

Perception of warning signals from the protective clothing for firefighters in the simulated utility conditions



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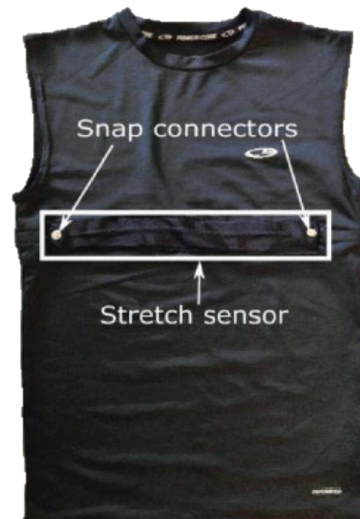
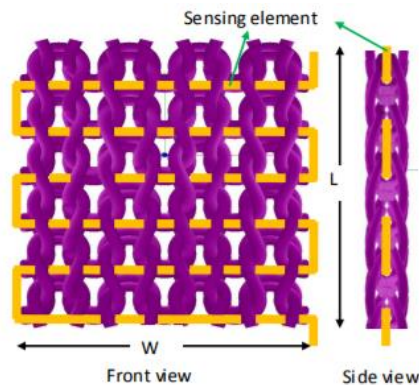
Wierzbowa 48, Łódź, Poland

State-of-the-art solutions in the field of smart protective clothing for firefighters

Particular interest in monitoring of health status and environmental parameters in close-to-the-body area

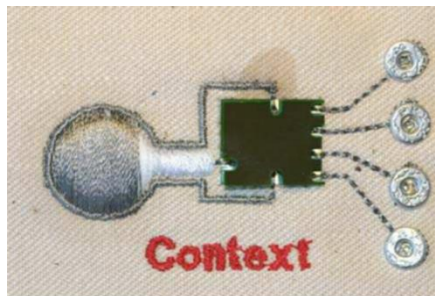
Exemplary sensors:

Temperature



Breathing rate

EMG



Wireless Sensor Network:

System Overview



Evaluation of smart systems for integration with PPE

- No requirements
 - No standardized test methods
- } How to confirm their safety and functionality in work environment?

New needs regarding smart systems integrated with PPE

- ✓ Smart systems cannot provide additional hazard to the user
- ✓ They need to be reliable in harsh and complex work environment
- ✓ They should perform their function regardless of the conditions



Evaluation of performance and functionality of smart systems integrated with PPE in the predicted simulated utility conditions

The influence of utility conditions on the perception of warning signals from the protective clothing for firefighters

