Task O2/A1.2

BIBLIOGRAPHY AND REPORTS RELATED CONSTRUCTION SITES ACCIDENTS

Erasmus+

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1. INTRODUCTION

In this Intellectual Output 2, the key situations will be proposed to be included in the 3D environments. As we have indicated in the aims of the work package the key situations will be based on previous reports, taking into account the main risk situations in robotic construction companies and the application of health and environmental prevention measures currently applied in this sector. These situations will be sent to all partners who will comment any addition or change that should be done.

The main objective of this report of the subtask O2/A1.2 is to develop a report on the bibliography available in each country participating in the project, both publications and reports issued by major construction companies.

2. Scientific papers

3D printing techniques used in construction. (Krzywoń, R., Dawczyńsk, R., Ibanes, A., Romón, J., Cyfryzacja w budownictwie i architekturze, 2019, 67-96 (in Polish)) The publication presents a comprehensive overview of the use of 3D printing in construction. The authors of the work focused in particular on the material used during printing.

8th International Conference Safety of Industrial Automated Systems – SIAS 2015

https://www.dguv.de/medien/ifa/en/vera/sias_2015_proceedings.pdf

Analysis of scaffoldings using new technologies. (Nowobilski, T., Sawicki, M., Szóstak, M., Builder, 2020, 7, 32-34 (in Polish)). The authors of the article proposed a methodology for assessing selected elements of the construction scaffolding structure using drones and BIM technology tools.

Analysis of the mechanisms of minor occupational injuries in the construction industry in Spain. (Benavides F.G., et al. 2003). Construction was the economic activity with the highest number of occupational injuries with sick leave in Spain in 2000. Almost all these casualties were minor after the adoption of numerous preventive norms. The aim of this research is to identify the specific mechanisms of minor occupational accidents in construction. https://www.scielosp.org/article/gs/2003.v17n5/353-359/es/

Application of a Design and Construction Method Based on a Study of User Needs in the Prevention of Accidents Involving Operators of Demolition Robots (Derlukiewicz, D., Applied Sciences,. 2019, 9, 1500). The paper presents a new method of design and construction aimed at developing a system that helps to prevent accidents involving demolition robot operators.

This paper emphasizes the importance of the connection between man and machine to overcome the lack of direct information flow in the case of mechanical operation.

Risks:

-robot overturning - crushing the controller

-loss of stability, despite extended supports, when the operating arm is fully extended.

-falling into a trench while working on the edge of the trench

-eye injuries caused by dust

-impacts caused by falling objects, construction elements

-noise damage to the ear

-risk of loss of stability and cases of faulty machine operation

-risk of machine failure

Application of drones to thermography testing of building (Noszczyk, P., Nowak, H., Materiały Budowlane, 2017, 11 (in Polish)). The article discusses the numerous uses of drones in the construction industry. The innovative solution presented in this article is to equip dron in a dedicated thermal imager.

Application of unmanned aerial vehicles for the control of building objects. (Nowobilski, T., Builder, 2020, 2, 18-20,(in Polish)). The article presents the most important conditions for the proper exploatation of UAV, along with applicable legal regulations.

Asymmetrical truss Created by the 3D printer. (Kampski, K, Builder, 2019, 10, 2-5, (in Polish)). The article presents an exemplary printout of the bridge truss model together with the element strength analysis.

Automation and Robotics for Road Construction and Maintenance. (Skibniewski M., Hendrickson C., Journal of Transportation Engineering, 1990, 116(3)). The article presents the taxonomy of work tasks and categories of work automation in road construction. The basic technologies in the development of automated road construction were also presented**.**

A Robotic System for Automated Masonry. (E. Gambao, C. Balaguer, F. Gebhart, 1999). The traditional methods for masonry have reached their system limits and cannot contribute to further effectiveness. A certain innovative leap is required by a system approach that combines the already existing construction technologies with new information and robot technologies. An integrated automation system has been developed in the European ESPRIT III ROCCO (Robot Assembly System for Computer Integrated Construction) project. Block assembly tasks are performed by means of two robotics systems.

