PANOPTIS

Development of a Decision Support System for increasing the Resilience of Road Infrastructure based on combined use of terrestrial and airborne sensors and advanced modelling tools-

Grant Agreement Number: 769129

D9.1: Preliminary Exploitation Plan

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Legal Disclaimer

CONTENTS

LIST OF ABBREVIATIONS

PANOPTIS	
C2	Command and Control
COP	Common Operational Picture
DOW	Description of Work
EC	European Commission
HRAP	Holistic Resilience Assessment Platform
IP	Intellectual Property
IPR	Intellectual Property Rights
PDF	Portable Distribution Format
PPT	Power Point
R&D	Research and Development
REA	Research Executive Agency
RI	Road Infrastructure
ROM	Rough Order of Magnitude
SAR	Synthetic Aperture Radar
SC	Steering Committee
SWOT	Strengths, Weaknesses, Opportunities and Threats
UAS	Unmanned Air System
UAV	Unmanned Aerial Vehicle
WP	Work Package

1 INTRODUCTION

This document presents the preliminary exploitation plan for PANOPTIS. At this stage of the project, there are not yet any concrete feed-backs on the system performances as assessed by the end-users and stakeholders during the tests and demonstration campaigns that will start at T0+2 years in Spain and in Greece. The performances of PANOPTIS system and its components will be then benchmarked with the performances of the traditional ("manual") method. However, there is already some material brought by the two end-users in the consortium (ACCIONA and Egnatia Odos) that can be exploited for this first exploitation plan.

The document will thus present:

- The present business case, including the stakeholders analyses,
- The possible business models.
- The foreground.
- The consortium exploitation strategy.
- The partners' individual exploitation strategy.

2 REFERENCE DOCUMENTS

The following documents define the contractual requirements that all project partners are required to comply with:

- Grant Agreement N°769129 (which includes DOA, Grant Preparation Forms and annexes)

  This is the contract with the European Commission which defines what has to be done, how and the relevant efforts..

- Consortium Agreement

  This defines the obligations of the partners towards each other and the management of IPRs..

Each of the above documents was established at the start of the project, and copies were supplied to each partner. Each document could potentially be updated independently of the others during the course of the project following a prescribed process. In the event of any such update, the latest formal issued version shall apply.

In the event of a conflict between this document and any of the contractual documents referenced above, the contractual document(s) shall take precedence.

3 BUSINESS CASE

3.1 Current status

PANOPTIS project was built in close collaboration with Road Infrastructure managers or owners. All the elements that constitute the system are therefore of high relevance for them to perform their work, either operational (traffic management) or predictive and curative maintenance (to keep the RI in a good status).

The development of road infrastructure throughout Europe varies greatly in the member states. Some regions have largely complete networks, with some parts built more than 50 years ago. Extreme weather events and the long term effects of climate change, together with increasing traffic loads will put further strain on Europe's infrastructure. Maintaining this infrastructure and protecting it against climate and traffic conditions not envisaged at the design stage is of great importance, and cost effective solutions to extend the service life are required. According to the EC, weather stresses represent from 30% to 50% of current road maintenance costs in Europe (8 to 13 billion € p.a.). About 10% of these costs (~0.9 billion € p.a.) are associated with extreme weather events alone, in which extreme heavy rainfalls & floods events represent the first contribution. Conversely, some regions are still developing their road infrastructure networks, and cost-effective solutions to design and construct new roads with in-built resilience are thus desirable.

Transport activity across Europe is expected to continue growing. From 2010 to 2050, it is estimated that passenger transport will grow by about 42 percent. Freight transport is expected to grow by 60 percent. The cost of EU infrastructure development to march transport demand has been estimated at over € 1.5 trillion for 2010-2030.

In this context, one of the greatest challenges facing transport operators and engineers today is the fast and efficient inspection, assessment, maintenance and safe operation of existing infrastructures including highways and the overall Road Infrastructure (RI) network.

As for the majority of critical infrastructures, the inspections are costly and time consuming. The tunnels request for the traditional method trucks with cranes to inspect the intrados and this task cannot be done at high speed as most of the visible part of the defects is quite small (the project ROBO-SPECT, ICT, Contract N. 611145 made a deep analysis of this and estimated the global budget for tunnel inspections at 30 Billion € per year).

The inspection of bridges is even more demanding since the accessibility of the beams and piers can be very difficult (height that necessitates alpinists, rivers that make all measurements difficult due to the impossibility of using trucks as nacelle lifting capabilities).

In addition, the inspections if done with vehicles request the closing of the road (or part of the road) during one day or more which can cause a reduction of traffic fluidity (or a diversion solution) and for the motorways a loss of financial incomes (tolls).

The reaction to an incident or accident requests the use of vehicles to assess the damages and to implement solutions. So, depending on the distance between the event and the vehicles posts, it can take quite a long time and of course create traffic jams or worse additional accidents.

The prediction of risks is still not precise to take focused (in time and space) measures. As demonstrated during the last winters, the measures can be too optimistic and lead to a chaos where people will live their cars on the road (Snow events in Paris 2010 and 2018) or in reaction too pessimistic (Snow events in Paris in 2019 where important roads were closed during a long time only as a measure of precaution). Due to the climate change, flash floods

are more and more violent in the Mediterranean basin, leading to cars being caught in the streams, large trees being transported by the flood, old bridges collapsing and landslides. Precise alerts and response are both difficult since the area can be very large and local solutions rare.

So the four sub-systems of PANOPTIS (risk assessment, vulnerability assessment, sensing/road monitoring and information system with COP and HRAP are very useful for road infrastructure managers or owners. France has 29 operators for motorways or important RI. Each of the 95 department have a departmental management service. In most of the countries in Europe, the management of RI is shared between the state (which can be divided in regions) and private operators (in general for motorways). The operators have in their contract with the state a lot of KPIs that they need to respect otherwise they can get fined and the fines can be important. The states are also now liable for accidents due to improper maintenance or traffic management. Both in terms of money saving and problems mitigation, the PANOPTIS solutions are interesting for all RI managers. During the project, it is important to check that the developed solutions are affordable for their budgets.

3.2 Stakeholders analyses

From PANOPTIS first workshop with end-users and stakeholders in May 2019, the following feed-backs were gathered:

The need for UAV surveillance is now a must. The use of light UAVs is (and will be) easier in the shared aerospace (if the UAV is less than 20 kg and flies below 150 ft, there is no need for special authorisation). The inspections of infrastructures are now less problematic, provided that the safety rules are respected (as demonstrated in AEROBI project – www.aerobi.eu). The users in PANOPTIS are asking for two main types of inspections with UAVs:

1. The detailed inspection of elements of the Road Infrastructure (bridges, tunnels, problematic shoulders that move, etc.). The objective of these inspections is to detect anomalies that are the sign of the deterioration of the element (cracks, spallings, exposure of re-bars, small movements, etc.). These inspections are in general done by VTOL (helicopters) UAVs as the transition speed needs to be low to have exploitable images from the camera. The images from the camera are exploited automatically by the computer vision (EYE-D in PANOPTIS) which proposes the list of anomalies to the operator that will validate them.
2. The inspection of a road segment (that can cover several kilometres). In this case, the fixed wing UAV is a better solution since its range and speed are more adapted. But of course, due to the speed and resolution, only macro-events can be detected (ice, snow, landslides, etc.). The exploitation should be also automated for the recurring events described in the PANOPTIS user-requirements document (D2.1).

The PANOPTIS sub-system for the inspections consists in the UAVs, the data link(s) and the Generic Ground Control Station (which constitutes a UAS (Unmanned Air System). All the RI operators and managers are interested in procuring this type of system (budget from 50 to 100k€ as an order of magnitude). This sub-system can be used in a stand-alone way (mostly for routine inspections or connected to the information systems in case of accidents/disasters.

The need for satellite surveillance is also interesting for the following items:

- Large area event (earthquake, large land-slides, floods, forest fires): the satellite image can cover a large area and can be used for a quick damage assessment in the region.
- Land changes (vegetation growth, change of land-use, new buildings, etc.).

This capability is integrated in the Generic Ground Control Station. The pending question is the choice of the constellation(s) and type of instrument inside the constellation. Due to the important costs of satellite images, the choice should rather go to the cheapest solutions. The Sentinel satellites offer free images (SAR for Sentinel 1 and 1A, multi-spectral for 2 and several instruments for 3, with a higher resolution SAR). The PANOPTIS analyses are currently being done to optimise the choice for each event, keeping in mind the cost factor.

The ground sensors (cameras, weather stations, accelerometers, etc.) connected to the information systems to have real time information is a general demand from all the end-users and stakeholders. The additional request is to develop local processing to avoid the transmission of large volumes of data that are not useful for the management of the Road Infrastructure. So the sensors should be transformed in “smart sensors” that will only report alarms and alerts rather than raw data.

The sub-system developed in WP3 (impact of weather or natural events) provides services that are more detailed than the existing services. The present of status of the project does not allow to make a detailed cost-benefit analysis of the services. It is of course different for each end-user as it depends from the type and severity of the events in the region and on the vulnerability of the components (e.g. bridges, especially high and long ones, are much more sensitive than roads on solid terrain).

The sub-system developed in WP4 is interesting to be integrated in information systems, especially since it proposes a standardisation of the vulnerability elements.

The middleware of the system, hosting all the data bases and connecting all the elements is considered as extremely positive due to its low cost (ROM of 100k€ for the middleware to which the adaptation of sensors and specific C2 characteristics have to be added).

Finally, the Command and Control system, associated to HRAP could not be assessed in detail since its definition is still high level and only generic displays are available. The difference in costs can be important if the customers want a system shared between different organisations (operator, owner, safety, security…), if the system is dealing in a separate way with operations and maintenance and of course the level of centralisation of the operations (local, regional, national).

As a conclusion, a solid business case is here for all the components of the system and for the whole system, with different level of maturity depending on the easiness of implementation in the current systems (or absence of systems in many cases). Combining PANOPTIS and AEROBI, all major operators and owner of RI are interested by all or parts of the system, starting by the most obvious nowadays, the inspection by UAVs.

3.3 Feasibility Study

At this stage of the project, the feasibility study validated the viability of the UAVs solution to replace the current inspection methods (cars equipped with sensors). The UAVs can inspect the road elements much quicker than the teams in the cars and can also inspect many things that the ground vehicles cannot do (high bridges, intrados of tunnels, road shoulders). The end-users can make an easy benchmark between the current methods and the UAV solution (this benchmark was also previously done on AEROBI project). For an inspection with the current method, a team of 3 persons minimum is needed (simple inspection on a small element that do not necessitate lifting capabilities or special vehicles) but it can go up to 10 (order or magnitude) when several vehicles are needed - as well as specific specialties (alpinists, etc.). With the UAV, a team of 3 persons maximum is needed (pilot, civil engineer and UAV technician). The inspection with the UAV will take around 15 mn for a bridge span whereas with the current method with the various vehicle movements and positioning, it will take more than 1 hour.