Three variants of personal warning systems



PWS with a LCD display

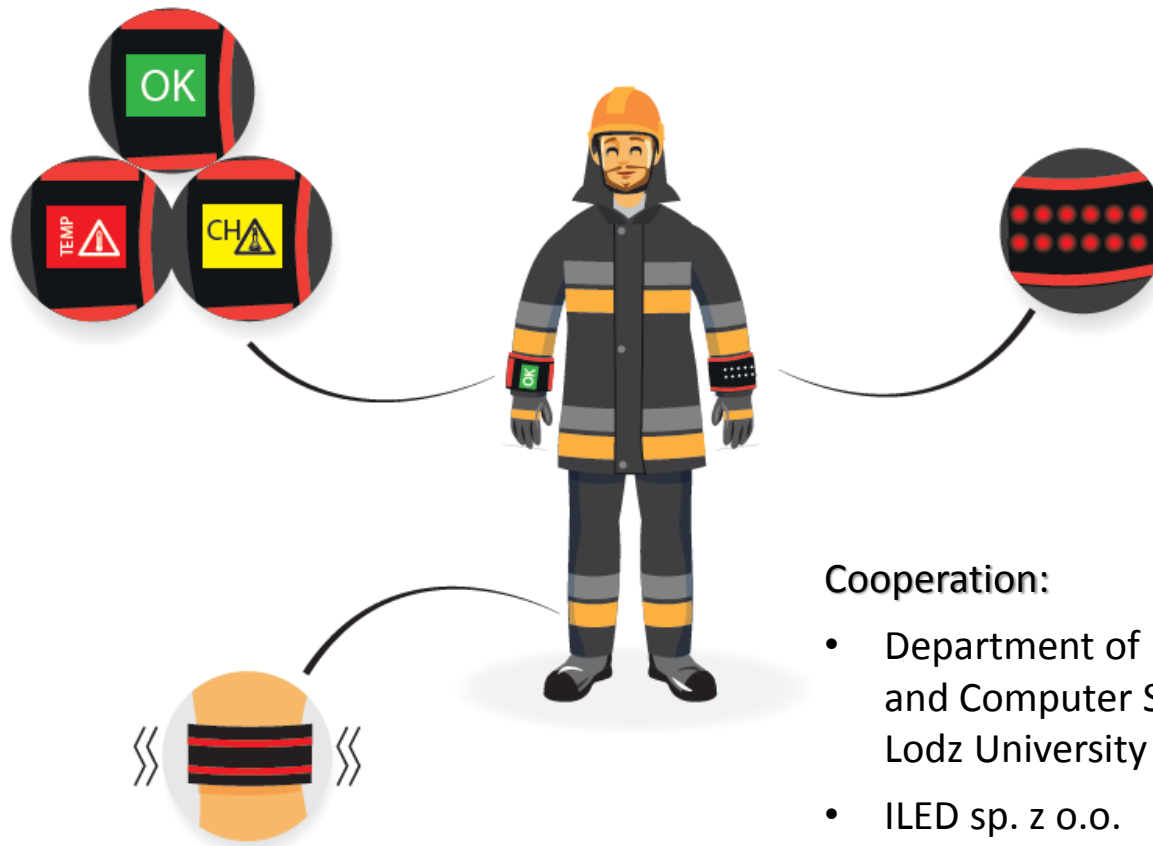


PWS with LED diodes



PWS with vibrating element

Intended location for personal warning systems



Cooperation:

- Department of Microelectronics and Computer Science, Lodz University of Technology
- ILED sp. z o.o.

Laboratory for testing and demonstration of technologically advanced personal protective equipment and verification of its functionality in simulated utility conditions



Research capabilities of a new laboratory of CIOP-PIB:

- ✓ Interdisciplinary measuring equipment for evaluation of ergonomics of PPE



Testing methodology

Simulation of potential utility conditions – fire in tenement house

➤ Environmental conditions

- Temperature: 25°C
- Relative humidity: 50%
- Air velocity: 0,24 m/s
- Light intensity: 1450 lux / 10 lux
- Light temperature: 6500 K / 2700 K
- Smoke
- Noise

➤ Warning signals generated from the computer application

➤ Physical activities



Monitoring of physiological parameters

Equival wearable LifeMonitor

- Heart rate
- Respiratory rate
- Galvanic skin response

Registration of voice response time

Intercom EJEAS – wireless voice communication between operation and laboratory rooms

Eye tracking

Tobii Pro Glasses 2



Survey questionnaire

- ✓ 3 sections of questions – for each PWS separately
- ✓ Evaluation of the influence of utility conditions on the functionality of PWS:
 - Environmental conditions
 - Physical activities
 - Overall rate of PWS functionality

