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H2020 Project HERON

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Project HERON: scientific and technical content

SCOPE : HERON is among the projects funded by the EU under the H2020 program for road infrastructure maintenance. Within HERON's scope is the implementation of a road infrastructure plan,

CONTEXT : The Forever Open Road (FOR) concept has been developed, with its national declinations (R5G in France for example) by the association of European Road Research Laboratories (FEHRL). HERON answers the three concepts of FOR, namely the resilient, the automated and the adaptable road (www.foreveropenroad.eu). As outlined by FOR, HERON integrates existing technical components, including off-the-shelf technologies and outcomes from previous or ongoing research projects.

GOAL : The goal of HERON is to develop an integrated automated system capable of conducting various road maintenance and improvement tasks, such as crack sealing, pothole patching, asphalt rejuvenation, autonomous replacement of Removable Urban Pavement (RUP) elements, and road marking/painting. Thus, HERON is tasked with supporting both pre- and post-intervention phases, which involve automated and controlled visual inspections, as well as the placement and removal of traffic cones.

Use cases

Nowadays, the rapid and effective inspection, evaluation, maintenance and safe management of existing road infrastructures including highways and the overall road infrastructure network transport present a significant challenge for many operators and engineers.

The HERON system relies on enhanced intelligent control of a robotic vehicle (fig. 1), improved computer vision, Artificial Intelligence/Machine Learning methods, along with appropriate sensors, decision-making algorithms, and Augmented Reality (AR) components to carry out corrective and preventive maintenance tasks.

As a result, HERON enables a modular design of system operations, enhancing its versatility and adaptability to various transportation infrastructures. This approach helps in reducing fatal accidents, maintenance expenses, and traffic disruptions, thereby enhancing network capacity and efficiency.

By using advanced data from various sources like Unmanned Ground Vehicle (UGV) and Unmanned Aerial Vehicle (UAV) for surveillance, and established methods from existing research and industry, the automated system can handle emergency maintenance tasks when necessary. HERON is working on developing and validating a new robotic platform designed for these tasks to be done safely, quickly, reliably, and with flexibility (fig. 2).

