Improved Robotic Platform to perform Maintenance and Upgrading Roadworks: The HERON Approach

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D9.1: Exploitation Strategy (version 1)

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Abbreviation List

Abbreviation	Definition
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
COP	Common Operational Picture
CUD	Chaussée Urbaine Démontable[1]
DF	Data Fusion
DL	Deep Learning
GDPR	General Data Protection Regulation
IMS	Incident Management System
KER	Key Exploitable Results
ML	Machine Learning
PoI	Point Of Interest
RI	Road Infrastructure
SLAM	Simultaneous Localisation and Mapping
TI	Transport Infrastructure
V2I/X	Vehicle-to-Infrastructure/-Everything
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UI	User Interface
WP	Work Package

[1] Demountable Urban Roadway

Executive Summary

Deliverable 9.1 “Exploitation Strategy (version 1)” provides the first version of the project Exploitation Strategy, which comprises the common strategy to exploit the HERON results (in individual and collective way) and to ensure that the results are taken up by relevant stakeholders. It stems from Task 9.1 “Exploitation and Business Plan – Development”, under Work Package 9 “Exploitation of Results, Standardization and Sustainability Activities”. D9.1 is written in an early stage of the project (M18) and, thus, most of the research outcomes have only been partially produced, tested, and validated. Consequently, the Exploitation Strategy proposed herein requires continuous updating and refinement throughout the project lifetime.

As a first step towards consolidating the exploitation potential of the HERON technologies, herein we give heed on the definition of the Individual Exploitation Plans of the consortium partners, by outlining the background knowledge and Intellectual Property (IP) assets that they will employ during HERON as well as the foreground that they will produce (especially interested in the exploitable foreground), while also defining a draft strategy on how they intend to exploit the project results on their own.

Subsequently, the deliverable deals with the identification and description of the HERON Key Exploitable Results (KERs), which may comprise either single sub-results produced by individual partners or the combined outcome of two or more sub-results. A total of six KERs are identified: (1) Middleware and Data Fusion (DF) services, (2) Computer Vision Detection System, (3) Robotics-based Inspection, (4) Incident Management System (IMS) and Decision Support System (DSS), (5) Augmented Reality (AR) application and AR Glasses, and (6) Integrated Road Infrastructure (RI) Monitoring System. For each KER, a preliminary exploitation plan is proposed by defining the leader of the KER (i.e., the partner responsible to commercialize/exploit the result) and other involved partners, as well as identifying the KER’s key stakeholders and competitors.

1 Introduction

1.1 Purpose of the document

The HERON Deliverable 9.1, namely "Exploitation Strategy (version 1)", introduces the first version of the project Exploitation Strategy, which comprises the common strategy to exploit the results (in individual and collective way) and to ensure that the results are taken up by relevant stakeholders during and after the project lifetime.

Exploitation is the utilisation of results for one of the following purposes: (a) further research activities other than those covered by the HERON project, (b) developing, creating, and marketing a product/process, (c) creating and providing a service, and (d) in standardisation activities. Making use of the results can take the form of patents, spin-offs, products, standards, services, open or copyleft licences, societal activities, and policy changes. The project partners can exploit the results themselves, or facilitate exploitation by others, e.g., through making results available under licences.

The purpose of this report is to provide the Individual Exploitation Plans of the HERON consortium partners, which is a critical first step to measure the exploitation potential of the project's research outcomes as well as to develop comprehensive roadmaps and business plans. Subsequently, the deliverable deals with the identification and description of the six HERON Key Exploitable Results (KERs), by identifying key beneficiaries, stakeholders, and competitors.

1.2 Intended audience

The targeted audience of the present document is the HERON consortium partners. This report delineates the partners' Individual Exploitation Plans (based on their received input), while it offers a preliminary investigation of the six KERs of the HERON project, which will be used as a basis by all the technical partners involved in Work Package (WP) 9 "Exploitation of Results, Standardization and Sustainability Activities" in order to perform the market analysis, business plan development, and roadmap definition.

1.3 Project Concept and Consortium

The HERON project aims to develop an integrated automated system to perform maintenance and upgrading works on Road/Transport Infrastructures (RIs/TIs), as well as supporting the pre/post-intervention phase including visual inspections and dispensing and removing traffic cones in an automated and controlled manner. To accomplish these goals, the system employs improved intelligent control of an autonomous robotised vehicle, improved Computer Vision (CV) and Artificial Intelligence/Machine Learning (AI/ML) techniques combined with proper sensors, decision-making algorithms, and Augmented Reality (AR) components to perform corrective and preventive maintenance and upgrading of roadworks. By using advanced data coming from various sources, including Vehicle-to-Infrastructure/-Everything (V2I/X) and aerial drone surveillance, and well-established methods (from existing know-how from research and industrial projects), the automated system can provide some non-routine (emergency) maintenance operations when required. Overall, the integrated **HERON system** consists of:

1. The autonomous ground robotic vehicle, supported by autonomous drones to coordinate maintenance works, inventorying activities, and the pre-/post- intervention phase;
2. Various robotic equipment, including sensors and actuators (e.g., tools for cleaning pavements surface, surface material placement and compaction, modular components installation, laser scanners for 3D mapping, painting systems, injectors, pumps, weighting and volume measuring systems) placed on the main vehicle;

3. The sensing interface installed both to the robotic platform and to the RIs to allow improved monitoring (situational awareness, presence of stopped vehicles, obstacles or vegetation covering pavements surface or signalling) and inspection of RI's, (which mainly includes considering the HERON scope: pavements surfaces, safety elements, signalling and road markings' conditions);
4. The control software that interconnects the sensing interface with the actuating robotic equipment;
5. AR visualization tools that enable the robotic system to see in detail surface defects and markings under survey;
6. Artificial Intelligence/AI-based toolkits that act as the middleware of a twofold role for: a) optimally coordinating the road maintenance/upgrading workflows and b) intelligently processing the distributed data coming from the vehicle and the infrastructure sensors or other data sources (e.g., cameras on general patrolling vans);
7. Enhanced visualisation User Interface (UI) to support decisions;
8. Communication modules to allow for V2I/X data exchange for predictive maintenance and increase users' safety.

The following table contains the full and short names of all the members of the HERON Consortium.

#	Full name	Short name
1	INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS	ICCS
2	ACCIONA CONSTRUCCION SA	ACCI
3	OLYMPIA ODOS ANONYMI ETAIREIA LEITOURGIAS GIA TON AUTOKINITODROMO ELEFSINA-KORINTHOS-PATRA-PYRGOS-TSAKONA (OLO)	OLO
4	UNIVERSITE GUSTAVE EIFFEL	UGE
5	EIDGENOESSISCHE TECHNISCHE HOCHSCHULE ZUERICH	ETHZ
6	ROBOTNIK AUTOMATION SLL	ROB
7	CONFEDERATION OF ORGANISATIONS IN ROAD TRANSPORT ENFORCEMENT AISBL	CORTE
8	SATWAYS - PROIONTA KAI YPIRESIES TILEMATIKIS DIKTYAKON KAI TILEPIKINONIAKON EFARMOGON ETAIRIA PERIORISMENIS EFTHINIS EPE	STWS
9	RISA SICHERHEITSANALYSEN GMBH	RISA
10	INNOV-ACTS LIMITED	INAC
13	AINOOUCHAOU PLIROFORIKI AE	IKH
12	RESILIENCE GUARD GMBH	RG

Table I: Project Consortium.