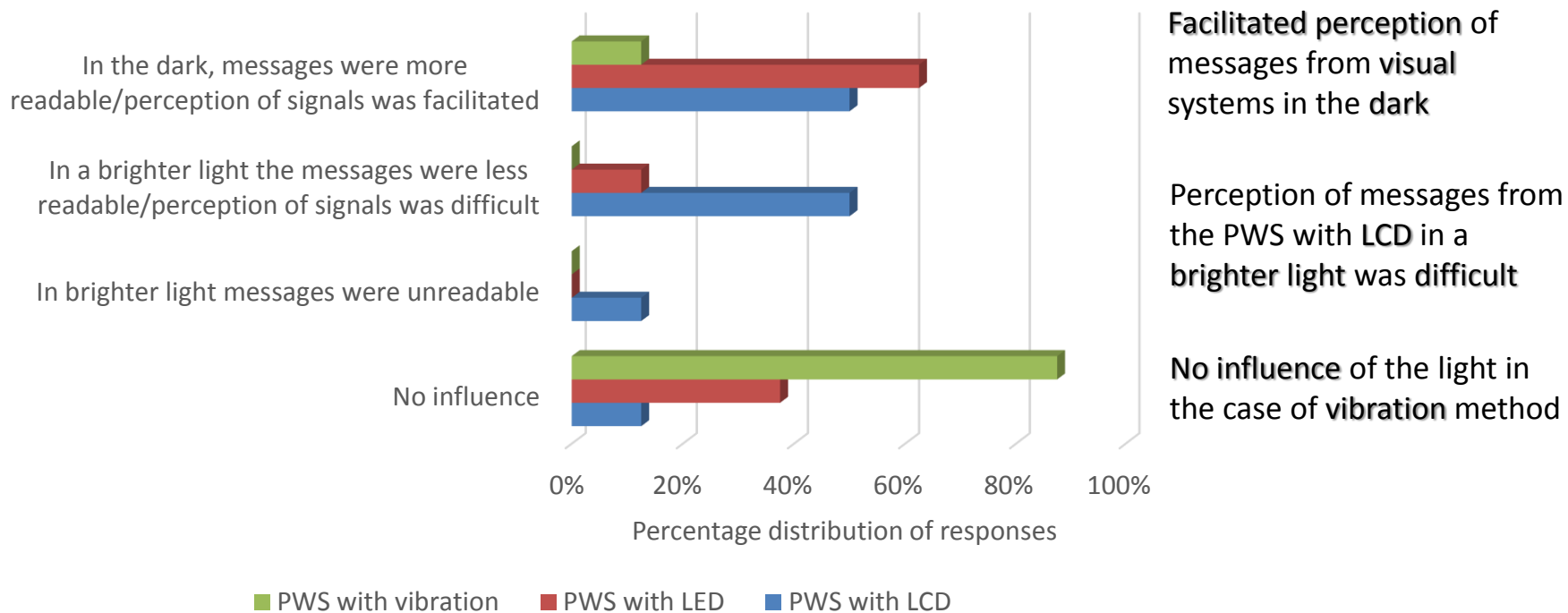


Indications for use of PWS
with smart protective clothing for firefighters



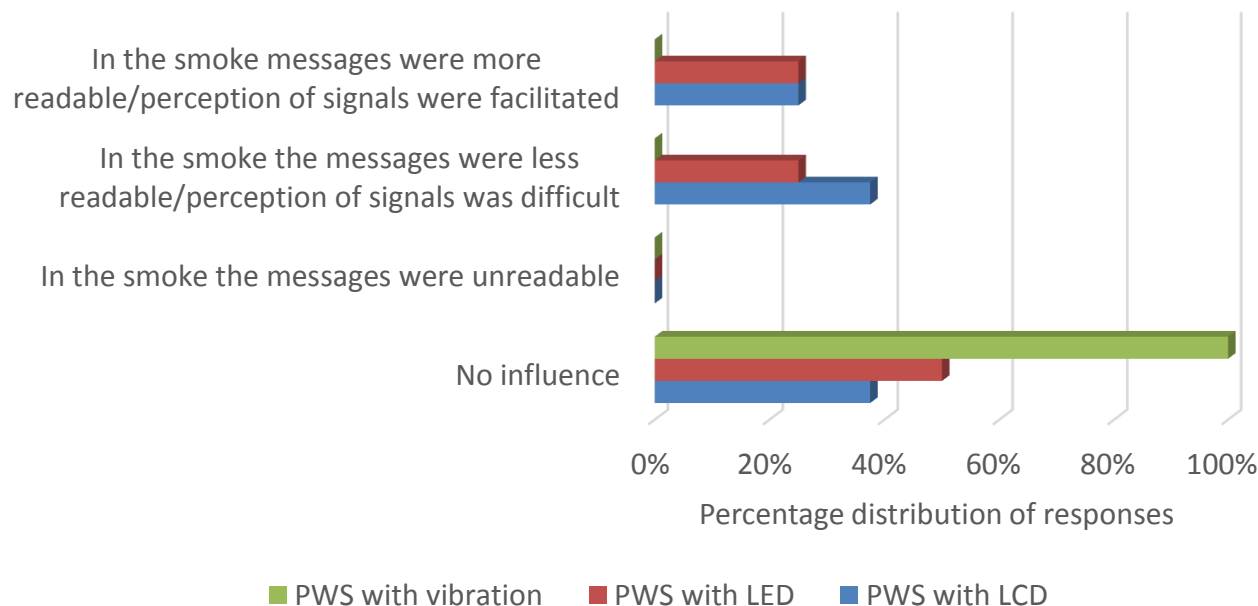
Influence of the environmental conditions on functionality of PWS

