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Work Safety in Shipyard Workshops: an Application to a Case Study

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***Abstract*— The proposed paper deals with the issue of safety on working sites, in particular the application of an innovative system to a selected case study. In some cases, safeguard can be implemented to give more guarantees to workers, by means of ICT systems. We examined the case of a shipyard, where risk conditions are particularly related to suspended loads, with the idea of expanding successively the proposed safety system to construction buildings sites. With regard to suspended loads, it was decided to integrate the risk assessment with appropriate innovative prevention measures that gave rise to the design of a proactive safety system. The first step was to circumscribe an area of study where there was high interference between suspended loads and workers. Then an analysis on the current used products was carried out and the most suitable technology was chosen. UWB (Ultra-Wide Band) allows creating a system that does not create interference with metallic materials, it can be used indoor and has a range of action that can reach even 50 meters of extension. It has economically low commercial solutions and has open-source software for data processing. The Localino® system produced by Heuel & Löher GmbH & Co. has been adapted to the needs of this monitoring and applied in the chosen site, with economic observations, too. The paper aims to illustrate this study.**

Keywords*— *safety, working sites, interferences, UWB

I. INTRODUCTION

The issue of smart management of safety in workplaces is widely debated and tackled both in the academic and in the industrial field, in order to reduce the overall accident situation, of which social and health costs remain relevant. The International Labour Organization (ILO) estimated an economic cost of accidents and occupational diseases in the working places between 1.8% and 6% of the total gross domestic product (GDP), with an average of 4% [1]. The data collected as at 31 December of each year show a national increase in 2022 compared to 2021 both in cases that occurred at work, which went from 474,847 in 2021 to 607,806 in 2022 (+28.0%). The alarming data of deaths at work, which report INAIL statistics, are a source of interest for the development of safety systems with technological support. Many experiences have been made in the development of tools and methods for the improvement of working conditions in the workplace [2, 3]. HSE International has patented a pair of glasses that allow the onshore operator to identify the area of influence of an excavator during excavation activities. At the same time, other multinational companies in the field, Google and Microsoft in the front line, have made substantial investments for the development of "augmented reality" glasses [4]. The interest has also been extended towards the development of smart clothing for particularly disadvantaged workplaces, such as construction sites (heated jackets allowing the operator to keep warm by means of reduced and lightweight system; jackets equipped with internal cooling system to reduce discomfort in conditions of high external temperatures, etc.). As part of the various problems and complexities of safety management, the focus of this work is on workplaces where the risk related to suspended loads by means of overhead crane is consistent, such as construction materials [5, 6, 7, 8] and waste treatment [9, 10] sectors. The meaning of "suspended load" is broad and refers, in a comprehensive manner, to any element, placed in the air or retained or anchored in suspension or supported at altitude or mechanically moved, by means of cranes, winches, overhead cranes, work platforms. At the international level, the OSHA 1926.753 standard deals with the problem of suspended loads in the workplace and describe the rules of good practice for the safe execution of workings around a suspended load [11]. The interference between suspended loads and crane operators in the area of influence has been the subject of careful evaluation and resolution through a system of automatic alarms generated. The present study concerns, in particular, a shipyard-workshop with overhead crane and focuses on the choice of the most suitable smart technology [12] for objects locating (workers and loads) within an indoor workplace [13] and the analysis of the interferences generated by the constant tracking of localization systems through the support of a software.

The construction, maintenance and repair of ships are part of the largest set of manufacturing activities and the statistics report in the period 2000-2005 a number of indemnified accidents equal to 16,706, with an annual average of about 2,800 accidents per year, and a number of deaths equal to 12, with an average of 2 per year. In terms of type of accident, the statistics say that over 16 thousand accidents, about 3 thousand (18%) occurred due to passive action by the operator, which is hit, overwhelmed or crushed by a load and/or by a work equipment [14]. This process leads to the generation of alarms that are automatically transmitted by an operations center to workers, who, after being warned of the risk condition, are put in a safe condition.