2 Individual Exploitation Plans

Herein we delineate the Individual Exploitation Plans of the HERON consortium partners, by summarizing their main contribution to the HERON project, outlining the background knowledge/technologies/products that they will employ throughout the project lifetime, as well as the foreground that they will produce (especially interested in the exploitable foreground), and finally defining a draft strategy on how they intend to exploit the project results. These individual plans comprise the first key step for the identification of the KERs of the HERON project, as well as for the definition of the Intellectual Property (IP) relationships within the Consortium. RG is responsible for continuously updating and refining the partners' Individual Exploitation Plans in order to accommodate the new outcomes and IP opportunities that may arise as the project's maturity increases.

2.1 ICCS

2.1.1 Partner description

The Institute of Communications and Computer Systems (ICCS) is a non-profit academic research body that carries out research and development activities in the area of telecommunications, systems and techniques, computer systems and their applications in transceivers, radar, electromagnetic sensors, satellite and wireless communications, electromagnetic phenomena modelling, neural networks, systems, software and hardware engineering, telematics and multimedia applications, transport applications, control systems, biomedical engineering and electric power. The Laboratory of Photogrammetry, Signal Processing & Computer Vision (P-SP-CV Lab.) performs research in spectral analysis, signal processing, machine learning and environmental applications. The laboratory is involved in several research projects in the area of security, image processing/computer vision, software technology, machine learning and artificial intelligence.

2.1.2 Contribution to the HERON project

The following list summarizes the main contributions of ICCS to the HERON project:

- Project coordination and management (WP1)
- Implementation of AI-driven image segmentation and feature extraction algorithms (WP3)
- Development of methodologies for georeferencing and precise 3D localization of Points of Interest (WP3)
- Deployment of the aerial drones and integration with the Unmanned Ground Vehicles (UGVs) (WP5)
- Integration of the sensing interface and AI component into the HERON Middleware in order to receive input from the sensors of the UGV and Unmanned Aerial Vehicle (UAV) (WP6)
- Collection of security requirements and establishment of the necessary rules (WP6)
- Support to the field integration, demonstration, and validation activities (WP7)
- Release of the HERON Annual Magazine (WP8)
- Development of ethics requirements (WP10)

2.1.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by ICCS in order to deliver its contribution:

- Know-how related to project coordination and management
- Know-how related to project dissemination activities
- Know-how related to ethics requirements definition
- Know-how related to photogrammetry and 3D modelling

- Know-how related to CV and ML techniques
- Know-how related to fusion and co-learning techniques that utilize RGB and stereo image data
- Know-how related to UAV control and effective data acquisition
- Involvement in numerous research projects related to the work done in HERON, such as:
  ROBOSPECT (FP7): *ROBotic System with Intelligent Vision and Control for Tunnel Structural INSPECTion and Evaluation*
  PANOPTIS (H2020): *Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools European Union*
  ZONESEC (FP7): *Towards a EU framework for the security of Widezones*

2.1.4 Foreground

The following list summarizes the outcomes that will be produced by ICCS during the HERON project and have strong exploitation potential:

- Computer Vision Detection Tools: Development of ML and CV tools for image semantic segmentation as well as recognition, classification, and localization of key Points of Interest (PoIs) that are critical to the RIs, taking into consideration actual General Data Protection Regulation (GDPR)[1] requirements (e.g., license plates of road users blurred). The detection tools will offer the following features: crack features, pothole features, asphalt ageing features, Chaussée Urbaine Démontable (CUD) features, safety elements, road markings and signalling features, complementary visual inspection features, and traffic cone features.
- Deployment of the Aerial Drones and integration with the UGVs: A comprehensive solution for deploying multiple drones for inspection of large areas and information acquisition of required scenes. The solution can be utilized both preoperative (i.e., for planning the action), as well as during operations (e.g., checking the action). When utilized with UGVs, the drones offer reliable 3D mapping for robot navigation, obstacle detection and avoidance, and support to inventorying tasks.

Moreover, ICCS will produce the following deliverables:

- D1.1: *Quality Assurance Plan*
- D1.2: *Data Management Plan (first version)*
- D1.3: *Societal impact report (version 1)*
- D1.4: *Societal impact report (version 2)*
- D1.5: *Quality Assurance Report (version 1)*
- D1.6: *Quality Assurance Report (version 2)*
- D1.7: *Project Management Plan (version 1)*
- D1.8: *Project Management Plan (first period)*
- D1.9: *Project Management Plan (second period)*
- D1.10: *Project Management Plan (Final period)*
- D1.11: *Data Management Plan (second version)*
- D1.12: *Data Management Plan (third version)*
- D1.13: *Data Management Plan (fourth version)*
- D2.3: *Geographic data and services inventory*
- D3.1: *AI - driven image segmentation and feature extraction*
- D3.4: *Point of interest georeferencing and precise localisation software*
- D5.2: *Drones Implementation*
- D8.5: *Information Packs for referenced and networked communication amplifiers*
- D8.6: *Annual Magazine issued (first version)*

- D8.9: *Annual Magazine Issues (second version)*
- D8.10: *Annual Magazine Issue (third version)*
- D8.11: *Annual Magazine Issue (Fourth version)*
- D10.1: *H - Requirement No. 1*
- D10.2: *POPD – Requirement No. 2*
- D10.3: *EPQ - Requirement No. 3*

2.1.5 Draft exploitation strategy

ICCS expects to gain high knowledge on project topics and enhance their visibility by collaborating with the industrial partners of the Consortium. HERON's results will be exploited by postdoctoral researchers, PhD students and multiple research teams. Research-wise, ICCS will gain experience and increase its reputation and make easier to successfully join future Research & Development (R&D) projects, thus increasing its resources.

2.2 ACCI

2.2.1 Partner description

Acciona Construcción (ACCI) is a leading European construction company designing, constructing, and managing buildings and civil infrastructures under sustainability principles. At European level, ACCI plays an active role in the European Construction Technology Platform, leading the Energy Efficient Buildings Committee. ACCI has a wide experience in R&D projects both at National and at European level, as well as in international projects beyond Europe. The maintenance company of ACCI has more than 30 years of experience in infrastructures maintenance (mainly of publicly-owned infrastructures but also as service provider of private road operators).

2.2.2 Contribution to the HERON project

ACCI actively participates into the HERON project by offering the following main contributions:

- Organization of the first end-user's workshop (WP2)
- Contribution to the development of the User Requirements document (WP2)
- Contribution to the training of the CV and Deep Learning (DL) systems and algorithms (WP3)
- Contribution to the development of the Incident Management System (IMS) specifications (WP6)
- Contribution to the validation and testing of the HERON Middleware by providing data from e.g., road cameras, weather stations, inspections (WP6)
- Integration of particular HERON developments in the actual Asset Management System and general patrolling deployed in A2 Motorway (WP6)
- Organization and implementation of the "A2 Motorway" pilot study for the refinement and validation of the integrated HERON system (WP7)

2.2.3 Background

ACCI employs the following background technologies/knowledge/products in the context of the HERON project:

- Know-how related to developing, installing, maintaining, and operating wireless sensor networks (software and hardware) in the field of the construction sector
- Know-how related to RI maintenance, with more than 30 years of experience in publicly-owned infrastructures but also acting as service provider of private road operators

- Know-how related to applying drone-technology and photogrammetry techniques to RI and assets upkeep
- Background experience with research projects that are related to HERON, such as:
  PANOPTIS (H2020): *Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools European Union*
  ZONESEC (FP7): *Towards a EU framework for the security of Widezones*

Background mentioned above is provided for use within HERON project only. Parties will be granted access only to information considered necessary in order to carry out their own activities. Knowledge provided cannot be transmitted outside the scope of project activities. Access to ACCI's background for exploitation purposes and result actions undertaken by Parties distinct from ACCI, will require legal consent of the company and discussion of possible financial terms or copyright terms.