Influence of the light on PWS functionality



Influence of the environmental conditions on functionality of PWS

Influence of the smoke on PWS functionality

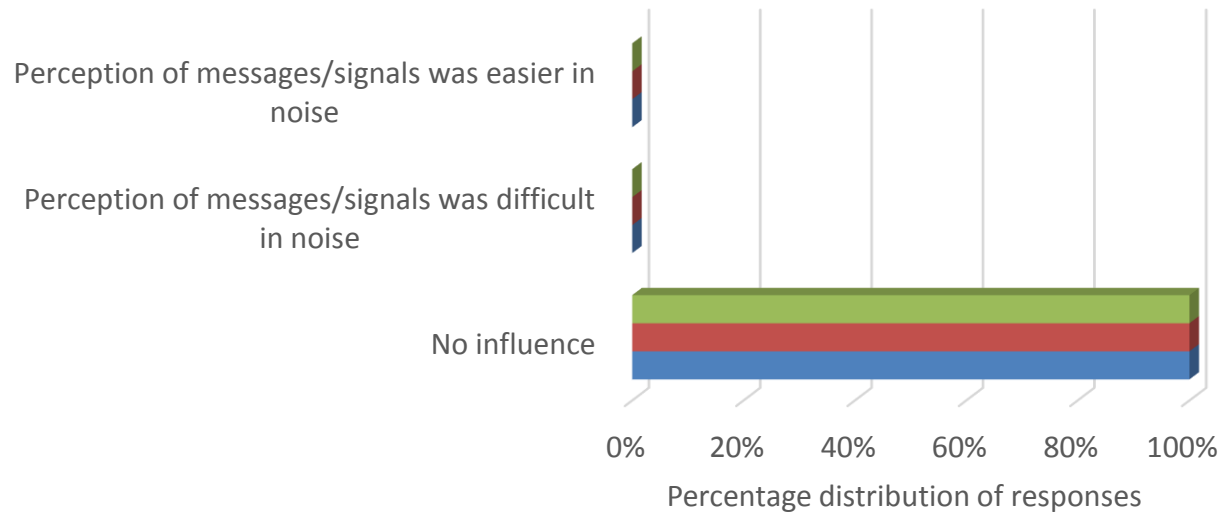


In the case of PWS with LCD about 38% stated that in the smoke the perception of messages was difficult

No clear influence of smoke on the perception of signals from all PWS

Influence of the environmental conditions on functionality of PWS

Influence of the noise on PWS functionality



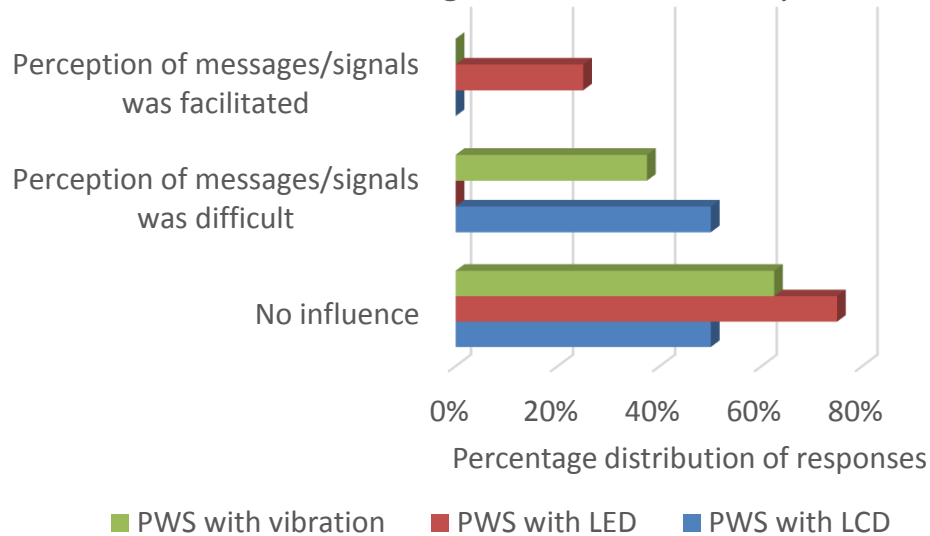
No influence of the noise on perception of signals from all PWS

■ PWS with vibration ■ PWS with LED ■ PWS with LCD

Influence of the physical activity on PWS functionality

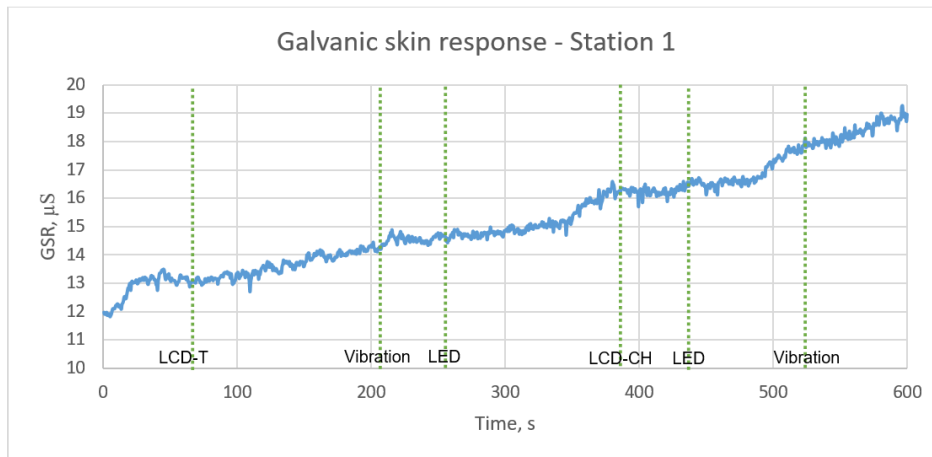
Station I - March to the place of incident

Influence of marching on PWS functionality



50% respondents stated that the perception of messages from PWS with LCD was difficult

