items related the system, situations, simulator, and the vehicle. For item 13, a category of driver monitoring was also added. The distribution of answers to questionnaire item 12, regarding what was good about the simulator, is shown in Fig. 5. In summary, participants are very happy with the general realism, especially with Rig 2, and also with the diversity of situation scenarios.

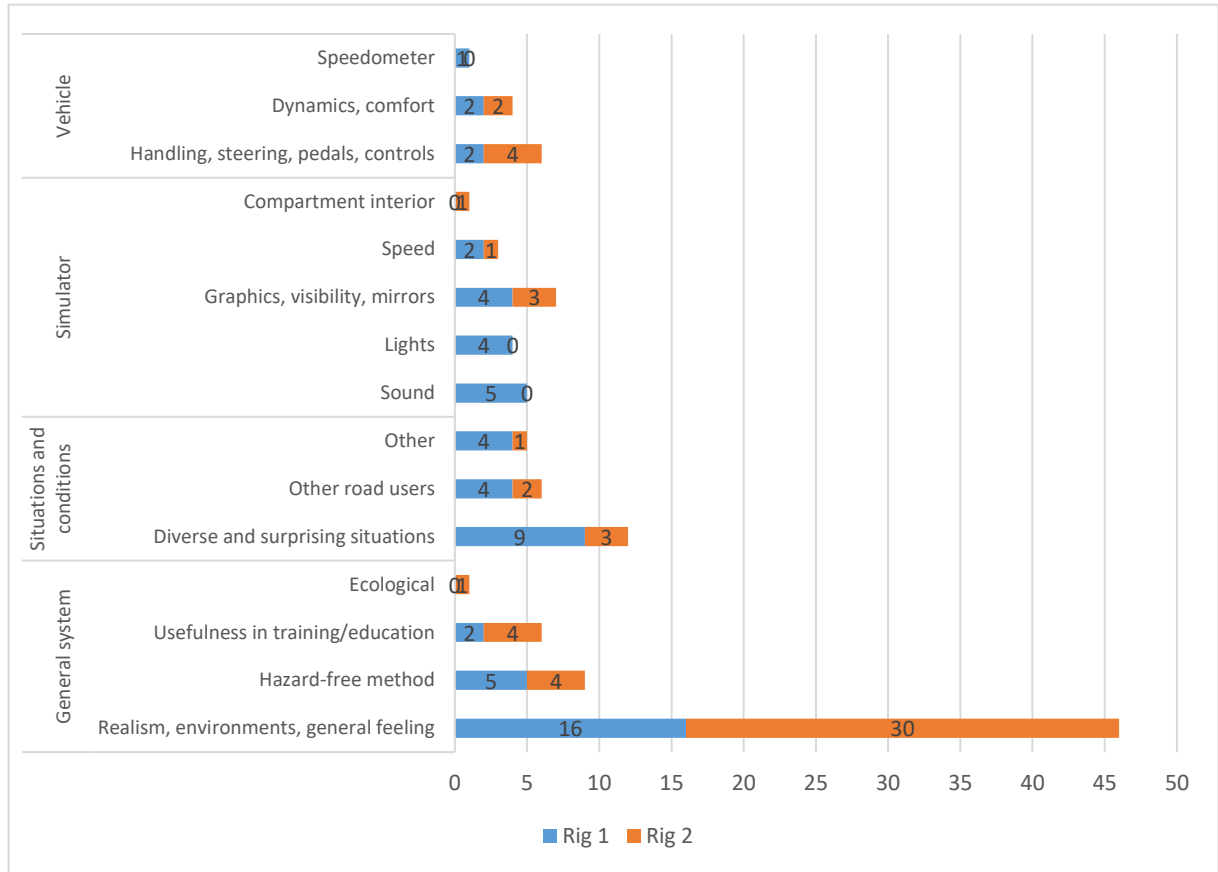


Fig. 5 A total of 122 answers provided by 107 participants to the questionnaire item 12, “what was good about the simulator”