For the whole information system, concrete information will be available after the first tests. One part of the procurement cost is composed of recurring costs (corresponding to what is developed in the project as the generic system). The other part is the customisation/implementation costs which can be very different from customers to customers (as a function of the organisation – number of centres to equip, number of different organisations involved, integration with legacy systems, adaptation of HRAP to local conditions and peculiarities, etc.). An important cost driver is linked to the communication networks (if the system can be implemented on an existing communication network or not (SCADA for instance)). A first estimation shows that the recurring costs are less than 50% of the procurement costs, so the business models have to be adapted accordingly.

Regarding the external services that can be connected to the operational system (WP3 outcomes), they are an evolution of existing services, so each end-user needs to analyse the Cost/Benefit of subscribing to these new services (with regards to their obligations and their need to predict some types of events).

3.4 Cost considerations and planning

At this stage of the project, the costs of PANOPTIS solutions are only related to the generic components. As stated above, the costs of customisations are more important and very variable from customer to customer. However, the following elements have been discussed with the end-users:

- WP3 (impact of weather and environmental events): The business model is to pay for the services (subscription). If the services are widely used in Europe by a majority of RI managers and operators, the costs can be affordable and in the same order of magnitude than current services. The issue is to have a precise modelling of the area in the system and precise vulnerability of the components to make the best of the new capabilities. This component should be at TRL7/8 at the end of the project, requesting only limited effort for industrialisation.
- WP4 (vulnerability): Mainly a data base with standardised information and data on the component of the RI. Marginal cost (licence) – typically around 1000 € per year maximum. Limited effort for industrialisation.
- WP5 (sensors integration and information management): the ground sensors are integrated to the middleware. The integration is easy for the large majority of sensors (a few days) and the middleware in a secured cloud is inexpensive (ROM; 100k€ for the set-up of the private cloud and 10k€ per year for the installation of new services/maintenance). The solution is based on existing solutions that need to be customised, so only little effort for industrialisation will be needed.
- WP5 (UAVs): With the basic configuration (cameras and VTOL or hybrid), the purchase cost of one system should be between 50k€ and 100k€, which is achievable with PANOPTIS solutions. As for all the systems based on mini-UAVs, the critical cost driver is the sensors (and the ground system, but this one is developed within PANOPTIS). Cameras can cost several hundred thousands Euros (HD, long range), but the preliminary PANOPTIS tests and AEROBI lessons learnt demonstrate that cameras around 500 Euros are fit for PANOPTIS applications. Here, the industrialisation will take longer (ca 1 year) to deliver a drone system that can be used by non-specialists.
- WP5 (satellites): the study is still on-going on the choice of satellite constellations and tools. A first approach with Sentinel satellites combination (1, 2 and 3 – SAR images and camera images) looks satisfactory for large area monitoring, but detailed analyses will probably request more precise (and expensive) solutions.
- WP6 (information system, C2, COP, HRAP): the solution is highly dependant on

the organisation of each end-user and the baseline is constituted by off-the-shelf software products that need to be configured and customised as per the end-user requirement. The development has just started, so the cost aspects remain vague. The market prices should be below 1 M€ for the whole system (hardware and software included for the customer centres).

3.5 Return on Investment (ROI)

The business models have not yet been fixed for the moment. They will be after the tests and trials as the end-user need to use each component to determine the best models. The preliminary elements are:

Environmental impact (WP3): the business model is clearly “service on demand or alerts” through subscriptions. As the services will be developed during the project, the subscription cost will be a fee and a price per demand or event.

Vulnerability: licence fee. Very short ROI as the cost of the development is covered by PANOPTIS.

Middleware: customisation of existing solutions. ROI < 1 year.

UAVs. The business models are multiple and don’t depend only on PANOPTIS as other prospects need to be taken into account to adapt the prices as a function of the dimension of the serial production.

Satellites: the ROI will depend on the need or not to develop new image interpretation capabilities (for SAR essentially).

Information system, C2, COP, HRAP: the non-recurring part is important. The possession cost will need to b studied during the test campaigns.

3.6 SWOT

The following table shows an early SWOT analysis that will be later enriched with tests feed-backs.

Strengths	**Weaknesses**
• System design elaborated with end-users • Use of proven building blocks to develop the system • Modularity • Standardisation of interfaces • Long experience of the partners in sensor integration and remote sensing • Lessons learnt from AEROBI and other projects	• Information system, C2, COP and HRAP are complex to design to keep an acceptable level of recurring components • Only one large industry in the consortium • Low feed-backs on similar systems • Large variety of end-users on RI (operators, managers, operations, maintenance, civil protection, police, etc. and therefore diverse requirements
Opportunities	**Threats**
• Contacts with several organisations inside and outside the consortium to start developing systems • Large volume of immediate needs to operate UAVs for inspection (operators in UK, Belgium, France, Spain, Greece) • Short term needs to deploy information systems that can be shared between	Fragmented budgets (few large operators) The implementation of new capabilities is more driven by legal constraints than long term optimization Civil engineers domain (still reluctant to important automation and IT solutions) The customization requirements can be very high and can make the market difficult due to a small percentage of recurring costs.

agencies • New cheap satellites options (SENTINEL constellation)	

4 EXPLOITABLE FOREGROUND

4.1 Overview

The system is an integrated platform addressing multi-hazard risk understanding, smart prevention and preparedness so as to increase the resilience of RI/TI.

It is composed of four sub-systems, which are loosely integrated:

- modelling tools and simulator,
- existing and new sensors,
- vulnerability assessment tools,
- HRAP platform, which gathers data from the sub-systems above-mentioned.

A Common Operational Picture as well as an Incident Management System can be visualised on the HRAP and enable to take operational decisions.

The system can be procured as a whole or by components.

4.2 Detailed components

The list of components that can be marketed is described here-below. Some can be marketed independently and other need to be integrated in a legacy system.

4.2.1 Modelling tools and simulators

These tools include land-surface model, risk modelling interface, multi-hazard modelling tools (related and geo-hazards, inundation maps, new quantification and modelling approaches).

A specialized Structural/Geotechnical Safety Assessment (SGSA) simulator exploits data from traditional and advanced sensors in order to assess the current condition of the RI.

A forecasting module for risk assessment associates best prediction and uncertainty data. It uses hydro-meteorological sensors blended with short term radar and mid-term weather forecasts.

4.2.2 Existing and new sensors

Sensors used are ground and airborne instruments, and improved computer vision techniques are used. Microclimate stations, smart tags and fog detection systems are added to the existing sensors. Surveying procedures and scheme are implemented for the organization of regular and maintenance operations.

4.2.3 Vulnerability assessment tools

These tools enable the collection of data on “hot-spots” and vulnerabilities of the RI.

The final shape of these tools and their interface with HRAP are not fully defined at the moment. Machine learning techniques are used in this sub-module.

4.2.4 Data link

The data link used in PANOPTIS is based on middleware and data fusion services. The interfaces between sub-modules and the HRAP are not known yet.

4.2.5 Holistic Resilience Assessment Platform

The HRAP provides and advanced simulation environment that integrates all the hazard and impact assessment tools and modelling data. The platform enables to run “what-if” scenarios

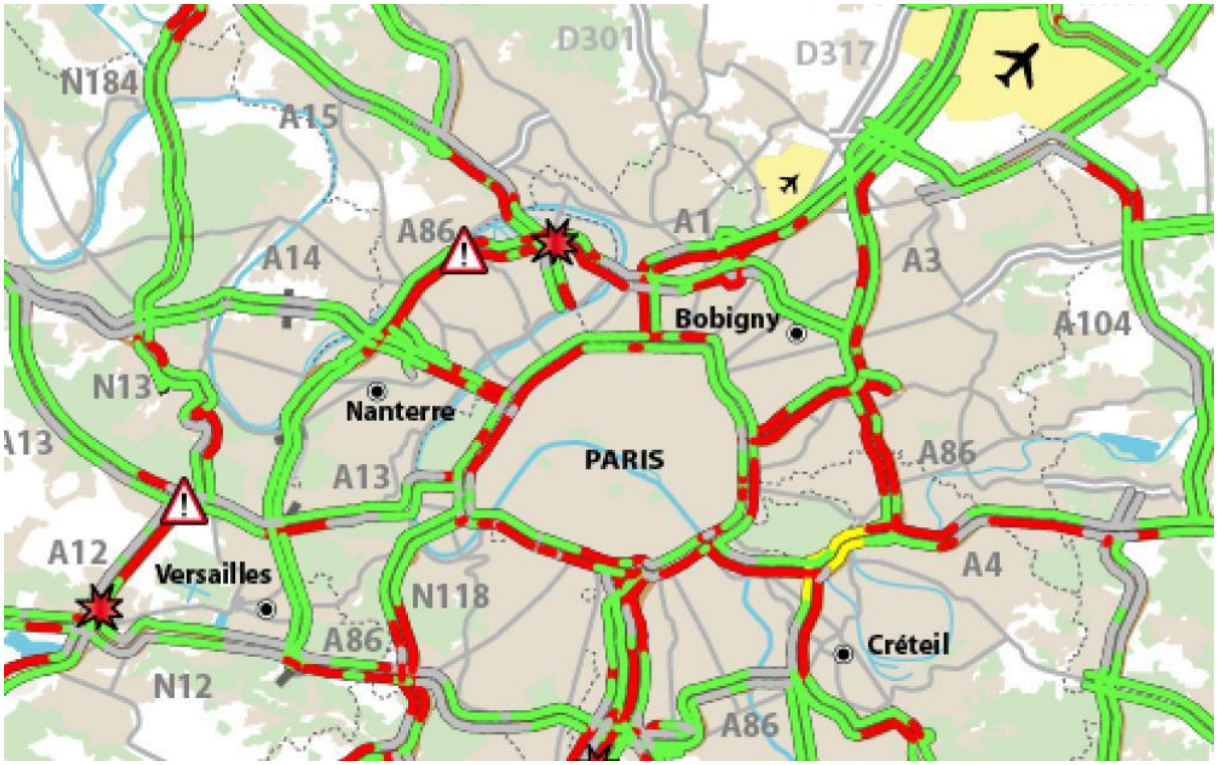
and support decision taking. A Common Operational Picture, a Decision Support System and an Incident Management System (IMS) are displayed in the HRAP tool.

The product can be marketed as an information system (without the decision support system) to display the situation or as a full HRAP.