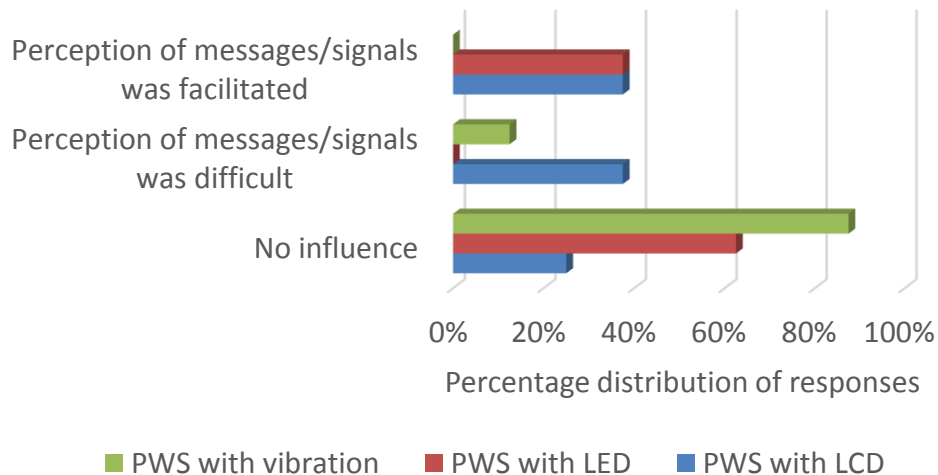
	Time of answer	Lack of answer
LCD	12.00 s	75%
LED	3.33 s	0%
Vibration	7.17 s	0%



Influence of the physical activity on PWS functionality

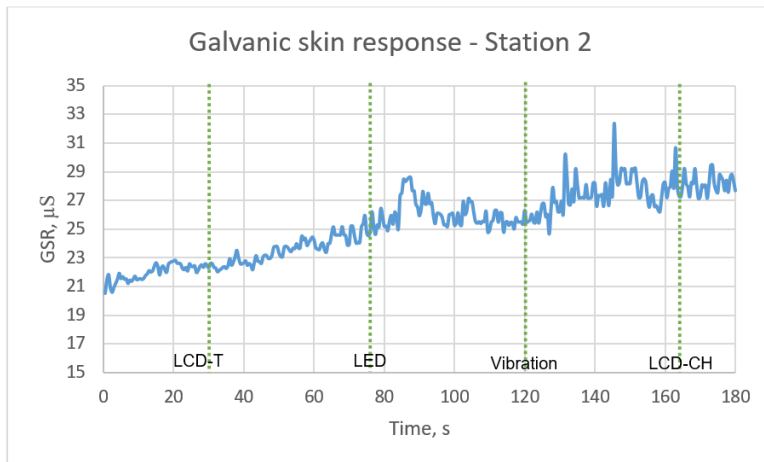
Station II – Walking up the stairs

Influence of walking up the stairs on PWS functionality



Varied responses but only 20% stated that this activity had no influence on functionality of PWS with LCD

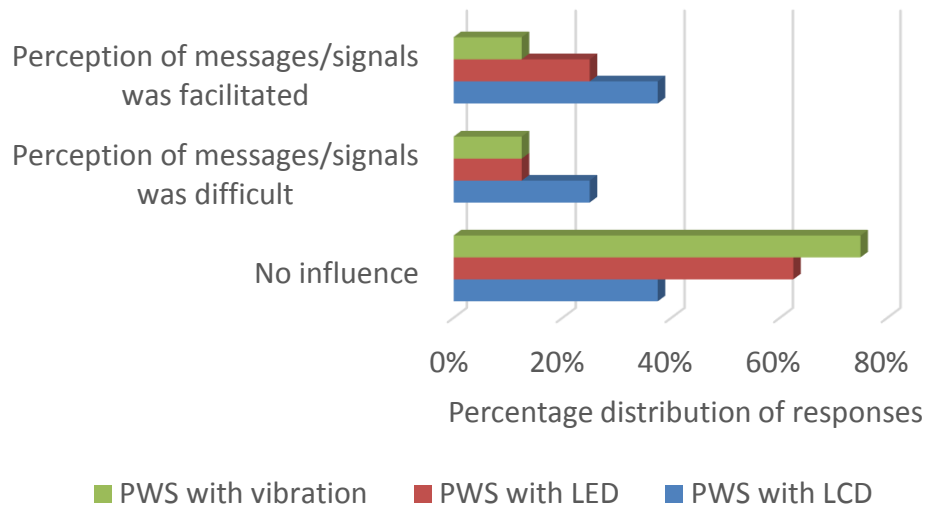
	Time of answer	Lack of answer
LCD	8.25 s	50%
LED	2.50 s	0%
Vibration	6.13 s	0%