The obtained systems improve the manual block assembly tasks reducing dramatically the construction time and efforts.

http://www.iaarc.org/publications/fulltext/A_robotic_system_for_automated_masonry.PDF

Building industrialization: robotized assembly of modular products. (Martínez et al., 2008) The increasing of mechanization levels used in tasks execution in construction, as a way to increase productivity, requires its rationalization, the adoption of new assembly-ready materials and methods, and the application of robotics capabilities. In this way, using concepts as design for manufacture and assembly and lean construction, modular products can be developed for their assembly by robotics systems onsite. This paper aims to review developments.

https://doi.org/10.1108/01445150810863716

Comparison of Construction Robots and Traditional Methods for Drilling, Drywall, and Layout Tasks (Brosue et al., 2020) This study developed three comparative cases evaluating a drilling robot, a drywall robot, and a layout robot against traditional construction methods. Further, it establishes an initial feasibility check that evaluates the lit between product, organization, and process variables, and then measures the robot's impact on safety, quality, schedule, and cost. This study also outlines common implementation challenges to become aware of the effort faced to harness the robots' benefits and provides strategies to mitigate these challenges.

10.1109/HORA49412.2020.9152871

Comparative study of health and safety legislation and accident rates between the Dominican Republic and Spain (Peña et al., 2016). This research aims to present a comparative study between Spain and the Dominican Republic, based on the acting legislative regulations on safety and health, from their inspections to infringements taking place by breaking them. Another point to note is the analysis of accident rates in the construction sector and the risks that lead to their origin.

https://upcommons.upc.edu/bitstream/handle/2117/87725/Estudio%20comparativo%20de%20la%20legislaci%C3%B3n%20sobre%20seguridad%20y%20salud%20y%20la%20siniestralidad%20entre%20Rep%C3%BAblica%20Dominicana%20y%20Espa%C3%B1a..pdf

Construction 4.0: towards sustainability in the construction sector. (Manzanares, Gonçalves and González, 2020) This paper establishes isdustrialized construction from a 4.0 perspective through a literature review and reflects on the 4.0 construction approach towards the principles of sustainability and sustainable development for future societies.

http://dspace.aeipro.com/xmlui/bitstream/handle/123456789/2443/AT02-013_20.pdf?sequence=1&isAllowed=y

Construction in the era of innovation (Burzyńska, K., Przegląd Budowlany, 2018, , 12, 30-32 (in Polish)) Impact of innovation (including Drones) on construction**.**

Construction industry accidents in Spain. (Miguel A. Camino López, Dale O. Ritzel, Ignacio Fontaneda and Oscar J. González Alcantara, 2008). This paper analyzed industrial accidents that take place on construction sites and their severity.

https://www.sciencedirect.com/science/article/abs/pii/S0022437508001229?via%3Dihub

Construction Robotics (Bock, 2006) This paper presents an overview of different types of construction robots and the future possibilities and challenges posed by robots in the construction industry.

www.DOI10.1007/s10514-006-9008-5

Construction robotics and automations development directions part I. (Budny, E., Chłosta, M. Technologia i automatyzacja montażu, 2016, 1, 24-29 (in Polish)) The basic information on automation and rbotics in construction (ARC) was presented in the introduction of the paper.

Construction robotics and automations development directions (Part II) (Budny, E., Chłosta, M, Technologia i automatyzacja montażu, 2016, 4, 26-28 (in Polish)) The basic information on automation and rbotics in construction (ARC) was presented in the introduction of the paper.

Creating 3d models of building using a drone (Mika, W., Ferenc, A., Czaja, S., Przegląd górniczy, 2019, 07, 55-62 (in Polish)) The article presents of examples of using a drone for 3D modeling of building objects.

Determining the causes of the arm member fractures of the brokk 90 demolition machine with use of high-speed camera and finite element method. (Cieślak M., Derlukiewicz D., 8-th International Symposium on Mechanics and Structures, 2015, Augustów, Poland) The methods of testing boom systems mounted on demolition robots are presented. The main goal is to identify places exposed to stress concentration. A fast camera was used to record the work of the demolition robot.

Risks:

-causes of arm fractures: stress build-up, resonance.

Developing trends of unmanned aircraft systems. (Becmer, D., Skorupka, D., Duchaczek, A., Problemy Techniki Uzbrojenia, 2015, 136, 4, 19 – 40,). Authors of the paper present possibilities of using unmanned aircraft systems for identification and neutralisation of threats.

