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INNOVATION IN TUNNEL OPERATION AND MAINTENANCE

SOME EXAMPLES FROM THE LATEST WTCs and ITA AWARDS

- Information Modelling in Tunnelling
- Energy saving lighting
- Digitalization
- Predictive maintenance
- IoT
- GPS underground

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INFORMATION MODELLING IN TUNNELLING

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Information Modelling in Tunnelling

ITA WG22 has started to deliver guidelines on how Information modelling in Tunnelling will serve the industry

Asset life Cycle

- Strategy and initial phases
- Delivery phase
- Operational phase
- Post operational phase

Figure 1: Asset Life Cycle for Built Assets.

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ENERGY SAVING LIGHTING LUMINESCENT MATERIAL FOR SUSTAINABLE AND ENERGY-SAVING LIGHTING FOR TUNNELS (LUMA)

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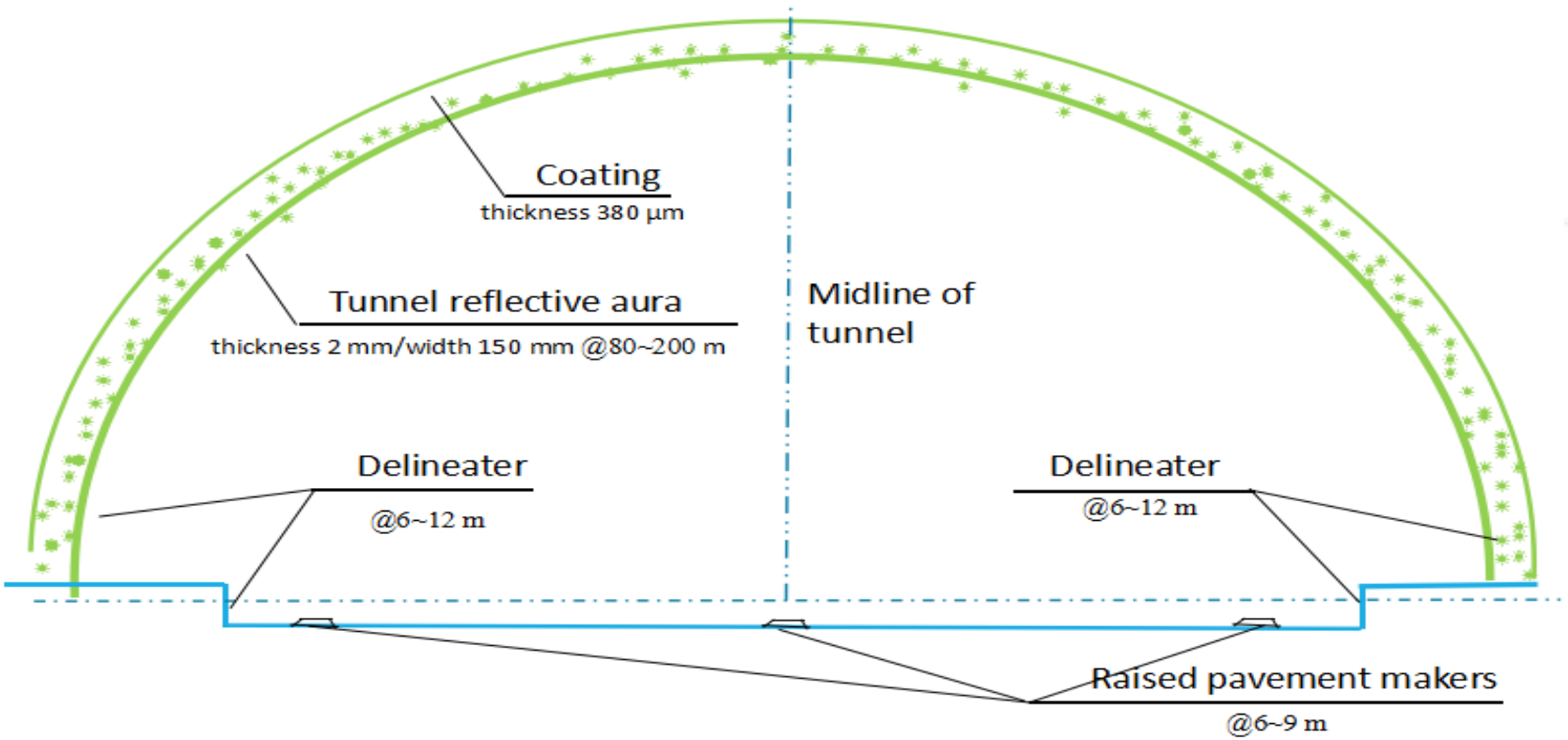
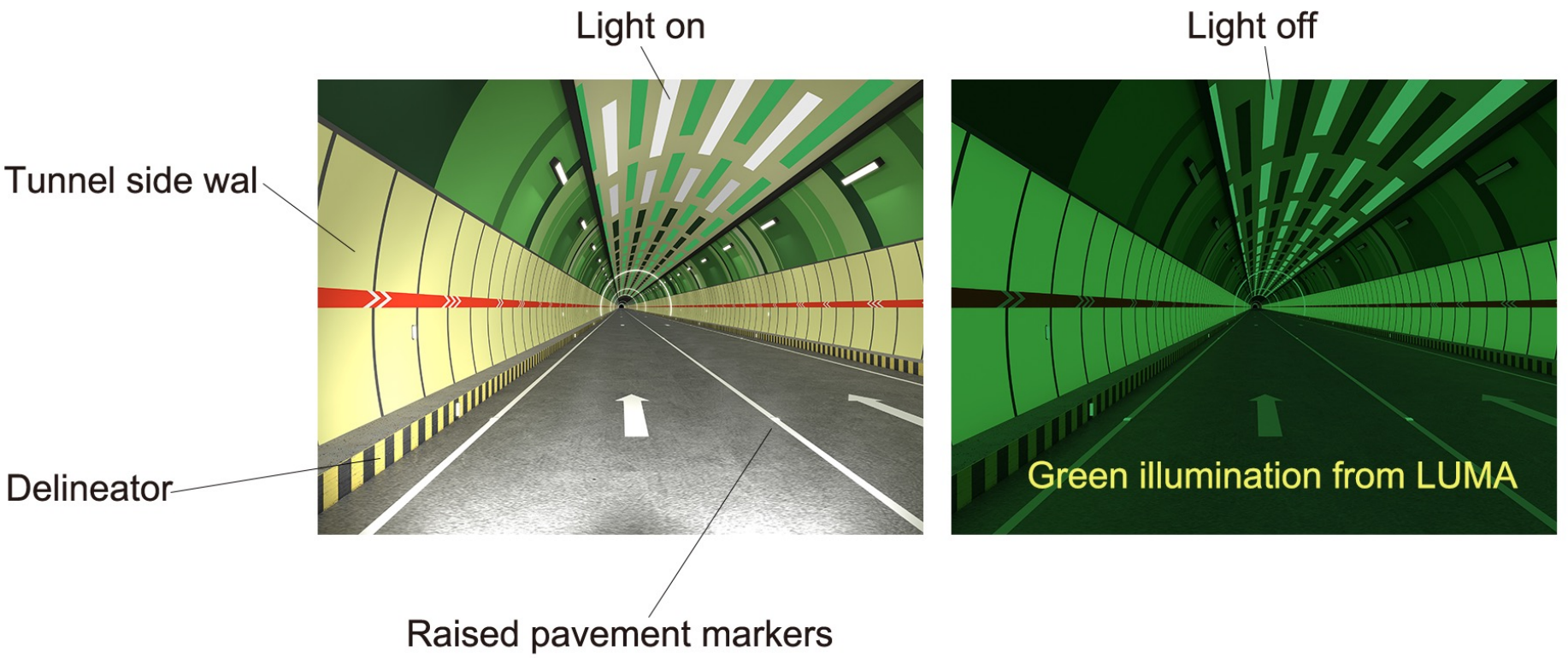
Energy saving lighting

