# IMPACT OF PROJECTION SYSTEMS FOR VEHICLE SIMULATORS ON SYMPTOMS OF SIMULATOR

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**ABSTRACT**
Authors present a comparative study aimed at answering the question about quality of projection systems designed for vehicle simulators. They decided to make an attempt to give the preliminary answer to a question on which studied projection systems causes lesser degree of symptoms of simulator sickness during training. For the purposes of examinations two test platforms were prepared. One was equipped with a screen with a cylindrical projection system, the second with "on screen" projection system. This paper presents the results of comparative tests carried in consortium by Police Academy in Szczytno, Poland, as a part of scientific project "Building simulator of driving privileged vehicles in typical and extreme situations".

Keywords: simulation, visualization, projection systems, simulation sickness, cylindrical view, on screen

## 1. INTRODUCTION

Simulator's disease is a condition characterized by a number of symptoms in extreme conditions: nausea, vomiting, pallor, and increased sweating. They occur in humans under conditions of exposure to virtual or real visual motion stimuli, associated or not with kinetic stimuli. Those incentives are not physiological for a human and they are not adapted with humans. This definition is a broad concept encompassing: simulator, motion, air, maritime, automotive and space sickness, etc. The negative impact of the virtual environment of simulator to humans is therefore undesirable. For the first time the phenomenon was studied by Miller and Goodson (1958, 1960), who had symptoms that occur as a result of training in a simulator called motion sickness, because of the similarity of most of the symptoms of this disease to balance disorders. According to factors that affect the human body we can divide simulators on those where only exclusively kinetic incentives are used (Coriolis sample), with kinetic and visual incentives (simulators with visual stimuli on mobile platforms) and with only visual incentives (stationary simulators with visual stimulation). Due to this a simulator sickness name is more associated with the device on which symptoms can be occurred than with the phenomenon itself. Therefore, if the negative impact of the virtual environment simulator, regardless of the nature of the stimulus, we most often use name simulator sickness in relation to the set of symptoms occurring as a result of training on the simulator. Simulator disease is characterized by a rich and diverse symptomatology depending on the degree of its advancement. It often starts as stomach discomfort, bodily warmth, headache, dizziness and/or drowsiness, then proceeds to stomach distress, then nausea and vomiting. There are increasing nausea, often accompanied by symptoms of hypersensitivity to unpleasant taste and olfactory sensations, loss of appetite, headache, anxiety, adding to the ataxia and spatial disorientation. Due to the intensive tracking a virtual image at all times during examination the feeling of fatigue is common with blurred vision. In extreme cases the disease may be associated with violent vomiting, fatigue, apathy, and drowsiness and reduced mental capacity for concentration and muscle activity. Different configurations of symptoms in individual participants depends on the sensitivity of individual acting stimulus, the nature of the stimulus, the level and duration of action. Currently there is no conclusive statement about causes and prevention for simulator sickness. In the simulation of mobile objects, there are three main methods of visualization: on a helmet, on windows of a vehicle and on an external display.

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## 2. TEST PLATFORMS SPECIFICATION

This paper presents the results of comparative tests carried out in consortium by Police Academy in Szczytno, Poland, as a part of scientific project "Building simulator of driving privileged vehicles in typical and extreme situations". The study involved a standard and widely used system of cylindrical projection and the increasingly popular projection system called "on screen".

For the purposes of examinations two test platforms were prepared. One equipped with a screen with a cylindrical projection system, the second with "on screen" projection system.

Simulator with cylindrical projection system.

- Cabin - of intercity bus Autosan A1012T Leader

• Screen (cylindrical: with radius R = 4.1 m and a height h = 3.75 m, angles of sight from a point of view of the driver: angle width: vfov = 180 deg, angle height hfov = 50 deg)
• Projection system (four projectors Projectiondesign F22 SX +, 1400 x 1050 resolution, brightness - 2100 ANSI lumens, contrast ratio: 2500:1, type of matrix: DLP)

That made the projection system provided an angular resolution in front of the driver's sight - 2.9 arc minute / pixel.

Simulator with on screen projection system.

• Cabin – Mercedes Acros truck.
• Screen - “on screen” - stuck projection foil to all front and side windows allowing view using the rear projection type, rear windows were completely blacked out.
• Projection system:
- 3 ultra-short throw projector Mitsubishi WD380U-EST serving front and left window (brightness: 2800 ANSI lumens, resolution: 1280 x 800, contrast ratio: 3000:1, type of matrix: DLP),
- 1 projector Panasonic PT-LB1E displays the image on the right window (brightness: 2200 ANSI lumens, contrast ratio: 500: 1, resolution: 1024 x 768, type of matrix: LCD).

That made the projection system provided an angular resolution in front of the driver's sight - 2.1 arc minute / pixel.

Photos 1-2 show the simulator with a cylindrical projection system.

Fig. 1. Simulator with a cylindrical screen - a view of the cabin and the screen with displayed image, from outside and from inside of the cabin.

Fig. 2. Simulator with a cylindrical screen - visible cabin, cylindrical screen and projection system.