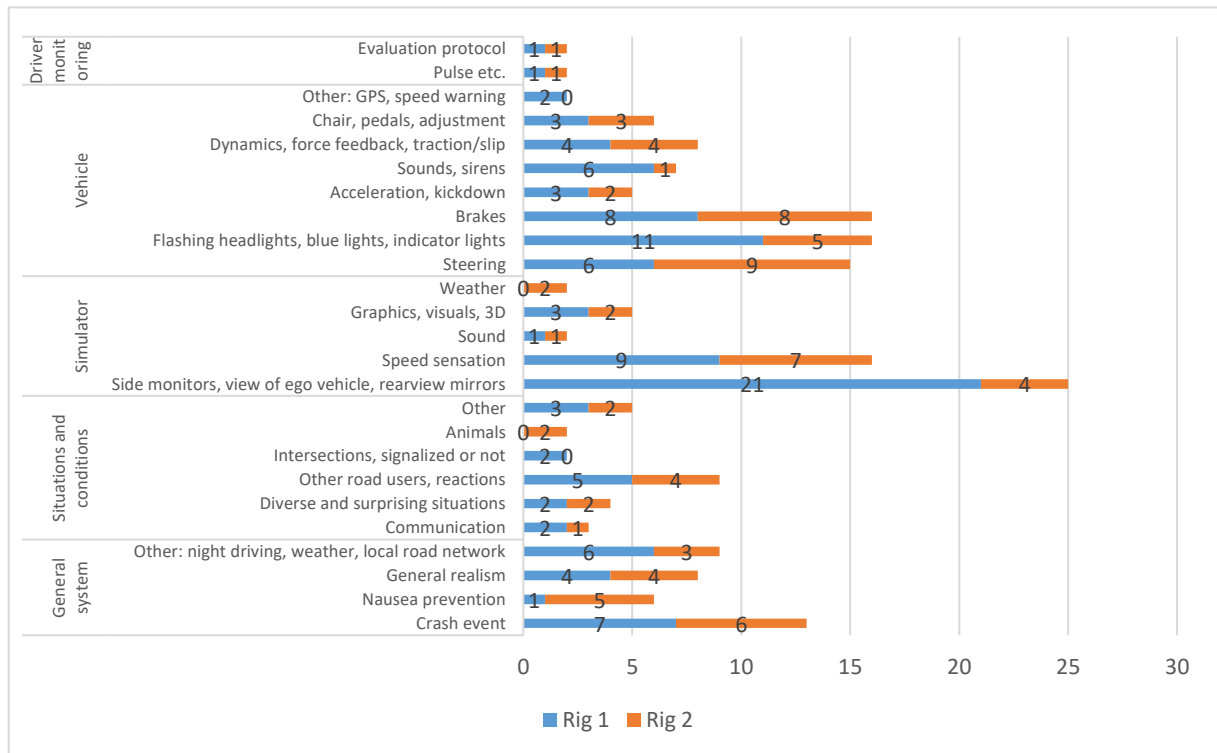


Fig. 6 Answers with 183 suggestions provided by 107 participants to the questionnaire item 13, regarding “suggestions for improvements”

The distribution of suggestions in response to question item 13, regarding what should be improved regarding the simulator, is shown in Fig. 6. Suggestions regarding adding side monitors, flashing headlights, siren and blue light controls were dominant with Rig 1 but all these improvements were made with Rig 2. Realistic crash events and more interactive response from fellow road users are highly rated suggestions, remaining to be implemented. Some participants also suggest driver monitoring to help assess levels of stress and provide feedback to drivers.

Of the 78 participants, only 41 answered questionnaire **item 9**, which was an open question regarding **places or situations when it is not appropriate to communicate EVA-messages** to other road users. Out of these 41, 10 stated that EVA is always appropriate, so the total number of non-respondents are 47. Of the 31 respondents suggesting inappropriate places or situations, 15 (48.4%) were paramedics, 14 (45.2%) worked with the fire brigade and 2 (6.5%) were part of the police force. The non-responses were evenly distributed over the professions. Inappropriate places and situations suggested were divided into the following five categories: At limited road choices such as bridges, 2+1 roads or queues; Complex or crowded city traffic; Anonymous missions or risk for suicide; If the timing is wrong (too early or too late); It is never appropriate. The distribution of responses is displayed in Fig. 6.

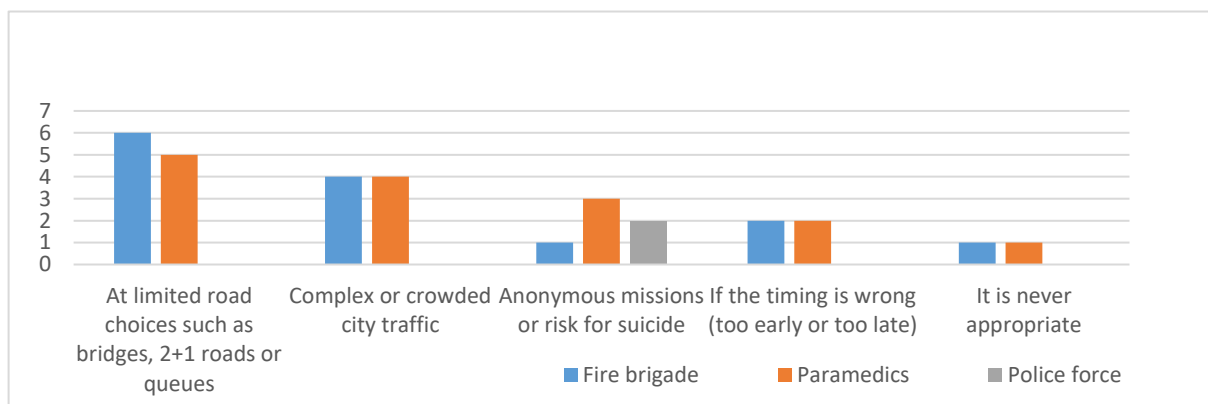


Fig. 6 Answers provided by 31 participants to the questionnaire items 9 in Table 1: Places or situations when it is not appropriate to communicate EVA-messages to other road users. Divided into 5 categories and presented per profession.

