

Task 03.A5

TECHNICAL CONCLUSIONS OF FINAL INTERNATIONAL SEMINAR IN BRISTOL (UK)



This work is licensed under a [Creative Commons Attribution-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-sa/4.0/)



This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Contents

1. INTRODUCTION	3
2. Short presentation on the Safecrobot-Project [UWE]	5
3. Presentation of objectives and results [UWE]	6
4. Presentation of contents.....	8
5. Demonstration of VR technology tool [UWE]	9
6. Discussion [UWE]	11
Feedback of participants.....	11
NUMBER OF ATTENDEES.....	13
APPENDIX A – SUMMARY OF PRESENTATIONS AT SEMINAR	15
APPENDIX B – SEMINAR BROCHURE	18

1. INTRODUCTION

The First International Seminar on SafeCROBOT project results in Bristol (UK), is a task with the deliverable identified as O3/A5 "Technical conclusions of First International Seminar in Bristol (UK)".

This task is included in Intellectual Output 3 "OER and ICT based tool for training and raising awareness" of the SafeCROBOT project.

This Multiplier Event held in Bristol hosted by UWE on 11th November 2022 and was focused on the Virtual reality (VR) and OER Platform with the organisation of presentations and demonstrations covering different topics on this project. Experts in safety of robotised and automated for construction sector attended this event and participated in the round table discussions.

This technical report compiles and analyses the main conclusions which aimed at implementing corresponding improvements in the project results.

AGENDA

11 November 2022, Bristol UK

15.30 - 16.15 Registration and coffee.

16.15 - 16.30 Welcome and Safecrobot Introduction (UWE - L Mahdjoubi).

16.30 - 17.45 Presentations by Partners and invited experts:

1. Robotics adoption barriers and lessons (UWE Guest - Prof A. Weightman)
2. Perspectives on Functional Safety Assurance of Construction Robots and their Human-Robot Interaction (HRI) (UWE - Dr C Harper)
3. Is the safety law keeping pace with technology (UWE Guest - Dr N Bell)
4. Unmanned Aerial Vehicles (Drone) Safety for Construction (WUST M. Szostak et al).

18.15 - 19.30 Safecrobot Virtual Reality (VR) and OER Tool Demonstration (UWE - Dr A. Mahamadu and A. Prabhakaran)

19.30 - 20:30 Networking and Dinner

The Final International Seminar was held at Bristol, UK and hosted by coordinator of the Safecrobot project (UWE). It was carried out by the project team including Mr Abhinesh Prabhakaran, Dr Abdul-Majeed Mahamadu and Prof Lamine Mahdjoubi.

UWE Bristol has extensive expertise in construction education and training as well as cutting-edge research emerging technologies such as robotics and autonomous systems. The institution has been at the forefront of training and skills development the construction sector of UK and has strong links with industry players as well as vocational training partnerships in the entire South West region of England. In addition to training, UWE Bristol has immense expertise in digitalisation and use of novel techniques for training. The seminar was attended by trainers, lecturers, construction professionals, workers and organisations with interest in safety, robotics and digitalisation in general. The event was advertised on Eventbrite Website with the following link: <https://www.eventbrite.co.uk/e/safety-implications-of-the-adoption-of-robotics-in-construction-tickets-440250349647?aff=ebdssbdestsearch>

The awareness of the risks associated with the use of robots and autonomous systems in construction is emerging and the training needs have been well demonstrated by this project. There is a gap in the market in relation to appropriate understanding of the risk situations as well as available training resources. Therefore, the VR training tool from the Safecrobot project was found to be very novel, timely and useful for industry in UK in particular where most attendees came from. All the presentations and interventions of the Final International Seminar will be posted on the Safecrobot project website, to be made available to all interested parties through the following link:

<https://safecrobot.pwr.edu.pl/en/reports>

The event was advertised on Eventbrite Website with the following link: <https://www.eventbrite.co.uk/e/safety-implications-of-the-adoption-of-robotics-in-construction-tickets-440250349647?aff=ebdssbdestsearch>