Influence of the physical activity on PWS functionality

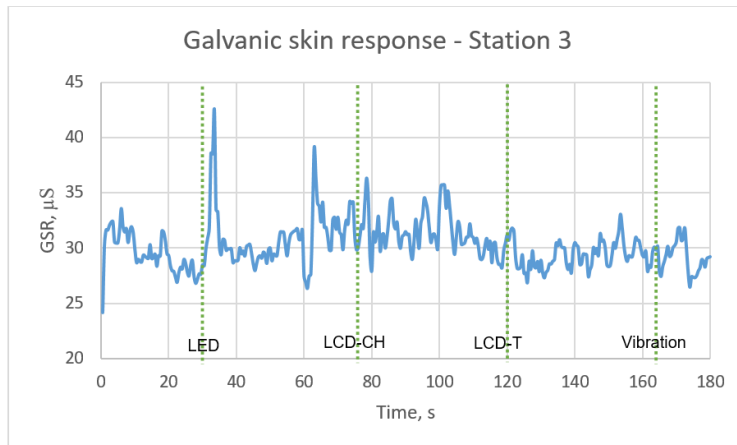
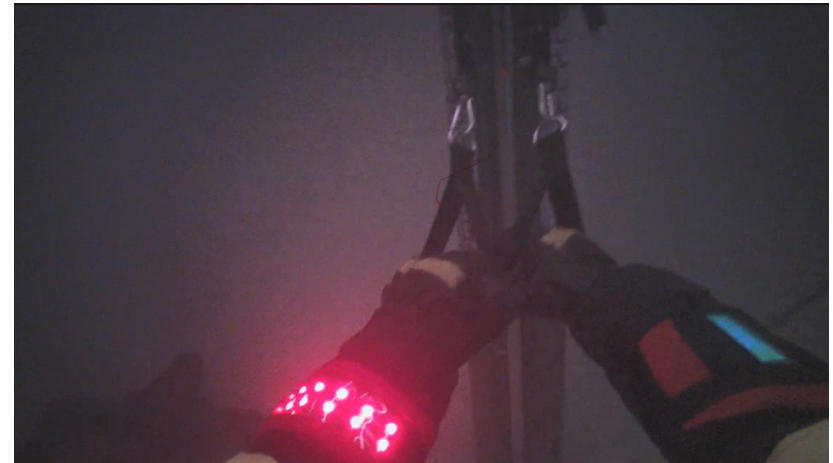
Station III – Crashing an obstacle

Influence of crashing an obstacle on PWS functionality



In total 75% of respondents stated this activity as facilitating or having no influence on perception of messages from PWS with LCD

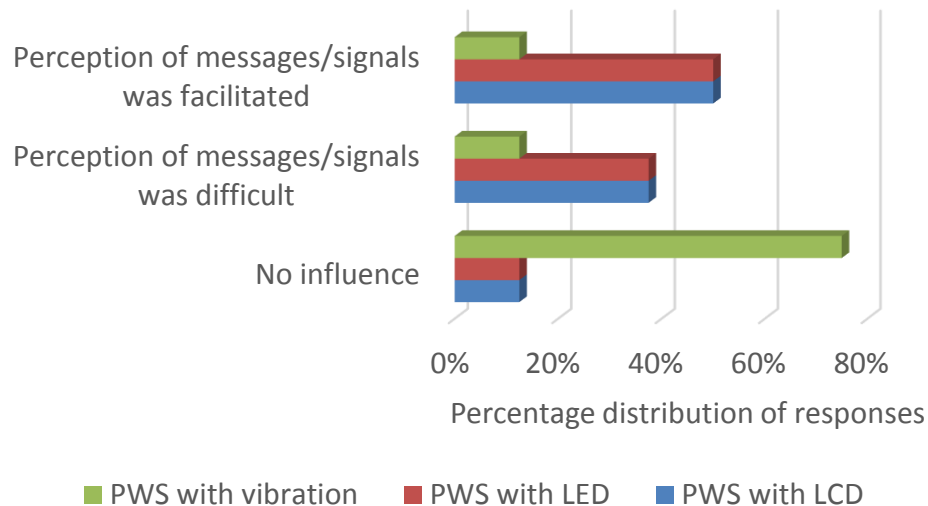
	Time of answer	Lack of answer
LCD	6.71 s	12.5%
LED	2.50 s	0%
Vibration	5.13 s	0%