Application Design



Energy saving lighting

Application Design



Energy saving lighting

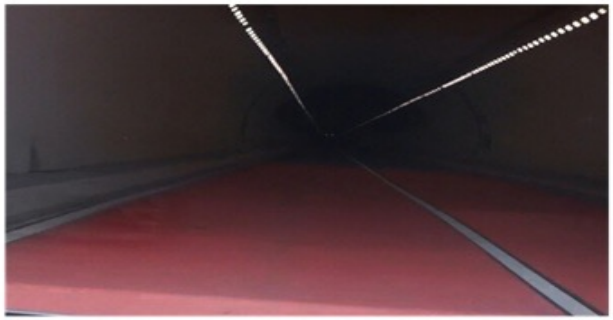
Effect- Brightening and brightening

Energy saving lighting

Eliminate the "black hole" and "white light"

(a) "Black hole" phenomenon

(b) "White light" phenomenon



(c) "Black hole" eliminated

(d) "White light" eliminated

When LUMA is set at the tunnel opening, and there is less contrast of light inside and outside the hole (exit). So it helps to reduce traffic accidents!

DIGITALIZATION

Digitalization

The planning and the management of existing infrastructures (and tunnels) is already a central challenge for industrialized countries in order to manage heritage and strategic infrastructures ensuring a sustainable and resilient asset. In the last years, a larger amount of the tunnel industry follows the lead of the mechanized excavation method and the issue for the management and the maintenance of this particular kind of underground structures increases through the years.

Example of an innovative multidimensional mobile mapping system

ARCHITA

is a multidimensional mobile mapping system with linked and integrated equipment of survey and position sensor installed on a vehicle. A large set of information (geometry, status, structural condition) are obtained in a single passage and integrated in one output environment for the maintenance, design and the management of infrastructure