2. Short presentation on the Safecrobot-Project [UWE]

On behalf of the project team **Prof Lamine Mahdjoubi** welcomed participants and in his opening address provided overview of project as reiterated below. UWE Bristol is committed to developing material and content for training and further education needs of the entire construction industry. This includes training on ways of working with emerging technologies and materials. One of the key emerging areas being the use of robotics and autonomous systems. Advanced robotic systems are becoming commonplace on construction sites including increasing use of autonomous and semi-autonomous equipment. However, construction still requires high degree of human involvement thus creating working environment with high interaction between workers and machinery including these autonomous and semi-autonomous machines. As a result of these developments, the EU commission of Safety and Health has forecast that one of the greatest occupational safety risks will emanate from Machine-Human-Interactions (MHI) in the near future. In order to address this, the UWE led the Safecrobot project to investigate the risks associated with automation and advanced machinery use in construction environments then develop innovative training system for safe engagement using Virtual Reality (VR). This VR application will help impart construction workers with essential knowledge and skills for interacting with advanced machinery and autonomous equipment in construction environments across Europe. Project partners were from across Europe: Spain (CTM); Poland (WUST) and Germany (BZB) providing unique perspectives that has contextualised the training tool to fit vocational training needs of these countries. In the opening address and project introduction Prof L Mahdjoubi introduced the project background and described above and introduced project partners. Prof L Mahdjoubi is also the Director of UWE Centre for Architecture and Built Environment Research. The Centre responsible for specialisation in construction automation, safety and digitalisation. In attendance were project partners from Germany (BZB Bertelmann-Angenendt, Frank) and Poland (WUST, Mariusz Szóstak and Piotr Grzempowski).



Figure 1: Opening Remarks Bristol International Seminar

3. Presentation of objectives and results [UWE]

Dr Abdul-Majeed Mahamadu and Abhinesh Prabhakaran gave a brief presentation of the tasks and expected results of the project, emphasizing that this project is of educational scope for training purposes for the construction industry specifically

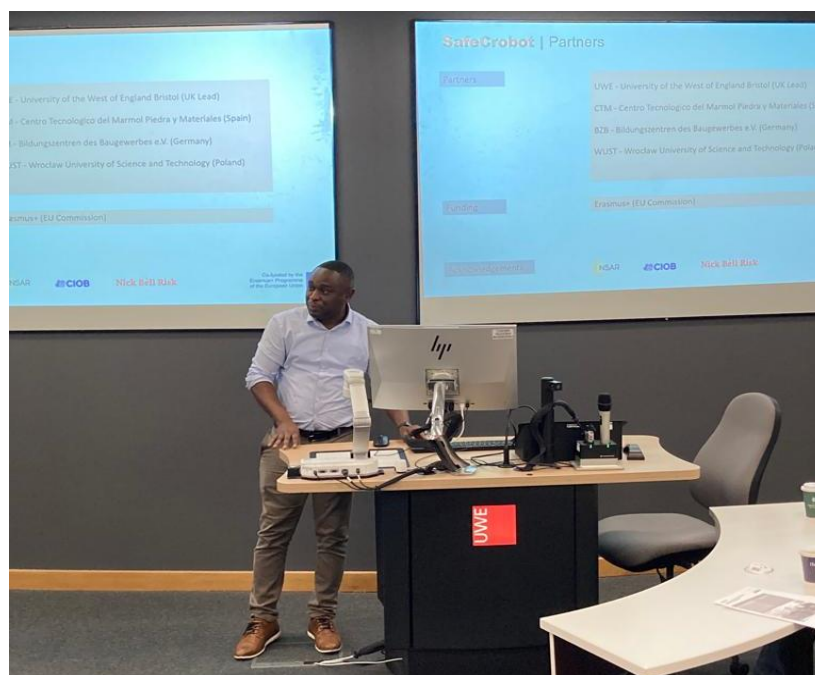


Figure 2: Bristol Seminar Project Overview Presentation



Figure 2: Project Methodology Presentation

They explained the project objectives and the gap in the industry in terms of understanding risks as well as training needs. They also outlined limitations of traditional training approaches therefore resulting in the use of VR for more effective training in the Safecrobot project.