2.2.4 Foreground

Being one of the three end-users of the HERON integrated system, ACCI will gain foreground experience and knowledge related to: (a) the integration of the HERON components into ACCI's operational systems (which includes the development, use and exploitation of the required Communication Systems/Application Programming Interfaces (APIs) and the use of the developed systems in the general patrolling vans of the company), (b) the demonstration and assessment of the HERON components during the pilot study, and (c) the comparison of the automated road inspection, inventorying and maintenance procedures tested in HERON with respect to ACCI's current practices.

2.2.5 Exploitation strategy

ACCI will exploit the results mainly through its subsidiary companies for Infrastructure Maintenance and Assets Operation. ACCI aims to increase the efficiency of RI maintenance, inspection, and inventorying activities, while at the same time minimising the risks linked to human intervention during the pre, post and intervention phases of these activities and reducing the costs derived from those services to the customers and thus positioning better against competitors in future tenders. This will also enhance the company reputation and image strengthening the new "people centric and positive impact approach" implemented by the company as part of its last Sustainability Master Plan. In addition, the adoption of the technologies developed in the project will enable the company to gain a competitive advantage against competitors in terms of innovations deployment and digitalisation and therefore improving its market position.

Finally, as part of the joint exploitation strategy of the HERON consortium, ACCI will discuss and agree with the relevant partners special conditions for the company, to maintain the project outcomes into ACCI's operational systems after the project end.

2.3 OLO

2.3.1 Partner description

Olympia Odos (OLO) is a Motorway Concession Project of particular strategic importance on national and regional level for the development of the Peloponnese and Western Greece. The Operation organisation of OLO provides operation and maintenance services on behalf of the Concessionaire, such as toll collection, traffic management & safety and routine maintenance. The motorway supervised by OLO includes: 2 existing motorway sections "Elefsina – Korinthos" and "Patra by Pass" and the "National Road from Korinthos to Patras", conventionally called "Korinthos-Patra NNR", 120 km long, the construction and upgrade of which to motorway was completed in 2017.

2.3.2 Contribution to the HERON project

The following list summarizes OLO's main contributions to the HERON project:

- Organization of the second end-user's workshop (WP2)
- Contribution to the development of the User Requirements document (WP2)
- Contribution to the training of the CV and DL systems and algorithms (WP3)
- Contribution to the development of the IMS specifications (WP6)
- Contribution to the validation and testing of the HERON Middleware by providing data from e.g., road cameras, weather stations, inspections (WP6)
- Organization and implementation of the "Elefsina-Korinthos-Patra Motorway" pilot study for the validation of the integrated HERON system (WP7)

2.3.3 Background

The following background technologies/knowledge/products are employed by OLO in the context of the HERON project:

- Extensive know-how on the organisation and implementation of any kind of civil and/or EEM routine maintenance activity as well as on the coordination of a big number of subcontractors of various specialisations.
- Extensive know-how on the usage of the i-Maint program: I-Maint is a Routine Maintenance Planning and Management software that manages motorways' assets, resources and I&M annual plan through individual projects and tasks and produces daily/monthly reports regarding maintenance progress.
- Extensive know-how on the usage of the Motorway Management System (MMS): MMS is a software mainly used by Traffic Management Center in order to monitor traffic condition of the motorway in real time taking also into account alarms from EEM equipment.

2.3.4 Foreground

Being one of the three end-users of the HERON integrated system, OLO will gain foreground experience and knowledge related to: (a) the integration of the HERON components into OLO's operational systems (e.g., integration of the I-Maint and MMS software into the backend system of HERON), (b) the demonstration and assessment of the HERON components during the "Elefsina-Korinthos-Patra Motorway" pilot study, and (c) the comparison of the automated road inspection, inventorying and maintenance procedures tested in HERON with respect to OLO's current practices.

2.3.5 Draft exploitation strategy

OLO together with the other end users will promote the project results to the industry. On top OLO will provide market studies in RI inspection addressing the possible markets (with possible adaptations). As a major end-user OLO aims to bring HERON into the actual inspection and maintenance plans of Olympia Odos (Greece) as well as to introduce HERON into the inspection and maintenance plans of other privatized motorways in Greece.
Finally, as part of the joint exploitation strategy of the HERON consortium, OLO will discuss and agree with the relevant partners special conditions for the company, to maintain the project outcomes into OLO's operational systems after the project end.

2.4 UGE

2.4.1 Partner description

Université Gustave Eiffel (UGE) is a new type of university comprising six existing bodies (e.g., university Paris Est, research institute IFSTTAR, engineering schools) covering multidisciplinary thematic to address the continuous transformation of cities. UGE's research interest is multifaceted ranging from social sciences to nanotechnologies, while it brings in

movement the educational, research, and economic environment towards the development of smart, resilient, and resource-efficient cities of tomorrow. Amongst others, UGE's primary goal is to address societal challenges of tomorrow, to provide cutting-edge skills to the students, to offer international education programmes, while it delivers advisory services to public authorities at international, national, and local levels.

2.4.2 Contribution to the HERON project

The following list summarizes UGE's main contributions to the HERON project:

- Production of the User Requirements document (WP2)
- Contribution to the training of the CV and DL systems and algorithms (WP3)
- Organization and implementation of the "Transpolis" pilot study for the validation of the integrated HERON system (WP7)
- Organization and implementation of the pilot study to test the usage of hexagonal concrete slabs in the concept of urban removable pavements (i.e., CUD pavements).

2.4.3 Background

The following background technologies/knowledge/products are employed by UGE in the context of the HERON project:

- Know-how related to the design and fabrication of CUD components
- Know-how related to testing of autonomous vehicles and V2I communication
- Know-how related to RI maintenance, traffic data management, impact assessment
- Background experience with research projects that are related to HERON, such as:
  PANOPTIS (H2020): *Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools European Union)*
  I-STREET (French national project): *Implementation and study of R5G concepts*

2.4.4 Foreground

Being one of the three end-users of the HERON integrated system, UGE will gain foreground experience and knowledge related to: (a) the integration of the HERON components into UGE's operational systems, (b) the demonstration and assessment of the HERON components during the "Transpolis" pilot study, (c) the demonstration and assessment of the autonomous replacement of CUD elements during a pilot study, and (d) the comparison of the automated road inspection and maintenance procedures tested in HERON with respect to UGE's current practices.

Moreover, UGE is the IP owner of the following produced deliverables:

- D2.1: *End-user needs and KPIs report*
- D2.2: *Architecture specification*

2.4.5 Draft exploitation strategy

Involvement in International Technical Committees of CEDR, ERTRAC, RILEM, and IABSE and fib. Active members of Eurocodes committees. It is also linked with CEN TC250/104/51 and 229 dealing with concrete (EC2 and norm EN206), and FEHRL or CEDR networks. Engineers and researchers from materials and building companies will be especially involved in the project because it is linked to the evolution of standards.