Questionnaire **item 11** was answered by 91 participants, where of 88 were positive towards **pre-alerting vehicle drivers who are approaching an incident or crash scene**. Only three respondents answered “No” and of these three, 2 were paramedics 1 a technical engineer.

5. Discussion

One aim of the study was to initiate user-centered development of a driving simulator for training of emergency vehicle drivers. A second aim was to collect information about how to best communicate EVA messages. A further technical goal was to develop a new simulator rig and simulator scenarios that could be used in present and future projects supporting both aims above.

The two **problematic situations** reported with highest rating were vehicles in front suddenly braking and failure in other vehicle drivers noticing the emergency vehicle. The average detection time (between 3.6, and 3.9 s) is only marginally longer than the 3 s generally recommended in driving education as the shortest acceptable head-time in road traffic. This indicates that EVA-messages would be useful to guide the drivers to the right behavior. However, the situation with vulnerable road users failing to notice the emergency vehicle suggests that the EVA needs to be extended to reach also this group. In the research question, answered by questionnaire item 7, it is clear from the standard deviations, which are all in the same order as the estimate, that this was a difficult judgement task.

There was a clear consensus regarding the **desired behavior of other road users**, which is also highly associated with common sense and the obligation for other road users to yield to and provide free passage for emergency vehicles (Svea Trafikutbildning AB, 2019). Somehow showing that you have seen the emergency vehicle is expressed as a desirable behaviour and this corresponds to the difficulties described in 5.1. Apparently, this

interaction between emergency vehicles and other road users is not working smoothly, possibly due to drivers being surprised or lacking the knowledge of how to react, and therefore don't yield as desired. This implies that it might be necessary to practice yielding for emergency vehicles in the general driving education. This is one task that could be favorable to implement in a simulator for driver training (also for private drivers).

Regarding **how to develop simulator-based driving training**, the most frequent responses on what to train in a simulator for emergency vehicle driving was city traffic in the road environment category; congestion, queues, obstacles and limited view in the category named situations and conditions; and reactions, unexpected behaviour, panic braking in the category other road users. This corresponds to the difficulties described in 5.1 and with the situations mentioned regarding desired behaviour in other road users. This makes sense and implies that there is a consensus about where the problem is most apparent and what is most urgent to train. Answers to questions regarding what was good and should be improved regarding the two simulator rigs that were developed show that several issues with the visual system and controls of Rig 1 were indeed rectified in Rig 2. Remaining areas of improvement are for instance more interaction with other road users and the addition of realistic crash event feedback. It was also suggested to provide drivers with feedback on stress and driving performance.

An adamant yes was expressed concerning the **communication of EV driving** to other road users. As many as 88 respondents out of 91 were positive toward pre-alerting vehicle drivers who are approaching an incident or crash scene, and 47 respondents out of 78 were positive towards sending out EVA-messages. This is well in line with the ongoing technical development to facilitate emergency vehicle driving. When suggesting situations or places where EVA-messages are not appropriate, most concern was expressed about limited road choices and complex or crowded traffic situations. The two respondents from the police force suggested to avoid situations where they are under anonymous missions. Apparently, more research is needed in this area and for cost efficiency and safety it would be suitable to use driving simulators (Skoglund, Bolling, Åsberg, & Reichenberg, 2015; Burke, Salas, & Kincaid, 2001; Lundälv, Philipson, & Sarre, 2010),

One **consideration regarding the method** worth more attention in future studies, is that participants were mainly paramedics or from the fire brigade and the police force is underrepresented in this sample, which is a natural consequence of visiting these specific conferences. It would be interesting to collect more data also from participants from the police force.

6. Conclusions and future work

The most difficult situations for emergency vehicle drivers are vehicles in front suddenly braking and failure in other vehicle drivers noticing the emergency vehicle. Desired behaviour in other road users is to yield to the right and if braking, brake smoothly. Most urgent to train in a driving simulator is city traffic with congestion, queues, obstacles and limited view, and other road users' reactions, unexpected behaviour and panic braking. Participants were in general very satisfied with the realism in both simulator setup and situations, and suggest more interaction within scenarios, and developed feedback to the driver on stress and performance. The attitude towards communication of EV driving to other road users is positive, regarding both pre-alerting drivers who are approaching an incident or crash scene and sending out EVA messages. VTI will continue the user-involved agile work with the emergency driving simulator. There are also plans for a continuation of the Nordic Way 2 project and for other projects looking at how to present EVA messages to both manually driven and automated cars. A national project has also been initiated to examine possible inclusion of driving simulators as part of the driving test.

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