5 COMPETITION

5.1 Information systems

The competition is essentially composed of companies that develop Road Information Systems. From a technical point of view, these systems are in general composed of a Geographical Information System (GIS) on which the objects and events can be positioned. A typical example is SYTADIN, the system that monitors the traffic in real time in Paris region:



SYTADIN system: Overall view of traffic conditions in real time around Paris

This system is an information system for the drivers. The system is owned by the Ile-de France (Paris region) Roads direction. It presents the data and information gathered by the reporting posts (a big part of them are the results of traffic camera exploitation). The events are those who are generated by the traffic (accidents, traffic jams) and the known maintenance closures. The data are purely factual and are not directly interpreted for the road owners and road managers (no HRAP).

5.2 Hazards prediction

National or regional meteorological agencies are responsible to disseminate alarms (wind, rain, snow, icing, etc.). There are generally two types of products from these agencies: 1. public (free) situations and alarms that are disseminated on media. The precision is at town/village level, available during a slot of several hours (depending on the proximity in time). The alarms are on large areas as a precaution measure, 2. Specialised - more accurate - predictions (paying – with special discounts for public/governmental services). In PANOPTIS, the targeted precision will be one step beyond to enable the decisions and measures at local level (to avoid over-response.

5.3 Vulnerability

The vulnerability studies are nowadays largely manual with specialised tools. The analyses are based on human expertise.

5.4 Integration of sensors

The most widely spread sensors in road monitoring are cameras. The cameras are integrated in video management systems and equipped (or not) by computer vision systems that are optimised to detect categories of objects or types of events. Typically, this type of systems ids implemented by integrator companies (Thalès for instance). PANOPTIS proposes to add remote sensing based on satellites and UAVs and to integrate other types of in situ sensors (weather stations, accelerometers, etc.) and to fuse/correlate the data where relevant.

PANOPTIS also proposes long duration monitoring. On phenomena such as land-sides, erosion, corrosion, the evolution is checked yearly, so it does not make sense to have the sensors/platforms connected in permanence. The configuration of the system has to be flexible enough to connect additional sensors on demand or remove them when useless.

6 JOINT EXPLOITATION STRATEGY

The preliminary ideas for the joint exploitation strategy of PALAEMON outcomes are the following ones:

For the Hazards prediction and risks elaboration, the product should be industrialised and managed by an operator (linked to FMI) that will propose adapted services to the RI owners/managers. This type of service is of course not limited to RI. Any domain of activity outdoors that depends on weather conditions or is subject to environmental risks can be interested.

For the infrastructure vulnerability, the targeted business model is also to propose inspection services to the RI owners/managers. The contracts for this type of services should be long term contracts as a huge volume of data on the infrastructure are needed to compute the vulnerability (infrastructure data on all the components and environmental data are pre-requisite for the computation).

For the information system and HRAP, the offer should be a system offer where the end-users will buy the system that will be configured jointly between the end-user and the joint venture that will industrialise the system.

The sensors, UAVs and satellite capability can also constitute a product that can be sold as an inspection system, similarly to AEROBI project (inspection of bridges by UAVs).

7 INDIVIDUAL EXPLOITATION PLAN

7.1 ADS

7.1.1 Exploitation strategy

The development of civilian applications for UAVs is important priority for ADS. The Airbus Aerial was created in the beginning 2017 to fuse ADS' constellation of high-resolution satellites along with fleets of UAVs and develop the services related to the collection and exploitation of remote sensing data. PANOPTIS is an opportunity for ADS to develop portfolio in developing unmanned systems and fully integrated operational system (information and C2). PANOPTIS will be useful for ADS to work with SMEs that can provide technical solutions for developing large monitoring systems, e.g., DSS, specific sensors.

7.1.2 Background

ADS have already implemented a lot of research projects on the monitoring of transportation infrastructure: ROBO-SPECT (ICT-Robotics) for tunnel inspection by robot (ADS were lead integrator of the system), SURICATE (ITEA2) for the monitoring of the railways networks by UAVs (ADS were WP leader), AEROBI for the bridges inspection combining several UAVs including one with an articulated arm to measure defects with and ultrasonic sensor.

Applications that ADS developed based on satellite images/remote sensing are numerous and are built around multi-satellites/surveillance aircraft Ground Stations.

7.1.3 Identification of the foreground

The foreground will be a Generic Ground Station optimised for the monitoring of RI and a VTOL UAV equipped with the relevant sensors.

7.1.4 Planned roadmap for exploitation

The roadmap is to integrate PANOPTIS outcomes in the generic roadmap of monitoring systems composed of information systems, Generic Ground Stations and airborne monitoring platform (piloted or not).

7.2 NATIONAL TECHNICAL UNIVERSITY OF ATHENS - NTUA

7.2.1 Relevance of the project in the strategy of the entity

NTUA is the oldest and most prestigious educational institution of Greece in the field of engineering. Since its foundation, NTUA has contributed to the country's scientific, technical and economic development. As a public institution of higher education, NTUA is a non-profit organization that will not perform commercial exploitation of the project's results. Instead, NTUA's priorities are education and scientific research. NTUA's research fields coincide with PANOPTIS' targets. In particular, any means that promotes safety, cost minimization and improvement of life quality are inherently incorporated in both NTUA's and PANOPTIS' objectives.

7.2.2 Exploitation strategy

The exploitation strategy of NTUA emphasizes three domains: a) education, b) research, and c) collaborations with the private sector.

At the educational level, relevant courses and associated instruction materials will be improved. The research work and the methodologies that will be developed in PANOPTIS regarding structural risk and vulnerability assessment will be incorporated in our cutting-edge Master's graduate-level courses. The concepts of seismic hazard and risk assessment are presently taught in one undergraduate and two graduate courses at the School of Civil

Engineering. Plans are already underway to enhance all three of them based on the experience, the case studies and the worked examples gained through the PANOPTIS project.

Subjects related to road planning, monitoring the infrastructures, and damage assessment appear in multiply undergraduate courses at the school of School of Rural and Surveying Engineering. Particularly, students receive knowledge from relevant to PANOPTIS concept courses. These courses are related to road construction and general principles of roads conservation, as well as the use of GPS, photogrammetry and remote sensing tools for applications related to road monitoring. There are also post graduate courses related to the use of Information Systems (expert systems, geographical information systems, automation and robotics systems and telematics) in road infrastructures. A further insight on these topics, by employing automation tools, machine learning and computer vision algorithms will enhance the transfer of knowledge process. Consequently, students will familiarize themselves with modern tools, used in PANOPTIS, that can boost the assessment performance and minimize any human factor related errors.

The same concepts and material will appear in summer schools, industry seminars, keynote lectures and professional society presentations, enhancing the status of the NTUA team and promoting new ideas both to the new generation of engineers as well as to practicing professionals within an inherently traditional and slow-to-change profession.

At the research level, the technological tools developed, the knowledge acquired and the published research of PANOPTIS will enhance NTUA's visibility as a strong partner in risk/resilience assessment of critical infrastructures, automated road monitoring analysis, pattern recognition and user profiling research fields. Particularly, the knowledge gained from the network reliability, vulnerability estimation, pattern detection, deep neural networks and infrastructure risk assessment modules, will establish NTUA’s position in these cutting-edge fields. Knowledge gained from PANOPTIS project will lead the way for future research/consultancy projects, while future partnerships will be established.

Apart from educational and scientific impact, future innovation opportunities for knowledge transfer to market through establishment of new partnerships, will be presented. The NTUA team expects to gain knowledge on state-of-the-art topics and enhance its visibility by collaborating with strategic industrial partners within and outside the consortium in the field of robotics, sensors, structural inspection, and resilience assessment. PANOPTIS results will be exploited by postdocs, PhD students and all NTUA researchers involved. They will gain experience, increase their reputation through the project, and offer a dynamic presence in international conferences, making it easier for NTUA to successfully participate in future related R&D projects, thus increasing its resources. .

7.2.3 Background

NTUA’s involved laboratories have a significant background in research fields related to the PANOPTIS project. A brief description for each of the research fields is provided bellow:

Photogrammetry Laboratory: A range of research disciplines are involved in this lab, including computer vision, machine learning, 3D reconstruction, and decision support systems. The know-how on tunnel inspection using computer vision, robotic technology and semi-supervised learning methods from ROBINSPECT project, will serve as base for the development of new type of algorithms, appropriate for the problem at hand. Consortium members have also experience on data handling from numerous, widely dispersed sources (project ZONESEC).

Institute of Steel Structures: The laboratory’s research activity focuses on integrating structural modeling, computational techniques, probabilistic concepts and experimental results into a coherent framework for the performance evaluation of structures and infrastructure under extreme natural hazards (earthquake, wind, wave, corrosion, etc.). Of most relevance to PANOPTIS is the extensive expertise on the assessment of bridges under seismic loads, and the assessment of transmission towers and steel overhead sign

structures under icing and extreme wind conditions, as well as the estimation of seismic hazard at multiple sites. These shall form the basis for the comprehensive hazard, vulnerability, risk and resilience assessment that will be implemented in the project.

Laboratory of soil mechanics: This laboratory involves three independent divisions carrying out complementary research (experimental Soil Mechanics and Dynamics, Theoretical-Analytical Soil Mechanics, and Simulation of Soil-Structure Systems). Numerical Analysis Algorithms for nonlinear dynamic soil response and Soil–Structure Interaction have been developed over the years and validated against a plethora of experiments conducted in-house and independently. These tools are useful for the analysis of potentially catastrophic landslides enabling simulation of earthquake actions as well as the detrimental effect of excess rainfall. Members of the laboratory have actively participated in past projects (LESSLOSS, DARE) dealing with the performance assessment of soil–foundation systems subjected to slope displacements.

7.2.4 Identification of the foreground

Photogrammetry Laboratory: A set of algorithms will be designed specifically for defect identification (i.e. cracks, erosion, potholes, etc.) over concrete areas. The main source will be RGB images from ground cameras or UAVs. Additionally, algorithms for obstacle detection (i.e. landslides, fire, flood, etc.) on the road surface will be developed. The usage of satellite images is also considered. The development will use open source software and the latest approaches in deep learning and tensor based learning.

Institute of Steel Structures: Both simplified and reduced order models will be developed for structural systems involved in the project, specifically concrete bridges and overpasses, power transmission towers and highway overhead sign structures. All will be comprehensively analyzed under pertinent environmental stressors (e.g., earthquake, wind, corrosion, etc.). The methodology for generating simplified models of the RI assets (i.e. bridges etc.) using open source programs will also be developed along with algorithms for combining their results with those of the detailed models for fragility and vulnerability assessment. The results will be coded in open-source vulnerability modules that can be combined to estimate risk and resilience of the entire road infrastructure. Additionally, the seismic hazard will be estimated based on the current European Seismic models and basis of the methodology for assessing the risk in the RI will be developed.