2.5 ETHZ

2.5.1 Partner description

ETH Zurich (ETHZ) is an academic institution with an excellent track record of research and teaching. The Autonomous Systems Lab (ASL) of ETHZ, performs research on field of

autonomous robot design and navigation and has great experience in design and navigation of wheeled, legged, and flying robots operating in different types of environments. ASL is involved in several National, European and ESA projects together with both academic and industrial partners. Research achievements in the lab have been commercialized by realizing several spin-off companies.

2.5.2 Contribution to the HERON project

The following list summarizes the main contributions of ETHZ to the HERON project:

- Development of an online motion planning approach for the robot arm (WP4)
- Research on approaches for learning the low-level manipulation actions needed for road repair applications and implementation for the robot arm (WP4)
- Development of state abstractions for high-level planning (WP4)
- Research and development of high-level planner using symbolic actions representations (WP4)
- Contribution to the development of techniques for 3D Simultaneous Localisation and Mapping (SLAM) (WP5)
- Integration and testing of the high-level planner for manipulation to the HERON system (WP7)
- Support to the field integration, demonstration, and validation activities (WP7)

2.5.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by ETHZ in order to deliver its contribution:

- Know-how related to software design for mobile robot control, planning and navigation and numerous widely-used open-source software packages
- Know-how related to robot navigation and manipulation, including SLAM, localization, planning, control, learning and dexterous manipulation
- Know-how related to design of workflow planning
- Background experience with research projects that are related to HERON, such as:
  TRADR (FP7): *Long-Term Human-Robot Teaming for Disaster Response*
  SHERPA (FP7): *Smart collaboration between Humans and ground-aErial Robots for imProving rescuing activities in Alpine environments*
  SubT Challenge (DARPA)*: Winner of the DARPA SubT Challenge with Team Cerberus, the most prestigious competition on autonomy for robots*

2.5.4 Foreground

The following list summarizes the outcomes that will be produced by ETHZ during the HERON project and have strong exploitation potential:

- High-level planner: Development of a robotic manipulation and interaction pipeline for complex, multi-step RI maintenance and intervention tasks. Various complex actions will be available by the high-level planner such as (a) sealing of cracks and patching potholes, (b) painting of road markings, (c) autonomous replacement of CUD elements, (d) asphalt rejuvenation, and (e) cone disposal and removal.

Moreover, ETHZ will produce the following deliverables:

- D3.5: *High level planner*
- D4.2: *Motion Planning and Learning Manipulation Actions*
- D4.3: *Representation for high level planning*

2.5.5 Draft exploitation strategy

The autonomous systems lab at ETHZ has a strong history of translating research to industry through dedicated partnerships with incubators and technology translation centres (such as the relationship between ETHZ and Wyss Zurich). In this way, HERON will continue contributing to Europe's vibrate start-up culture. ETHZ will produce several publications at top conference in robotics and aims to publish code for their research on novel manipulation capabilities for road intervention tasks. These may be used in future projects as well by third parties to develop technology and products for autonomous road intervention.

2.6 ROB

2.6.1 Partner description

Robotnik (ROB) is a leading company in the European service robotics market. ROB is specialized in Mobile Robotics: (i) products: robotics product manufacturing (mobile robot platforms, mobile manipulators), (ii) service Robotics Applications: (development of robots for performing autonomous tasks for the wellbeing of humans or machines, excluding manufacturing), principally Robots for Logistics and Robots for Inspection. ROB owns the following certifications: (i) ISO 9001:08 Design, manufacturing and commercialization of products and systems based in robotics technology. (ii) OHSAS 18001 Certification of occupational health and safety management system.

2.6.2 Contribution to the HERON project

The following list summarizes the main contributions of ROB to the HERON project:

- Design of a low-level control pipeline for the robot arm (WP4)
- Testing of different sensing devices and strategies for the end-effector (WP4)
- Development of enhanced robot navigation techniques using 3D map reconstruction (WP5)
- Design, development, and testing of the HERON Robotic Platform (WP5)
- Support to the deployment and integration of the aerial drones with the UGVs (WP5)
- Implementation of the AR interfaces with the HERON Robotic Platform (WP5)
- Integration, validation, and verification of the HERON Robotic Platform (WP7)
- Support to the field integration, demonstration, and validation activities (WP7)
- Performance of Market Analysis and development of Business Plan (WP9)

2.6.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by ROB in order to deliver its contribution:

- Know-how related to robot navigation, mobile manipulation, low-level control and sensing of end-effectors and tooling
- Know-how related to robot manufacturing, testing, and validation
- Know-how related to vehicle robotization, which will be based on the RB-Vogui system of ROB
- Know-how related to integration of different sub-systems, pilot preparations, tests and validations
- Know-how related to the development of high TRL prototypes of different robotic systems and solutions
- Background experience with research projects that are related to HERON, such as:
  Bots2ReC (H2020): *Introducing, testing and validating an operational process for the automated removal of asbestos contamination at a real-world rehabilitation site using a robotic system*

BADGER (H2020): *RoBot for Autonomous unDerGround trenchless opERations, mapping and navigation*

2.6.4 Foreground

The following list summarizes the outcomes that will be produced by ROB during the HERON project and have strong exploitation potential:

- HERON Robotic platform: Implementation of an automated robotic platform for RI maintenance and rehabilitation actions such as: painting of road markings, sealing of cracks and patching potholes, asphalt rejuvenation, disposal and removal of traffic cones. The platform employs the omnidirectional Unmanned Ground Vehicle (UGV), plus a robotic arm, and different robotized devices for the intervention actions (e.g., sprays, pumps, sweepers, air blowers or rollers). It also allows onboard drone take-off to facilitate the inspection of large areas.

Moreover, ROB will produce the following deliverables:

- D4.1: *Design and Implementation of the low-level controller*
- D5.1: *3D Mapping and Autonomous Navigation*
- D5.3: *Design and Development of the Robotic Platform with adaptive and enhanced capabilities*
- D7.3: *First version (V1) of the HERON System*
- D7.4: *Final version (V2) of the HERON System*
- D7.5: *Acceptance tests for the HERON system*
- D9.3: *Market Analysis and Business Plan (first version)*
- D9.4: *Market Analysis and Business Plan (second version)*

2.6.5 Draft exploitation strategy

ROB as a service robotics company is very interested in the exploitation of the HERON robotic system. It will be used to improve and enhance the capabilities of our applications in service mobile robotics, including a new robotics market niche as the maintenance and upgrading roadworks. This system will allow the company introduce robotics in certain sectors where dangerous, repetitive, and low value tasks are to be executed, improving our global market visibility, and providing us great industrial relevance in this sector.

2.7 CORTE

2.7.1 Partner description

CORTE is an international (non-profit) organization, which brings together national transport authorities and private sector entities (from EU and non-EU countries) operating in the field of road transport, road security and road safety. reach its objectives CORTE: (i) provides a platform for discussing and reaching agreements between national road transport authorities, national and international road transport associations, as well as the road transport industry, (ii) supports definition of policies, outlining priorities defined by the European and international organisations and governmental bodies, (iii) gives advice on the implementation of these priorities by preparing roadmaps, action plans and studies and (iv) supports activities of its members and stakeholders, the European Institutions, the United Nations, and other international organizations.