The purpose of this study is to design a useful and reliable alarm system related to suspended loads movements in order

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to support to the management of safety in the workplace [15], in this case in the shipyard workshop, so as to facilitate the tasks of safety persons in charge and introduce new procedures, such as to make the control tools (Risk assessment document and interference risk assessment document) more effective. An important point of this system is the type of data transmission technology. Among all the technologies, Ultra-Wide Band (UWB) was chosen because it is more suitable with regards to the characteristics and constraints of the case study area, a shipyard workshop, within it the handling of suspended loads is very frequent, as evidenced by the presence of several cranes and/or ship cranes. [16, 17].

II. TECHNOLOGIES FOR MONITORING IN WORKPLACE

Through the processing and communication of information by digital means, ICT allows smart monitoring in the workplace and improves the conditions of safety at work [18, 19]. Its use makes significant improvements also to work activities through the reduction of time and costs for production control, management and maintenance costs, defects in delivery and accidents as well as increase in productivity. The main technological systems used today to monitor materials handling into workplaces and the identification of workers' accesses are: AIDC (Automatic Identification and Data Collection) and RTLS (Real-Time Location System). The technical infrastructure is similar and consists of tags (printed circuit board - pcb - applied to workers and loads to be moved), anchors (pcb to which the tags communicate their position permanently placed within the area to be monitored with the task of transmitting data to the server) and software, for the detection of interference. AIDC and RTLS differ in the way data is read and transferred (passive or active transmission). While for AIDC systems a specific equipment is required for reading the tags, for RTLS systems, being a real-time system, it is not necessary that to be identified the object must pass from a fixed detection system or it must be scanned by portable equipment [20]. Every object with a tag can be localized communicating directly with the anchors and consequently with the server. The technology chosen for the case study is the Ultra-Wide Band (UWB) [21] which is part of the RTLS systems. It is a wide bandwidth communication that uses radiofrequency pulses of extremely reduced duration. The impulses are very short and therefore occupy a very wide spectrum, with the consequence of a high immunity to interference to the effects of multipath, due to the reflection of the radio wave on the obstacles, combined with a high capacity of penetration through the walls. This is why it is suitable for indoor environments.

III. MATERIALS AND METHODS

A. *The case study: a shipyard workshop*

The design of this system is aimed at integrating prevention and technology. The basic design idea proposes to alert individually the workers in an appropriate way to the workplace, particularly, where the main activities are carpentry, welding and grinding, and especially when they operate under poor visibility and in the presence of loud noises [22]. The alarm system concerns a small device, wearable by the worker, programmable, wireless and equipped with colored LEDs. This device (tag) must constantly communicate with an operations center that serves as technical support to the head of the prevention and protection service. Among various types of workplaces, the shipyard is distinguished by high frequency of load handling by means of overhead cranes. The selected area of interest of is the shipyard workshop, that is characterized by continuous handling of loads and it is divided into two functional areas: the one dedicated to the assembly of sheets and beams (pre-assembly and prefabrication phase), the other dedicated to the realization of blocks (assembly phase). The first one is divided into two lines, on the one hand the simple profiles are realized, on the other the curved ones, being 3600 square meters wide with a pedestrian path that crosses it in the middle and has three 60 tons overhead cranes. The second one is organized in a 2660 square meters single area, with three 10-tons capacity overhead cranes. Along the internal perimeter of the workshop, there are other pedestrian routes. The workshop is 32.5 m height and the overhead cranes are installed at a height of 21 m above the ground. The workshop structure is composed of 40 m wide and 3 m height roof trusses. The pedestrian path is 1.5 m wide. There is also a toilet area and an office area. The main load handling maneuvers were investigated and various cases of interference were identified between the area of influence of the suspended load with the pedestrian paths and the presence of workers below. Four main cases were identified. "Case 1" concerns the interference between load oscillation and the underlying ship block within which workers operate. "Case 2" concerns the interference between load oscillation and the entry into the workshop of workers, heavy and light vehicles. "Case 3" concerns the interference between the load oscillation and the center line pedestrian path located in the prefabrication area. Finally, "Case 4" concerns the interference between the oscillation of two neighboring loads. In Fig. 1, among all the projections, the red ellipses represent the most dangerous oscillations of the suspended load, due to the possible presence of workers below. The oscillation of the load was represented by an ellipse because the load, in addition to having its own oscillation due to the lifting, undergoes a displacement along the axis of the overhead crane and along the longitudinal direction of the workshop.