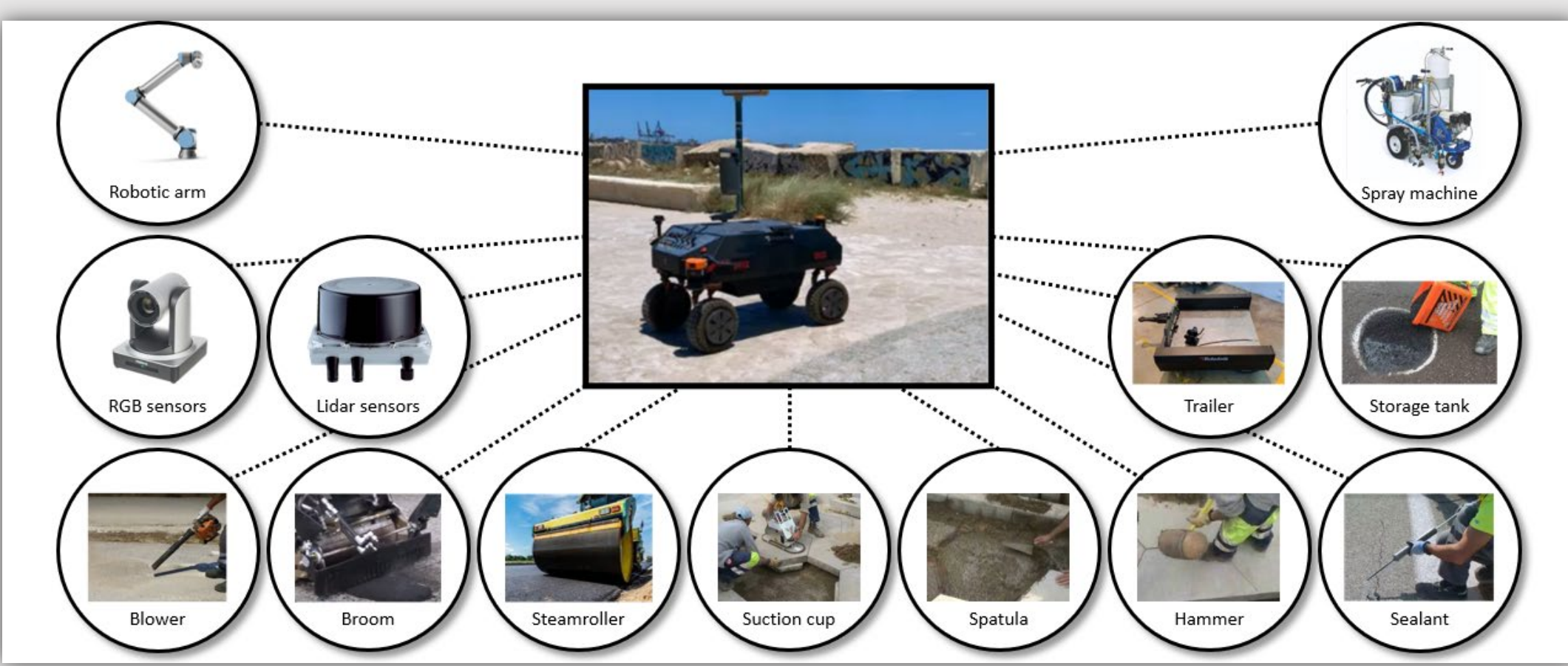


Figure 1 : From traditional tools to robotic sensors and actuators

The HERON system consists of:

- Autonomous ground robotic vehicle complemented by autonomous drones for coordination;
- Diverse robotic equipment, including sensors and actuators (tools for cutting and filling, placing and compacting surface materials, installing modular components, laser scanners for 3D mapping) embedded on the main vehicle;
- Installation of a sensing interface both to the robotic platform and within the infrastructure to enable enhanced monitoring (situational awareness) of structural, functional and road surface conditions, as well as markings;
- Control software linking the sensing interface with the robotic equipment for actuation;
- Augmented Reality (AR) visualization tools facilitating detailed observation of surface defects and marking during surveys by the robotic system;
- Implementation of Artificial Intelligence/AI-based toolkits serving a dual purpose: a) efficiently coordinating road maintenance/upgrading workflows, and b) intelligently processing distributed data from vehicle and infrastructure sensors to ensure safe operations without disrupting routine activities or traffic flows;
- Integration of all data into an advanced visualization user interface to support decision-making;
- Communication modules enabling Vehicle-to-Infrastructure/Everything data exchange for predictive maintenance and enhanced user safety.