2.7.2 Contribution to the HERON project

The following list summarizes the main contributions of CORTE to the HERON project:

- Support to the identification of the user needs and technical requirements (WP2)
- Development of HERON's Dissemination and Communication Plan (WP8)
- Coordination of HERON's dissemination activities (WP8)

- Participation to clustering activities with other relevant EU-financed projects (WP8)
- Participation to the organization and implementation of the Consensus
- Support to the organization and implementation of the Consensus-Building Workshop (WP10)

2.7.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by CORTE in order to deliver its contribution:

- Know-how related to project management and coordination
- Know-how related to dissemination and exploitation activities
- Know-how related to collaboration with the Horizon Results Booster
- Know-how related to regulation frameworks and governance models in the transport sector
- Large network of national transport authorities, transport organizations, and companies for the organization of stakeholder workshops, promotion, and communication activities
- Background experience with research projects that are related to HERON, such as:
  PANOPTIS (H2020): *Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools European Union*
  LEMO (H2020): *Leveraging Big Data to Manage Transport Operations*

2.7.4 Foreground

CORTE is a member-based international non-profit organisation with a public mission of supporting smarter and safer road transport through the adoption of technology and smart road transport practices and policies, and will therefore not develop commercially exploitable technical innovations. However, in the context of the HERON project CORTE will gain foreground experience and knowledge related to the management and implementation of dissemination and exploitation activities, as well as the organization of large stakeholder workshops and clustering actions.

Moreover, CORTE will produce the following deliverables:

- D8.3: *Dissemination and Communication (first version) Plan*
- D8.4: *Dissemination and Communication Plan (second version)*
- D8.7: *Report on the project clustering activities (first version)*
- D8.8: *Report on the project clustering activities (final version)*

2.7.5 Draft exploitation strategy

CORTE will engage with national authorities in charge of RI and road safety, to exploit the results with RI operators and authorities. Sustainable transport, including transport safety, is part of the core mission of CORTE and this will be an integral part of the contribution to the exploitation of HERON's results.

CORTE will transfer results achieved by HERON to all 70 CORTE Members comprised of 33 road transport national authorities (Ministries of Transport & Infrastructure, Road Safety Agencies), 13 transport associations (representing themselves 1000s of transport companies as well as vehicle manufacturers) such as the International Road Union (IRU) and the Association representing vehicle manufacturers in Europe (ACEA), and 24 transport companies in the EU and neighboring countries, in order to promote and support dissemination and exploitation of HERON results, as well as to ensure that appropriate public policies and possibly regulatory measures enable the deployment and use of technologies developed by HERON. The CORTE Membership is composed of both public and private organisations all active in road transport, covering both EU countries and non-EU countries, as well as transport associations and

transport companies, providing thereby very strong geographical coverage as well as stakeholders' coverage.

2.8 STWS

2.8.1 Partner description

Satways Ltd. (SWTS) is a company whose main activity is the development of integrated geospatial command and control and situation awareness solutions for Security and Public Safety applications for users such as Fire Brigade, Police, Coast Guard, Emergency Medical, Civil Protection, Critical Infrastructure protection and Border Authorities. STWS offers a range of mission critical enterprise solutions empowering governments and businesses around the world to make better and faster operational decisions. Its product line includes C2 and C3I enterprise software packages that respond to different operational requirements of Public Safety and Security Agencies such as Distributed Geospatial Data management, Operational Resources Tracking, Incident Management and Dispatch, Physical Security Information Management, Natural &Technological Hazards Crisis Management and Border Surveillance.

2.8.2 Contribution to the HERON project

The following list summarizes the main contributions of STWS to the HERON project:

- Development of the AR components, UI development and integration (WP5)
- Development of the Common Operational Picture (COP) using data from various sources (WP6)
- Customization of the IMS and development of the Communication Systems/Application Programming Interfaces to support RI operations (WP6)
- Support to the field integration, demonstration, and validation activities (WP7)
- Support to the system integration and acceptance tests for the AR components (WP7)

2.8.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by STWS in order to deliver its contribution:

- Know-how related to the development of integrated Geospatial command and control and situation awareness solutions for Security and Public Safety Agencies as well as for Critical Infrastructure Operators
- Know-how related to the development of Decision Support Systems (DSS) and Enhanced Visualization Interfaces
- IP owner of the ENGAGE IMS/C2 Suite, which is an enterprise Incident Management / C2 system
- IP owner of the ENGAGE Mobile, which has been developed to support field commanders and coordinators operations in cases of major events
- IP owner of the Climate Infrastructure Resilience Platform
- Background experience with research projects that are related to HERON, such as:
  PANOPTIS (H2020): *Development of a Decision Support System for increasing the Resilience of Transportation Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools European Union*
  EU-CIRCLE (H2020): *A pan European framework for strengthening Critical Infrastructure resilience to climate change*

2.8.4 Foreground

The following list summarizes the outcomes that will be produced by STWS during the HERON project and have strong exploitation potential:

- AR application and AR Glasses: Design and development of the UI for AR glasses to support robot operators and road supervisors during inspection, inventorying, maintenance and intervention actions. Using the AR app, the operator can obtain real-time visual information about the environment (e.g., road, pavements and other areas) and possible hidden structural and/or functional elements or additional damages.
- Customization of the IMS to support RI operations: Extension of the ENGAGE IMS application of STWS to support RI operations (e.g., inspection, maintenance and upgrading operations, inventorying activities and coordinated response), interactive AR visualization tools, and efficient UI for generating the COP.

Moreover, STWS will produce the following deliverables:

- D5.4: *Development of the AR components*
- D6.3: *COP and Customized IMS for RI operations*

2.8.5 Draft exploitation strategy

STWS will enhance its expertise and position in the global transport and road infrastructures' market, and use this knowledge for research and development. The participation in the project will also serve to: (1) expand the company's network aiming to be further enrolled in research projects and to communicate the company's portfolio. (2) strengthen its new product development plan and enrich the competition watch and (3) expand the company's target markets focusing on RIs. The following actions are foreseen: a) Marketing and Sales efforts via trade fairs, exhibitions; specific marketing initiatives to address new customers by presenting the technology, b) sales activities via our distribution network, c) active participation in industrial seminars.

2.9 RISA

2.9.1 Partner description

RISA Sicherheitsanalysen GmbH (RISA) is a leading vendor of large IT platform solutions. Their field of activities comprises complex information system applications, platforms for decision analysis/support, optimisation and data analysis, including Big Data and IoT, for various other industries and engineering offices (from railway, automotive and aviation transportation to nuclear industries), as well as government agencies (including the German Ministry of the Environment). The company has been a partner in several EU-funded projects on probabilistic structural reliability and/or on the development of tools and interoperable platforms for situation awareness and decision support on structural maintenance, strengthening and repair of various civil engineering structures.

2.9.2 Contribution to the HERON project

The following list summarizes the main contribution of RISA to the HERON project:

- Support to the implementation of the AR components and UI developments (WP5)
- Development of the HERON Middleware and Data Fusion (DF) services (WP6)
- Contribution to the development of the DSS by providing a Complex Event Processing (CEP) tool (WP6)
- Implementation of the back-end integration (WP7)
- Support to the field integration, demonstration, and validation activities being the main software integrator (WP7)

2.9.3 Background

During the HERON project implementation, RISA's contribution will be based on the following technologies/knowledge/products:

- Know-how related to the development and deployment of UI modules

- Know-how related to the design and implementation of DSS
- Know-how related to the design and implementation of software development solutions and system integration
- Know-how related to the development of middleware and DF services
- Background experience with research projects that are related to HERON, such as:
  - HYPERION (H2020): *Development of a Decision Support System for Improved Resilience & Sustainable Reconstruction of historic areas to cope with Climate Change & Extreme Events based on Novel Sensors and Modelling Tools*
  - RESIST (H2020): *RESilient transport InfraSTructure to extreme events*
  - AEROBI (H2020): *AErial RObotic System for In-Depth Bridge Inspection by Contact*
  - ROBOSPECT (FP7): *ROBotic System with Intelligent Vision and Control for Tunnel Structural INSPECTion and Evaluation*

2.9.4 Foreground

The following list summarizes the outcomes that will be produced by RISA during the HERON project and have strong exploitation potential:

- HERON Middleware and DF services: A software toolkit that incorporates current information systems (e.g., weather, GIS, transport authorities) and available sensor networks (mobile platforms, satellite, GPS, cameras, weather stations) in order to coordinate information delivery between control and device planes. In specific, middleware will stand at the core of the HERON system enabling the interaction among the various system components. By employing the HERON middleware, the RI operators will be able to: (a) optimally coordinate the road maintenance/upgrading workflows and (b) intelligently process distributed data coming from the UGV and the infrastructure sensors for safe operations, avoiding the disruption of other routine operations or traffic flows. Finally, the DF interpreter by elaborating the information processed and produced by the middleware will be able to inform the operator regarding the possible RI maintenance/upgrading activities with the engine(s) that are presently deployed in the HERON platform.