Influence of the physical activity on PWS functionality

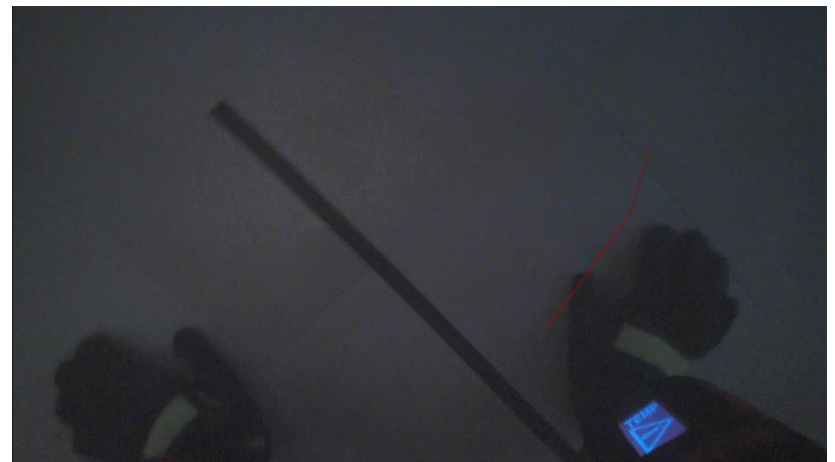
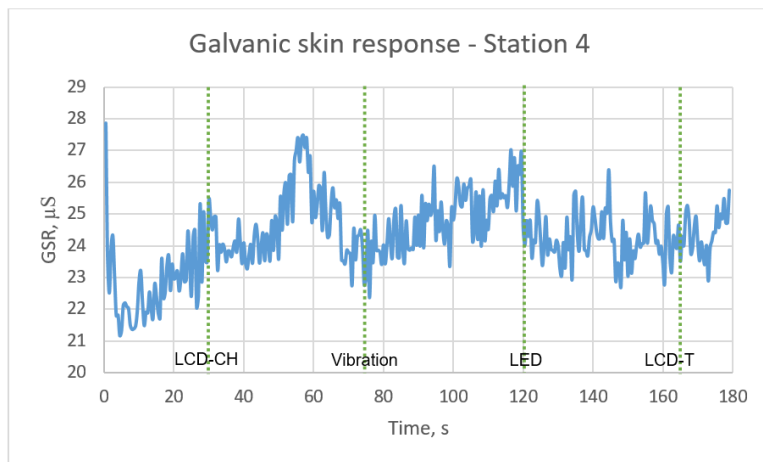
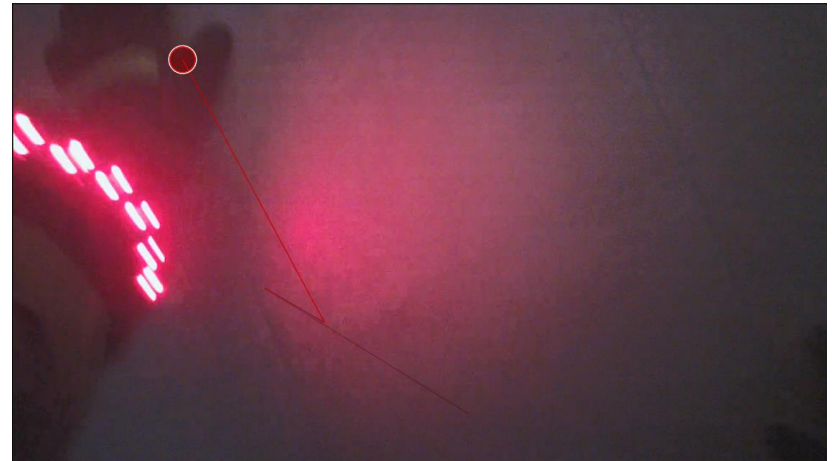
Station IV – Moving on all fours

Influence of moving on all fours on PWS functionality



50% of respondents stated moving on all fours as facilitating perception of signals in the case of signalisation by means of visual methods

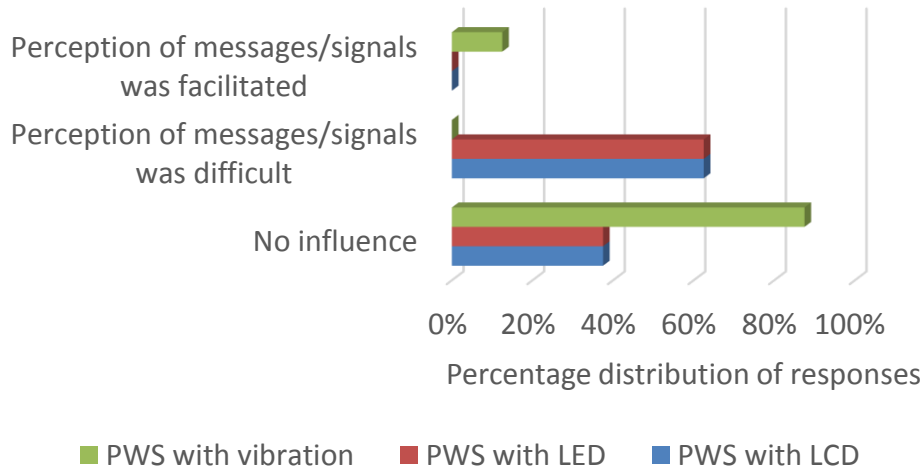
	Time of answer	Lack of answer
LCD	5.33 s	25%
LED	1.63 s	0%
Vibration	5.63 s	0%