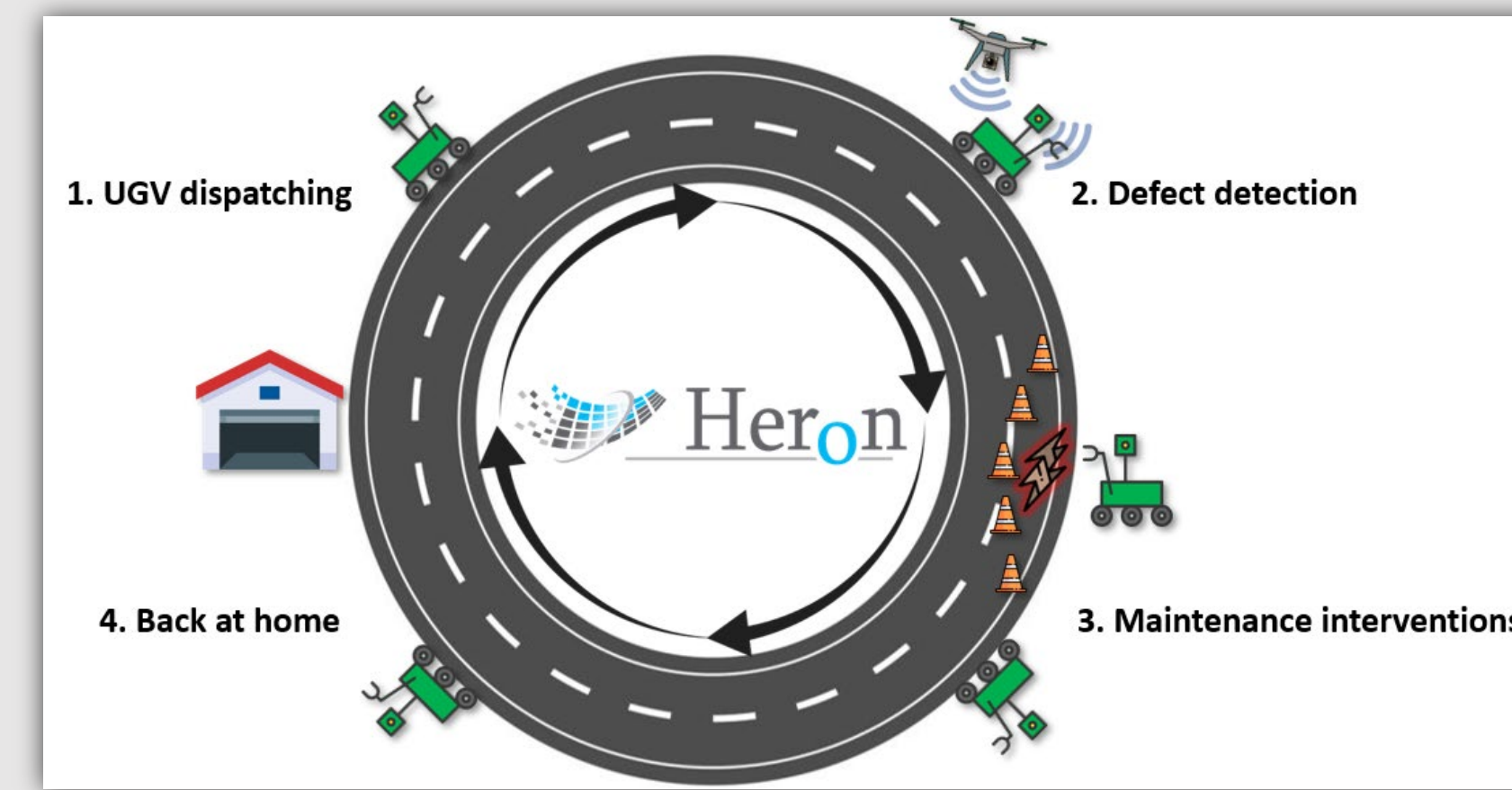


Figure 2 : HERON's concept

Conclusion

HERON proposes an unified automated system along with an independent ground robotic vehicle designed for maintaining road infrastructures complemented by autonomous drones for coordination with exchange infrastructure data to enhance user safety. An extensive database is currently being constructed to enhance potential anomaly detection performance. Deep learning detection algorithms are already showing promising results.

Transpolis and RUPs testing

Transpolis (France) is an 80-hectare testing facility established by a consortium of 5 entities, including Gustave Eiffel University, officially opened in 2019 (fig. 3). Primarily, it serves as a controlled environment for testing autonomous vehicles, thanks to several kilometers of roadways (notably 12 km in the "city area") and all reinforced concrete buildings. The facility is equipped with various types of Vehicle-to-Everything (V2X) and Vehicle-to-Infrastructure (V2I) communication capabilities, alongside camera surveillance.



Figure 3 : Aerial view of Transpolis site

In terms of telecommunications, Transpolis features over 320 km of optical fiber, providing access to an Ethernet network across most areas of the facility. An open LoRa network spans the whole proving ground, enabling the installation and use of a wide array of Internet of Things (IoT) sensors. Additionally, the site is covered by a 5G network coming from an antenna located centrally within the tracks. Energy needs are met by a private electrical distribution network, ensuring power supply throughout the facility, particularly in the "city area".

Transpolis serves as the proving ground for various use cases, including:

- Detection and repair of road markings;
- Detection and repair of cracks in reinforced concrete;
- Continuous V2I communication, between the vehicle and road side units.



Figure 4 : Installation of RUP test structure at Gustave Eiffel University

One of the current objectives is to enumerate from Deep Learning algorithms based on image captures:

- Hexagonal, half-edge and quarter slabs;
- Paving stones surrounding the structure.