Moreover, RISA will produce the following deliverables:

- D6.2: *Middleware and DF services*

2.9.5 Draft exploitation strategy

RISA will exploit the project results on a commercial basis by enhancing its current tools in order to provide advanced Data Management System, e.g., middleware, and DSS. RISA expects the project to: a) advance its skills on the development of middleware and DSS and also prepare the grounds for future participations in other projects relevant to HERON; b) strengthen its position in the challenging RI protection systems market; c) provide an adaptive platform that could be used with small changes targeting other vertical business sectors; d) promote RISA as a contributor to EU framework projects; e) propagate the used engineering/IT standards in HERON at local and international level; and f) use the experience gained from the participation in HERON in order to improve and upgrade its current products and services with an ultimate goal to provide products of higher quality to its current clients, as well as attracting new ones.

2.10 INAC

2.10.1 Partner description

Innovation Acts Ltd (INAC) is an ICT and business consulting firm, which offers software development and business consulting services, as well as project management for services

related to various sectors, with particular emphasis on Security, FinTech and Industry4.0. Its consulting services are based on the founders' expertise in IoT, BigData/AI, blockchain and Cyber-Security technologies. The consulting services of the company include business modelling, business planning, and techno-economic analysis services. Its software development services span the areas of blockchains and data analytics technologies. INAC is developing novel products and services in the areas of Data Analytics, FinTech services personalization and personal data management.

2.10.2 Contribution to the HERON project

The following list summarizes the main contributions of INAC to the HERON project:

- Support to the specification of user requirements and use cases (WP2)
- Support to the implementation of the AR components and UI developments (WP5)
- Development of communication architecture and security elements (WP6)
- Support to the development of the pre-processing layer and APIs of the HERON Middleware (WP6)
- Field integration of the HERON components for the three pilot sites (WP7)
- Validation, benchmarking, and demonstration of the HERON integrated system (WP7)

2.10.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by INAC in order to deliver its contribution:

- Know-how related to the development of communication architectures and secure networking systems
- Rich experience in the implementation of integrated platforms for the protection of large-scale infrastructures as well as in the fintech domain
- Know-how related to the implementation of pilot activities and the coordination of actions for integration and validation of large-scale systems
- Background experience with research projects that are related to HERON, such as:
  PLEDGER (H2020): *Performance optimization and edge computing orchestration for enhanced experience and Quality of Service*
  INFINITECH (H2020): *Tailored IoT & BigData Sandboxes and Testbeds for Smart, Autonomous and Personalized Services in the European Finance and Insurance Services Ecosystem*

2.10.4 Foreground

In the context of the HERON project, INAC will gain foreground experience and knowledge related to (a) the cutting-edge technologies for RI maintenance and upgrading activities, (b) the development of secure communication systems for RI operations, (c) the coordination of field integration activities, and (d) the validation and demonstration of integrated systems to support RI workflows.

Moreover, INAC will produce the following deliverables:

D6.1: *Secure Communication and Networking infrastructure*

D7.1: *Definition and testing of the interfaces of the HERON sub-components*

D7.2: *Report on the system configurations for the field trials and deployment at the demonstration sites*

D7.6: *Reports on pilot testing (version 1)*

D7.7: *Reports on pilot testing (final version)*

2.10.5 Draft exploitation strategy

INAC will exploit the results of the HERON, on a twofold basis: (a) incorporation of current exploitable outcomes as new features in its existing portfolio of commercial offerings and (b)

establishment of synergies with HERON partners towards the development of new products, that will exploit INAC's safe communication and security elements.

2.11 IKH

2.11.1 Partner description

The company iKnowHow (IKH) provides custom-built automation solutions to industry and software solutions to the public and private sector. Its field of expertise is related to data acquisition, communication, storage, and processing. IKH's tailormade services culminate in cyber-physical systems where the physical and computational elements are intertwined to augment human capabilities. It is an engineering consultancy employing its expertise in service robotics, IoT, machine learning, and data intelligence to offer tailor made solutions across industry functions and markets.

2.11.2 Contribution to the HERON project

The following list summarizes the main contributions of IKH to the HERON project:

- Development of algorithms to refine the segmented road images by employing geometric and textural criteria (WP3)
- Assessment and classification of the PoIs using DL algorithms and Engineering processes (WP3)
- Support to the field integration, demonstration, and validation activities (WP7)

2.11.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by IKH in order to deliver its contribution:

- Know-how related to leading end-to-end robotic solutions and data driven intelligence
- Expertise on the development of AI-based systems, computer vision, ML and embedded control
- Experience on product promotion and IPR management activities
- Background experience with research projects that are related to HERON, such as:
  Detection of safety critical cracks and corrosion in ships using novel sensors and systems based on ultrasonic linear phased array technology
  Development of a robotic system for the inspection of large steel plates in industrial plants

2.11.4 Foreground

The following list summarizes the outcomes that will be produced by IKH during the HERON project and have strong exploitation potential:

- Software for refinement of segmentation results: A CV and image processing software that refines the results of road segmented images in order to increase precision accuracy taking into consideration actual GDPR requirements (e.g., license plates of roaf users blurred)
- Point of interest recognition and classification software: An AI-driven classification software that labels detected segmented regions (whose precision accuracy has been increased from the refinement algorithm) into high level semantic entities

Moreover, IKH will produce the following deliverables:
D3.2: *Software for refinement of segmentation results*
D3.3: *Point of interest recognition and classification software*

2.11.5 Draft exploitation strategy

IKH plans to exploit the increased innovation capacity created through HERON by integrating computer vision techniques and ML algorithms created during the project in renewable energy

infrastructure maintenance robots. By preparing and executing a solid marketing plan to achieve increased sales to existing customers and attract new ones on an international level.

2.12 RG

2.12.1 Partner description

Resilience Guard GmbH (RG) is a consultancy company offering professional services and training related to Business Continuity Management, Resilience Management, Crisis Management, Risk Management & Business Assurance, across Europe. RG acquires many years of expertise in the area of Resiliency for both organizations as well as municipalities and governments and brings the practical knowledge and application of resiliency approaches so as to ensure great applicability of the proposed solutions. RG's business and research focus has been to continuously find innovative methods to measure Resiliency Maturity for organisations through a matrix that assesses Structure, Systems and Strategy of an organisation against a 5-scale grade, that helps to get a much better understanding of the opportunities for improvement, creating at the same time the proper roadmap in order to facilitate, actions, investments and management commitment.