DGUV-Information: Collaborative robot systems

https://www.inmotion.global/wp-content/uploads/2019/05/080_collaborativerobotsystems.pdf

DGUV-Information 209-074: Idustrial robots.

https://publikationen.dguv.de/widgets/pdf/download/article/3150

Drones in scaffolding condition assessment. (Nowobilski, T., Sawicki, M., Szóstak, M, Builder, 2020, 1, 40-41, (in Polish)). The article presents the possibilities of using unmanned aerial vehicles to assess the technical condition of building scaffoldings.

Drones in public space (Robak, W., TTS Technika Transportu Szynowego, 2015, 22, 12 (in Polish)). The article presents the problem of safe operation of equipment and autonomous unmanned aerial vehicles (drones and robots) in public spaces.

Enhancing perceived safety in human-robot collaborative construction using immersive virtual environments (You et al., 2018) This study introduces the Robot Acceptance Safety Model (RASM) and employ immersive virtual environments (IVEs) to examine the perceived safety of working on tasks alongside a robot. Results in IVE show that separation of work areas between robots and humans increases perceived safety by promoting team identification and trust in the robot. In addition, the more participants felt it was safe to work with the robot, the more willing they were to work alongside the robot in the future.

https://doi.org/10.1016/j.autcon.2018.09.008

Exploring conditions and usefulness of UAVs in the BRAIN Massive Inspections Protocol. (Serrat,C., Cellmer, A., Banaszek, A., Gibert, V., Open Engineering, 2018, 9, 1, 1-6) In the paper authors conduct a case study analysis by implementing the use of UAVs in the data collection within the BRAIN framework for the failures diagnosis of facades.

Human-Robot Collaboration and Sensor-Based Robots in Industrial Applications and Construction. (Ahola et al., 2018) This paper presents the Principles, safety and control technologies of human-robot collaboration are outlined and sensor-assisted control of industrial robots, as well as a dynamic safety system for industrial robots, are described in more details. The applicability of sensor-based robotics in building construction and the potential of robotics in building construction, in general, are also evaluated.

https://link.springer.com/chapter/10.1007/978-3-319-70866-9_2

Identifying the possibility of using unmanned aerial vehicles in the process of construction projects implementation (Waniewska, A., Scientific Journal of the Military University of Land Forces, 2020, 52, 3(197), 643-650). In the article present the possibility of using unmanned aerial vehicles in construction projects, for economic and time reasons, as well as to perform work in places that are inaccessible or too dangerous for humans.

Information of BGHM: Industrieroboter (only in German)

https://www.bghm.de/fileadmin/user_upload/Arbeitsschuetzer/Praxishilfen/Schwerpunktthemen/2020-08-Industrieroboter.pdf

Integration kollaborativer Roboteranwendungen - Sicherheitsinformation für Führungskräfte (Integration of collaborative robot applications - Safety information for managers); M·plus 940

https://www.auva.at/cdscontent/load?contentid=10008.738104&version=1597737259

Introduction to the issue of the use of unmanned aerial vehicles in local government. (Ministerstwo Przedsiębiorczości i Technologii, Polski Fundusz Rozwoju (in Polish)). General information on the use of drones in Poland.

Machine control systems for leveling areas for road investments. (Szafranko E, IOP Conference Series Materials Science and Engineering 2020, 709, 022077) The article contains basic information on the machine control system in earthworks with the use of a laser system and GNSS.

Mechanisation and automation technologies development in work at construction sites. (Sobotka A., Pacewicz K, IOP Conf. Series: Materials Science and Engineering, 2017, 251, 012046) The article contains general information on the condition of mechanization and automation in construction in Poland, based on a survey conducted by construction companies.

Newtechnologies of monitoring in earthwork – practical. (Rybka, I., Nowobilski, T., Stolarz, M, Builder, 2020, 5 44-47 (in Polish)). The article presents the most important BIM technology tools and drones used for the analysis of earthwork carried out on a large geotechnical investment in Poland.