Laboratory of soil mechanics: Comprehensive numerical modeling of critical landslides and, where applicable, their interaction with motorway structures will be undertaken using finite element packages and appropriate constitutive relationships for nonlinear soil response. Where possible, the numerical methodology will be calibrated/updated with respect to field measurements of soil displacements and pore pressures. Simplified numerical algorithms will also be developed to permit timely conduction of vulnerability assessments.

7.2.5 Planned roadmap for exploitation

Research outcomes will be publicly available through scientific journals and conference proceedings. The NTUA partner site will also provide structured information on the related topics, linking to worked examples, open source code and databases of results for scientific transparency. The participation in specialized scientific and/or professional workshops will be pursued. There is a highly probability that developed algorithms can be used in a wide range of applications, since there are multiple end users, including local authorities, manufacturers, private sector. Additionally, project outcomes can be beneficial in other ongoing projects, and in the expected transition of the PANOPTIS system into a full-fledged commercial product, where the NTUA team plan to position itself as one of the key suppliers of hazard, damage and vulnerability information for future applications.

7.3 ACCIONA ENGINEERING (ACCI)

7.3.1 Relevance of the project in the strategy of the entity

ACCI is a global company with profile of transport infrastructure designer, builder, operator, and maintenance company. In PANOPTIS, ACCI participates with the Engineering business division in close collaboration with the Infrastructure Maintenance division as well as the Concessions division. Within its portfolio ACCIONA Engineering has designed more than 3,200 Km of highways and 1,400 km of high speed highways internationally, whereas ACCIONA Infrastructure Maintenance deals with the maintenance of 1,500 km of highways, 8,250 km of conventional roads and more than 180 km of tunnels including more than 3,000 km of winter maintenance. On the other hand, ACCIONA Concessions has an accumulated experience of over 1300 km of concession roads and a current portfolio of over 750 km.

ACCI is in search of incorporating innovative technologies as driving force to improve processes and products, increasing its competitiveness in international tendering process. In this line, ACCI aims to be a leader in smart roads implementation and operation, and thus, shares technical objectives with PANOPTIS project. Particularly, ACCI aims to integrate the latest trends on intelligent transport systems (ITS) in its projects:

- Advanced weather observation and forecasting systems,
- Application of image analysis and machine learning for deterioration monitoring of the road surface and other road infrastructures (cracks on concrete of bridges, soil erosion of slopes),
- Integration of UAV technology into inspection procedures, making possible to inspect areas of difficult access,
- Integration of structural health monitoring sensors to monitor road infrastructures
- Integration of early warning systems,
- Integration of multi-hazard models to provide an integrated management of risks in road infrastructure,
- Implement a multi-contract asset management tool for managing different contracts. Use this asset management tool for having a multi-criteria decision support system (MDSS) tool that contribute to work efficiency.
- Integration of a powerful operational picture using risks maps into the data management tool to improve the management of emergency situations

Implement a specific tool for winter road maintenance operations dealing with fleet management, thermal maps (showing road surface temperature) and de-icing agents maps (showing amounts of de-icing agents spread) and a predictive system to activate the de-icing treatments.

7.3.2 Exploitation strategy

ACCI will exploit the results obtained in PANOPTIS through different business divisions: the Engineering division, the Construction division (and particularly ACCIONA Infrastructure Maintenance subsidiary company) and the Concessions division. With the help of PANOPTIS technologies, ACCI will be able to increase the efficiency in the infrastructure maintenance planning and performance, reducing the costs derived from those services to the customers and thus positioning better against competitors in future tenders. ACCI will introduce PANOPTIS into the inspection and maintenance plans of other highways concessions globally and strengthen the cooperation with technology developers and suppliers to do so. In addition, the adoption of the technologies developed in the project will enable the company to gain competitive advantage against competitors and therefore obtaining a higher amount of new contracts

The results obtained from PANOPTIS will enable the company to increase the efficiency of its operations by means of a better understanding of the potential risks affecting the normal operation of the RI and the identification of possible preventive actuations to mitigate their

impact. In particular, the prediction of ice prone areas along the road corridor, to be demonstrated and validated by ACCI in PANOPTIS, will enable the reduction of the costs associated to their operatives, as the application of such system would reduce the number of traffic cuts and delays due to ice/snow events and optimise the use of resource such as snow ploughs and de-icing compounds. Moreover, the application of innovative monitoring processes supported on Computer Vision techniques (UAVs and ground based) and ML techniques to assess performance and degradation status of RI corridors will enable ACCI to streamline some inspection processes, introducing automation and increasing the quality of appraisals thanks to the quantitative information provided by 3D models and the access to remote locations using UAVs. Finally, the implementation of multi-hazard and end-to-end early warning models will allow ACCIONA to achieve a substantial reduction of disaster events, such as floods, landslides or collapse of reinforced concrete infrastructures due to corrosion of the reinforcement. The associated cost reduction will improve the profitability of the concessions and will also contribute to obtain new contracts internationally as previously mentioned.

7.3.3 Background

- ACCIONA road infrastructure management tool, accessible with user and password from **https://es-aim.iternova.net**, gathering all the data of the A2T2 highway contract: including ITS (CCTV, weather stations, GPS-fleets, route information panels, SHM, inductive loops), daily operations, routine maintenance, results of inspections, road safety management, viability management, store management, resources management, rehabilitation works, records management, etc.
- Know how in relation to geotechnical engineering and civil infrastructure engineering applied to road infrastructure conservation
- Know-how in relation to developing, installing, maintaining and operating wireless sensor networks (software and hardware) in the field of the construction sector
- Know-how in relation to methodologies related to maintenance activities for critical transport infrastructures
- Know-how in relation to methodologies related to road assets management
- Know how in relation to installing, maintaining and operating corrosion sensors on reinforced concrete structures, specifically maritime caissons and wastewater plants
- Know how in relation to models for predicting service life of steel-reinforced concrete structures exposed to chlorides
- Know how in relation to road-surface auscultation to asses structural and functional variables of the road surface
- Know how in relation to winter operations management including the removal of snow and ice, as well as applying deicing materials on all state highways and bridges
- Know-how in relation to loading programmes of de-icing agents and fuel for optimised ploughing and de-icing operations
- Know how in relation to 3D laser scanning of infrastructure using a terrestrial Laser Scanner system, and processing of the points cloud obtained to produce 3D models of infrastructure
- Know how in relation to applying drone-technology and photogrammetry techniques to road infrastructure and assets upkeep
- Background developed by H2020 CLARITY project whose aim is to develop a Climate Services Information System (CSIS) to integrate resilience to climate change into urban infrastructure, including roads

Background mentioned above is provided for use within PANOPTIS 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 ACCIONA's background for exploitation purposes and result actions undertaken by Parties distinct from ACCIONA, will require legal consent of the company and discussion of possible financial terms or copyright terms.

7.3.4 Identification of the foreground

- Application of image analysis techniques to monitor soil erosion on cut-slopes
- Application of UAV-photogrammetry techniques to monitor soil erosion on cut-slopes
- Application of 3D point cloud processing obtained with terrestrial laser scanning system to monitor soil erosion on cut-slopes
- Application of a corrosion monitoring system to monitor and predict corrosion of steel-reinforced concrete infrastructure in roads exposed to winter operations (e.g. bridges, underpasses). The corrosion monitoring and prediction system is based on insitu measurements of remote wireless corrosion sensors installed in the steel reinforcement feeding a service life model.
- Application of computer vision and machine learning algorithms for assessment of road surface deterioration
- Application of computer vision and machine learning algorithms for assessment of cracks in concrete infrastructure (bridges and tunnels)
- Application of computer vision and machine learning algorithms for assessment of damages of road furniture
- Application of computer vision and machine learning algorithms for assessment of corrosion in steel-reinforced concrete infrastructure
- Application of computer vision and machine learning algorithms for assessment of vegetation encroaching
- Application of weather forecasting and monitoring systems to optimise road operations management, focusing on winter operations management
- Application of predictive maintenance techniques to optimise fleets management
- Application of a reactive road maintenance framework based on the integrated use of terrestrial, UAV and satellite monitoring platforms comprising different kind of sensors (RGB, LiDAR, IR, multispectral) depending on the monitoring target

7.3.5 Planned roadmap for exploitation

ACCI plans to exploit further the results obtained through the following strategy:

- Technologies that need further development for commercial applications (low TRL) will be exploited by participating in new innovation projects. ACCI is willing to use its road/railway concessions as demonstration sites for validating innovative ITS technologies
- ACCI aims to implement PANOPTIS modules and technologies that reach commercial maturity (high TRL) and proves to be successful during the demonstration phase of PANOPTIS, in the A2T2 concession and/or other road/railway concessions. Special interest lays on:
    - The integration of weather forecasting system to support winter operations, for example in the contracts in Canada,
    - Implementation of image analysis and machine learning techniques to automatically detect damages/deterioration on the road surface and concrete infrastructure (tunnels and bridges),
    - Early alarms of problems in asphalt, road marking and vertical signals,

  - Integrate slope monitoring systems based on image analysis, UAV-photogrammetry and 3D point cloud analysis techniques to prevent landslides (also in railway contracts)
  - 3D point cloud modelling of road infrastructure
  - Early warning alarms, such as corrosion alarm in concrete infrastructure
  - Integration of UAVs fleet in road upkeep frameworks
  - Data management tools with incorporated risk models, risk maps and DSS
- ACCI aims to include successful PANOPTIS modules and technologies mentioned above in international tenders in close collaboration with PANOPTIS responsible partners.

7.4 EGNATIA ODOS AE

7.4.1 Relevance of the project in the strategy of the entity

No input.

7.4.2 Exploitation strategy

EOAE together with the major end users in the consortium will effectively promote the project results to the industry. On top EOAE will provide market studies in RI inspection addressing the possible markets (with possible adaptations). As a major end-user EOAE aims to bring PANOPTIS into the actual inspection and maintenance plans of Egnatia Motorway (Greece) as well as to introduce PANOPTIS into the inspection and maintenance plans of tunnels of other privatized motorways in Greece. As the majority of the bridges in Egnatia motorway are not easily accessible and are located on seismic and landslide prone areas, the upgrade of the responsiveness on future extreme events that may induce damage on critical structures of the road and of the efficiency of the after extreme event management in order to increase resilience of the road infrastructure by adopting PANOPTIS solutions/tools is top priority. The same is true for road infrastructures managed in the frame of Private Concession Contracts, where PANOPTIS results can be exploited by the contribution of EOAE.