The UWE Safecrobot project team explained the methodology adopted to deliver the project and outputs. These included guidelines on safety and health risks, as well as environmental protection measures in the use of robotics and autonomous systems in construction. The VR training tool for the safe handling of the most representative types of equipment has been developed on this project and will be freely accessible on the learning platform (OER) for further education.

They presented the project methodology which included initial research to identify common types of robotics and autonomous systems as well as the associated risk situations. This was followed by detailed evaluation to identify the 10 typical risk situations that is most representative of robot and autonomous systems use in construction. This represented the 10 scenarios for which training material and tools was to be developed. This was then converted into scripts and VR system development requirements. The gaming engine, programming approach and user requirements were also outlined. The VR training tool developed and based on the 10 risky scenarios adopted from the previous research steps was also outlined. The tool constitutes project deliverable which will be made available on project website to be used as part of teaching resource.

4. Presentation of contents

Below is a summary of expert presentations that served as precursor to seminar discussions, project evaluations and demonstrations.

Prof Andrew Weightman (UWE Guest Speaker - Invited robotics expert from Manchester University). Delivered a presentation on '*Robotics adoption: barriers and lessons from other industries.*' This provided foundation for Safecrobot project background and justification. His presentation highlighted the fact that there is a lack of training and awareness of risks which remains one of the most critical barriers to robotics adoption in construction. His presentation included results from extensive research in UK on the barriers to robotics adoption. He also provided a general overview of the different types of robots and their application in construction.

Dr Chris Harper (UWE) Presented on '*Functional Safety Assurance of Construction Robots and their Human-Robot Interaction (HRI)*'. This presentation highlighted that there are no specific safety standards for robotics in construction (either from ISO/TC 195 Construction machinery or ISO/TC 299 Robotics). Dr Harper highlighted safety design considerations for robotics and highlighted that as a result of dynamic environment of construction it is impossible to tackle safety only through robot design. He Highlighted the role of human users and site workers in ensuring safety with references to job hazard analysis frameworks.

Dr Nick Bell (UWE Guest Speaker from Nick Bell Consultancy). Dr Bell is a safety training expert and has developed safety training and other interventions for many organisations and workers in the UK. His presentation focussed on current safety regulations in construction. He reviewed the role of EU Directives, The Health and Safety at Work Act 1974 and Construction Design and Management Regulations 2015 (CDM) UK. He highlighted emerging frameworks such the Framework on 'Robotics and automation safety' from the European Agency for Safety and Health at Work. He highlighted all applicable regulations and standards but also highlighted the lack of a specific regulation robotics scenarios. In conclusions he outlined the gap in knowledge and the role of training programmes. He emphasised the importance of the Safecrobot project in the light of the skills gap.

Dr Eng. Mariusz Szóstak (WUST). Presented on Unmanned aerial vehicles (UAV), colloquially called drones, for construction. He highlighted that this is one of the most utilized forms of robotics in construction industry. There's however a lack of availability of training and general awareness of safety risks, requirements and regulation around drone use. He noted that they are used for building inspections, damage assessment, land measurements, safety inspections, monitoring the progress of works, and others. He outlined research and a procedure (protocol) which was developed by WUST for the correct and safe preparation and planning of an unmanned aerial vehicle flight during construction operations. He highlighted the relevance and use of this protocol in developing training tools in the Safecrobot project.

5. Demonstration of VR technology tool [UWE]

Dr A-M Mahamadu and A Prabhakaran explained the safety training tool aimed at improving the understanding of safety requirements for working with robots and autonomous systems in construction. This training tool has been developed in a virtual reality (VR) game environment. It consists of 10 risks scenarios involving operating and interaction with different categories of construction robots/autonomous systems. It requires the user to evaluate the 10 different situations and interactively complete missions (quiz) in each scene. The mission addressed noticeable safety/health risks, violations or best practice requirements. In each situation, the worker (trainee) will have to observe the environment and complete each of the mission (quiz) then a score of their performance is provided giving them an opportunity to retake the mission/quiz.