Occupational safety and health in Spain. (Albert Sesé, Alfonso L. Palmer, Berta Cajal, Juan J. Montaño, Rafael Jiménez and Noelia Llorens, 2002). This paper summarizes the organizational structure of the Spanish National Occupational Safety and Health System, its effective safety and health laws, and statistics on the Spanish work environment obtained from the III National Survey of Working Conditions (1997). The researchers hope that the conclusions of this work will have an impact on Spanish industry that will subsequently allow the improvement of working conditions and the development of models of evaluation and intervention in occupational safety and health, from a theoretical position that integrates environmental, human and organizational factors.

https://www.sciencedirect.com/science/article/abs/pii/S0022437502000543#preview-section-abstract

Optimization of the choice of unmanned aerial vehicles used to monitor the implementation of selected construction projects (Skorupka, D., Duchaczek, D., Waniewska, A., Kowacka, M, AIP Conference Proceedings, 2017, 1863, 230013, 1-4). The paper presents the optimization of the choice of unmanned aerial vehicles using the Bellinger method.

Paradigms and safety requirements for a new generation of workplace equipment. (Missala T, International Journal of Occupational Safety and Ergonomics 2014, 20, 2, 249-256) The article presents selected examples of robot-human cooperation and discusses the safety requirements and safety functions developed

People and robots coexsistance environment – how assure the safety?. (Missala T. Napędy i sterowanie, 2015, 3, 141-146 (in Polish)) Two stages of robotics' evolution are mentioned in the paper – the first with industrial robots separated from people and the second with robots (industrial, service and social) cooperating with people or helping them.

Planning and executing construction inspections with unmanned aerial vehicles. (Freimth and Konig, 2018) This paper presents a workflow for the structured planning, simulation and execution of inspection tasks. An application was developed that allows the operator to plan inspections in a 3D environment. The application automatically generates collision-free flight paths based on Building Information Modelling (BIM) data.

https://www.sciencedirect.com/science/article/pii/S092658051730290X

Possibilities of dron application for bridge inspection. (Kaleta, D., Macheta, D., Reizer, E., Rajcherm M., Archives of institute of civil engineering, 2017, 24, 141-149, (in Polish)). The article presents actual possibilities of using drones (unmanned aerial vehicle) in the construction industry, with an emphasis on the use bridge inspection.

Possibilities of monitoring the work environment safety by means of drones (Kasperska, R., Polskie Towarzystwo Profesjologiczne, Instytut Inżynierii Bezpieczeństwa i Nauk o Pracy, Uniwersytet Zielonogórski, Problemy Profesjologii, 2019, 1, 83-90 (in Polish)) This article focuses on the problem of the possibility of the use and application of remote-controlled aircraft to monitor and control the work environment. The main purpose of using drones is to increase the safety and efficiency of employees.

Risks:

-traffic accidents involving drones (e.g. collisions with a car, with a low-flying plane, entanglement of a drone in the high-voltage grid).

-unforeseen breakdowns

Proactive Ffilure prevention by Human-Machine Interface in Remote-Controlled demolition robots. (Derlukiewicz D., Ptak M., Koziołek S., Advances in Intelligent Systems and Computing, 2016, 445). The objective of the paper is to design an advanced Humane Machine Interface implemented in remote-controlled robot for demolition works.

Question of the possibility drones building. (Baryłka, A., Inżynieria Bezpieczeństwa Obiektów Antropogenicznych, 2017, 1, 24-35 (in Polish)). The paper presents the problem of the possibilities and legal conditions for the use of drones in the construction industry.

Real-time simulation of construction workers using combined human body and hand tracking for robotic construction worker system. (Kurien et al., 2018) This paper attempts to tackle the safety issues in the construction site by moving the human construction worker off-site and remotely link his/her motions to a Robotic Construction Worker (RCW) on-site. a novel system that combines 3D body and hand position tracking was developed to capture the movements of a human construction worker. This combination of tracking enables the capture of changes in the orientations and articulations of the entire human body. Second, a real-time simulation system that connects a human construction worker off-site to a virtual RCW was developed to demonstrate the proposed concept in a variety of construction scenarios. The simulation results demonstrate the future viability of the RCW concept and indicate the promise of this system for eliminating the health and safety risks faced by human construction workers.

https://www.sciencedirect.com/science/article/pii/S0926580517300493

Risk analysis arising from use of unmanned aerial vehicles (drones). (Fellner, A., Mańka, A., Mańka, I., TTS Technika Transportu Szynowego, 2015, 22, 12 489-491 (in Polish)). The article presents the classification of UAVs and the most significant risks associated with the BSP and result of risk analysis with using the FMEA method.