7.4.3 Background

EOAE in the past, in the frame of National, European projects of by self funding projects, has developed systems for the continuous monitoring of its major road structures, using permanent and moveable instrumentations, the prediction of damage on critical structures under catastrophic events (earthquake), the inspection and assessment of its structures. Recently EOAE leaded the field trials of HORIZON 2020 projects concerning aerial robotic inspection based assessment of bridges (AEROBI) or new type of sensor for measuring extreme srains on bridges. Therefore EOAE as followed the research efforts of the PANOPTIS topic, in the last decade, and as they are deeply concerned on progress of risk management of road infrastructure, they know hot to first test and then practically exploit the results of PANOPTIS project.

7.4.4 Identification of the foreground

No input.

7.4.5 Planned roadmap for exploitation

EOAE plans to adopt and integrate PANOPTIS tools/methodologies and software that will be developed and successfully demonstrated on the selected Egnatia Motorway section for field trials, in its future inspection and maintenance plans for this as well for other similar road sections in the West Sector of the motorway. EOAE activity plans, regarding the health

monitoring, inspection, assessment and fast response as well as immediate remedial measures decision taking, for all the critical structures of the specific road section, will be based on successful results of PANOPTIS field trials. In the West Sector of Egnatia Odos, other similar sections is planned to be treated using PANOPTIS

7.5 FUTURE INTELLIGENCE LTD (FINT)

7.5.1 Relevance of the project in the strategy of the entity

FINT's commercial offerings include several integrated suites of remote management solutions for devices based on wireless media and remote management applications. FINoT Platform, the product of FINT's portfolio for IoT solutions, is equipped with data gathering mechanisms capable of interconnecting different sensors while also provides robust wireless transmission/reception interfaces and incorporates intelligent data management and visualization tools. The solution is divided into three major segments, IoT mesh sensor networking at sensor layer, adaptable middleware layer and the upper layer which is a flexible management platform. On the top of this solution, FINT provides additional features through appropriate software modules which make possible the implementation of different business processes.

FINT expects to utilise its developments in PANOPTIS acquiring very important insights through the use cases and trials that will be implemented during its duration. These trials will enable the company to build different commercial flavours of the middleware platform specifically adapted for road management infrastructure purposes. The variety of different interfaces, models and subsystems that will be interconnected to FINT's middleware will allow the implementation of a very robust and multi-purpose software solution that will definitely help the company to penetrate the specific market, start new product offerings while also will provide new solutions to current FINT's customers. Moreover the company is already providing custom solutions to the agricultural segment with its weather stations products. In PANOPTIS the company will build specifically adapted micro-climate stations for road infrastructures. Combining with the above described middleware, as also other company's products (e.g. outdoor smart lighting) FINT will be able to provide top down solutions for management of road infrastructures. All above will eventually lead to new revenue streams that will be generated by the company's combined offerings of IoT and road infrastructure related applications.

7.5.2 Exploitation strategy

FINT's core business pillars include solutions for industrial and semi industrial domains. FINT has already developed solutions for Smart Cities (Smart Lighting, Smart Parking, Environmental monitoring, Integrated Smart City Platform etc), Smart Roads, Smart Borders, Smart Ports, Smart Agriculture and other specific applications. FINT will take advantage of PANOPTIS developments in order to exploit:

- Eventual productization of the technologies, middleware and micro climate stations. Use the platform to offer a key service that can enhance EU Smart Road Resilience, Impact Assessment and connected will already installed IoT platforms in cities and roads
- Focus on incorporating PANOPTIS middleware to company's commercial IoT platform based on FIWARE, making the solution fully interoperable in EU scale
- Enhance current company's solution portfolio for smart cities and roads as also critical infrastructures
- Attempt to create joint venture with some partners of the consortium in order to minimise time to market for a PANOPTIS commercial offering and increase the quality of the end product.

7.5.3 Background

The following company's background has been identified that is going to be exploited during the project. Specific developments of middleware platform and micro-climate stations will use the following background:

1. Data storage and security

2. Mechanisms capable to acquire data from various interfaces over FIWARE based Middleware

3. IoT device interconnection on field level (connect micro climate stations to legacy systems or third-party sensors)

This identified background will be accessible royalty-free strictly on a need-to know basis and in the context of work plan. If this Background will be needed for exploitation of results, access rights have to be requested to be granted by FINT on fair and reasonable conditions. Specific conditions under which access rights will be granted will be set in a separate agreement by the relevant parties that will need it.

7.5.4 Identification of the foreground

The identified foreground that FINT expects to exploit is related to the developments of:

- Road side micro climate stations capable to be interconnected with legacy road subsystems and third-party sensors
- Software middleware that be able to have interfaces and data handling mechanisms for: Climate data, models & scenarios of climate, climate risks, extreme weather, weather sensor data, ice sensor, precipitation levels, wind speed, seismic data, chloride hazard maps, flood hazard maps, fire risk maps, structural damages, business impact results, structural impact results

The above-mentioned developments are expected to be implemented during the project duration and will be based on different expertise and assistance of related partners.

7.5.5 Planned roadmap for exploitation

FINT will try to start the deployment of micro-climate stations at the two trial site the soonest possible. The implemented technologies need to mature enough before they become fully commercial solutions and PANOPTIS contexts provides this so needed playground to test and evaluate these technologies. After the successful completion of the trials and based on the concussions and end user feedback, FINT plans to freeze the function set of the solution and start certification process of HW parts. Combining with the SW parts that will be mature enough at that point, the end offering will be ready to be provided. Starting from the end users that will be already power users of the solution, FINT will try to expand the installation across bigger span of the road infrastructure while will showcase the benefits to other customers. The main target is to deploy the solution at as many road operator infrastructures in EU as possible. A detailed exploitation plan and business plan will be conducted in a later stage of the project.

7.6 UNIVERSITEIT TWENTE (ITC)

7.6.1 Relevance of the project in the strategy of the entity

The faculty of Geo-Information Science and Earth Observation (ITC) has the mission to build capacity, particularly in less developed countries. In order to solve complex challenges that relate to climate change, population growth and food-, health-, water- and energy-security, spatial methodologies may offer a solution. Therefore, ITC expertise lays in the field of disaster management, food security, geo-health, governance, smart cities and water management.

Research activities within disaster management relate to damage mapping using Unmanned Aerial Vehicles (UAVs) and post-disaster recovery assessment. Within PANOPTIS, ITC aims to develop methods for fast damage assessment using satellite, ground-based, mobile mapper and UAV-based data. More specifically, ITC aims to develop degradation assessment methodologies in routine situations and damage assessment methodologies in post-disaster situations using state-of-the-art 2D and 3D machine learning frameworks. Moreover, ITC aims to advance UAV monitoring capabilities in post-disaster scenarios, by researching the applicability of state-of-the-art hybrid UAV (combination between a vertical take-off and landing and a fixed wing UAV). These goals align with ongoing research activities within the field of disaster management.

7.6.2 Exploitation strategy

As an academic institution ITC mainly exploits R&D outcomes from project in our education and wider research program. Work on image analysis, UAVs and damage mapping has been ongoing for many years, evolving with developments in hard- and software developments, hence the project outcomes keep us at the edge of development. Whilst being a non-profit organisation ITC does support product exploitation, adapting the typically remote-sensing based methods we develop to fit into commercial products that are created with the end of projects. Through our networks, including regional ones on safety and security (e.g., Veiligheidsregio Twente) research outputs are also brought into practical use as first responder and public safety organisations adopt them for their work.

7.6.3 Background

ITC was a partner in the INACHUS project[1] that ended in December 2018. INACHUS focussed on post-disaster response and urban search and rescue, using ground, UAV and satellite-based data and robots. ITC will build upon the 3D machine learning methodologies developed in INACHUS. Moreover, ITC partnered in RECONNAS[2] that ended in May 2017. ITC focussed on calibrating and validating synoptic damage mapping using satellite imagery. Moreover, methodologies were developed for detailed building damage assessment using UAV imagery and 3D point clouds. For a detailed description of the methodologies developed in RECONASS, refer to [1]. For detailed descriptions of the methodologies developed in INACHUS, refer to [2]. ITC will advance the developed structural damage assessment methodologies by incorporating additional information on road infrastructures. This information comes from additional sensors (multi-spectral, LiDAR) from mobile mappers, and hybrid UAVs.

7.6.4 Identification of the foreground

ITC will develop the following innovations in PANOPTIS:

- A monitoring framework with a focus on hybrid UAV monitoring capabilities.
- Methodologies for degradation assessment in the road corridor using ground-, air and space-based 2D and 3D sensor data by deploying state-of-the-art machine learning frameworks in routine scenarios.
- Methodologies for damage assessment in the road corridor using ground-, air and space-based 2D and 3D sensor data by deploying state-of-the-art machine learning frameworks in post-disaster scenarios.

7.6.5 Planned roadmap for exploitation

ITC plans to disseminate research output through different channels. These consist of open access ISI journals, seminars, workshops, conferences, or general public media. ITC expects

[1] https://www.inachus.eu/

[2] http://www.reconass.eu/

to output at least three publications during the project. ITC expects to give at least one demonstration during the project to display the developed methodologies and UAV monitoring framework. Possible consumers of the developed research output consists of other research institutes, first responders or road operators.

7.6.6 Literature list

[1] A. Vetrivel, “Automatic information extraction from remote sensing images and 3D point clouds for building damage assessment,” "International Institute for Geo-Information Science and Earth Observation - ITC, 2018.

[2] D. Duarte, F. Nex, N. Kerle, and G. Vosselman, “Towards a more efficient detection of earthquake induced facade damages using oblique UAV imagery,” in *The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2017, vol. XLII, no. 2, pp. 93–100.

[3] D. Duarte, F. Nex, N. Kerle, and G. Vosselman, “Satellite Image Classification of Building Damages using Airborne and Satellite Image Samples in a Deep Learning Approach,” in *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2018, vol. IV, no. 2, pp. 89–96.

7.7 INSTITUT FRANCAIS DES SCIENCES ET DES TECHNOLOGIES DES TRANSPORTS, DE L’AMENAGEMENT ET DES RESEAUX (IFS)

7.7.1 Relevance of the project in the strategy of the entity

Road infrastructure is ageing and less budget is available to maintain it. Therefore, Ifsttar is working to make it smarter, which means automated and fast inspections and vulnerability assessments.

The department Mast of Ifsttar is working generally in the traditional domain of civil engineering, therefore this project is a means to create the link to IT experts. The issue is to create strong collaborations between traditional civil engineering experts and new technology experts.

7.7.2 Exploitation strategy

Involvement in International Technical Committee 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 specially involved in the project because it is linked to the evolution of standards.

7.7.3 Background

The background of the involved people from Ifsttar is in the field of civil engineering: vulnerability analysis of road infrastructure and resilience assessment of a road network. There is no background in terms of software or database.

7.7.4 Identification of the foreground

The gained foreground will be in terms of application of existing frameworks (vulnerability assessment or resilience calculation) to given road infrastructure elements, and implementation of new technological approaches in terms of assessment (machine learning, neural networks) and inspection (UAVs).