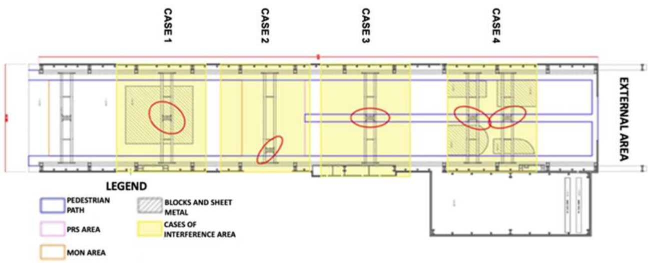

Fig. 1. The analysed four case studies of interferences.

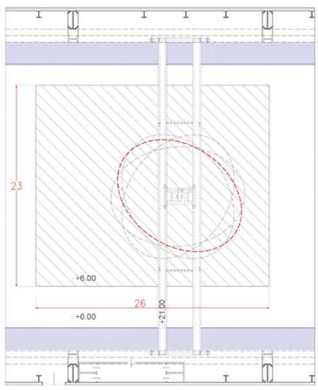

Fig. 2. Suspended load and operations on the naval block.

The “Case 1” was deeply focused (Fig. 2), as it is the most dangerous because of the constraints imposed by the area and the type of work (metal carpentry, welding and grinding made within tight spaces), due to the interference between the oscillation of the load and the underlying naval block. The net rectangle represents the average size of a naval block (23x26 m), on which several workers (carpenters, welders and grinders) operate. The overhead crane has 10 tons payload.

B. The chosen monitoring technology

The choice of technology to be used in this case study is based on the analysis of the technological systems on the market. Recognizing the most appropriate technology means analyzing the following factors:

- figures of the case study area (difference in technological choice between indoor and outdoor environments);
- maximum distance between tags and anchors to determine the technology that can support this range of communication;
- technological system and the environment interference;
- choice of active or passive localization system;
- accuracy of tag localization;
- system and software’s costs of production and installation;
- availability on the market.

The constraints in a naval workshop are:

- indoor area;
- presence of metallic material (workshop structure and naval pieces);
- high distances between tags and anchors: it was decided to place the tags on the workers through a wristband and on the hoist blocks of the overhead cranes, the anchors on the structure of the workshop. Being a workshop with a large surface, few anchors, at least 50 m range of action covered, were used;
- need to reduce the size of the tags: carrying out welding and carpentry work, often in cramped environments and with a lack of light, the visual field of workers is very low. The tag, therefore, must be ergonomic, thus not hindering the workers and easily visible due to the working conditions;
- need to firmly fix the anchors: having to place these ones directly on the structure of the workshop (metal structure), for convenience, and to reduce the application time of the system, the anchors’ bases are equipped with a magnetic system (magnet), in such a way as to be easily placed;
- low costs: the costs of monitoring systems on the market are high. In an environment where technological safety systems can make the difference, it is right to encourage the use of such systems by finding economic, but effective solutions.

In order to complain the requirements, constrains and considerations above reported, a technology adopting the UWB technology system [23] was chosen, and in particular, a commercial system known as Localino® [24] was chosen. It is a configured system for the localization of people and objects and is one of the cheapest compared to those on the market because the basic software is open source and the devices are easily and quickly available online. The basic kit “Localino v1.3 w/o TRX” is composed of:

- Localino® 1.3 PCB (Printed Circuit Board): circuit printed on an Arduino® board and makes it possible to operate as a localization tag or as an anchor for detecting and transmitting information from tags (Fig. 3);
- Atmel ATmega 328p microcontroller: electronic device integrated on a single electronic circuit. It is used for embedded systems or specific digital control applications;
- Welded Surface Mount Device (SMD) components: electronic devices designed to be mounted on the PCB;
- Descriptions and links for using the software.