Figure 4: Virtual Reality Demonstrations

They introduced the following 10 scenarios and commented on the individual mission steps shown.

1. Drones (Unmanned Aerial Vehicle) - Preparing for flights on construction sites in day light
2. Drones (Unmanned Aerial Vehicle) - Flying on construction sites in favourable weather conditions
3. Drones (Unmanned Aerial Vehicle) - Flying on construction sites in adverse weather conditions
4. Drones (Unmanned Aerial Vehicle) - Preparing for flights on construction sites at night

5. Autonomous Site Transport Vehicle - Indoor site conditions
6. Autonomous Site Transport Vehicle - External and outdoor site conditions
7. Remote Controlled Equipment (Demolition Robots) - General Reequipments
8. Remote Controlled Equipment (Demolition Robots) - Indoor site conditions
9. Remote Controlled Equipment (Demolition Robots) - External and outdoor site conditions
10. Remote Controlled Equipment (Diggers/excavators) - External and outdoor site conditions

They gave participants an opportunity to test the tools using VR Headsets and underscored, the learning outcomes. This includes that fact that by the end of this VR training the user will be able to identify personal and collective protective equipment and practices in robotised construction environments. They will understand the common types of robots and autonomous equipment used in construction, the risks associated and identify best practices. These best practices are based on both individual and collective safety as well as regulations for safe operation of the equipment. This also includes environmentally safe practices as well as health protection aspects.

The VR based immersive animations were designed and produced on the basis of all the previous information developed in the project, to support the implementation of Safecrobot training courses and the OER. This VR based Immersive training tool will be available for free on the project's website and on the YouTube channel to be created in the project, which can be used as support material for the courses that will be developed for awareness and learning about safe environments in the construction industry for the application of robotics and autonomous systems.

6. Discussion [UWE]

All presentations and the demonstrations of the Safecrobot VR safety training tool was followed by discussion with participants. They had the opportunity to express their opinions, perspectives, doubts and concerns regarding the project to seminar speakers.

Feedback of participants

Participants were generally of the opinion that this is an extremely useful training tool. The tool and procedure has been developed to cover some of the most important safety concerns as well as focussed on very useful categories of robotics equipment for the construction sector. Participants had some concerns regarding access to VR devices/equipment. The Safecrobot team explained that the type of VR device that the tool was designed for is low budget and widely available (Oculus quest). Also, they clarified the intention is for training providers to provide the devices and not individual trainees although any individual interested can use this very popular device. Participants from external companies were very eager to get their colleagues and workers to start using the tool.

A survey was administered to a total of 9 participants who agreed to evaluate tool and the event organisation. A selection of summarised responses is presented below. This is indicative of majority of participants being male albeit significant female participation at 33% (Figure 5). Majority of respondents (56%) were between ages 25 and 45 years old (Figure 6). Participants had some knowledge of robotics and VR albeit limited experience especially of the safety aspect (Figure 7). Participant's views and knowledge significantly improved and were overwhelmingly more positive after the seminar (Figure 8). Participants were generally happy with event organisation quality (Figure 9).