-possible collision with another the unmanned aerial vehicles.

-failure of a single navigation system.

-damage to the drone, need to stop the flight,

Risk assessment of remotely piloted aircraft systems (Kardach,M., Fuć, P., Galant, M., Maciejewska, M., Journal of KONBiN, 2019, 49, 95-106,) The article presents the legal conditions for unmanned operations and the risk assessment methods used in areas of human activity. On this basis, an original method of risk assessment in unmanned systems was proposed.

Risk prevention in the Spanish construction industry. (Fontaneda et al., 2005). This publication shows how physical conditions in construction are worse than in industry and considerably worse than in services; how training and recognition of workers is lower and the importance of overexertion in sick leave.

http://adingor.es/congresos/web/uploads/cio/cio2005/prevencion_riesgos//118.pdf

Robotic construction: a future in progress. (Rubio, 1990) This article highlights the importance of developing robotics adapted to construction and cites the possibility of doing so through EU-funded projects.

https://www.sciencedirect.com/science/article/pii/S2352710219300889

Robotic technologies for on-site building construction: A systematic review (Gharbia et al., 2020) To gain an improved understanding of the trend and trajectory of research on robotics application for on-site building construction, this paper provides a systematic review of 52 articles. The results show that robotic technologies for on-site construction is a growing application field, where additive manufacturing (AM), automated installation system, automated robotic assembly system, autonomous robotic assembly, and robotic bricklaying seem to be most studied and have a potential to influence the development of robotics research in building construction.

https://www.sciencedirect.com/science/article/pii/S2352710220313607

Robotics and automated systems in construction: Understanding industry-specific challenges for adoption (Davila et al., 2019) This paper presents an investigation into the industry-specific factors that limit the adoption of robotics and automated system in the construction industry. The main identified challenges were grouped into four categories and ranked in order of importance: contractor-side economic factors, client-side economic factors, technical and work-culture factors, and weak business case factors.

https://www.sciencedirect.com/science/article/pii/S2352710219300889

Robotics and Automation in Construction. (Balaguer, Abderrahim, 2008) This book addresses several issues related to the introduction of automaton and robotics in the construction industry. The chapters are grouped in 3 main sections according to the theme or the type of technology they treat. Section I is dedicated to describe and analyse the main research challenges of Robotics and Automation in Construction (RAC). The second section is dedicated to the technologies and new developments employed to automate processes in the construction industry. Among these we have examples of ICT technologies used for purposes such as construction visualisation systems, added value management systems, construction materials and elements tracking using multiple IDs devices. Section III is dedicated to describe case studies of RAC.

https://books.google.es/books?hl=es&lr=&id=ogehDwAAQBAJ&oi=fnd&pg=PR7&dq=construction+robotised+spain&ots=EMrynALDIr&sig=0_7aFylSK5rUWCkkRLxC9vPsTt0#v=onepage&q=construction%20robotised%20spain&f=false

Robotics and automation. Technological innovation in construction industry. Part 4. (Marcinkowski, R., Krawczyńska-Piechna, A., Biruk, S. Builder, 2018,22, 7, 66-69 (in Polish)) The article presents technological innovations in construction based on examples from around the world.

Robotics and Health and Safety at Work. (Uguina and Ruiz, 2019) This study presents an analysis of the main changes due to robotics disruption in the workplaces. In particular, the article focuses on health and safety at work taking into account the EU regulatory framework as well as the international technical safety standards. The study carried out by the authors reveals that the legislator is unable to specify the wide range of mechanisms due to the impossibility of keeping up with the pace of creation of new machines (industrial and collaborative robots). Therefore, the ISO standards are a cornerstone in order to understand the prevention duties of all parties (manufacturer, integrator) directly involved in the adoption of safety measures.

https://www.longdom.org/open-access/robotics-and-health-and-safety-at-work-18253.html

Robots and robotic devices - Safety requirements for personal care robots (ISO 13482:2014);

(distributed by Beuth; 245,10 €)

Safety Issues in Human-Robot Interactions. (Vasic and Billard, 2013) This study reviews possible hazards associated with Human-robot interaction and overviews the methods used for accident risk reduction. This study highlights the sources of injuries and attempts to classify the injuries into two categories which are pinch and impact.

www.10.1109/ICRA.2013.6630576

The Numerical-Experimental Studies of Demolition Machine Operator Work (Derlukiewicz D., Ptak M.,Wilhelm J., Jakubowski K.., Proceedings of the 13th International Scientific Conference, 2016, 129-138) The demolition robot is designed to work in difficult working conditions such as high temperature, dust, radiation or noise. The publication presents an approach to increase both the robustness of the machine and the ergonomics of the machine operator through the implementation of a human-machine interface (HMI).