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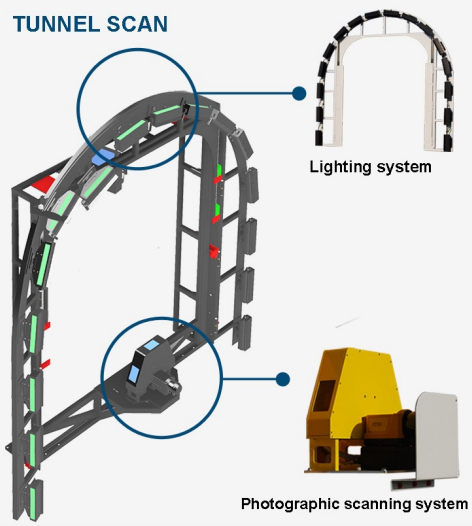
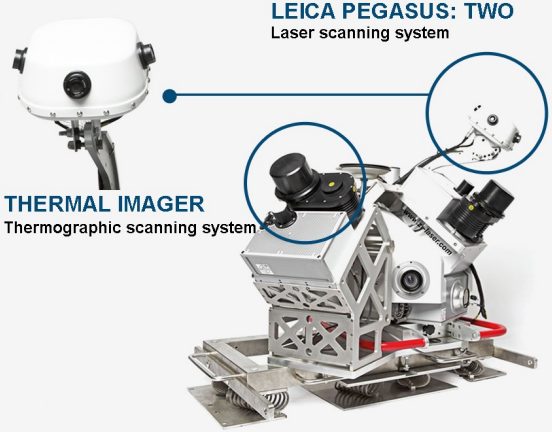
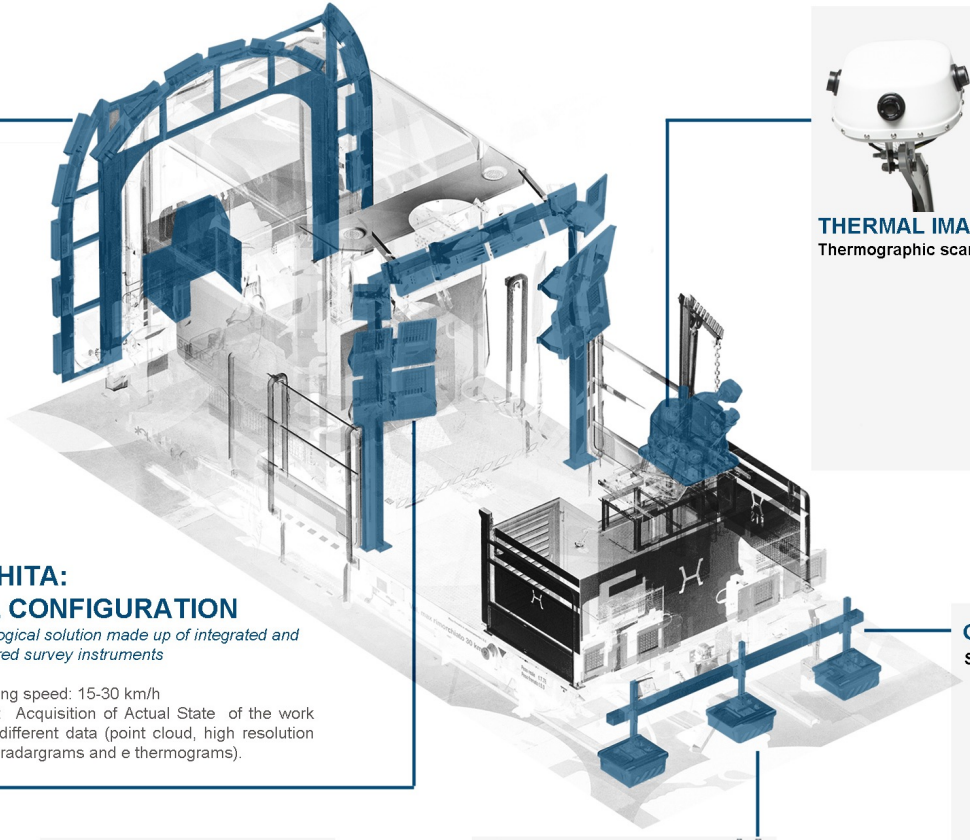
TUNNEL SCAN



LEICA PEGASUS: TWO
Laser scanning system



THERMAL IMAGER
Thermographic scanning system



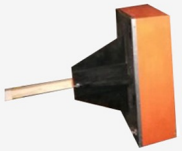
LIGHTING

ARCHITA: RAIL CONFIGURATION

Technological solution made up of integrated and engineered survey instruments

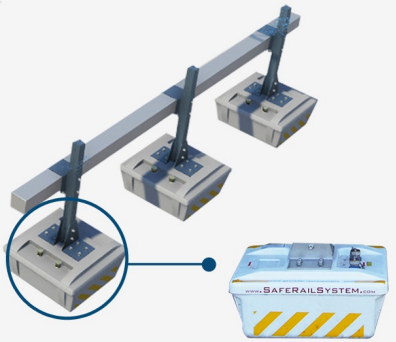
· Operating speed: 15-30 km/h
· Output: Acquisition of Actual State of the work through different data (point cloud, high resolution images, radargrams and e thermograms).

