
control engineering
SINA
Railway
facilities

ABOUT SINA

SINA, a design company of the Gavio Group, protagonist for over fifty years in the Study, Design, Implementation and Management of new infrastructural works in the road and rail transport sector, incorporates SINECO, a company belonging to the same Group, from 1 September 2017, thus expanding its activity in the field of Control Engineering and Maintenance of Large Transport Infrastructures.

In particular, SINA holds now a specific knowledge in road, railway and airport surveying and maintenance engineering being mainly engaged in the surveillance engineering and revamping of bridges, viaducts and tunnels (more than 1000 building and or recovery sites are currently being supervised in parallel over 100,000 meters of tunnels monitored every year).

SINA also plays a winning role in the quality control of those materials exploited for maintenance purposes and/or for construction and, fi nally, in the setting up of maintenance and revamping management through integrated systems feedback driven.

The distinguishing and qualifying plus belonging to products and services offered by SINA is the yearly consistent investment plan to gain excellence in innovation and further development of those services and products as well as through a daily effort of SINA team at all, both technicians and engineers.

SINA has a considerable expertise in consultancy for railway sector, offering services aimed at the diagnostic inspection of structural works through technologically advanced instruments and integrated services, as well as a deep know-how in maintenance engineering.

SINA Services in the RAILWAY sector

SINA has a wide know-how in the supply of specialized consulting services and it specifically operates in the following fields:

Engineering

The Company gained over the years a significant in-depth knowledge in the sector of materials exploited for maintenance, repair and rehabilitation (MR&R) interventions also thanks to its own ability to assess robustness meant as residual life time of the operating structures. The engineering activity consists in a ***Risk Assessment*** based on structural checks aimed to determine wherever safe operability of the structures is in place or not (in these activities also consist of an ***Earthquake Simulation*** run on resulting survey data set and a steady state stage and structural test too in order to assess the whole structure behaviour). The Company provides services related with ***Preliminary/Final/Construction Design*** of rehabilitation interventions, as well as ***Construction Supervision, Material and Works Quality Control, Safety Supervision and As-Built Documentation.***

Surveillance of main infrastructures

The inspection methods developed by SINA aim at verifying the stability and safety of a structure and at predicting how its degradation will evolve. The activity consists in Inspections and checks of bridges, tunnels and buildings, aimed at evaluating the state of preservation and at defining specific action plans, as well as, upon request, at implementing specific ***"B&TMS"*** (Bridge and Tunnel Management Software) in order to provide the Managing Agency with a decision-making supporting system with which to identify and optimize the repair/rehabilitation interventions ***(MR&R)*** and the allocation of financial resources.

Non-destructive technologies

Technologies applied to the diagnostic of major works, such as monitoring, final testing and checks on structures and buildings applied thorough structural/functional check-ups, quickly and in such a way as to minimize the subjective interpretation of the collected data. In addition to the more commonly tests (such as the sclerometric tests, pull-out, etc.), the Company can carry out ***load tests, vibrodina tests, remote surveys, convergence readings, sonic tests, radar analyses, etc.***

Laser surveys

Execution of laser mobile mapping and laser static surveys, also using new and advanced data acquisition techniques such as the ***Laser Mobile Mapper*** for the dynamic survey of railway networks -from the platform to the surrounding environment- the Tunnel Scanner System for the profilometric, thermographic and photographic survey of tunnels and the ILRIS 3D static laser for the survey of civil engineering works (buildings, bridges, etc.) and slopes

Material Testing Laboratory

The testing laboratory is technically advanced and equipped with the latest instruments. The lab headquarter is located in Tortona (Piedmont, Italy), and operates in the following sectors: ***concrete, steel, bituminous materials, soil, rock, paint, geo-synthetic materials and geotechnic.***

Environment

Using the latest instruments, SINA can assess the level of noise pollution produced by railway traffic, draw up acoustic models and studies, and design any noise abatement measur es as necessary.
Lastly, the Company carries out checks on atmospheric pollution, at both the particulate (TSP and thin PM10 and PM2.5) and gaseous pollutants level.

