Robotic Challenges in Construction for the First Open Call for ESMERA Experiments (ESMERA-FOCE)

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Expected duration:	9 months for experiments in Phase 1 (max 18 months for experiments advancing to Phase 2)
Total budget for the 1st Call:	€2,200,000 (maximum 16 experiments for the Phase 1 and maximum 8 experiments for the Phase 2). Maximum funding per proposal: €200,000 (€75,000 for the Phase 1, €125,000 for the Phase 2, including 25% indirect costs)
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Glossary/ Acronym Terms

ESMERA: European SMEs Robotics Application

SME: Small and Medium-sized enterprises form a specific target group for the experiments and the CCs in ESMERA. The term is used in the same way as defined by the EC (http://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/).

Experiment: An experiment is a small to medium sized scientific research and/or technology development project carried out by a team of at least one SME and potentially additional research institutions, robot manufacturers and robot and automation users, which typically lasts no longer than 9 months.

CC: A Competence Centre is a physical infrastructure supporting different user groups by providing state-of-the-art hardware, software components, and support in form of experienced staff.

RTD: Research and Technology Development.

BIM: Building Information Modelling

Robotic Challenges in Construction for the First Open Call of the ESMERA Experiments

The ESMERA project calls for contributions that propose solutions to two predefined real-life challenges in the construction area, involving but not limited to nearly autonomous robots or human-robot collaboration and demonstrate these in real-world scenarios. In the first challenge, we ask SMEs to develop a solution for a "**Heavy Tool Carrier in Construction Environments"** problem in the building area with "**ESMERA-C.1**" Challenge ID. The problem description, the desired robotic technology and the support from the Challenge Provider, MOSTOSTAL, are explained in Section 1.

For the second challenge in this area, we request from SMEs to find a solution to a "**Vegetation Management**" problem in the infrastructure and utilities area with "**ESMERA-C.2**" Challenge ID. The problem description, the desired robotic technology and the supports from the Challenge Provider, Network Rail, are explained in Section 2.

1. ESMERA-C.1 – Heavy Tool Carrier in Construction Environment

1.1. ESMERA-C.1 challenge description

Introduction

In construction, the working environment fluctuates often as the infrastructure or building construction progresses: new elements appear, others disappear, the infrastructure grows vertically, horizontally... The size of the facility can vary between hundreds to several thousands of square meters. Most of the activities are performed manually by workers, assisted by hand tools. In their day-to-day activity, workers have to move tools and other elements (such as material needed for construction, for instance sacks and drums) from one side to another using wheelbarrows, forklifts or cranes and manipulate heavy tools. These activities can be the source of ergonomic problems. Figure 1.1 is included for the sake of illustration, no corresponding to the reference construction environment that will be available for testing.

Figure 1.1. Working environment examples[1,2]

The current process

In general, most processes in this sector are carried out manually. Several tasks may be performed in different way, as some of the operations can be executed with the use of special devices for drilling

[1] The picture on the left is taken from https://enriquealario.com/ladrillo-o-pladur/#lightbox/0/
[2] The picture in the middle is taken from https://www.ulmaconstruction.es/es-es/encofrados/puntales-cimbras/puntales/ puntal-certificado-acero-ep

etc., Materials and devices on the construction site are transported using conventional wheelbarrows or forklifts or cranes.

Challenge scenario

In this call, we are looking for a system (mobile manipulator, a quadruped with an attached manipulator on it or any other configuration) which carries heavy materials (plaster sacs, wood or metallic parts, bricks, etc.), follows and helps workers to handle heavy tools used for different applications such as drilling holes or painting walls (the higher degree of autonomous execution of such operations will be positively evaluated).

General requirements

The performance metrics of the desired system depend on the type of the construction sides or the process, but it is expected that the robotic system should be capable to verify the following features:

1. ***Improvement in working conditions*****:** It is expected that the system will contribute to improve the current conditions in terms of the number of weights transferred and handled (25-50 kg to be transferred, 2.5-10 kg tool manipulation), the number of injuries, the accuracy of performed tasks.
2. ***Autonomy*****:** The platform needs to be energy autonomous to move from one place to another but, once at the final position, it can be assumed that there is external power supply available for tool manipulation and activation (and battery recharging if needed).
3. ***Adaptable to the changing environment*****:** The system should work in a flat terrain which has obstacles (such as pieces of wood, bricks (or broken bricks), small stones etc.). It is not mandatory, but it is a plus if the system can climb stairs or ramps inside the building where a crane cannot be used, to allow moving from one level to another in the building. The environment and the lighting conditions depend on the type of the construction and it is expected that the system is capable of to adapt to different conditions. It should be taken into account that dust and humidity are very common in construction environment which means the system should not be affected by their presence.
4. ***Sensing capabilities*****:** For the autonomous navigation and safety assurance, it is expected from the system to have sensing capabilities.
5. ***Helping the worker while performing the tasks*****:** It is expecting from the system to handle the tool (such as hammers, drillers) and using gravity compensation features so the worker runs the operation easily, focusing on the task and not in the payload of the tool. In the case of load transportation, the system has to be able to follow the worker at a predefined distance, although it is assumed that the load is placed on the platform manually by the worker.

Performance metrics

In addition to other metrics specified by the experiment consortium to demonstrate the efficiency/performance of the solution, the following metrics by the Challenge Provider will also be evaluated.

1. ***Dimensions*****:** The system must work inside buildings which limits their width to 80 cm since it needs to pass through doors. For transportation of goods, the system has to be able to carry sacks of 75 mm x 40 mm x 15 mm (approximate values). Tools considered in this challenge for collaborative tool manipulation are those that workers manipulate by hand (cutters, grinders, drill drivers, etc.).
2. ***Integration with Building Information Modelling (BIM)*****:** It is not mandatory, but it is a plus if the system can be integrated with BIM.