The Localino® System is low consumption, especially in resting mode. Its PCB is universal and the boards can be used both as tags and anchors. Its dimensions are reduced (27 mm x 44 mm) and is composed of 3 LEDs, one of which can be used to signal the low battery (see Fig. 3).

Fig. 3. Localino® 1.3 pcb.

IV. Results and Discussions

The calculation of the distances was arranged on the base of the dimensions of the naval workshop, in order to identify tags and anchors positions, within the communication network. In the case reported, six anchors were located for data transmission within the workshop, about 200,000 m^3, plus an additional anchor to cover the distance between the workshop, where data is transmitted between workers and suspended loads, and the external office, where the server is located. The number of tags depends on the number of workers within the area. The anchors are fixed thanks to a magnetic system with adhesive magnet on the metal structure of the workshop, the tags are put inside the wrist bands. Cost analysis for construction of this monitoring infrastructure shows a total amount lower than € 5,000. The prefabrication and assembly naval workshop, chosen for its specific activities and risks related to suspended loads, covers an area of 42 m x 220 m. Each anchor placed inside the workshop is strategically located, according to its 50 m maximum range of action and, thus from anywhere, it is possible to pick up the information transmitted by the tags (Fig. 4). Anchors and tags are nothing more than similar printed circuit boards programmed with different functions, so the range limit does not vary both for reading and for communicating information. Once the anchors are placed, it is necessary to define a communication scheme between the tags and the anchors. The arrangement of the anchors is such that two anchors can pick up the same tag, if this is located within the intersection area of the circumferences, with the center in the anchor and 50 m radius.

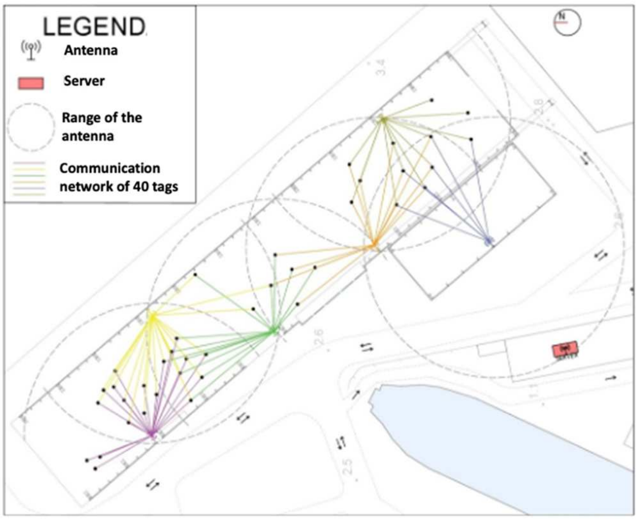

Fig. 4. Anchors disposition inside the naval workshop.