7.7.5 Planned roadmap for exploitation

The exploitation will be in terms of application of the gained knowledge to research projects (national or European) and structures-related expertise studies.

7.8 ILMATIETEEN LAITOS (FMI)

7.8.1 Relevance of the project in the strategy of the entity

Two research entities from FMI are involved in the project. First, *the Weather and Climate Change Impact Research* is a research unit whose mission is to do climate change impact research to support in climate change adaptation and risk assessments. The group focuses on weather extremes, their impacts, variability, predictability and change. Their involvement in the PANOPTIS project adheres closely to their strategy and operational expertise.

The second entity is *the Atmospheric Dispersion Modeling* group whose strategy is to provide modeling solutions to a wide range of atmospheric boundary layer flows, as well as air pollution dispersion, exposure, and emission problems. The group's research efforts place emphasis on establishing an unbroken chain of modeling approaches that span the full spectrum of temporal and spatial scales in atmospheric dispersion processes. Currently strong focus is assigned to pursuing more localised, high-resolution modeling techniques to address the complexity of real world problems.

7.8.2 Exploitation strategy

The regional climate modelling method with downscaling in several steps to the local level is expected to be a major outcome of the project that will also be used for other purposes where site-specific information is needed after the project. Additional CORDEX simulations performed within the project will be published through the CORDEX data nodes and thereby made available for a wider user community.

The regional climate model data from CORDEX project will be used to analyse the severe weather events. We will provide both the actual data for LES modelling (downscaling) and analysed severity frequencies of the past, current and future climate. Both are important steps when moving towards the local site analysis.

7.8.3 Background

At the *Atmospheric Dispersion Modeling* group the current know-how on conducting high-resolution atmospheric boundary layer flow simulations with Large-eddy simulation (LES) approach featuring complex real-world topography, is documented in the following peer-reviewed publications:

Hellsten, A., Luukkonen, S. M., Steinfeld, G., Kanani-Sühring, F., Markkanen, T., Järvi, L., & Raasch, S. (2015). *Footprint evaluation for flux and concentration measurements for an urban-like canopy with coupled Lagrangian stochastic and large-eddy simulation models*. Boundary-layer meteorology, 157(2), 191-217.

Auvinen, M., Järvi, L., Hellsten, A., Rannik, U., & Vesala, T. (2017). *Numerical framework for the computation of urban flux footprints employing large-eddy simulation and Lagrangian stochastic modeling*. Geoscientific Model Development.

Kurppa, M., Hellsten, A., Auvinen, M., Raasch, S., Vesala, T., & Järvi, L. (2018). *Ventilation and air quality in city blocks using large-eddy simulation - urban planning perspective*. Atmosphere, 9(2), 65.

The Seasonal and Climate Applications group has the expertise to analyse and provide high-resolution regional model data. The group has also been part of road safety related studies, as described in the following peer-reviewed publications:

Pietikäinen, J.-P., O'Donnell, D., Teichmann, C., Karstens, U., Pfeifer, S., Kazil, J., Podzun, R., Fiedler, S., Kokkola, H., Birmili, W., O'Dowd, C., Baltensperger, U., Weingartner, E., Gehrig, R., Spindler, G., Kulmala, M., Feichter, J., Jacob, D., and Laaksonen, A.: The regional aerosol-climate model REMO-HAM, Geosci. Model Dev., 5, 1323-1339, https://doi.org/10.5194/gmd-5-1323-2012, 2012.

Pietikäinen, J.-P., Markkanen, T., Sieck, K., Jacob, D., Korhonen, J., Räisänen, P., Gao, Y., Ahola, J., Korhonen, H., Laaksonen, A., and Kaurola, J.: The regional climate model REMO (v2015) coupled with the 1-D freshwater lake model FLake (v1): Fenno-Scandinavian climate and lakes, Geosci. Model Dev., 11, 1321-1342, https://doi.org/10.5194/gmd-11-1321-2018, 2018.

Vajda, A., Tuomenvirta, H., Juga, I., Nurmi, P., Jokinen, P., and Rauhala, J.: Severe weather affecting European transport systems: the identification, classification and frequencies of events, Nat. Hazards, 72, 169–188, https://doi.org/10.1007/s11069-013-0895-4, 2014.

7.8.4 Identification of the foreground

The dynamic downscaling of climate stressors on site-specific road infrastructures requires (particularly for wind-related hazard assessments) a novel, scalable approach that employs pre-computed, high-precision maps of impact levels. These are generated by exploiting meso-scale weather data from statistically relevant extreme events to drive high-resolution LES simulations which, in turn, generate detailed distributions of site-specific weather impacts. These maps can be scaled according to regional weather stations measurements to provide an accurate prediction on the local road conditions relevant to operational safety. This scalable meso-to-local scale downscaling of impacts is a new and previously undocumented approach.

7.8.5 Planned roadmap for exploitation

The initial phase (months 1-24) of the PANOPTIS project will be devoted to the development and testing of the downscaling method. But, the demonstrations of the technologies and the related feedback collection from the operator clients will be initiated already within the development phase, preferably during months 18-24. This is important to ensure the operational utility of the hazard assessment system. We will also provide information about the frequency of severe road conditions in the current climate and prepare estimated what is the contribution of the climate change in these. This will be done in the initial phase and is based on the existing CORDEX data.

7.9 ILMATIETEEN LAITOS (FMI)

7.9.1 Relevance of the project in the strategy of the entity

Two research entities from FMI are involved in the project. First, *the Weather and Climate Change Impact Research* is a research unit whose mission is to do climate change impact research to support in climate change adaptation and risk assessments. The group focuses on weather extremes, their impacts, variability, predictability and change. Their involvement in the PANOPTIS project adheres closely to their strategy and operational expertise.

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7.9.2 Exploitation strategy

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Kurppa, M., Hellsten, A., Auvinen, M., Raasch, S., Vesala, T., & Järvi, L. (2018). *Ventilation and air quality in city blocks using large-eddy simulation - urban planning perspective*. Atmosphere, 9(2), 65.

The Seasonal and Climate Applications group has the expertise to analyse and provide high-resolution regional model data. The group has also been part of road safety related studies, as described in the following peer-reviewed publications:

Pietikäinen, J.-P., O'Donnell, D., Teichmann, C., Karstens, U., Pfeifer, S., Kazil, J., Podzun, R., Fiedler, S., Kokkola, H., Birmili, W., O'Dowd, C., Baltensperger, U., Weingartner, E., Gehrig, R., Spindler, G., Kulmala, M., Feichter, J., Jacob, D., and Laaksonen, A.: The regional aerosol-climate model REMO-HAM, Geosci. Model Dev., 5, 1323-1339, https://doi.org/10.5194/gmd-5-1323-2012, 2012.

Pietikäinen, J.-P., Markkanen, T., Sieck, K., Jacob, D., Korhonen, J., Räisänen, P., Gao, Y., Ahola, J., Korhonen, H., Laaksonen, A., and Kaurola, J.: The regional climate model REMO (v2015) coupled with the 1-D freshwater lake model FLake (v1): Fenno-Scandinavian climate and lakes, Geosci. Model Dev., 11, 1321-1342, https://doi.org/10.5194/gmd-11-1321-2018, 2018.

Vajda, A., Tuomenvirta, H., Juga, I., Nurmi, P., Jokinen, P., and Rauhala, J.: Severe weather affecting European transport systems: the identification, classification and frequencies of events, Nat. Hazards, 72, 169–188, https://doi.org/10.1007/s11069-013-0895-4, 2014.

7.9.4 Identification of the foreground

The dynamic downscaling of climate stressors on site-specific road infrastructures requires

(particularly for wind-related hazard assessments) a novel, scalable approach that employs pre-computed, high-precision maps of impact levels. These are generated by exploiting meso-scale weather data from statistically relevant extreme events to drive high-resolution LES simulations which, in turn, generate detailed distributions of site-specific weather impacts. These maps can be scaled according to regional weather stations measurements to provide an accurate prediction on the local road conditions relevant to operational safety. This scalable meso-to-local scale downscaling of impacts is a new and previously undocumented approach.

7.9.5 Planned roadmap for exploitation

The initial phase (months 1-24) of the PANOPTIS project will be devoted to the development and testing of the downscaling method. But, the demonstrations of the technologies and the related feedback collection from the operator clients will be initiated already within the development phase, preferably during months 18-24. This is important to ensure the operational utility of the hazard assessment system. We will also provide information about the frequency of severe road conditions in the current climate and prepare estimated what is the contribution of the climate change in these. This will be done in the initial phase and is based on the existing CORDEX data.

7.10 ARISTOTELIO PANEPISTIMIO THESSALONIKIS

7.10.1 Relevance of the project in the strategy of the entity

The Laboratory of Heat Transfer and Environmental Engineering (LHTEE) of the Aristotle University of Thessaloniki conducts research in the field of energy systems and environmental engineering with emphasis on the assessment of the environmental burden caused by various processes and the optimisation of environmental control and management practices. Within this frame, the Laboratory has developed significant expertise in meteorological and air quality modelling, focusing on the simulation of transport and chemical transformation of air pollutants with the use of advanced numerical models. LHTEE has a long experience in the assessment of air quality and exposure at all scales via modelling techniques, through its involvement in European funded projects. The Laboratory is also involved in air quality management through the assessment of measures for reducing air pollution levels, and has participated in numerous environmental impact and risk assessment as well as environmental policy studies, in order to provide scientific support to public authorities and the private sector. The common goal connecting all its research and consulting activities is the promotion of environmental resilience and sustainability of human infrastructures in view of challenges such as air pollution, climate change and accidental or extreme situations, in line with PANOPTIS objectives.

7.10.2 Exploitation strategy

Exploitation of research results produced within the frame of the PANOPTIS project includes the population of EU climate databases with high resolution data. These data will be available to the scientific community and the relevant stakeholders who participate in policy making. LHTEE will also exploit the downscaling toolset and methodologies for enhancing its placement as a provider of climate services. The developed know-how and modelling tools are expected to become part of a multiscale simulation platform for providing focused risk assessment and management services.

7.10.3 Background

LHTEE has developed extensive competences in the application of numerical models in Meteorological and Air Quality assessment and management, as well as in the application of mesoscale and microscale/CFD models in a multiscale modelling framework. The modelling

tools that have been developed and applied by LHTEE are suitable scientific tools for studying environmental issues that are relevant to the objectives of PANOPTIS. In particular, LHTEE has been involved in studies aiming to simulate air pollutant distribution patterns in urban areas related to transport emissions and the evolution of meteorological indices in high spatial and temporal resolution for climate research.

