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

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PANOPTIS aims at increasing the resilience of the road infrastructures and ensuring reliable network availability under unfavorable conditions, such as extreme weather, landslides, and earthquakes. The main target is to combine downscaled climate change scenarios with simulation tools (structural/geotechnical) and actual data (from existing and novel sensors), so as to provide the operators with an integrated tool able to support more effective management of their infrastructures at planning, maintenance, and operation level.

In this magazine …

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A 3D Road Survey management tool

PANOPTIS employs a 3D monitoring tool (3DRS) which offers multiple advantages:

A. Offers a comprehensive 3D view of the survey environment and mission activities.

B. Defines local missions for the different operators and their means. Figure 1 illustrates a heavy-duty UAV carrying a lidar scanner. The lidar scanner can be triggered remotely and a subsample point cloud can be displayed in real-time during flight.

C. Simulates missions to check consistency including obstacle detection, landscape shadowing effects/inter-visibility, coverage, and many more.

D. Pushes these mission details to each operating dedicated system. 3DSMT can create and simulate operational fly plans and share (send) them to the proprietary UAV Ground Control Stations (Figure 2).

E. Monitors the mission operation in real-time, by following the device GPS/Telemetry in a 3D map of the area, and check for collision risks between systems (Figure 3).

F. Displays on accurate 3D location, in real-time or after postprocessing, the results/products gathered or generated by the different sub-systems (UAV pictures, ground or airborne Lidar point clouds, photogrammetric meshes, Satellite coverage…) (Figure 4).

The panel on the right allows to choose which device and associated sensors are commanded/controlled in real-time.

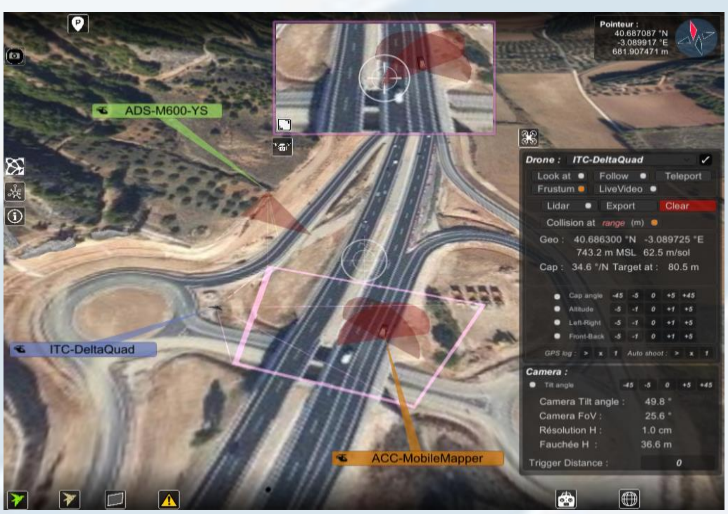

Figure 4: Illustration of the 3 devices deployed in Guadalajara with the virtual traces of their respective sensors.

*Figure 1: **ADS-M600-YS** - An Airbus UAV carrying a YellowScan lidar scanner.*

Figure 2: **ITC-DeltaQuad** - A hybrid drone carrying an RGB camera. The footprint of the camera is displayed in real time on ground surface

*Figure 3: **ACC-MobileMapper** - The Acciona's MobileMapper carrying dual laser scanners analyzing the road surface.*

