

HEPHAESTUS—Highly Automated Physical Achievements and Performances Using Cable Robots Unique Systems [†]

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[†] Presented at the Sustainable Places 2018 (SP 2018), Aix-Les-Bains, France, 27–29 June 2018.

Published: 6 September 2018

Abstract: Highly automatEd PHysical Achievements and performancES using cable roboTs Unique Systems (HEPHAESTUS) is a Horizon 2020 EU-funded project carried out by 9 partners from across Europe that addresses novel concepts to introduce Robotics and Autonomous Systems use in construction, where this type of products is minor or almost non-existent. It focuses to give novel solutions to one of the most important fields in construction, the field related to the façades, and the works that need to be done when this part of a building is built or needs maintenance. HEPHAESTUS proposes new automatized ways to install these products, providing a whole solution not only highly industrialised in production but also in installation and maintenance.

Keywords: robotics; façades; autonomous systems; construction

1. Introduction

The HEPHAESTUS project explores the innovative use of robots and autonomous systems in construction, a field where the incidence of such technologies is minor to non-existent. The project aims to increase market readiness and acceptance of key developments in cable robots and curtain walls. Over the project lifetime it shall produce fundamental technical validation outside the lab, and deliver significant results such as:

- a prototype cable robot, designed to build, repair and maintain a building façade [1,2];
- a prototype curtain wall system, suitable for robot assembly; and
- a business plan for widespread commercial adoption.

HEPHAESTUS [3] focuses to give novel solutions to one of the most important parts of the construction sector which is the part related to the facades and the works that need to be done when this part of a building is built or needs maintenance. Furthermore, HEPHAESTUS project proposes a new automatized way to install these products providing at the end a whole solution not only highly industrialized in production but also in installation and maintenance. Finally, it has been conceived as a solution for accomplishing multiple tasks on vertical or inclined planes of the built and outdoor environment.

The HEPHAESTUS system is mainly based on a cable-driven robot and integrates several technologies that are already developed into a multiple job performer. Besides the cable-driven robot, there is a modular end-effector kit [4]. This modular end-effector kit is capable of hosting several tools. From one side, it can host task accomplishing tools, which can be different at each time where

HEPHAESTUS is applied. On the other side, it also hosts all the accessory devices that are necessary for the sensing and controlling the system.

It must be pointed out the multi-functionality of the system. Indeed, the HEPHAESTUS solution would be capable of accomplishing several tasks within the built environment, for instance, scanning of the building structure to obtain high accurate plans of its final state and the connection with the BIM (Building Information Modeling) model of the building, installation of prefabricated panels, painting, cleaning a curtain wall in a high-rise, replacing damaged elements, repair of cracks, maintenance of possible solar cells etc.

In conclusion, the project aims at automating the on-site execution or installation process for empowering and strengthening the construction sector in Europe and for positioning the European robotic industry as leader and reference in the huge and new growing market for the robotics.

2. Challenges

The main objective of HEPHAESTUS is to develop and test specific implementations and applications for cable driven robots in the outdoor built environment [5].

The construction sector still follows a mainly manual process and this leads to many problems:

- lack of safety,
- uncontrolled tasks, and
- low levels of accuracy.

In the case of the prefab wall manufacturing and installation, there is a gap regarding to the automation level. HEPHAESTUS aims to diminish this “automation gap” between the off-site manufacturing and on-site installation.

Figure 1 shows briefly how the system has been conceived by the Consortium

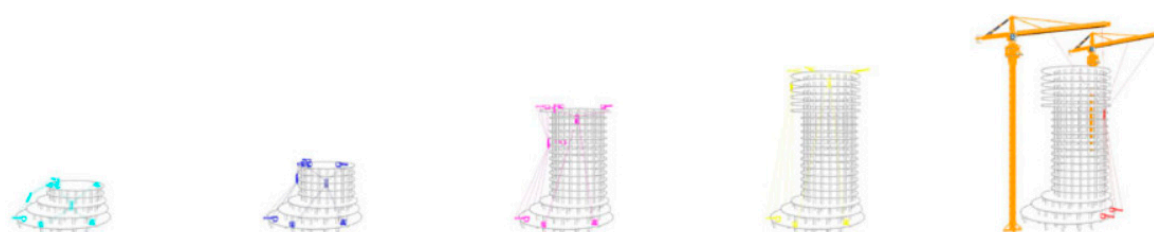


Figure 1. HEPHAESTUS system. Phases during installation of façades (picture developed by Iturralde et al.).

Besides, there is one main process that consists on using either tower or mobile crane that picks and uploads the façade panel whilst several operators inside the building, place and fix the panels onto previously anchored connector system. The overall installation is time-consuming, dangerous and expensive.

The main challenge to be addressed along the HEPHAESTUS project is to enable the installation of curtain wall modules by means of cable robots able to operate autonomously across a very large vertical workspace (up to buildings with 30–40 floors), in an outdoor environment and with active devices on-board the robot end-effector(s).

HEPHAESTUS project wants to develop a cost-effective, reliable, flexible, robust, efficient and ease of use highly automated Industrial Cable Robot System equipped with a modular end-effector kit with active devices onboard for outdoor built environment. The targeted system abilities are configurability, adaptability, interaction, motion, manipulation and perception abilities.