2.12.2 Contribution to the HERON project

The following list summarizes the main contributions of RG to the HERON project:

- Implementation of ethics assurance, knowledge, and information management (WP1)
- Development of the assessment and recommendations report (WP7)
- Organization and implementation of the training activities and consensus workshop (WP7)
- Coordination of actions to provide the corporate identity and project branding (WP8)
- Design and development of the HERON website (WP8)
- Creation and management of project's social media accounts (WP8)
- Coordination of project's exploitation activities and development of HERON roadmap (WP9)

2.12.3 Background

In the context of the HERON project, the following technologies/knowledge/products are employed by RG in order to deliver its contribution:

- Expertise on GDPR management and ethics assurance
- Expertise on standardization activities and planning
- Know-how related to project dissemination and exploitation activities
- Know-how related to project management and coordination
- Know-how related to training and awareness for multinational projects and multicultural organizations
- Background experience with research projects that are related to HERON, such as:
  HYPERION (H2020): *Development of a Decision Support System for Improved Resilience & Sustainable Reconstruction of historic areas to cope with Climate Change & Extreme Events based on Novel Sensors and Modelling Tools*
  7SHIELD (H2020): *Safety and Security Standards of Space Systems, ground Segments and Satellite data assets, via prevention, detection, response and mitigation of physical and cyber threats*

2.12.4 Foreground

In the context of the HERON project, RG will gain foreground experience and knowledge related to (a) the cutting-edge technologies for RI maintenance and upgrading activities, (b) the implementation and documentation of dissemination and exploitation activities for large-scale

projects, and (c) the preparation and implementation of workshops with key stakeholders and partners.
Moreover, RG will produce the following deliverables:
D7.8: *Trials assessment and recommendations*
D7.9: *Training Package and Consensus building workshop notes*
D8.1: *Corporate identity and general templates for dissemination material*
D8.2: *Project Website*
D9.1: *Exploitation Strategy (version 1)*
D9.2: *Exploitation Strategy (second version)*
D9.5: *Workshop Documentation*
D9.6: *The HERON Roadmap*

2.12.5 Draft exploitation strategy

HERON's outcomes shall be used in relevant advisory assignments to organizations. All results shall also be presented to public international conference where RG actively participates, promoting the resilient mobility and transport globally.

3 Key Exploitable Results (KERs)

Following the construction of the partners' Individual Exploitation Plans, this section focuses on the identification and definition of the Key Exploitable Results (KER) of the HERON project. In contrast to the individual sub-results produced by the partners, KERs often comprise the outcome of a joint contribution between two or more partners and, thus, IP relationships shall be comprehensively defined and agreed within the Consortium before testing the market uptake of the KER. At the current stage of the project (M18), a preliminary investigation is conducted on the six KERs that have been already identified at the beginning of the project (see the HERON Grant Agreement), by concentrating on the key beneficiaries, stakeholders, and competitors. Based on the new output that will be produced by the partners, an iterative procedure will be conducted until the end of the project, by first updating and assessing the exploitation potentials and IP opportunities of each KER (i.e., updating the present report until its final version, Deliverable 9.2 "Exploitation Strategy (second version)"), and then consequently updating and upgrading the HERON Business Model (see Deliverables 9.3 and 9.4 ,"Market Analysis and Business Model").

KER 1: Middleware and Data Fusion (DF) services		
Description		
The HERON Middleware comprises a software toolkit that incorporates current information systems (e.g., weather, GIS, transport authorities) and available sensor networks (mobile platforms, satellite, GPS, cameras, weather stations) in order to coordinate information delivery between control and device planes. By employing the HERON middleware, the RI operators can (a) optimally coordinate the road maintenance/upgrading, inspection, and inventorying workflows (including the pre/post intervention phase) and (b) intelligently process distributed data coming from the UGVs and the infrastructure sensors for safe operations, avoiding the disruption of other routine operations or traffic flows. Finally, the Data Fusion (DF) interpreter can inform the operator regarding the possible RI maintenance/upgrading activities with the engine(s) that are presently deployed in the HERON platform.		
#	**Partner Name**	**Partner Role**
1	RISA (Leader of KER)	– Design and implementation of the Middleware application – Validation and testing
2	STWS (optional)	– Integration of Middleware with the IMS
#	**Stakeholders**	**Value Proposition**
1	Highway operators	– Fast and easy access to plenty of pre-processed data per application domain related
2	Highway authorities	
3	Law Enforcement Agencies	
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	Middleware of the PANOPTIS project[2]	– Specialized for UGV data acquisition – Supports data fusion with AR glasses
2	Middleware of the HYPERION project[3]	

KER 2: Computer Vision Detection System

Description

Toolset of Machine Learning (ML) and Computer Vision (CV) modules for image semantic segmentation as well as recognition, classification, and localization of key PoIs that are critical to the RIs taking into consideration actual GDPR requirements (e.g., licence plates of roaf users blurred). The toolset supports the following features: crack features, pothole features, asphalt ageing features, CUD features, safety elements, road markings and signalling features, complementary visual inspection features, and traffic cone features.
The segmented images captured by various sources (e.g., drones, cameras) are refined by a CV software, which employs geometric/textural criteria to judge whether the road image has a particular PoI. Subsequently, the Artificial Intelligence/AI-driven classification software labels the detected segmented regions into high-level semantic entities. Finally, the detected regions of interest are georeferenced and mapped using image calibration/registration methods and 3D localization algorithms, respectively.

#	Partner Name	Partner Role
1	ICCS (Leader of KER)	– Provision of the ML structures for image semantic segmentation and analysis of PoIs – Development of the georeferencing and 3D localization tools
2	IKH	– Development of the CV refinement software – Development of the AI-driven classification software
#	**Stakeholders**	**Value Proposition**
1	Automation system designers	– Small price per service requested depended on the work needed – Fixed amount per month per RI type
2	Computer Vision SMEs	
3	RI inspection companies	– Price negotiated per RI depending on its complexity
4	Research institutions	– No cost for students and researchers by deploying an academic version of the toolset or licencing an open-source version
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	Third-party vendors that employ manned teams for RI inspection	– Reduced cost of inspections – Faster recognition, classification, and localization of PoIs – Automated georeferencing and 3D mapping of PoIs

KER 3: Robotics-based Inspection

Description

Automated robotic platform that is based on an Unmanned Ground Vehicle (UGV) for RI inspections. The platform can inspect the roadway with increased accuracy and efficiency, work in worse conditions (smoke, chemicals, etc.), determine routes for navigation, maintenance, tunnel lining and pavement in roadways. To accomplish such actions, the UGV

employs modern and carefully validated techniques for 3D map reconstruction from collected visual measurements to generate location-based information significant to assess the area of interest. In addition, the platform can carry various sensors (e.g., cameras, scanners, lidars) and deploy multiple UAVs for fast and efficient inspection of large areas. It is also designed to easily accommodate state-of the-art equipment for RI maintenance and upgrading tasks (e.g., robotic arm, robotized devices, materials for rehabilitation).		
#	**Partner Name**	**Partner Role**
1	ROB (Leader of KER)	– Design and development of the UGV – Design and development of the drone platform – Development of the autonomous navigation and control mechanisms
2	ICCS	– Development of the UAV deployment feature – Support to the design of the drone platform – Development of the 3D mapping algorithms
#	**Stakeholders**	**Value Proposition**
1	RI/TI managers/owners	– Reduction of the inspection logistics needs (trucks with cranes and scaffoldings are no longer necessary)
2	RI inspection for security (LEAs, RI/TI managers)	– Robotics can replace the manned inspection with an improved capability of comparison to previous condition
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	Manned inspection teams for security	– No humans are exposed to danger – Automatic update of the RI inspection database – Reduced cost of inspections
2	Aerial robotic system of the AEROBI project[4]	– Increased inspection time capability – Adapted not only to bridge inspection but on many more RI components