Risks:

-eye injuries caused by dust

-impacts caused by falling objects, construction elements

-noise damage to the ear

The future of drones in construction industry. (Szruba, M., Nowoczesne budownictwo inżynieryjne, 2017, 1-2, 30-33 (in Polish)). "Popular science" article about the use of drones in construction.

The regulatory equalization of health and safety on construction sites in Spain and the United Kingdom. (Martos, J.L, 2018). Research work on the regulatory comparison in construction works in Spain and United Kingdom with information obtained to the current laws.

http://tauja.ujaen.es/bitstream/10953.1/7860/1/TFG%20-%20MARTOS%20ROMERO%2C%20JOSE%20LUIS.pdf

The use of 3D printing technologies in the civil engineering (Major, M., Minda, I, Zeszyty Naukowe Politechniki Częstochowskiej. Budownictwo, 2016, 22, 238 – 247 (in Polish)). In the paper there is presented the use of 3D printing technology in building engineering, which is used both during performing of the architectural design by creating 3D models of planned construction as well as during the stage of erecting buildings.

The use of unmanned aerial vehicles in operations for public safety (Feltynowski, M., Wydawnictwo CNBOP, 2019 (in Polish)) A comprehensive publication (a collection of several articles) related to the use of drones and their impact on public safety.

The use of unmanned aerial vehicles in the investment process (Mrówczyńska, M. Grzelak, B., Cyfryzacja w budownictwie i architekturze, 2019, 55-66, (in Polish)). An example of the use of drones for geodetic measurements.

Trends and selected problems in the use of automation and robotization in the construction industry. (Adamowski, J) Materiały Budowlane, 2012, 83, 7-8 , 48-52 (in Polish). Article describes the directions of development and examples of most recent achievements in the field of automation in the worldwide construction industry.

Unmanned aerial system applications in construction: a systematic review (Zhou and Gheisari, 2018) This paper aims to assort academic studies on construction UAS applications, summarize the logics behind using UAS in each application and extend understanding of the current state of UAS research in the construction setting. UASs are used in building inspection, damage assessment, site surveying, safety inspection, progress monitoring, building maintenance and other construction applications. Cost-saving, time efficiency and improved accessibility are the primary reasons for choosing UAS in construction applications. Rotary

wing UASs are the most common types of UASs being used in construction. Cameras, LiDAR and Kinect are the most common onboard sensors integrated into construction UAS applications. The control styles used are manual, semi-autonomous and autonomous.

https://www.emerald.com/insight/content/doi/10.1108/CI-02-2018-0010/full/html

Using drones to environmental pollution monitoring (Bogusława, B., Chojnacki, J., Autobusy: technika, eksploatacja, systemy transportowe, 2017, 18, 7-8, 57-60 (in Polish)). The article discusses examples of the use of drones - Unmanned Aerial Vehicle (UAV) to evaluation of air quality.

3. H&S reports of big enterprises

ACCIONA. Its objective is to lead the transition to a low-carbon economy by providing technical excellence and innovation to all projects in order to design a better planet and contribute to the

economic and social development of the communities in which they operate. The company displays an integrated report accessible to all. https://accionacorp.blob.core.windows.net/media/3592170/informe-integrado-2019.pdf

ACCIONA shows on its website the number of accidents suffered by employees or contractors during 2019.

Its responsibility goes beyond ensuring the health and safety of its employees and subcontractors, while actively promoting a risk-free working environment in its sector and in all its infrastructure, renewable energy and water projects.