Photos 3 and 4 show the test stand with "on screen" rear projection system.

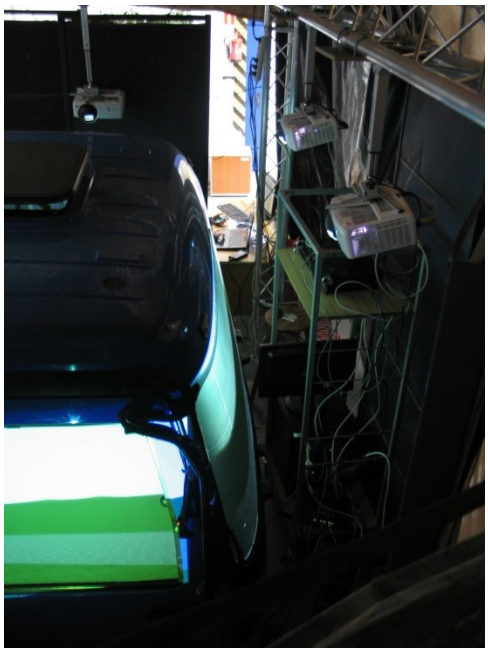

Fig. 3. The test simulator with "on screen" projection - visible cabin with "on screen" screens and projectors that support front and left side windows

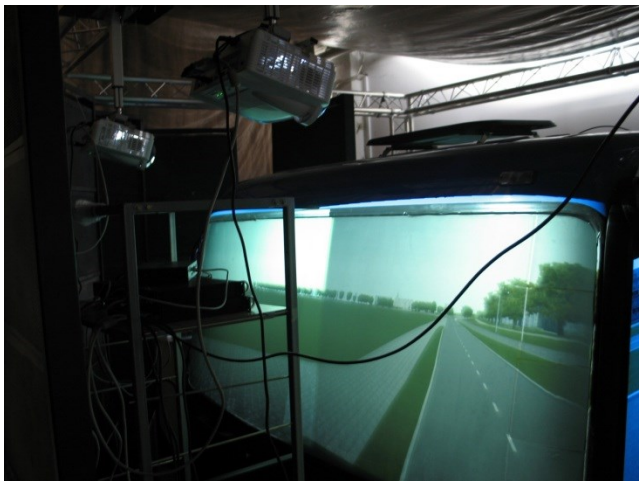

Fig. 4. The test simulator with "on screen" projection - visible cabin with "on screen" screens on the windscreen and windscreen supports projectors.

## 3. STUDY RESULTS

The study was performed on 15 individuals who have not previously practiced on simulators. Number of participants in the experiment is not easy to determine and depends on many aspects and especially on the purpose of the evaluation. Generally, the more participants, the research is more accurate. In preliminary tests, it seems reasonable to involve a homogeneous group of participants of similar age and experience. In ISO 16 673 standards, sufficient number of participants is 10. Taking this into account, it means that examination of 15 participants is sufficient, the acceptable minimum is 10 people.

Performed on these participants, a preliminary study has not identified diseases of their eye. Research on simulators with "on screen" and the cylinder projection system was performed at an interval of 10 days.

### Results of research conducted on the simulator with cylinder projection system

**The study carried out before training**

A. Interview

The interview with all participants indicated no disturbance, which could have an impact on training on the simulator. 3 people have symptoms of asthenopia negative (age-related abnormal accommodation, causing problems with reading without correction glasses).

B. Concerned ophthalmological examination

1. The study of eye diseases. Refraction survey using computer autorefractometer in 11 participants showed a visual impairment that does not exceed + / - 1.5 D, the refractive state, which usually does not require a spectacle correction. 2 participants the defect was -2.0 D, with a -3.75 / -3.5 D, and a -5.0 / -5.5 D. People with these defects are not excluded from training because, according to the rules they may have a driving license.

2. The study of visual acuity. The visual acuity of the right and left eye in 10 participants ranged from 0.8-1.0. In 5 participants it was within the limits 0.5-0.6. So in any of the subjects, there was no reduction in visual acuity, which disqualifies them from driving.

3. Examination of the tear film with non-invasive test with a disruption of the tear film (NIBUT)) and the stability of the tear lipid layer films checked with Tearscope camera. NIBUT study showed normal values in all 15 participants (> 10 sec.). Examination of the lipid layer showed no abnormally thin in 13 participants (values A-C). In 2 of participants thickness of the lipid layer was thinned (E)

4. Examination of the binocular vision – Worth test. The study showed normal binocular vision in all participants.

5. The study of stereoscopic view - "Fly" test. Very good stereoscopy (Grade 8-9) occurred in 14 participants. A small reduction in stereoscopic occurred in 1 patient (grade 5).

6. The study of eyes setting - "cover test". In this study, there was no stability problems at the position of both eyes during their alternating covering (no small-angle strabismus and latent strabismus).

**The study carried out after a training**

A. Interview

12 persons after a training session on the simulator did not provide any information about visual disturbances. Three people gave out information about small disturbances in the form of "a strange image", "light disturbances when turning" and "strange impressions associated with non-motion simulator". These symptoms can be classified as a first degree of simulator sicknes in Chilow classification.