Influence of the physical activity on PWS functionality

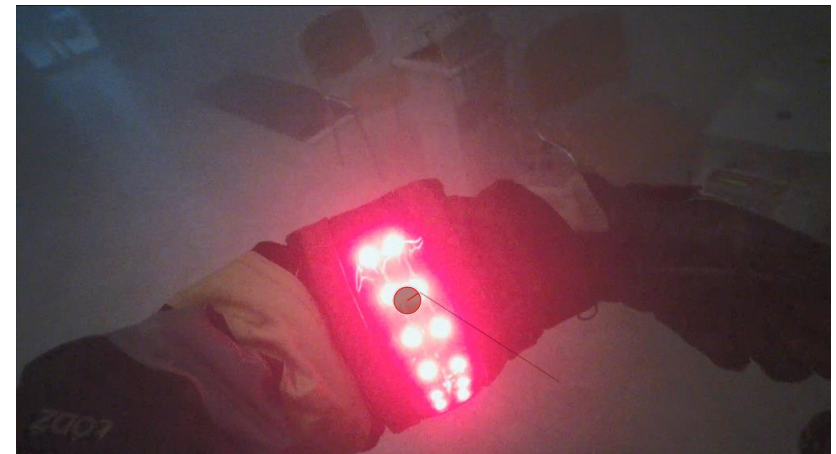
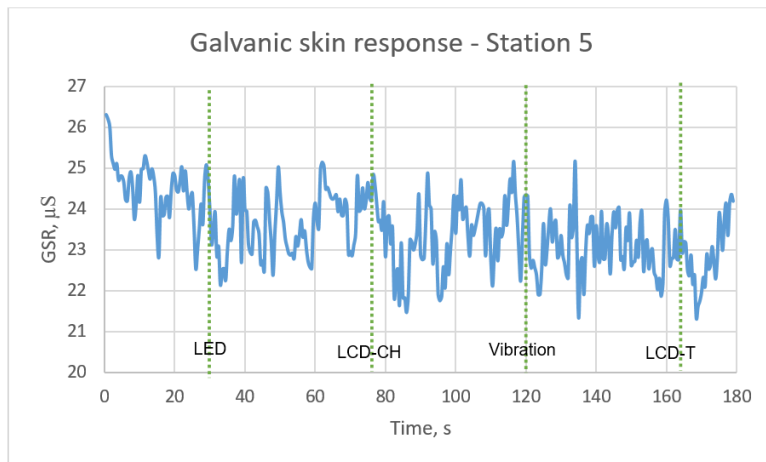
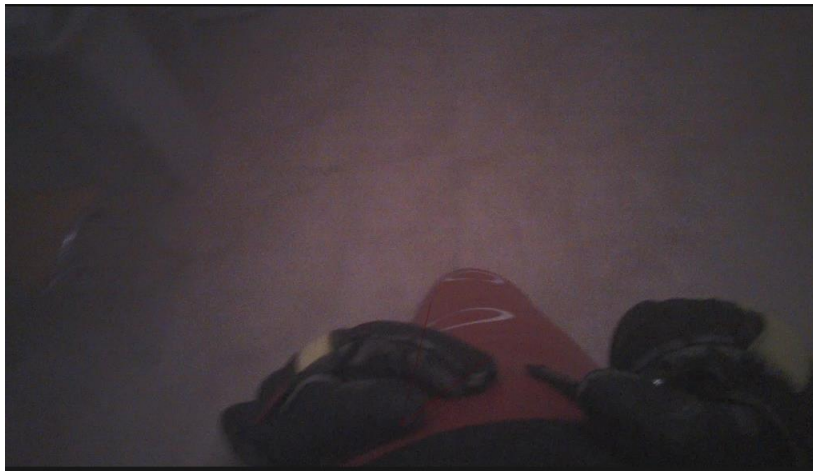
Station V – Moving with a load

Influence of moving with a load on PWS functionality



60% of respondents stated perception of signals by means of visual methods during this activity as difficult

	Time of answer	Lack of answer
LCD	6.14 s	12.5%
LED	2.13 s	0%
Vibration	5.50 s	0%



Overall rate of functionality of PWS

PWS with LCD



Result 5.1

Mean time of answer: 7.69 s; Mean lack of answer: 35%

PWS with LED



Result 8.6

Mean time of answer: 2.58 s; Mean lack of answer: 0%

PWS with vibration



Result 8.4

Mean time of answer: 5.83 s; Mean lack of answer: 0%

Summary

Signals generated by the developed PWS do not cause cognitive load of firefighters in the simulated utility conditions.

The type of physical activity has a statistically significant impact on the functionality of the PWS, particularly in the case of PWS using visual methods.

Signals generated from PWS with LEDs were statistically much faster received by users compared to PWS with LCD display and PWS with vibrating element.

Among the analyzed environmental conditions light has the greatest impact on the functionality of the PWS - in brighter light it was difficult to receive messages from the LCD display, and in the dark - it was easier in the case of PWS with LCD display and PWS with LEDs. There was no obvious influence of smoke.

Analyzed utility conditions did not have influence on the functionality of PWS with vibrating element.

Thank you!



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