Tags constantly communicate with anchors even if no suspended loads are being handled. This communication is used to locate the worker authorized to access these areas, tracing their movements and allowing the software to draw, in a model space in the Autocad® interface, the routes in real-time, intersecting them with those of the suspended loads. The communication between tags and anchors can be mono or bidirectional as with an integrated Localino® system it's possible to choose how the server should communicate with the tags to send the alarm signals. If the anchors receive only the data sent by the tags, then the communication is monodirectional and the system can be integrated with a direct communication between server and tags (Wireless); if, on the other hand, the communication between tags and anchors is both incoming and outgoing, then it is a bidirectional communication and the information from the server passes first from the anchors and then arrives at the tags. If the anchor is away from the server, information travels from anchor to anchor (hop to hop system) to reach its destination. The operations center consists of a work station, endowed with Localino® PCB (working as an anchor) with possible repeater unit if there is a need to amplify the reception signal. The basic Localino® system stops at the localization and graphical representation of the movements made by the tags. For the recognition of the intersection and the subsequent generation of alarms, it is necessary to integrate this system through the programming and writing of a code on the basic software. The Localino® PCB is endowed with a LED that warns (through an intermittent yellow light signal) when it is about to drain the battery, but two other LEDs can be mounted, which, if properly programmed, can indicate with a blue light, if the overhead crane has started operating and with a red light, if a load is moving. This is possible as on the hoist blocks (or on the overhead crane itself) a tag can be applied that constantly sends information about its localization; as soon as the software detects the movement of this tag, it sends the signal to the workers who will see on proper board the blue LED lights up. The loads on the ground, before moving, must be tagged to activate communication with the monitoring system. After the software recognizes the tag placed on the load, the interconnection process is activated with the neighboring tags. In this way the Localino® system is organized, the communication mode of the alarms is decided. The integrated system cannot only generate light signals on workers' tags to alert the danger, but it can also trigger an alert SMS communication to the RSPP, the site manager and the foreman and to the entire company organization in charge of monitoring safety at work. Communication between tags, anchors and server occurs constantly and simultaneously. However, for clarity's sake, the process has been divided into elementary diagrams shown below. To represent such phases, a workshop portion of 40 m x 40 m was considered, showing the pedestrian paths adjacent to the perimeter walls (gray screen), the secondary entrance located on the south-west side of the workshop, a 20 tons overhead crane, a fixed anchor (magenta) positioned at +0.00, the PC representing the server outside the workshop. Fig. 5 shows the condition in which the overhead crane and the load start to move. The orange dots represent the tags applied to the load, they must be two and placed at the lower ends, in the case of flat sheet, or at the opposite ends of the lower diagonal, if metallic block that develops in the three dimensions. The load starts from ground while the overhead crane is at an altitude of +20.00 m. The dotted lines indicate the route taken by the workers' tags and their direction. Although the overhead crane and the load are stationary, the workers' and load's tags constantly communicate with the nearest anchor to send information about their localization to the server. The localization of the tags, therefore, takes place regardless of the movement of the load and allows the software to graphically represent the objects' movements. The anchor sends information just received from the tags to the server. The server, through the software, detects possible interferences and in this condition of stationary load, it detects no interference, consequently not sending warning/alarm signals and the workers' tag remain off, thus no LED on the board is on. This is the moment when the load has already been hooked and is lifted without being moved. This involves an oscillation of the load whose projection on the plane describes an ellipsoidal shape indicated by a dashed orange line. The load share increases up to +12.00 m.

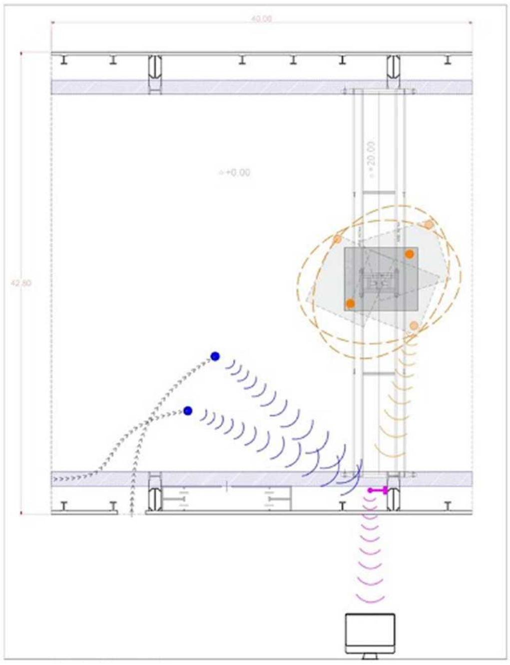

Fig. 5. Load in phase of lifting.

Fig. 5 shows the LEDs on the workers' tags are blue. This means that both types of tags (those related to workers and those placed on the load) are communicating with the server through the anchor and the software has detected a new situation that modifies the previous one. This involves transmitting a warning signal to neighboring tags. The warning consists of lighting the blue LED on the worker's Localino® PCB. This situation that cannot be properly defined as dangerous, but it is useful to send workers a warning signal that alerts them to the beginning of a movement. It represents the situation in which the overhead crane is moving and the load moves both perpendicularly and parallel to the axis of the overhead crane, due to its trolley. This is the moment in which the load must be moved from a starting point to a final point of the workshop. It shows, in transparency, the initial position of the overhead crane, which, after a few minutes from the start of the movement, is in the final position at the center of the image. As in the previous phase, the load is located at +12.00 m and continues to oscillate describing ellipsoidal figures in its projection. All workers' tags within the area of influence described by the suspended load give rise to interference. In this phase, the workers' tags continue to be represented in blue, but one of the two tags was intercepted by the load influence radius. Since the communication is constant, this incidence is immediately read by the server and recognized by the software as interference. This is the situation in which the worker enters the area of influence of the load and is in a dangerous situation. The risk of crushing can occur due to: breakage of the hoist drum, the wire ropes, the trolley or the engine brakes; exit of the trolley from the tracks; excessive weight of the load; excessive load oscillation with consequent unhooking; no correspondence of the driving commands sent by the radio control. Once the communication is received and the interference detected, the server sends an alarm signal to the workers' tags, consisting of lighting a red LED on the Localino® PCB. Being placed inside a wrist band and protected by a layer of transparent plastic, it is easily visible to the worker.