The results provided necessary information to a number of target groups, including decision makers and authoritative bodies, facilitating the more efficient detection of risks and the application of successful mitigation strategies in order to promote compliance with legislation. More specifically, LHTEE has expertise on the following methodologies related to environmental assessment and management of transport infrastructures:

- Application of an innovative multiscale modelling framework, involving on-line coupling of a mesoscale flow model (MEMO) and a microscale/CFD model (MIMO). This powerful methodology supports high-accuracy multiscale simulations in a variety of application areas, including simulation of interactions between the street- and local-scale flow effects induced by urban structures (buildings, artificial land covers) and the mesoscale meteorological fields of the wider area.
- Operational and off-line modelling services supporting air quality assessment in Cyprus. Since 2008, LHTEE has operated an advanced Air Quality Management System on behalf of the Department of Labour Inspection, Ministry of Public Insurance, Cyprus. The system has since been in operational use almost continuously and has proven to be very effective in communicating detailed information on pollution levels to regulators and to the general public, so that the relevant health and environmental risks can be minimized.
- Application of an innovative methodology for calculating urban- and street-scale concentration increments in European cities. The methodology combines data from measurements with model results and emissions inventories, in order to provide fast and reliable estimates of concentrations, down to the individual street scale. In this way, extremely high-resolution concentration maps can be obtained with the ability to resolve spatial features that lie below the typical grid size of conventional dispersion models. The detailed data on pollutant levels are particularly important in air quality management in the case of traffic hot-spot areas in urban centres.
- Dynamical downscaling of global- and regional-scale climate using the community model WRF. This expertise, developed within the framework of the EuroCORDEX program, provides the capability to a) assess historical climate patterns for specific areas at a very high spatial and temporal resolution, down to 1km and 1h, respectively, b) simulate future climate patterns under various climatic scenarios at the same high resolution, c) obtain both “average climate” parameters as well as statistics of extreme events for decade-long periods, at a very high resolution, d) use local-scale climate simulations to drive case-study specific meteorological and dispersion model simulations, i.e. examine climate effects on local micro-meteorological patterns and the local air quality.

The methodologies described in the previous section have been applied in a number of EU funded research projects related to the environmental impact and sustainability of transport infrastructures, including:

- Step2Smart (Cross-border cooperation between island urban areas to improve environmental conditions through the use of Intelligent Transport Systems http://www.eng.ucy.ac.cy/step2smart/workGR.html) INTERREG project focusing on the development and evaluation of an Original Interoperable Open Architecture System for Urban Transport Management and Environmental Impact Assessment.
- MEGAPOLI (Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation) project (http://megapoli.info/), in which LHTEE has examined methods for bridging the spatial and temporal scales that connect local emissions, air quality and weather patterns in the megacity environment.
- TRANSPHORM (Transport related Air Pollution and Health impacts – Integrated Methodologies for Assessing Particulate Matter http://www.transphorm.eu/), in which

LHTEE was primarily involved in the improvement of atmospheric dispersion modelling systems by focusing on the advanced treatment of specific emission sources related to the transport sectors.

- PM3 (Particulates Monitoring, Modelling and Management http://www.life-airquality.eu/) project aiming at facilitating efficient Particulate Matter (PM) management in the Republic of Cyprus, in which LHTEE was responsible for street scale modelling as part of an integrated modelling system, in order to assess the contribution of different sources in PM levels inside street canyons.

7.10.4 Identification of the foreground

Within the frame of PANOPTIS LHTEE will apply existing modelling tools and develop novel methodologies for the assessment of atmospheric and climate stressors. The existing modelling expertise will be adjusted to facilitate management of extreme environmental situations to promote the resilience and sustainability of transport infrastructures.
In particular, LHTEE will undertake the collection, quality control and pre-processing of existing EURO-CORDEX climate data, in order to support the critical selection and quantification of key impact indicators that will be used as metrics of climate extremes. LHTEE will coordinate all technical activities related to the compilation of high-resolution input data for the atmosphere- and soil-related modelling. Furthermore, LHTEE will refine the existing coupled meso/micro-scale modelling system, which will then be applied in order to provide high-resolution simulations of atmospheric and hydrothermal soil parameters in the specific-site scale.
Another scientific innovation will involve developing, testing and applying the data assimilation software system for operationally incorporating sensor data into the modelling components of the PANOPTIS platform.

7.10.5 Planned roadmap for exploitation

Scientific advances and novel methodologies developed by LHTEE within the frame of PANOPTIS will become available to the scientific community through presentation in relevant conferences, submission of papers to peer reviewed scientific journals and participation in scientific events such as thematic workshops. Research results and modelling data from downscaled climatic simulations will become available through collaboration with established datasets, such as the CORDEX data repositories. Furthermore, the scientific expertise that will be gained within the project and the collaborations with other scientific teams will result in strengthening LHTEE's profile in the field of climate change mitigation, climate assessment and environmental risk management, thus promoting its participation in future relevant funded research projects. South Mediterranean countries, such as Greece, will be particularly affected by climate change, which will increase the country's vulnerability in relation to environmental stressors such as wild fires. It is therefore expected that a number of research projects will focus on related issues, in which AUTH – LHTEE will be playing a leading role.

7.11 SOFISTIK HELLAS AE (SOF)

7.11.1 Relevance of the project in the strategy of the entity

SOFiSTiK Hellas S.A. (SME, Greece) is a software house specializing in the area of structural engineering. Main focus is given in the areas of structural analysis through the Finite Element Method (FEM), reinforced concrete design, and Computational Fluid Dynamics (CFD) applications. Advanced solutions methods are offered to solve problems of bridge engineering, structural steel, tunnelling, geotechnical engineering, aerodynamics, fluid-structure interaction, energy efficient design of facilities/buildings design, optimization of structures and geometrical modelling of complex geometries.

The software applications that SOF develops and/or commercializes in Greek market are extensively used for the structural design of RI elements such as bridges, tunnels, retaining

walls and so on. More over these applications are often used in the Structural Health Monitoring (SHM) procedures of such RI structural elements. RI/TI Construction and Operation Companies are among SOF's clients.

7.11.2 Exploitation strategy

SOF will commercialize the extended versions of the software tools for the structural/geotechnical simulation and assessment of RI/TI through all its well established channels that are directed to structural engineers, architects, contractors and public service offices. SOF will develop a marketing plan according to its well-established practice for marketing engineering software. The project engagement will be monitored by a ROI calculation.

7.11.3 Background

SOF has a vast experience in developing and marketing of engineering software. Along with software development, the company provides engineering consulting services and prepares specific technical studies, mainly on behalf of clients, for large scale projects with special requirements both in theoretical approach and modelling and evaluating the results of calculations. Moreover SOF has acquired, mainly through the successful participation in various EU research projects, a lot of experience in developing proper interfacing software tools for the collaboration of its software applications with external applications or platforms mostly in the domain of simulation of Coupled or Multi-Disciplinary problems.

7.11.4 Identification of the foreground

In PANOPTIS, SOF will develop the necessary software interface tools and procedures for the utilization of monitoring data, hazard intensity data and local climate data as direct or indirect input to the numerical applications of the SGSA simulator. Interface software tools will also be developed for post-processing and incorporation of the results into the HRAP environment in order to be available to the DSS of PANOPTIS.

7.11.5 Planned roadmap for exploitation

Beside the PANOPTIS consortium's exploitation activities as a whole, SOF will present PANOPTIS developments on the company's web page, in the information workshops for customers as well as in national and international fairs, workshops and congresses.

SOF will participate to the upcoming Greek Conferences on Concrete Structures and on Steel Structures and their parallel Exhibitions. Moreover SOF will participate, in cooperation with partners, to the STUVA-Expo that will take place parallel to the STUVA-Conference (International Forum for Tunnels and Infrastructure) on November 26-27, 2019 in Frankfurt. STUVA Expo is the industry meeting point for Infrastructure and is the ideal platform to show PANOPTIS developments.

SOF will also try to present its PANOPTIS developments in connection with BIM to the yearly event Autodesk University since all large European Engineering Consulting and Construction companies participate there.

7.12 C4 CONTROLS LTD

7.12.1 Relevance of the project in the strategy of the entity

C4C develops integrated geospatial C2i/C3i and decision support solutions for Public Safety and Site Management applications and for customers such as law enforcement, fire rescue, emergency medical agencies, critical infrastructure operators and border surveillance authorities. The common goal though, is to provide effective decision support, to simplify operations, to provide a Common Situational Picture and coordination tools across

organizations, to collect and disseminate data in the field and to coordinate response units and system users. In this respect, besides the coordination capabilities, an important component of such systems that facilitates the decision process at all levels of coordination, is the decision support and situation awareness tools.

C4Control Ltd was founded as a sister company of Satways Ltd. in order to further develop the products developed by Satways in specific verticals and promote them in the Global market. In the frame of EU and National funded activities, C4C develops decision support tools for natural and technological hazards risk/resilience assessment and crisis management. C4C participation in EU funded activities is strongly related to its products roadmap and overall business development strategy. C4C role was always related to its products development roadmap. Any new tool that is developed in the frame of such research activities and is proven useful to end-users, finds its way to C4C productization process. The benefits though from our participation has been proven up to now to be more than this. Collaborating with other important companies, integrating different systems towards a common target is creating synergies in both technology as well as commercial domains. Developing solutions in the frame of specific case studies with specifications proposed by end users from different countries, is helping adapting our solutions to the international market requirements. Last but not least, it provides also a good opportunity for C4C to demonstrate its products and capabilities to national and international stakeholders.

PANOPTIS is relevant with the company strategy as it will help C4C further enhance its position in the public safety market, enhance its portfolio in the domain of Convergent Security Information Management (CSIM) tools and provide an opportunity for demonstration to international stakeholders. CSIM systems base their existence on the need of bringing together different systems and devices with the scope of creating a unitary system that can monitor and manage all using a single graphical user interface. In addition, CSIM makes the underlying systems work as one by programming interactions between them to obtain systems' reaction for situational awareness.

In PANOPTIS, the Critical Infrastructure Risk Platform (CIRP) and the ENGAGE incident management suite will be used and further enhanced and integrated with almost all subsystems of PANOPTIS in order to access risks from weather, geotechnical and seismic hazards, create the common operational picture and manage emergency situations. The goal is to prove the opportunity for synergies with other partners to jointly promote related developments as an integrated product.

7.12.2 Exploitation strategy

The main exploitable results of PANOPTIS are considered the adapted ENGAGE and CIRP software solutions. The final form of the foreseen product will be the ENGAGE CSIM solution which will integrate the developments in WP4 and WP6. Modular design of IMS/CSIM software provides flexibility in adapting to multiple operational needs, businesses and verticals. Fully independent of any manufacturer, provides freedom in integrating almost any type of system, sensor or device. What differs though from the core of the software is the application layer. The CIRP and ENGAGE systems are both based on a common set of OSGi plugins under the name CEF (Common Enterprise Framework) Core. As such they consist of several OSGi bundles on top of CEF Core and can be integrated in a single end user software system (ENGAGE CSIM Edition).