G. Share the chosen products and associated reports to the Panoptis Head Quarters (Figure 5).

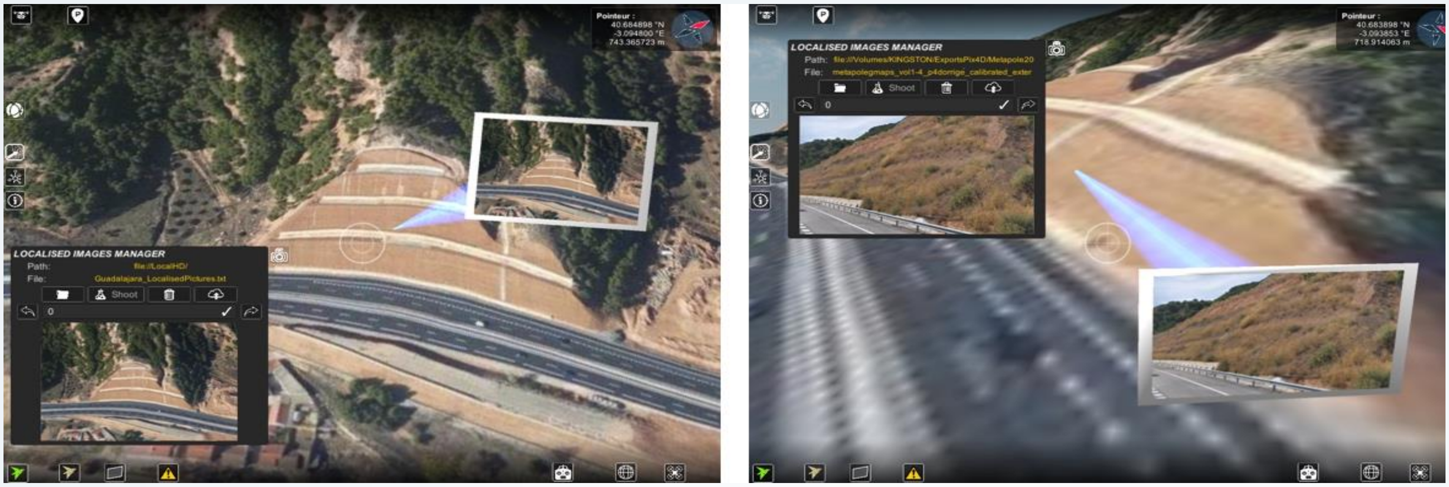

Figure 7: Presentation of the Localised Image manager and examples of a shot over the Guadalajara slope (simulation). The pictures appear "floating" in the air at the position and direction they were shot.

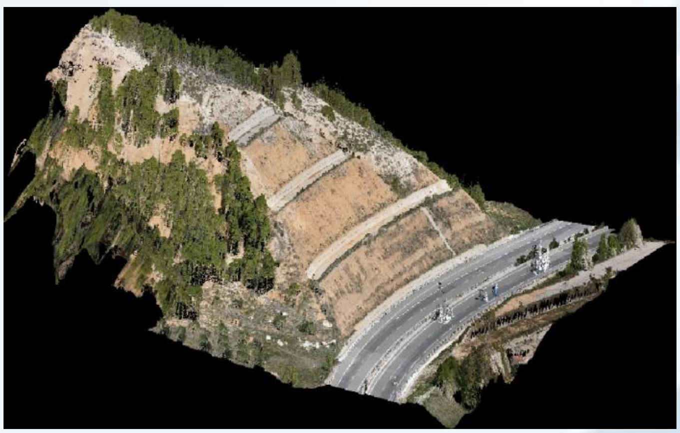

Figure 5: Example of point cloud of a slope in Spanish A2 motorway generated after processing with photogrammetric techniques.

Defects and erosion monitoring on slopes

UAVs can be used to monitor the degradation of slopes, due to weathering, paying attention to loss of stability due to erosion.

The A2-highway (located in Spain) slopes is an example case. This slope suffers intense erosion due to weathering, leading to the loss of significant amount of material thus putting in risk its stability. This slope is monitored through a permanent RGB camera, UAV missions and 3D laser scanning. Data coming from the sensors help identify the condition of the slope and update the current vulnerability modules (see next section) to an already prepared one that corresponds to the degradation level of the slope to allow rerunning an up-to-date risk analysis

In this scenario, one inspection per year would be sufficient, unless there is higher exposition to damages, such as strong storms or hard winters, with a lot of snow. In this case, an inspection mission every six months would be more convenient. The UAV mission can be planned using Android applications.

Finally, obtained data (video streams/images) can be processed using specific software packages and photogrammetric techniques. The outcome would be the creation of a georeferenced mosaic and point clouds (Figure 5).