B. concerned ophthalmological examination

1. The study of visual acuity. The study showed no difference in visual acuity compared with state before training on the simulator. Small differences of 0.1 are within the error limits of the method.

2. Examination of the tear film with non-invasive test with a disruption of the tear film (NIBUT)) and the stability of the tear lipid layer films checked with Tearscope camera. NIBUT test showed no prolongation of the tear film break in all the participants. The study of the lipid layer showed no changes in its thickness in 14 participants. In 1 person was a small thinning of the layer thickness of 1 degree, but it was located within the normal range.

3. Examination of the binocular vision – Worth test. The study showed no changes in binocular vision in all participants after training.

4. The study of stereoscopic view - "Fly" test. After training on the simulator, there was no reduction in stereoscopy in all subjects.

5. The study of eyes setting - "cover test". In this study there was no change in the position of both eyes after a training session on the simulator.

**Results of research conducted on the simulator with "on screen" projection system.**

**The study carried out before training**

A. Interview In an interview in all participants there were no abnormalities that could have an impact on training on the simulator. 3 people have symptoms of asthenopia (age-related abnormal accommodation, causing problems with reading without correction glasses)

1. The study eye diseases. Refraction survey using computer autorefractometer in 11 participants showed a visual impairment does not exceed + / - 1.5 D, the refractive state, which usually does not require a spectacle correction. 2 participants the defect was -2.0 D, with a -3.5 / -3.25 D, and a -5.25 / -5.25 D. People with these defects are not excluded from training because, according to the Polish rules may they have a driving license (category A and B) in accordance with the Minister of Health regulation from 15 April 2011.

2. The study of visual acuity. The visual acuity of the right and left eye in 10 participants ranged from 0.8-1.0. In 5 participants it was within the limits 0.4-0.7. So in any of the subjects, there was no reduction in visual acuity, which disqualifies them to drive motor vehicles (Polish driving license category A and B) in accordance with the Minister of Health regulation from 15 April 2011.

3. Examination of the tear film with non-invasive test with a disruption of the tear film (NIBUT)) and the stability of the tear lipid layer films checked with Tearscope camera. NIBUT test showed normal values in 15 participants(> 10 sec.). Examination of the lipid layer showed no abnormally thin in 11 participants (the AC). In 4 of them thickness of the lipid layer was thinned (DE value).

4. Examination of the binocular vision – Worth test. The study showed normal binocular vision in all participants.

5. The study of stereoscopic view - "Fly" test. Very good stereoscopy (Grade 8-9) occurred in 14 participants. A small reduction in stereoscopic occurred in 1 patient (grade 5).

6. The study of eyes setting - "cover test". In the study, there was no evidence of impaired the stability of the position of both eyes during their alternating covering (no small-angle strabismus and latent strabismus).

**The study carried out after a training**

A. Interview

10 persons did not provide any visual disturbances after a training session on the simulator with an "on screen" projection system. 5 people reported the disorder in the form of "breathing", “a strange image,” light nausea ," twisted image "and dizziness. These symptoms can be classified as 1 degree in 4 participants, and in one case as a second stage of simulator sickness in Chilow classification.

B. concerned ophthalmological examination

1. The study of visual acuity. The study showed no difference in visual acuity compared with state before training on the simulator. Small differences of 0.1 are within the error limits of the method.

2. Examination of the tear film with non-invasive test with a disruption of the tear film (NIBUT)) and the stability of the tear lipid layer films checked with Tearscope camera. NIBUT test showed no prolongation of the tear film break in all the participants. The study of the lipid layer showed no changes in its thickness in 14 participants. In 1 person was a small thinning of the layer thickness of 1 degree, but it was located within the normal range.

3. Examination of the binocular vision – Worth test. The study showed no changes in binocular vision in all participants after training.

4. The study of stereoscopic view - "Fly" test. After training on the simulator, there was no reduction in stereoscopy in 14 participants. In one person were reduced stereoscopic range of 1 degree (from 5 to 4).

5. The study of eyes setting - "cover test". In this study there was no change in the position of both eyes after a training session on the simulator.

## CONCLUSION

Why simulator sickness was more common in the simulator with the "on screen" projection system than a cylinder? It seems that this is due to the proximity of the screen. There is an analogy to the occurrence of symptoms when watching movies in 3D. Watching the three-dimensional films at the cinema rarely causes simulator sickness because the screen is far from the spectators. The introduction of 3D technology for television meant that the symptoms began to be felt much more often. It is estimated that it may occur in 10-20% of people watching 3D TV. They sit closer to the screen, so the probability of that feeling is greater.

The eye study showed that training on simulators with "on screen" and the cylinder projection systems does not cause changes in the organ of vision in participants with the form of a deterioration in visual acuity of the tear film, the state of binocular vision, stereoscopic view and eyes settings. Subjectively experienced symptoms of simulator sickness occurred less frequently after a training session on the simulator with a cylindrical screen than on the "on screen". It seems that the better tolerance of training on the simulator with cylinder screen is due to a greater distance from the screen.

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