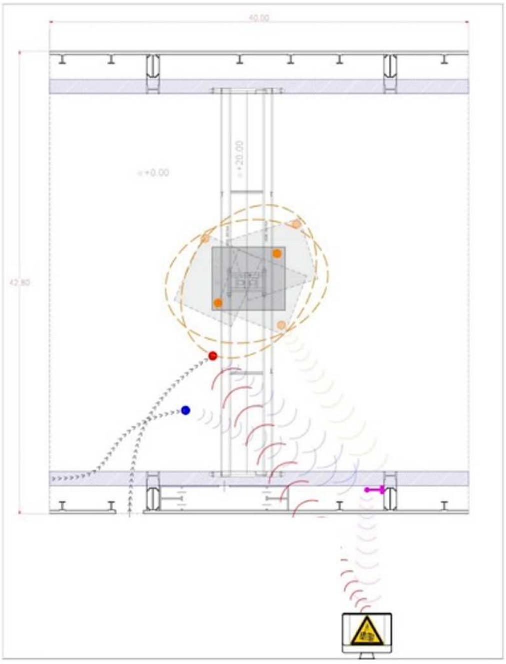

Fig. 6. The load-worker interference.

In Fig. 6, two tags are represented, one blue and one red. The first one has received a warning signal to move the load, but it is far enough away from not triggering the alarm. The second one, which is blue when the load starts moving, turns red in this phase, as the server generated the alarm due to the interference and transmitted it to the tag, thus warning the worker of the danger. The worker, who has been warned of the danger, signaled by the lighting up of the red LED on the tag, have to move away from the place where the alarm was generated. Once the adequate distance has been reached, the software, not reading danger situations, deactivates the red alarm, but if the overhead crane is in action, the blue LED will not be turned off.

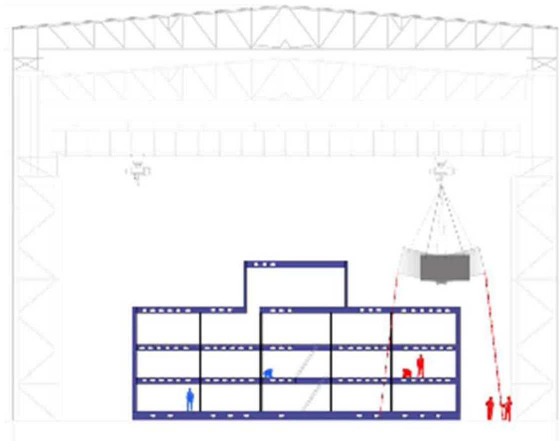

Fig. 7. Cross-section of a naval block. Red workers inside the interference area are in danger, blue ones are in safety area.

Fig. 7 shows the condition of a sheet that must be moved from one side to another of a naval block. The load oscillates and creates an area of interference between the dotted red lines. Workers entering this area are marked in red and may be subject to crushing.