ENGAGE is a commercial (TRL9) platform that is used already from First responders in operational environment with various deployments in the frame of commercial projects, the latest one being the National Incident Management and Dispatch System of the Greek Fire Brigade. The use of such a commercial grade platform in H2020 projects, was proven a wise choice up to now for several reasons:

a. The end users are experiencing the new functionalities developed in the frame of the project in a commercial grade C3 system that includes standard C2 functionalities they use to have in their own working environment that cannot be developed from scratch in the frame of a project. According to our experience this way the new

functionalities are better understood and accepted by the end-users when presented in the frame of a familiar to them environment.
b. It facilitates the productisation process and brings the projects outcomes very close to market.
c. It facilitates a lot the commercialisation of the developments of various partners as add-on modules of an already commercial product.

The following actions to support efficient exploitation and commercial utilisation are foreseen after the end of PANOPTIS:
a. Awareness creation through presentations in related workshops mainly in Europe & Middle East where C4C is active
b. Inclusion of the project developments to C4C productisation process
c. Marketing and Sales efforts via trade fairs, exhibitions; specific marketing initiatives to address new customers by presenting the technology and possibilities of the whole system
d. Marketing and sales activities via our partners and distribution network
e. Active participation in industrial seminars to communicate selected exploitable results.

The following actions to support efficient exploitation and commercial utilisation are foreseen after the end of PANOPTIS:
a) Marketing and Sales efforts via trade fairs, exhibitions; specific marketing initiatives to address new customers by presenting the technology and possibilities of the whole system
b) Sales activities via our distribution network

Active participation in industrial seminars to communicate selected exploitable results.

7.12.3 Background

As already mentioned, ENGAGE and CIRP are C4C background knowhow developed in the frame of previous projects as well as internal R&D.

ENGAGE C3 suite is a modular platform that has been initially developed by C4C internal R&D and is already customized in the frame of several projects up to and is planned to be further adapted in the frame of PANOPTIS to handle converged security and safety information as well as interoperability with Emergency Response Agencies C2. ENGAGE in the frame of the IMPRESS FP7 project has been extended in order to conform to the Incident Command System and its associated disciplines of role based communications, span of control, chain of command and unit integrity for emergency medical cases. In the frame of PERSEUS FP7 and ACRITAS border surveillance functionalities were added. In the frame of H2020 INSPEC^{2}T project, the ENGAGE capabilities are extended in order to conform to the community policing solution developed in the frame of this project.

CIRP on the other hand was developed in the frame of H2020 EU-Circle project. C4C integrated the various models/algorithms/services provided by other partners in the frame of the case studies to the CIRP platform, developed a chaining process in order to enable end-to-end risk scenario assessment. CIRP was tested in various CIs (transportation, energy, lifelines etc) as subject of various Climate change hazards. CIRP enables scenario based impact/resilience assessment following the so called consequences based risk analysis and EU-CIRCLE resilience methodology. It is an innovative platform that quantifies resilience assessment and will be customised in PANOPTIS for various weather, geotechnical and seismic hazards. The following table summarizes the background systems.

Background Product and Solution	Description
Critical Infrastructure Resilience Platform	CIRP is an end-to-end modelling environment for analysing the Risk and Resilience of Critical Infrastructures exposed to the direct and indirect effects of climate change by integrating new and

	existing modelling tools and data in a standardised fashion. It is a pluggable and extensible platform that will enable the Risk Management community to bring new data and modelling capabilities into practice allowing multiple scientific disciplines to work together in order to understand interdependencies, validate results, and present findings in a unified manner.
ENGAGE IMS/CAD	ENGAGE IMS/CAD suite is an integrated Call-Center solution for public & private safety organizations providing all the tools for call & incident management, computer aided dispatch, operational resource management and disparate crucial information data integration. It allows seamless interconnection of control centers and the field by deploying mobile dispatch capabilities on smartphones, and tablets allowing field personnel to update event details, access databases, and exchange rich media messages. Based on a highly modular and reconfigurable S/W platform and a reliable, distributed Event Driven architecture, ENGAGE supports comprehensive incident control and dispatching for Public Safety offering an unmatched combination of speed, reliability, and features adaptive to highly complex communication environments.
ENGAGE Mobile	In conjunction with ENGAGE IMS/CAD it provides field personnel access to critical information and allows seamless interconnection of control centers and the field. It enables organizations to deploy mobile dispatch capabilities on laptops, smartphones, and tablets and allows field personnel to update event details, access databases, and send and receive rich media messages (photos, videos).

7.12.4 Identification of the foreground

The following developments are part of the foreseen foreground.

PANOPTIS HRAP	The PANOPTIS Holistic Risk Assessment Platform that is going to be based on CIRP
PANOPTIS IMS	The PANOPTIS Incident Management system / CSIM that is going to be based on ENGAGE IMS/CAD

7.12.5 Planned roadmap for exploitation

During the PANOPTIS timeframe, the goal is to create awareness in our client base and business partners in order to anticipate a new edition of the ENGAGE suite (targeting mainly Transport but also other Critical Infrastructure operators).

The following table depicts the exploitation planning timeframe after the project completion:

Activities	**Timeframe (start month**

	after project completion)
Inclusion of the project developments to STWS productionisation process	0 (Expected to take 6 months)
Marketing and presentations material preparation	4 (Expected to take 4 months)
Awareness creation through presentations in related workshops	6
Marketing and Sales efforts via trade fairs, exhibitions	6
Marketing and sales activities via our partners and distribution network	6
Active participation in industrial seminars to communicate selected exploitable results	6

7.13 HYDROMETEROLOGICAL INNOVATIVE SOLUTIONS (HYDS)

7.13.1 Relevance of the project in the strategy of the entity

HYDS has developed a platform to provide services in relation to Early Warning Services and Crisis Support Services for weather induced emergencies. This platform has been developed in the framework of the H2020 ANYWHERE project and currently is focused on providing warnings and support in the weather induced emergencies for single elements at risk (campsites, industries, etc.), municipalities (with multiple elements to interact) and at regional/national level (for regional/national civil protection agencies).

PANOPTIS is completely aligned with HYDS' strategy of being a services provider for weather induced emergencies information (early warnings and decision support) since it provides the opportunity to enhance the current platform of the company with a solution for linear infrastructure managers (roads, trains, etc.). The aim is to expand HYDS' portfolio with the provision of services targeted to infrastructure managers.

PANOPTIS provides the opportunity for demonstration to international stakeholders, and also for synergies with other partners to jointly promote developments as an integrated product.

7.13.2 Exploitation strategy

HYDS plans to exploit the results of PANOPTIS project in two ways:

- Join exploitation of project results. HYDS would be part of the whole PANOPTIS solution through the real-time weather forecasting module. HYDS will collaborate in the global PANOPTIS exploitation strategy.
- Individual exploitation of real-time weather forecasting module. HYDS will enhance its current platform with the developments done in the framework of PANOPTIS and create specific services for infrastructure managers. After the end of PANOPTIS and to foster exploitation and commercialization HYDS will participate in fairs and exhibitions to promote the products and conduct marketing initiatives to address new customers.

7.13.3 Background

HYDS will build on its current platform to develop the real-time weather forecasting module. The current platform has been developed in the framework of the H2020 project

ANYWHERE and already contains valuable information (sensors, radar maps, NWP models, etc.) and technology to build on top specific services for PANOPTIS purposes.

7.13.4 Identification of the foreground

HYDS will design, develop and test a real-time weather forecasting module focused on providing information for the road managers within PANOTIS project.

7.13.5 Planned roadmap for exploitation

As explained in the previous section there will be two different exploitation strategies and thus two exploitation roadmaps:

- Join exploitation roadmap of project results. HYDS participate in the join PANOPTIS exploitation roadmap.
- Individual exploitation roadmap for the real-time weather forecasting module. HYDS will use real-time weather forecasting module to design a new service (Early Warning and Decision Support for weather induced emergencies) for linear infrastructure managers in the framework of HYDS' platform. Once the service is ready, will prepare commercial material (case example sheets, webpage, demonstration accounts, etc.) and participate in fairs and exhibitions to promote commercialization of the service.

7.14 CONFEDERATION OF ORGANISATIONS IN ROAD TRANSPORT ENFORCEMENT AISBL (CORTE)

7.14.1 Relevance of the project in the strategy of the entity

CORTE is a non-profit organization established to bring together national transport authorities from European and non-EU countries having a responsibility and interest in the field of road transport, road security and road safety. Sustainable transport, including road safety, is part of the core mission of CORTE and this public mission is an integral part of CORTE's contribution to the exploitation of PANOPTIS' results.

7.14.2 Exploitation strategy

CORTE will engage with national authorities in charge of RI and road safety, as well as exploit the results with RI operators and authorities. CORTE is a neutral platform putting together public and private interests in transport and this neutrality will be a strong asset for exploitation.

7.14.3 Background

CORTE brings together national transport authorities, transport associations and the transport industry and provides a platform for their collaboration. The objective of CORTE is to encourage, promote and assist the development and implementation of policies for road transport, road safety and road security in Europe and at international level.

7.14.4 Identification of the 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.

7.14.5 Planned roadmap for exploitation

CORTE will transfer results achieved by PANOPTIS to all 61 CORTE Members including 29 road transport national authorities, 12 transport associations such as the International Road Union (IRU) and the Association representing vehicle manufacturers in Europe (ACEA) and 20 transport companies in the EU and neighbouring countries so as to promote and support

the use of PANOPTIS technologies, as well as to ensure that appropriate public policies and possibly regulatory measures enable the deployment and use of technologies developed by PANOPTIS.

The CORTE Membership is composed of both public and private organisations all active in road transport, covering 21 countries EU countries and 19 non-EU countries, as well as transport associations and transport companies, providing thereby very strong geographical coverage as well as stakeholders' coverage: 29 road transport national authorities (e.g. Ministries of Transport & Infrastructure, Road Safety Agencies, etc.), 12 road transport associations (representing themselves 1000s of transport companies as well as vehicle manufacturers) and 20 road transport companies developing smart solutions for road transport.

8 CONCLUSION

With the initial design, the discussions with end-users and existing building blocks, the partners are now confident that the concept of PANOTPIS is sound and feasible and that the performances will be very interesting for a better Road Infrastructure management.. These promising results comfort a consortium strategy towards the industrialisation of the whole system while the components can also be marketed separately.

The most adapted business model for PANOPTIS services is the operator model. So the next effort will be focused on the teaming between a reliable operator interested by the domain and the consortium. For the information system and HRAP, the optimised business model is the purchase by the customer with a collaborative customisation.