3. Impact

HEPHAESTUS envisages a techno-economical assessment of the robotics and autonomous system in the construction sector and includes a business plan of the proposed solution, a prototype of the cable-robot with all its components, a prototype of the curtain wall façade and a prototype of

building to check how all the systems developed works in real conditions. All the elements allow the companies of the project to include all the developments and expertise into a relevant industrial sector, such as construction, that allows a massive consumption of the solutions. Demonstration activities devoted to products manufacturing will address scalability and replicability of the proposed concepts to end up with a TRL 8 solution where a system is complete and qualified. The proposal brings relevant impacts at different levels, i.e., increasing the market-readiness of robotics applications including in terms of technological validation outside the laboratory. Professional robotics technology has already become a cornerstone in many manufacturing industries (e.g., automotive).

However, the application of robotics and autonomous systems (RAS) to the construction sector remains very limited. The successful translation of current technical capabilities in robotics to the construction industry would result in a massive market uptake, with very strong socio-economic impacts.

The European construction sector constitutes an immense market. It is the biggest industrial employer in the European Union, contributing around 9% of its GDP. It has an annual turnover of €1,200,000 million and a direct workforce of 14 million people.

The development of the cable-robot and the possibility to move across big distances with a high grade of accuracy, the possibility to scan and build 3D models of the surfaces close to the robot and the activities performed by the 2 end-effectors (drilling the slabs and installation of anchorages and the movement and anchorage of the curtain wall modules) will provide many other new market opportunities as well, ensuring replication of the processes to facilitate market penetration of the new solutions. The further development and the new market opportunities will shift from those developed in the project to new ones based on the same products with different characteristics, such as: (i) maintenance and cleaning of facades and big structures (bridges, in general civil structures); (ii) automatic positioning of the cover structure of ships and planes; (iii) maintenance and cleaning of ships (iv) movement of products across big warehouses—automatic warehouses; (v) movement of products/components in factories; (vi) maintenance of aircrafts; (vii) maintenance of green walls (vegetable pruning/trimming); etc.

The HEPHAESTUS system will bring a series of social impacts very important and to be highlighted hereinafter: (i) creation of new direct high level jobs in the field of façade installation and maintenance of buildings; (ii) Creation of direct jobs mostly linked to SME companies that work in robotics, sensors, cameras, etc. HEPHAESTUS project aims at promoting a new field of work for these companies opening the possibility to enter in one of the big markets in Europe. Moreover the implementation of an innovative approach for robotized installation and maintenance of envelopes in the building sector will create the need for new skilled workers with specialized competences through all the life cycle of the building; (iii) reducing the risk of accidents, the construction sector is mainly responsible of fatal occupational accidents, 22.2% in UE in 2012 and 20.5% in USA in 2014, where 40% of accidents are due to falls with electrocution (8.5%) and struck by object (8.4%) following far behind. With the use of the proposed innovation, the potential dangers of working at great heights are eradicated, and so the risk of accidents at the construction site would be drastically reduced.

From the climate change point of view and the environment impact, it is worth to point out that: (i) Energy efficiency: The speed and efficiency delivered by HEPHAESTUS, together with the associated reduction in machinery and craneage, would reduce energy use during both its construction and maintenance stages. This would result in a reduction in fuel costs (less machinery) and improved energy efficiency due the higher quality in the installation, the increased possibilities to include renewable sources in the envelope and the higher life cycle of the curtain wall (due to a better maintenance); (ii) Reduction in materials and waste on site: when promoting modular construction for curtain walls instead of stick solutions and traditional facades in line with the industrialized concept, a reduction is expected both in waste generation (30–60%) and in use of materials (15–25%), based on similar experiences on the construction industry.

The HEPHAESTUS system will bring very large cost saving installing curtain wall modules: up 60% if HEPHAESTUS system is in renting for each task and up 44% if it installed in the building for facades maintenance throughout its life cycle.

4. Conclusion

HEPHAESTUS addresses novel concepts to introduce robotics and autonomous systems use in the construction sector. HEPHAESTUS project focus to implement novel solutions [6] in one of the most important parts of the construction sector which is the one related to façades and the works that need to be done when this part of a building is built or need maintenance. Besides, HEPHAESTUS proposes a new automatized way to install these products providing at the end a whole solution not only highly industrialized in production but also in installation and maintenance. Hephaestus envisages a techno-economical assessment of the foreseen approaches and includes a business plan of the proposed demonstrator, a prototype of the cable-robot with all its components, a prototype of the curtain wall façade and a prototype of building to check how all the systems developed works in real conditions. Hephaestus brings relevant impacts at different levels, as:

- Increasing the market-readiness of robotics applications including in terms of technological validation outside the laboratory
- New market opportunities
- Lowering of market entry barriers of a business or regulatory nature and increasing industrial and commercial investment in Europe at a rate comparable with other global regions
- Contributing to the faster growth of competitive small and mid-scale robotics companies in Europe
- Social impacts including employment

Supplementary Material: Please visit the HEPHAESTUS website at <http://www.hephaestus-project.eu>.

Author Contributions: L.E., R.A., J.C. and the HEPHAESTUS consortium contributed to the content of this work, summarizing the work done during the project.

Funding: This project was funded by European Union's Horizon 2020 Research and Innovation Programme under grant No. 732513.

Acknowledgments: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 732513. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information. The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

Conflicts of Interest: The authors declare no conflict of interest.

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