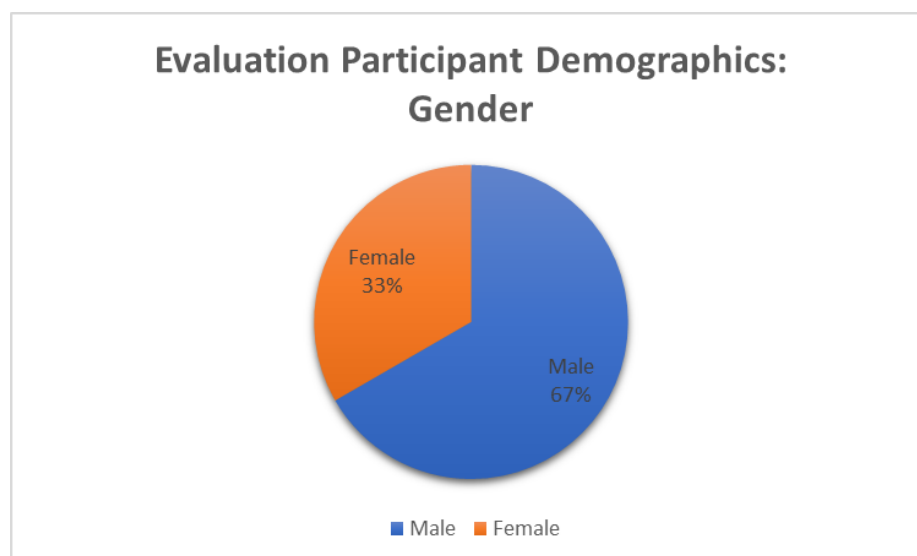


Figure 5: Evaluation participant's gender

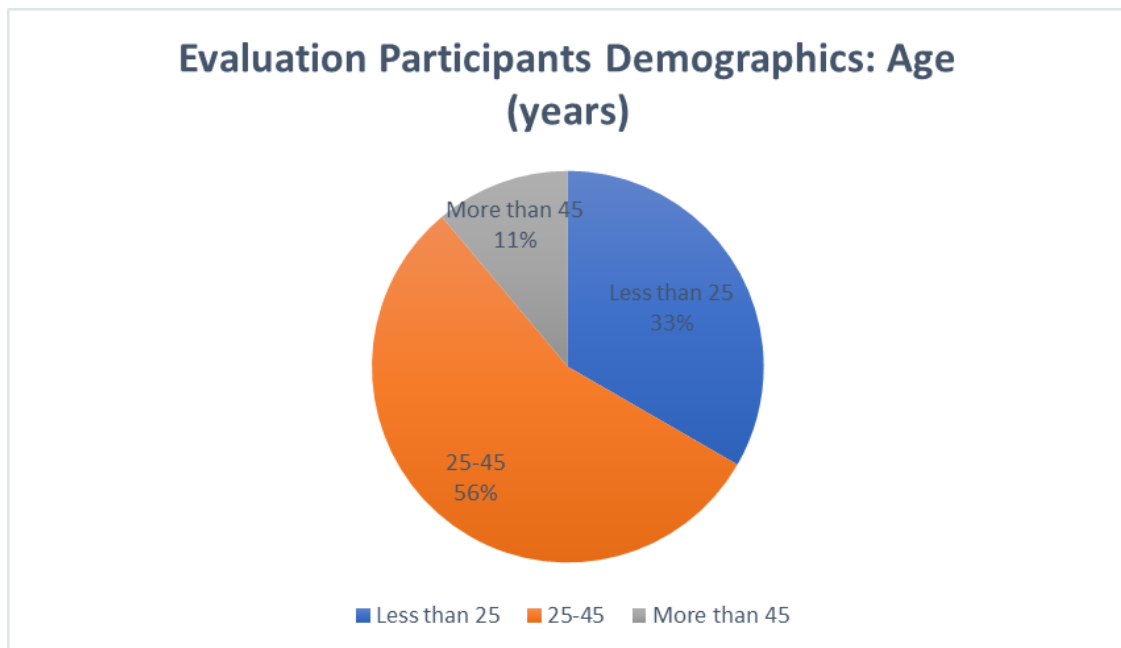


Figure 6: Evaluation participant age

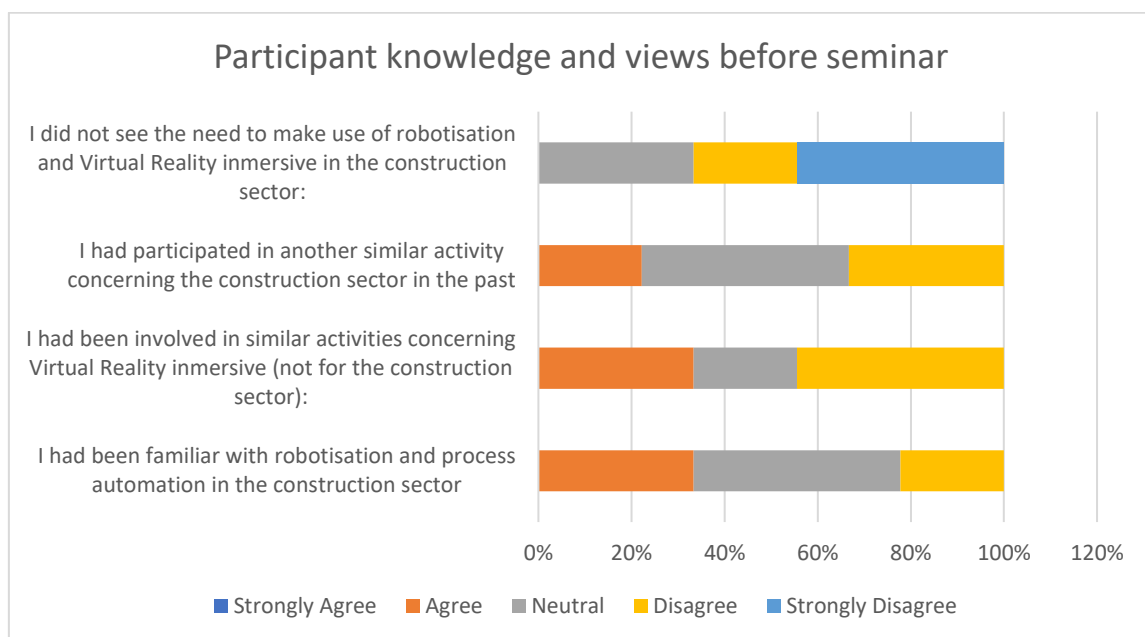


Figure 7: Views before to seminar

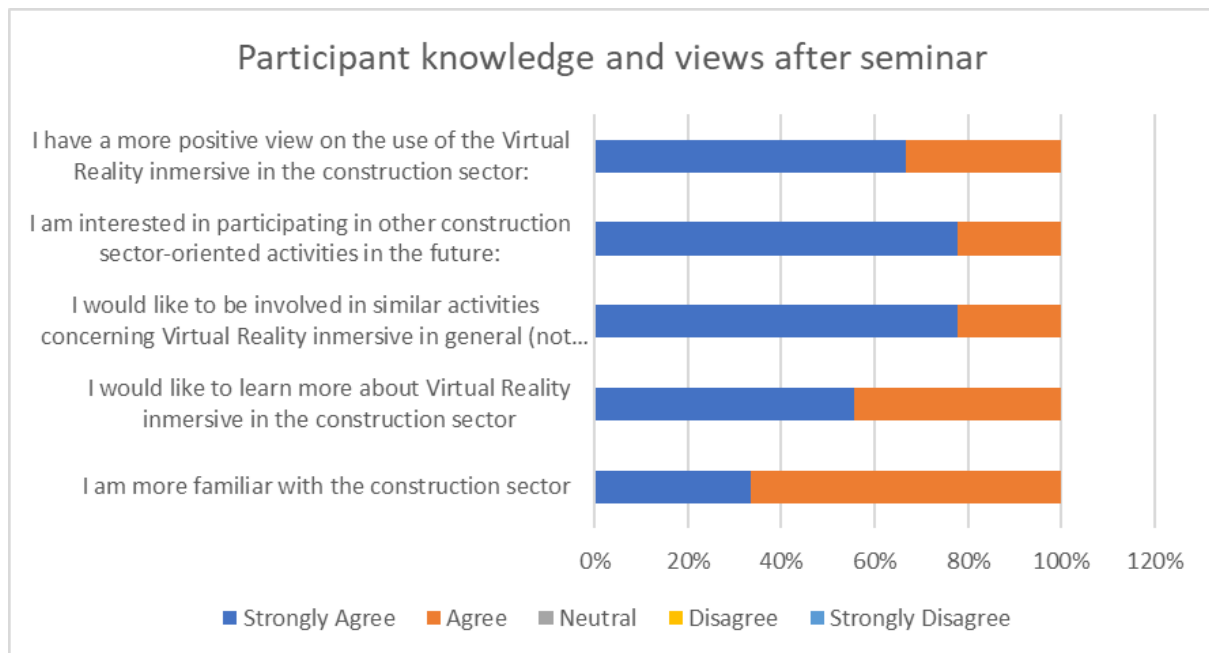


Figure 8: Views after seminar

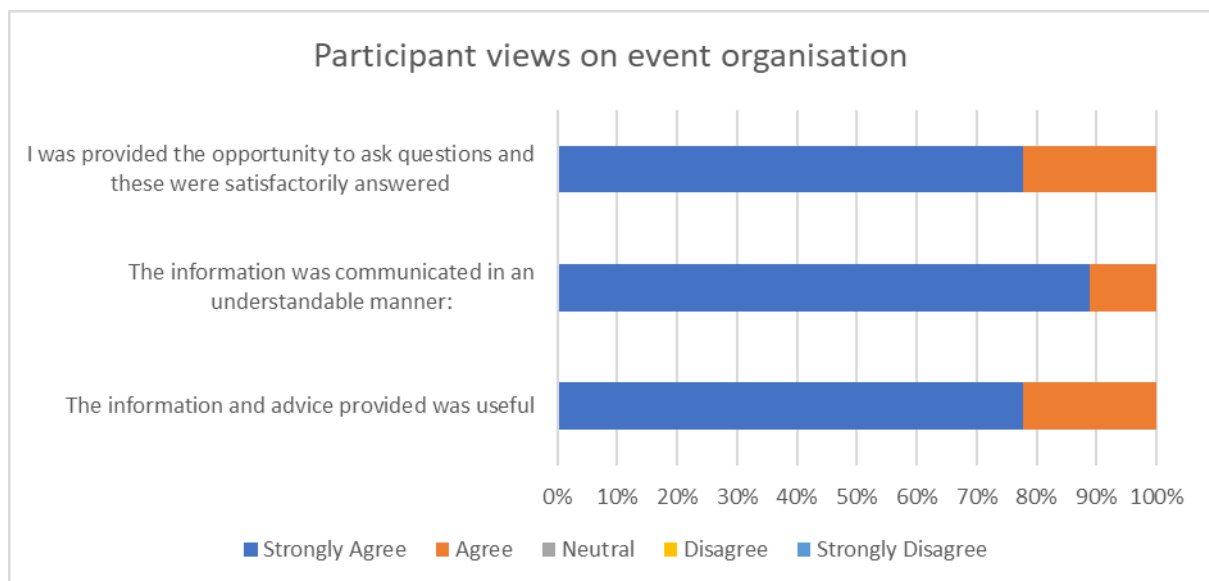


Figure 9: Views about organisation of seminar

NUMBER OF ATTENDEES

The total attendance at the Final International Seminar of the Safecrobot project was 35, consisting of 19 external participants in addition to the 6 project participants and 8 UWE student/staff observers:

Project Partners in Attendance:

University of the West of England (UWE) UK

Prof Lamine Mahdjoubi

Abhinesh Prabhakaran

Dr Abdul-Majeed Mahamadu

Wrocław University of Science and Technology (WUST) Poland

Dr Eng. Piotr Grzempowski

Dr Eng. Mariusz Szóstak

Bildungszentren des Baugewerbes e.V. (BZB) Germany

Frank Bertelmann-Angenendt

Expert Presenters - Guest Invited by UWE

Prof Andy Weightman (Robotics)

Dr Patrick Manu (Safety)

Dr Chris Harper (Robotics)

Dr Nick Bell (Safety Regulations)

Due to the Data Protection Law, the *Attendees list* is not available for public use.