The final objective is to identify potential structural anomalies of RUPs through multi-technique NDT methods on both the surface and subsurface:

- Gaps between the slabs;
- Differential settlements between the slabs;
- Spalling of the slabs;
- Rattling/flapping of the slabs.

In the frame of urban planning for the future city, the concept of Removable Urban Pavement (RUP) is studied, using hexagonal prefabricated concrete slabs. These removable slabs facilitate quick access to networks, enhance the longevity of road surface properties and are recyclable. Their prefabrication allows for the incorporation of additional integrated functions such as various textures, porous, noise-reducing or pollution-absorbing surface, as well as the integration of sensors, among others). Therefore, regular inspection of the RUPs for potential anomalies and timely repairs is of utmost importance

Two structural working of these RUP are possible:

- The independent slabs with an easy installation and removal. Large and heavy (700kg) to ensure flapping with elastomer seal at the connections. A site using independent RUPs is available in Saint-Aubin/France.
- The interconnected slabs with an easy installation and removal following a given path. Smaller and lighter (<300 kg) with sanded seal at the connections (fig. 4). Two sites equipped with interconnected slabs are available in Nantes/France : In city center a 12m x 7m site and at the pavement fatigue carousel at the Nantes campus of Gustave Eiffel University (2m x 8m site) (fig. 5).

Traditionally, the RUP slabs are non-porous, allowing for installation or removal using suction methods. However, recent advancements have introduced porous slabs to enhance structural durability. In such instances, manual arms equipped with clamps have been devised for handling these porous slabs.

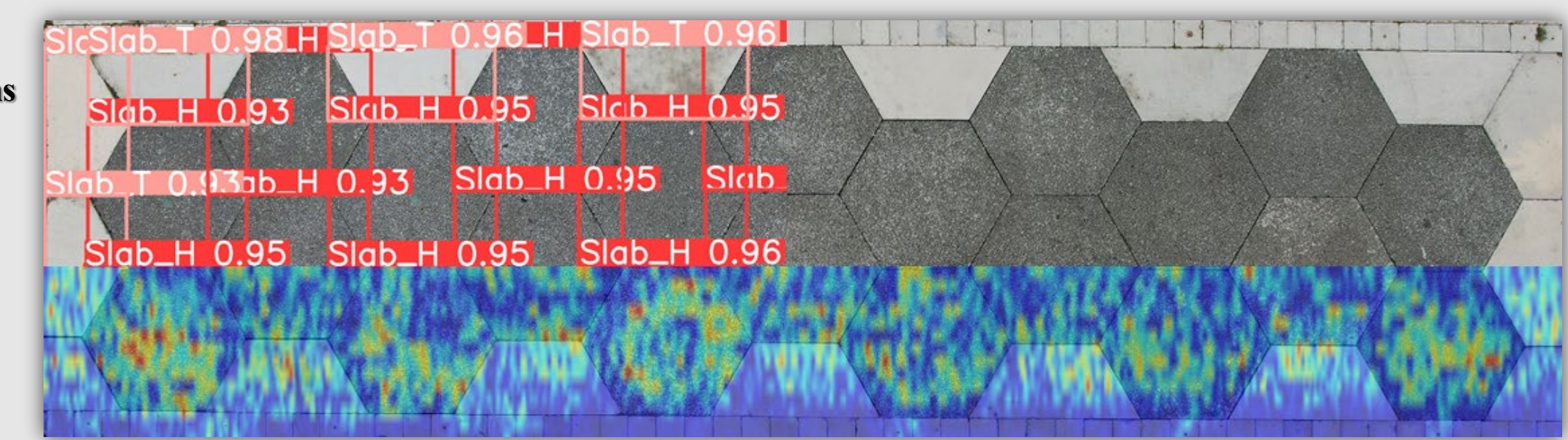


Figure 5 : Aerial view of Nantes Gustave Eiffel University RUPs test structure with slabs identification (deep learning method) and subsurface characterization by Ground Penetrating Radar (GPR)

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