GEORADAR



GEORADAR
Road system

GEORADAR
SafeRailSystem



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Miami, USA 18th November 2019

Ricardo Ferraro, Head of Survey Department

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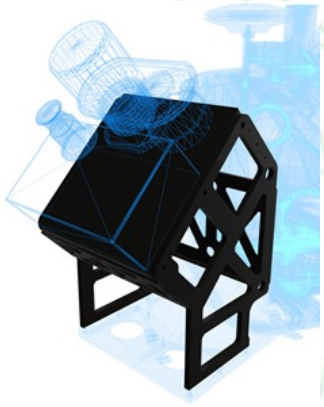

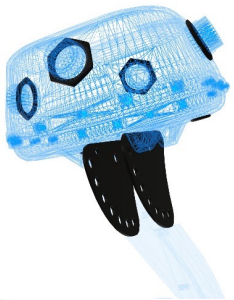

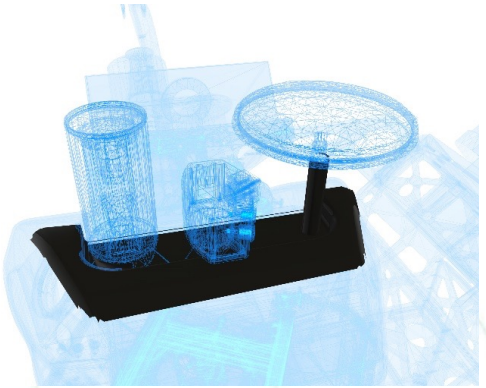

SURVEY SENSORS
No. 8 digital cameras with 2046 x 2046 resolution
No. 2 profilers Z+F 9012 in class 1 (2 mln p.p.s.)
No. 4 thermal imaging cameras

POSITIONING SENSORS
No. 2 GPS antennas
No. 1 IMU inertial platform
No. 1 optical odometer

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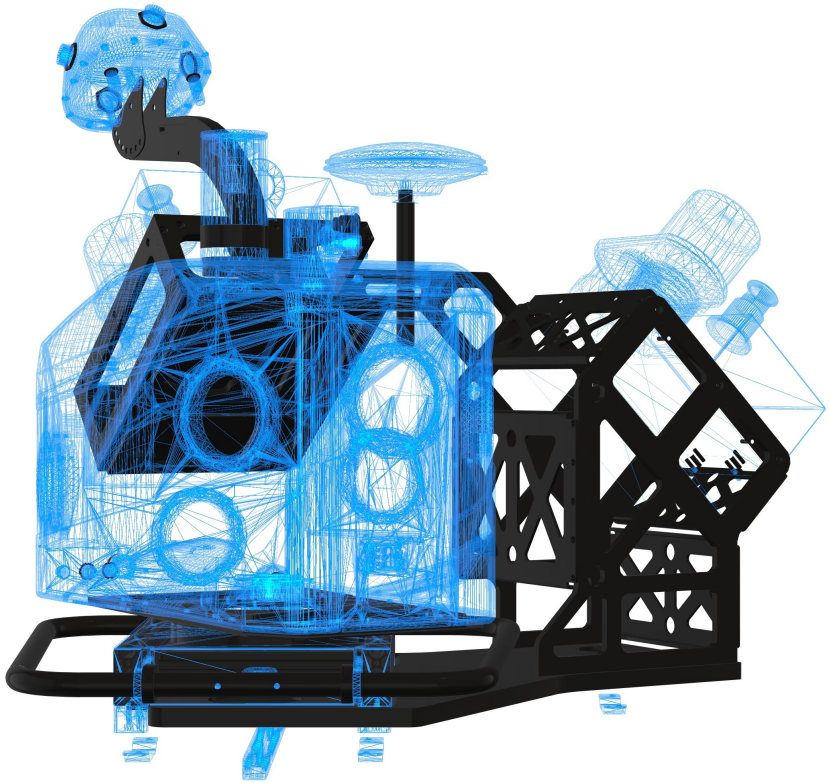