APPENDIX A - SUMMARY OF PRESENTATIONS AT SEMINAR



Dr Abdul-Majeed Mahamadu and Abhinesh Prabhakaran




SafeCROBOT

SafeCRobot

Safety Implications of the Adoption of Robotics and Autonomous Systems in Construction and Infrastructure

Professor Lamine Mahdjoubi



2020-1-UK01-KA202-079176







MANCHESTER
1824
The University of Manchester

Robotics adoption: barriers and lessons from other industries

Prof Andy Weightman
andrew.weightman@manchester.ac.uk



UWE Bristol | University of the West of England




brl Bristol Robotics Laboratory

Presented by:


Dr Chris Harper
Senior Research Fellow
Robotics & Autonomous Systems Safety Engineering
Bristol Robotics Laboratory (BRL)


Perspectives on Functional Safety Assurance of Construction Robots and their Human-Robot Interaction (HRI)


11th November 2022
UWE, Bristol



Wrocław
University of
Science
and Technology


 UWE Bristol
University of the West of England

 CTM
Centro Tecnológico
del mármol, piedra y materiales

 PWR
Politechnika
Wrocławska

 BZB
Bildungszentren des
Baugewerbes e.V.

Co-funded by the
Erasmus+ Programme
of the European Union




Unmanned Aerial Vehicle (Drone)

Safety for Construction

Speaker:

Dr Eng. Mariusz Szóstak
Wrocław University of Science and Technology
Faculty of Civil Engineering
Department of Building Engineering

WUST Team:
Prof. Bożena Hoła **Dr Eng. Piotr Grzempowski** **Msc. Eng. Tomasz Nowobilski**



SafeCROBOT

Is the law keeping pace with technology?

Dr Nick Bell

BSc(Hons) MSc PhD DipNEBOSH EnvDipNEBOSH DipSW PGDipASS CMaPS
PIEMA CertCii CPsychol CFIOSH

Honorary Principal Lecturer, Cardiff Metropolitan University

Visiting Lecturer, Reading University



APPENDIX B - SEMINAR BROCHURE

eventbrite
Search events

event ended

Safety Implications of the Adoption of Robotics in Construction

[View details](#)

Follow this organiser to stay informed on future events

UWE, Bristol
Event creator
Follow



SEMINAR

Safety Implications of the Adoption of Robotics and Autonomous Systems in Construction and Infrastructure

11th November 2022

15:30 -19:30 pm

FREE Entry (Limited seats)

UWE Bristol, Frenchay Campus

University of the West of England
Frenchay Campus
Coldharbour Lane,
Stoke Gifford,
Bristol
BS16 1QY
Google Map

Room: **6X269** (Bristol Business School)
Parking : Business School visitor's parking-
North Entrance

Summary

Advanced robotic and autonomous systems are becoming commonplace on construction sites including the adoption of drones, autonomous equipment and vehicles. However, construction still requires high degree of human involvement which creates a working environment with potentially high interaction between workers and these autonomous machines. As the robotisation is increasing, robotics safety has become paramount to the construction and infrastructure industry.

This seminar will examine salient safety issues in construction robotics and autonomous systems adoption as well as provide an in-depth overview of current and future trends. In addition, the seminar will be used to disseminate findings and outputs from the EU Erasmus+ Safecrobot project and showcase a novel virtual reality safety training applications for the construction and infrastructure industry

Programme:

- 15:30-16:15 - Registration and coffee
- 16:15-16:30 - Welcome address
- 16:30-17:45 - Speakers
- 17:45-18:15 - Safecrobot project demonstration
- 18:15-19:30 - Networking and dinner

Presentations:

Welcome address by Prof Lamine Mahdjoubi

Topic	Speaker	Organisation
Robotics adoption: barriers and lessons from other industries	Prof Andy Weightman	University of Manchester
Perspectives on human-robot interaction, safety and assurance	Dr Chris Harper	UWE Bristol
Is the law keeping pace with technology?	Dr Nick Bell	Nick Bell Risk Consultancy
Safecrobot Project: VR safety training demonstration	Dr Abdul-Majeed M Abhinesh Prabhakaran Dr Piotr Grzempowski Dr Mariusz Szóstak	UCL London UWE Bristol PWR Poland

The event has been organised as part of the Erasmus+ Safecrobot


Co-funded by the
Erasmus+ Programme of the
European Union