V. Conclusions

Safety in the workplace is an important and current topic. Despite the good regulatory framework in force and the efforts underway on the controls side, the index of accidents at work is still very high, as those mortal are still unacceptable. The application of the law is often partially disregarded, raising the level of risk in the workplace, already intrinsically dangerous. A contribution to worker safety can be given by an ICT-based system, through which information can be managed proactively, in order to prevent critical risk situations. The present study has elaborated the project of a proactive system aimed at improving safety in workshops equipped with high-risk overhead cranes. The technology chosen for this design application is the UWB able to adapt to all the constraints imposed by the workplace. The high cost of many UWB systems on the market led to individual devices supported by an open-source software. Localino® is the most suitable system from a technological point of view, due to the versatility of the boards in use as they can be used simultaneously as tags and as fixed anchors. The monitoring project was designed to solve the spatial interferences created by the movement of suspended loads on the underlying work areas, in order to improve the prevention and safety system. The difficulty of managing safety during load handling has led to the creation of a system that detects, through the design of a network of sensors (tags and anchors), the presence of workers below suspended loads. Workers and loads are therefore included in a UWB technological system. The anchors are positioned in fixed points inside the controlled space, the tags, instead, are placed on the loads to be moved (by adhesive magnets) and on the workers (through a wrist band). The innovation of the project stands on the use of these devices to relate each other to generate alarms in case of interference between suspended load and workers. The system operates by actively localizing loads and workers tags, without manual reading. Moreover, thanks to the Autocad® graphical interface, drawing the path made by the tags, it was decided to integrate the Localino® system as the software could read the intersections between the paths of the workers and the projection of the moving load. This integration includes sending the alarms to the devices, after the software has identified the danger. The system can also be expanded to the handling of loads through construction cranes and also applied to other types of construction sites. The future development of the study consists in creating prototypes of this system, varying composition and size, to be applied in shipyards with high frequency of handling loads.

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REFERENCES

[1] J. Takala,, P. Hämäläinen., K.L. Saarela, L.Y. Yun, K. Manickam, T.W. Jin, P. Heng, K. Tjong, L.G. Kheng, S. Lim, G.S. Lin, "Global estimates of the burden of injury and illness at work in 2012", J Occup Environ Hyg 11(5) 326-37, 2014. https://doi.org/10.1080/15459624.2013.863131.

[2] A. Modenese, F. Bisegna, M. Borra, C. Grandi, F. Gugliermetti, A. Militello, F. Gobba F, "Outdoor work and solar radiation exposure: Evaluation method for epidemiological studies [Praca na wolnym powietrzu a narażenie na promieniowanie słoneczne – Metoda oceny do stosowania w badaniach epidemiologicznych]", Medycyna Pracy, 67 (5), pp. 577 – 587, 2016. DOI: 10.13075/mp.5893.00461.

[3] M. La Gennusa, R. Macaluso, M. Mosca, G. Scaccianoce, F. Massaro, L. Cirrincione, "An experimental study on relationship between LED lamp characteristics and non image-forming", Proceedings of the 17th EEEIC / I and CPS Europe, 2017, art. no. 7977546. DOI: 10.1109/EEEIC.2017.7977546.

[4] M. Grabowski, A. Rowen, J.P. Rancy, "Evaluation of wearable immersive augmented reality technology in safety critical systems", Safety Sci 103, 23-32, 2018. https://doi.org/10.1016/jssci.2017.11.013.

[5] M. La Gennusa, P. Llorach-Massana, J.I. Montero, F.J. Peña, J. Rieradevall, P. Ferrante, G. Scaccianoce, G. Sorrentino, "Composite building materials: Thermal and mechanical performances of samples realized with hay and natural resins", Sustainability (Switzerland), 9 (3), art. no. 373, 2017. DOI: 10.3390/su9030373.

[6] C. Capitano, L. Cirrincione, G. Peri, G. Rizzo, G. Scaccianoce, "A simplified method for the indirect evaluation of the "embodied pollution" of natural stones (marble) working chain to be applied for achieving the Ecolabel brand of the product", J. Clean. Prod., 362, art. no. 132576, 2022. DOI: 10.1016/j.jclepro.2022.132576.

[7] G. Rizzo, L. Cirrincione, M. La Gennusa, G. Peri, G. Scaccianoce, "Green Roofs' End of Life: A Literature Review". Energies, 16 (2), art. no. 596, 2023. DOI: 10.3390/en16020596.