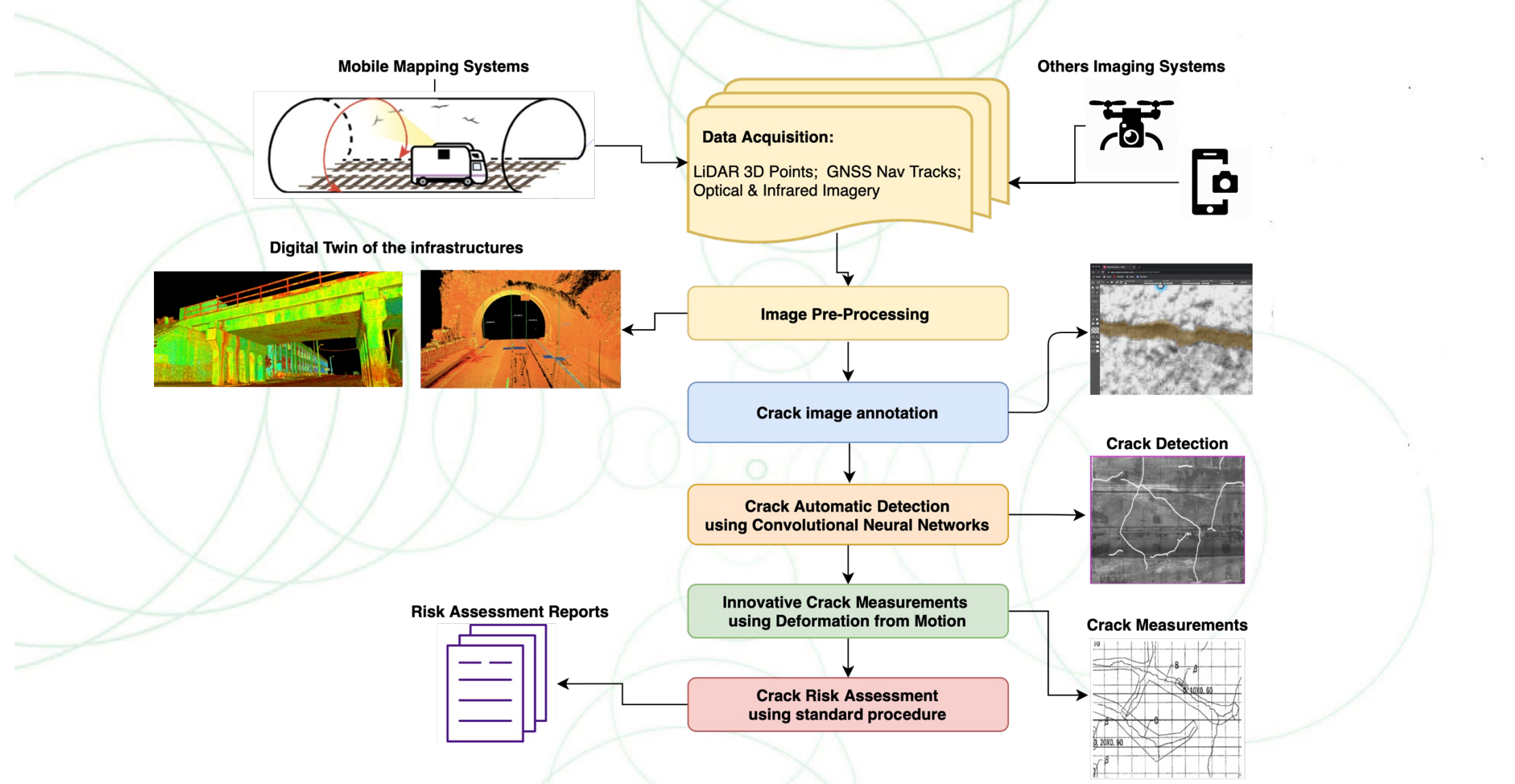
Example of Tunnel Automatic Crack Detection (TACK)

Digitalization

Tunnels in hard rock are typically supported with a thin layer of fibre-reinforced shotcrete in combination with rock bolts.

Cracks in the shotcrete could lead to corrosion of the fibres, which reduces the residual strength and could lead to downfall of shotcrete.