For this reason, they issue and make public a repertoire of safety alerts that reflect experiences of incidents suffered in their company and the conclusions derived from them, in order to serve as a lesson for anyone, available at the following link: https://www.acciona.com/es/nuestro-proposito/trabaja-con-nosotros/seguridad-salud-bienestar/

Some of the examples available are:

- FATAL ACCIDENT IN CONTACTOR CELL: https://mediacdn.acciona.com/media/ah4datym/accidente-fatal-en-celda-de-contactor.pdf#_ga=2.11843121.487734605.1613661909-824531276.1613661909

- ELECTRIC ARC IN TOP CABINET: https://mediacdn.acciona.com/media/zudebzu2/arco-electrico-en-armario-top.pdf#_ga=2.184119587.487734605.1613661909-824531276.1613661909

- ENTRAPMENT OF A SHACKLE NAMEPLATE CABLE: https://mediacdn.acciona.com/media/4pmdkvzq/atrapamiento-del-cable-de-placa-identificativa-de-grillete.pdf#_ga=2.159486264.487734605.1613661909-824531276.1613661909

- ARCING WHEN INSERTING A METALLIC GUIDE INTO A WIND TURBINE TRANSFORMER ENCLOSURE: https://mediacdn.acciona.com/media/lssnkqb4/arco-electrico-introducir-guia-metalica-en-recinto-transformador-aerogenerador.pdf#_ga=2.188397997.487734605.1613661909-824531276.1613661909

- BRAKE DISC ENTRAPMENT: https://mediacdn.acciona.com/media/kosnw2lp/atrapamiento-en-disco-de-freno.pdf#_ga=2.79469841.487734605.1613661909-824531276.1613661909

Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Commission Implementing Regulation (EU) 2019/947 — Issue 1, Amendment 1'. Methodology of risk assessment of operations using drones (according to the regulations currently in force in the EU).

ACS. The prevention of occupational risks is one of the strategic pillars of all ACS Group companies. Each of these companies and the Group in general are committed to achieving the most demanding standards in this area, and thus becoming a benchmark in the protection of the health and safety not only of its employees, but also of its suppliers, contractors and collaborating companies.

The ACS Group's ultimate objective is to implement a culture of prevention which enables it to achieve zero accident rate. Compliance with this objective is increasingly closer thanks to the work of the prevention services and the commitment of employees, suppliers, contractors and collaborating companies.

Although each company in the group is managed independently, most of them have common principles for managing the health and safety of their workers:

Compliance with current regulations on occupational risk prevention and other voluntarily subscribed requirements.

Integration of preventive action in all activities and hierarchical levels, through proper planning and implementation.

Adoption of measures beyond regulation to ensure the protection and well-being of employees.

Application of the principle of continuous improvement of the system. And the extension of its principles and the participation of workers through training and information.

Investment in personnel qualification and application of technological innovations for accident prevention.

Development of measures to protect the safety of third parties on company premises.

The vast majority of the Group's companies have a specific function and a health and safety management system to comply with the above action plans and priorities.

In the following links we can see their security statistics:

https://www.grupoacs.com/ficheros_editor/File/05_responsabilidad_corporativa/00%20PDFS/6.3.%20Seguridad%20y%20Salud.pdf

https://www.grupoacs.com/ficheros_editor/File/05_responsabilidad_corporativa/03_Seguridad/Indicadores%20SyS.pdf

ACS Group also usually has security plans as we can see in the following link:

COMPROMISOS	Objetivo 2020	Evolución indicadores					
		Indicador	Año base 2015	2016	2017	2018	2019
Seguridad y Salud							
Reducción de los índices de accidentalidad en empleados propios	Aumentar las certificaciones de empleados en Seguridad y Salud en el trabajo	Porcentaje del total de empleados cubiertos por la certificaciónOHSAS18001(Seguridad y Salud en el Trabajo)	83%	85%	88%	90%	91%
	Incrementar la formación de los empleados en temas de seguridad y salud y que el 100% de los empleados hayan recibido en 2020 al menos un curso en seguridad y salud.	Porcentaje del total de empleados que han recibido un curso de seguridad y salud laboral que han recibido al menos un curso durante su carrera profesional	99,5%	99,5%	99,9%	99,70%	99,20%
		Inversión en seguridad y salud en el trabajo por empleado (euros/empleado)	754	838	784	796	778

AECOM – UK Construction

AECOM is the world's premier infrastructure consulting firm, partnering with client to solve the world's most complex challenges and build legacies for generations to come. AECOM work on the safety framework Prevent Detect and Resolve. With this framework AECOM achieved lowest total recordable incident rate (0.29) which is considered as the best in class within and beyond the industry. Similarly AECOM was able to a lowest number of Lost workday case rate performance (0.06).