[8] F. Galvagnini, A. Dorigato, F. Valentini, V. Fiore, M. La Gennusa, A. Pegoretti, "Multifunctional polyurethane foams with thermal energy storage/release capability", Journal of Thermal Analysis and Calorimetry, 2022, 147(1): 297-313. DOI: 10.1007/s10973-020-10367-w.

[9] L. Cirrincione, M. La Gennusa, G. Peri, G. Rizzo, G. Scaccianoce, "The Landfilling of Municipal Solid Waste and the Sustainability of the Related Transportation Activities", Sustainability, 14 (9), art. no. 5272, 2022. DOI: 10.3390/su14095272.

[10] G. Peri, G.R. Licciardi, N. Matera, D. Mazzeo, L. Cirrincione, G. Scaccianoce, "Disposal of green roofs: A contribution to identifying an "Allowed by legislation" end–of–life scenario and facilitating their environmental analysis", Build Environ, 226, art. no. 109739, 2022. DOI: 10.1016/j.buildenv.2022.109739.

[11] EU-OSHA. 2009. Occupational safety and health and economic performance in small and medium-sized enterprises: a review.: Office for Official Publications of the European Communities, Luxembourg, https://osha.europa.eu/en/publications/reports/TE-80-09-640-EN-.

[12] K.L. Ming, W. Bahr, S.C.H. Leung, "RFID in the warehouse, a literature analysis (1995-2010) of its applications, benefits, challenges and future trends", Int J Prod Econ 145(1), 409-430, 2013. https://doi.org/10.1016/j.ijpe.2013.05.006.

[13] G. Deak, K. Curran, J. Candell, "A survery of active and passive indoor localization systems", Comput. Commun. 35(16), 1939-1954, 2012. https://doi.org/10.1016/j.comcom.2012.06.004.

[14] INAIL, 2006. Dati infortuni Nazionali Cantieri Navali Flussi informativi INAIL-ISPESL. https://appsricercascientifica.inail.it/BuonePratiche/cantieristica/allegati/INFORTUNI%202002-2005.pdf (Mar. 1, 2019).

[15] I. Brilakis, M.W. Park, G. Jog, "Automated vision tracking of project related entities", Adv Eng Inform 25(4), 713-724, 2011. https://doi.org/10.1016/j.aei.2011.01.003.

[16] S. Hwang, "Ultra-wide band technology experiments for real-time prevention of tower crane collisions", Autom Constr 22, 545-553, 2012. https://doi.org/10.1016/j.autcon.2011.11.015.

[17] I.J. Shin, "Factors that affect safety of tower crane installation/dismantling in construction industry", Safety Sci 72, 379-390, 2015. https://doi.org/10.1016/jssci.2014.10.010.

[18] V. Ahuja, J. Yang, R. Shankar, "Study of ICT adoption for building project management in the Indian construction industry", Autom Constr 18(4), 415-423, 2009.

[19] A. Carbonari, A. Giretti, B. Naticchia, "A proactive system for real-time safety management in construction sites", Autom Constr 20(6), 686-698, 2011. https://doi.org/10.1016/j.autcon.2011.04.019.

[20] H. Li, G. Chan, J. Kwok, W. Wong, M. Skitmore, "Real-time locating system applications in costruction", Autom Constr 63, 37-47, 2016. https://doi.org/10.1016/j.autcon.2015.12.001.

[21] J. Balakrishnan, A. Batra, A. Dabak, "A multi-band OFDM System for UWB communication", Proc. IEEE Conference on Ultra Wideband Systems and Technologies, Reston, VA, USA, 2003.

[22] S. Chae, T. Yoshida, "Application of RFID technology to prevention of collision accident with heavy equipment", Autom Constr 19, 368-374, 2010. https://doi.org/10.1016/j.autcon.2009.12.008.

[23] T. Cheng, V. Mantripragada, J. Teizer, P.A. Vela, "Automated trajectory and path planning analysis based on ultra wideband data", J Comput Civ Eng 26(2), 151-160, 2012. https://doi.org/10.1061/(ASCE)CP.1943-5487.0000115.

[24] Heuel & Löher GmbH & Co. KG, 2019. https://www.localino.net.