Therefore, routine inspections are carried out to maintain a safe tunnel. Today, visual inspections are mainly performed, which is timeconsuming and prone to human errors. TACK (Tunnel Automatic CracK Detection) is a research project that aims to develop an autonomous tunnel inspection method based on a hybrid approach of photogrammetry and deep-learning


Mobile Mapping Systems
Others Imaging Systems
Data Acquisition:
LiDAR 3D Points; GNSS Nav Tracks;
Optical & Infrared Imagery
Digital Twin of the infrastructures
Image Pre-Processing
Crack image annotation
Crack Detection
Crack Automatic Detection
using Convolutional Neural Networks
Innovative Crack Measurements
using Deformation from Motion
Crack Measurements
Risk Assessment Reports
Crack Risk Assessment
using standard procedure

GENERATING TRAINING DATA

One important aspect of an autonomous inspection system is the reliability and accuracy in detecting cracks. Therefore, the first step in this project focused on the training of a CNN architecture and the evaluation of its performances with imagery of cracks from tunnels. In general, during these types of investigations it is always necessary to adopt a set of images in which the object of interest (e.g. the crack) is manually labeled. In this way, during the training phase the CNN (Convolutional Neural Networks) model uses the information of the annotated dataset to learn how to recognise the pattern of interest in completely new and unseen images.

Use of IoT in the Tunnelling Industry

IoT for a better safety

Safety has historically been one of the most critical challenges faced by the tunnelling industry, especially given that half of all construction projects still use manual data readings – which is both risky and costly – or cables, which can be expensive and inconvenient, especially with regards to stopping traffic – meaning that in tunneling projects the laying down of cables leads to projects having to be put on hold. In contrast, wireless systems increase efficiency and reduce costs, making the monitoring process easier through introducing automation. Companies no longer need to think about how they're going to take readings. The automatic, remote monitoring process makes the workplace safer and improves compliance with industry regulations and standards. The experts on this webinar explore how wireless monitoring can be used to enhance risk management and improve instrumentation and monitoring in tunneling projects, helping operators to tackle the safety challenge head-on.

IoT for a better safety

Specific challenges in this sector include the dispersion of critical points that need to be monitored across a large area, a continually changing construction environment, and, if using sensors placed on cables, the need to make adjustments to those cables at every stage of the project. The way to deal with these challenges most efficiently and precisely is through aggregating real-time information, which accurately describes the performance state of the tunneling project and can be used by decision-makers to implement the most appropriate action, and instigating proactive risk-management approaches with alarm thresholds and response plans. One of the only ways to do this is through implementing an IoT wireless monitoring system, which is low-power, low-maintenance, durable, compatible with different types of sensors and monitoring software, and continuously gathers data in real-time.

IoT for a better safety

The future of tunneling is in IoT – a technology that offers operators the opportunity to generate greater efficiency through digitizing their operations. The type of real-time operational management currently enabled by wireless monitoring solutions will eventually allow for the creation of digital twins. These "videogame" models of the tunneling site will allow operators to plan ahead for any possible incidents and implement actions to prevent them first virtually, and then literally, improving the efficiency of their operations and reducing the risks of tunneling significantly.

Use of Global Navigation Satellite System (GNSS)

With world growth and the climate change challenges, Transportation has become a key element in modern cities. Used by billions every day, Transportation faces more and more safety and efficiency challenges.

As the most common location and navigation service available in the world, GNSS is the backbone of Transportation operations. Used to locate the fleets and monitor them in real-time, or by the public to navigate and commute, GNSS becomes naturally unavailable in indoor or underground environments.

Solutions to extend GNSS Coverage Extension to indoor & underground environments, as well as a set of powerful receivers to enhance assets' management for Transportation exist

To restore the GNSS commodity continuity of service indoor and underground, Syntony developed the SubWAVE™ technology. Based on GNSS simulators for Aerospace Industry, SubWAVE™ simulates in real-time GNSS signals compatible natively with all GNSS-enabled devices deployed in the area.

THANK YOU