For further reading please refer to :

https://aecom.com/content/wp-content/uploads/2019/06/AECOM-2018-Safety-Report-Section-v3.pdf

http://aecom.com/wp-content/uploads/documents/reports/AECOM_2019_Safety.pdf

https://aecom.com/about-aecom/safety/

AMAZON – USA

Amazon warehouse accidents and ill health increased by 50% in warehouses where robots and automation was adopted when compared to warehouses without robots. Among reasons: workers worked more as a result of the expected efficiency gains from the robots increasing accidents.

https://www.bbc.co.uk/news/technology-54355803

Balfour Beatty – UK Construction

Balfour Beatty plc is a British multinational infrastructure group based in the United Kingdom with capabilities in construction services, support services and infrastructure investments. Balfour Beatty works with Zero harm vision where no injury, ill health or environmental incident is caused by its work activities, and all operations are charged with constantly improving performance and sharing learning and best practice. The Zero Harm objective is supported by the Health, Safety, Environment and Sustainability (HSES) strategy. The strategy is based around 12 key areas, such as supply chain engagement and health and safety by design. Each of these key areas has associated three-year rolling action plans, designed to drive continual improvement.

For further readings please refer to :

https://www.balfourbeatty.com/investors/results-reports-and-presentations/

https://www.balfourbeatty.com/media/318461/balfour-beatty-annual-report-and-accounts-2019.pdf

https://www.kier.co.uk/about-us/safety-health-environment/

Bilfinger SE (2019)

Project "Road to Zero" supported by own software HSEQ (Health, Safety, Environment and Quality); The aim is to preventively protect workers, service providers and suppliers, to ensure smooth work processes and to constantly maintain and improve quality. Bilfinger SE has not reported any accidents in connection with robots.

https://www.bilfinger.com/fileadmin/corporate_webseite/investor_relations/berichterstattung/2019/Geschaeftsbericht_2019.pdf

Daimler (2019, worldwide):

Number of accidents: 2.957;

Incidence of accidents; (worldwide, number of work-related accidents that resulted in at least one lost day per 1 million hours of attendance): Rate 6,8

Number of employee deaths as a result of work-related accidents: 1

https://annualreport.daimler.com/2019/non-financial-report/employee-issues/occupational-health-and-safety

FORD FACTORY – USA

First human to be killed by an industrial robot was Robert Williams, an assembly worker at Ford's Flat Rock plant in Michigan USA.

https://wkfr.com/first-human-killed-by-a-robot/

TYPSA. TYPSA is an independent group of engineering, architecture and consulting services companies, leader in infrastructure, energy, environmental and urban solutions. It has more than 50 years of experience supporting institutional, public and private clients in the development of transportation, water, building, renewable energy and rural development projects, from conception to commissioning and operation.

They apply the highest technical, sustainability and integrity standards in our activity, which has allowed their participation in emblematic projects in the five continents and has contributed to maintain a long history of collaboration with Multilateral Financial Institutions.

The Group is growing through innovation, introducing the potential of BIM and virtual reality throughout the life cycle of buildings and infrastructure, with a circular economy approach, creating asset management platforms and developing new value engineering propositions.

Its annual report, accessible to all, can be found at:

https://www.typsa.com/informe-anual/

UBER - USA

Elaine Herzberg was killed by an Uber autonomous car in 2018 at approximately 40mph as she was crossing the road in Tempe, Arizona, USA.

https://www.bbc.co.uk/news/business-50312340

Volkswagen (VW) in Baunatal

There was last one (fatal) robot accident in 2015. A 29-year-old man was accused of having started a programme sequence of the robot system for a test in which the robot arm moved at high speed. The employee did this without first checking whether his colleague was still in the machine's work cell, i.e. in the danger zone.

The colleague was caught by the robot arm and pressed against a work table. According to a VW spokesperson after the accident, the young man's chest was crushed. He died a short time later as a result of his injuries.