KER 4: Incident Management System (IMS) and Decision Support System (DSS)

Description

Incident Management System (IMS) to enable enhanced situational awareness for the RI operators/managers by providing unified information regarding the RI facilities, equipment, personnel, procedures, and communications. The IMS integrates all the information provided by the various sources (e.g., tools, sensor data) as different layers in a unified enhanced visualisation UI generating the Common Operational Picture (COP). The system also implements protocols for multiagency interaction and communication to integrate and synchronize actions of participating organizations and jurisdictions to ensure unity of effort. Assisted by the Decision Support System (DSS) tool, IMS also manages seamlessly routine incidents as well as emergency situations in the RIs. The decisions and response procedures per reported incident are turned to actions and resource proposals by building related incident process workflows to support the decision making of RI operators. The visualization is

finally enriched with AR components to allow for the user to have an in-situ supervision of the automated maintenance and upgrading operation process.		
#	**Beneficiaries**	**Partner Contribution**
1	STWS (Leader of KER)	– Extension of the ENGAGE IMS of STWS to support RI features – Development of the COP visualisation interface – Support to the integration of the DSS with the IMS
2	RISA	– Development of the DSS and integration with the IMS
#	**Stakeholders**	**Value Proposition**
1	RI/TI operators	– Solution Consolidated Pricing
2	Maintenance & inspection teams	
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	Holistic Risk Assessment Platform (HRAP) & DSS of the HYPERION project[3]	– Supports AR capabilities – Several features specific for RI operations (e.g., COP, interaction with the robotic platform)
2	Closed-Circuit Television (CCTV) and Transport Management Systems	– Assists decision-making on problems that cannot be solved through simple reasoning – Enhanced situational awareness using data from various sources and not only cameras – Automated incident warning and reporting

KER 5: Augmented Reality (AR) application and AR Glasses

Description		
User Interface (UI) for Augmented Reality (AR) glasses to support robot operators and road supervisors during inspection, inventorying, maintenance, and intervention actions. The UI can retrieve information from the wearable glasses as well as from cameras, robotic arms**,** sensors, and drones. Subsequently, the app collects, fuses, and displays the relevant information in a non-intrusive way in the AR device to provide practitioners with guidance in complex tasks and environments or in cases of hidden elements during repair & maintenance. As a result, the RI operator can obtain real-time visual information (while being remote) about the environment (e.g., road, pavements**,** safety elements, road signalling and markings and other areas) and possible hidden structural and/or functional elements or additional damages.		
#	**Beneficiaries**	**Partner Contribution**
1	STWS (Leader of KER)	– Development of the AR app – Integration of the AR components with decision support tools
#	**Stakeholders**	**Value Proposition**
1	RI operators	

2	Maintenance & inspection teams	– Enhanced Precision as well as time and cost-saving maintenance and upgrading operations
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	ARki[5]	– Specialized features for RI operations (e.g., data fusion from various sources, interaction with the robotic platform) – Integration of the AR app with the IMS and DSS for enhanced decision-making
3	AR Instructor[6]	

KER 6: Integrated RI Monitoring System

Description

The HERON integrated RI monitoring system, which comprises the combined outcome of several sub-results of the HERON project, aims to support the inspection, inventorying, maintenance, and upgrading processes on modern motorways, as well as the management of emergency situations. To accomplish such goals, the integrated system employs ► the autonomous ground robotic vehicle, supported by autonomous drones to coordinate maintenance works and the pre-/post- intervention phase; ► various robotic equipment, including sensors and actuators (e.g., tools for cut and fill, surface material placement and compaction) placed on the main vehicle; ► the sensing interface installed both to the robotic platform and to the RIs to allow improved monitoring (situational awareness) of the structural, functional and RI's and markings' conditions; ► the control software that interconnects the sensing interface with the actuating robotic equipment; ► AR visualization tools that enable the robotic system to see in detail surface defects, safety elements, road signalling and markings under survey; ► AI-based toolkits to optimally coordinate the road maintenance/upgrading workflows and process intelligently the distributed data coming from the vehicle and the infrastructure sensors; ► Enhanced visualisation UI to support decisions.

#	Beneficiaries	Partner Contribution
1	ROB (Leader of KER)	– Design and development of the autonomous ground robotic vehicle – Integration of the robotic arms (manipulators) and drones with the UGV
2	ICCS	– Development of the CV and ML detection tools – Development of algorithms for 3D SLAM – Implementation of the drone deployment
3	ETHZ	– Design and development of the high-level planners for the robotic arm
4	STWS	– Implementation of COP and IMS – Development of the AR component
5	RISA	– Main software integrator – Development of the Middleware – Development of the DSS
6	INAC	– Development of the communication architecture and security elements

7	IKH	– Development of CV system – Development of ML algorithms for infrastructure inspection – Development of collision avoidance algorithms to instruct the robotic arms
#	**Stakeholders**	**Value Proposition**
1	Highway operators	– Fast and efficient inspection & maintenance – Low-cost for operators of the RIs (in general transport infrastructures)
2	Maintenance teams	
3	Inspections teams	
4	First Responders / LEA units	– Better preparedness – Reaction time can be reduced as the situation assessment will not need human action on the spot.
#	**Competitors**	**Benefits of KER Over Existing Solutions**
1	Sensabot Inspection Robot[7]	– Automatic operation of the system – No R/C control need
2	Laser Tunnel Scanning System (LTSS)[8]	– Adapted to inspect whole highway – Real-time processing capability

4 Conclusions

Deliverable D9.1, namely "Exploitation Strategy (version 1)", which was developed within the WP9 "Exploitation of Results, Standardization and Sustainability Activities", by the responsible partner ResilienceGuard GmbH, aimed to deliver the first version of the HERON Exploitation Strategy, which comprises the common strategy to utilize the project results (in individual and collective way) and to ensure that the results are taken up by relevant stakeholders during and after the project lifetime.

The deliverable first presented the draft Individual Exploitation Plans of the HERON consortium partners, by summarizing their main contribution to the HERON project, outlining their background and foreground knowledge and Intellectual Property (IP) assets, and finally defining a draft strategy on how they intend to exploit the project outcomes. The individual sub-results with the highest exploitation potential were then combined into the following six Key Exploitable Results (KERs): (1) Middleware and Data Fusion (DF) services, (2) Computer Vision Detection System, (3) Robotics-based Inspection, (4) Incident Management System (IMS) and Decision Support System (DSS), (5) Augmented Reality (AR) application and AR Glasses, and (6) Integrated Road Infrastructure (RI) Monitoring System. For each KER, a preliminary exploitation plan was given, comprising the definition of the KER leaders and other involved beneficiaries, as well as the identification of the key stakeholders and competitors.

All the results and exploitation strategies presented in this deliverable will be further updated, monitored, and extended throughout the duration of the project, and reported in Deliverable 9.2 "Exploitation Strategy (second version)") in M48. Ultimately, these plans will form the basis for the development of the HERON business plan, the engagement of public stakeholders, and finally the definition of the long-term vision roadmap of the project.

References

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