1.2. Support to the experiment

Support from the lead Competence Center

The TEKNIKER CC is responsible for the challenge and the currently available equipment list can be seen in our website. The replicated environment will be prepared by the TEKNIKER CC in their premises and will be available for the selected experiments to test/develop their solutions. Support by other CCs for development is also available for the experiment proposers.

Support from the Challenge Provider

The Challenge Provider will provide a facility for testing purposes and qualified personnel for the assessment.

2. ESMERA-C.2 – Vegetation Management

2.1. ESMERA-C.2 challenge description

Introduction

Millions of trees of different kinds together with smaller plants are growing along the railway and managing vegetation is hugely important for the safe running operation of railways. If it is not managed well, encroachment of vegetation and even fallen leaves may pose a risk to the safe running of the railway and cause delays or accidents. In the UK, incidents caused by vegetation can cost the railway upward of £100 million in 2017[3]. The management of the lineside principally deals with: i) the management of vegetation along the railway and within the boundary to reduce or avoid risk to the railway and ii) assuring that a boundary is provided to both satisfy legal requirements and prevent trespass or incursion. The system needs to work within current legislation and best practices regarding health and safety. Where herbicides are to be applied the system should comply with current legislation and guidance on their application.

Figure 2.1. Some views from the railways showing the vegetation

The current process

The current process is performed purely manually and the current inspection regime for lineside assets both is ineffective and inherently unsafe. Workers are expected to negotiate slopes, barriers, unstable ground, hidden hazards and poor lighting to carry out visual and tactile inspections.

Figure 2.2. The current process in vegetation management

The topography of the lineside can even prevent access altogether for inspection. Technology could supplement or replace the need for accessing such areas. Figure 2.3. shows how the threat of trees and other vegetation to the railway are evaluated.

[3] https://www.theguardian.com/uk-news/2018/may/01/tree-cutting-helps-the-trains-run-on-time-and-is-vital-for-safety

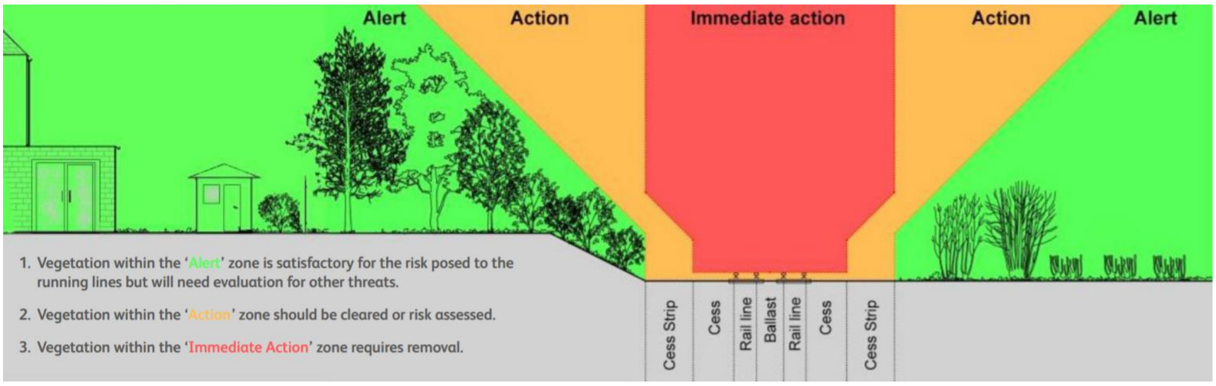

Figure 2.3. The evaluation the threat of trees and other vegetation to the railway[4]

Challenge scenario

In this call, we are looking for a robotic system that should be able to carry out a comprehensive survey to identify:

- The current stage of vegetation growth within the boundaries of the railway system,
- The state of the boundary structure to ensure it is structurally sound.

Additionally, it would be advantageous for any application of herbicides to be targeted so as to minimise runoff and environmental damage. The system should be easy to deploy and use with the minimum of operator intervention. The system should operate in most weathers and be capable of operating trackside, without impinging on train operations (this must be guaranteed).

General Requirements

The following list describes important requirements for the end user that will be evaluated positively for each proposal.

1. ***Operation environment:*** The system would need to operate on all areas of open rail system up to the railway boundary. The system should be able to work in all weather conditions including the possibility of working at night.
2. ***Mobility:*** The system should be easy to deploy and to use, and carried to the deployment site by road.

Performance metrics

The proposed solutions should be capable of verifying the following features defined by the Challenge Provider:

1. ***Speed of Operation:*** The system should be capable of inspecting the trackside area with at least the same speed as a human operative.
2. ***Operational time:*** Since there is no source of energy for the system, it should be energy autonomous. The system should be capable of continuous operation for periods up to 8 hours at a time.
3. ***Accuracy:*** The system should identify any structural problems with boundary structures and missing boundaries with at least 99% accuracy.
4. ***Reliability:*** The system should be able to correctly identify vegetation and selectively apply a sufficient dosage of herbicide to each plant where it is implemented.

[4] The picture is taken from https://cdn.networkrail.co.uk/wp-content/uploads/2018/05/Vegetation-Management-explained.pdf

The system should be easy to deploy and use, and mobile enough to be carried to the deployment site by road.

2.2. Support to the experiment

Support from the lead Competence Center

The TEKNIKER CC is responsible for the challenge and the currently available equipment list can be seen in our website. Support by other CCs for development is also available for the experiment proposers. Besides them, in case that the solution provider requests, the LMS CC and BOR (especially if the solution requires drones) can also offer expertise on this area.

Support from the Challenge Provider

The Challenge Provider provides photographs of typical trackside settings. They can also provide a facility for testing purposes and qualified personnel for the assessment.