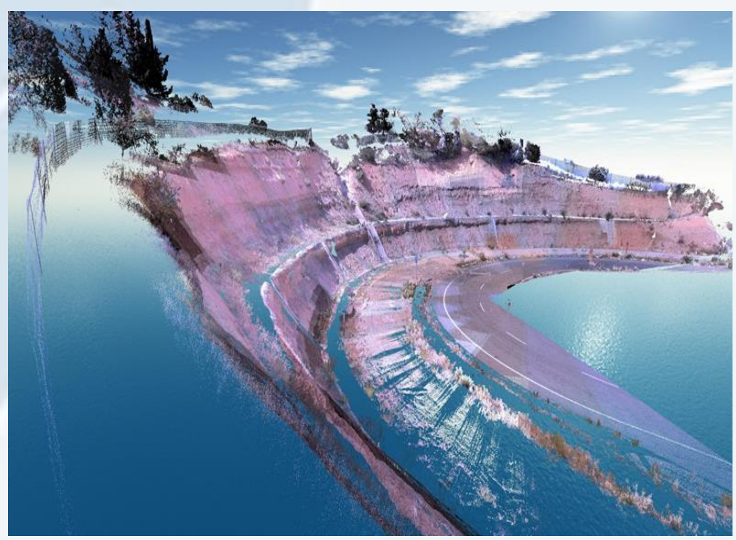

Figure 6: Point cloud of slope of Spanish A2 motorway in format .las, generated by Scanning total station Trimble SX10.

LIDAR mobile mapping – Detection capabilities

The point clouds generated by LIDAR mobile mapping are currently used for detailed digitalization of the road and/or its road assets.

There is a possibility to add asset attributes in different layers if combined with GIS applications. The different layers can be road, signaling, structures, buildings etc.

In this sense, the models could help operators to optimize the management of operations (Figure 6). Also, these point clouds are used as built projects of tunnels and bridges (Figure 7). The accuracy of the point clouds is 4 cm (relative accuracy).

Vulnerability Modules

Multi-Hazard Vulnerability Modules (MHVMs) are defined and used within the Holistic Risk Assessment Platform (HRAP) of PANOPTIS. MHVMs are essentially integrated software and data modules that characterize each unique asset of the Road Infrastructure (RI). They are site, user, and structure specific and they contain all the necessary data to allow estimating the consequences per asset given the input of each of the hazard assessment modules.

Figure 8 demonstrates the model of a bridge asset. The bridge is modeled in detail by incorporating tendon prestressing information and careful modelling of section stresses during the multiple phases of the balanced cantilever construction.

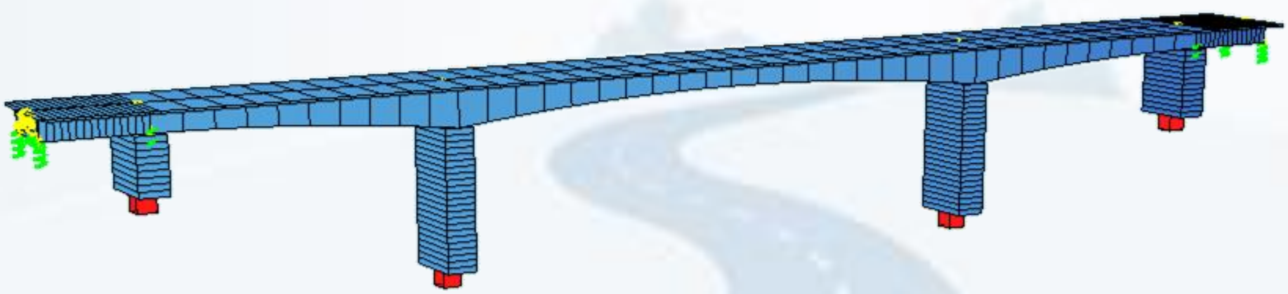

Figure 8: *Detailed bridge model using the Sofistik software platform*

Complex network analysis for RI

Complex network analysis assesses the performance of the road infrastructure-network and road vulnerability with the implementation of graph theory (Figure 8). This assessment is related to the resilience concept for the protection against risks and natural hazards.

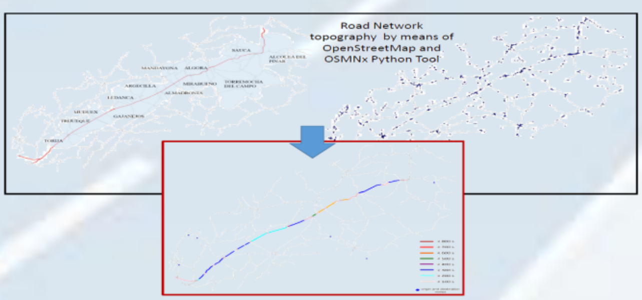

Figure 9: Road network of Autovia del Nordeste

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