SINA is certified UNI EN ISO 9001:2008 and counts on a testing laboratory in line with UNI EN ISO/IEC 17025:2005 "General requirements for the competence of testing and calibration laboratories" for tests listed on Accredia website (www.accredia.it)

SOFTWARE APPLICATIONS

During its twenty years operations, SINA has developed different software applications to increase value added for involved customer. These applications have been designed and developed keeping in mind a simple useful principle: “Agencies managing infrastructures need a cockpit to drive them efficient and safe by a convenient financial ratio”. SINA focused over the years how to move from black boxes containing surveying achieved data to mining them for query, analysis and prediction models purposes. The results of this effort are several software solutions and in particular:

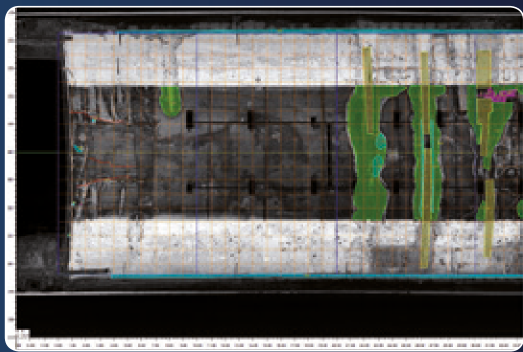
“TuView®” software

The concept behind TuView® is to allow a kind of “tunnel inspection on the screen” using the recorded data.
TuView® allows visualisation and analysis of data obtained with the tunnel scanner that, in a single recording sweep, generates an image recording of the tunnel surface, a thermographic image and a three-dimensional measurement survey (see figures from 13 to 22). Function keys for the “direction of motion”, searching for a certain point, zoom and outline displays are as much part of the programme as a positioning scale and the option of changing brightness and contrast for the improved analysis of certain spots allowing the computer-based combination and opening up a wide variety of different analysis options.

It is tailor-made for the needs of test engineers. Its functionality has been - and still is - developed in close contact with our customers. Many functions realised today go back to suggestions and input given by our users. The programme is easy, intuitive and self-explanatory, allowing the specialist engineer to concentrate fully on his or her task.

“Tunnel-Inspector®”software

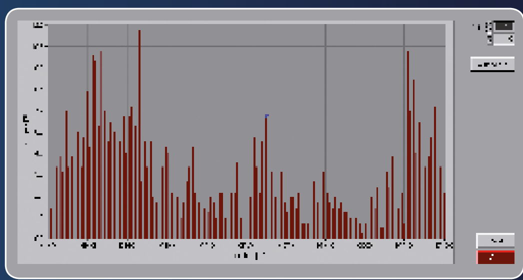
This software combines digital processes for the acquisition and processing of information with usual set-up methods of in situ investigations.



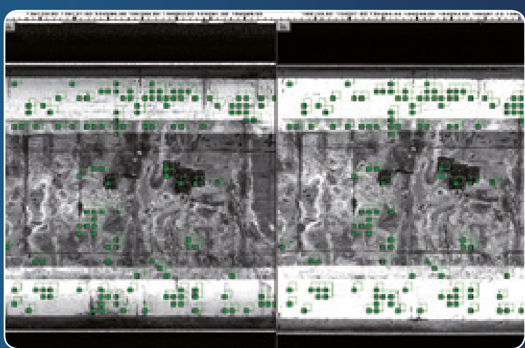
Starting from the data of the survey carried out with the TSS “Tunnel Scanner System”, the technicians, with the help of the application, can estimate and catalogue deteriorations by severity and extent, monitoring their evolution, studying in a systematic way actions plan that combine the economic optimum with the expected service level. The processed data allow “one to many” comparison to be performed by tunnel type, by construction technologies or by the effectiveness of the maintenance, repair and rehabilitation (MR&R) interventions that took place.

“Tunnel-Info®” software

This software is used to “flow through” tunnels network, making it possible to display all detail information about an actual tunnel or a specific survey run, and to compare inspections carried out in different years on the same structure or on a specific part of the structure. The differences between two consecutive surveys are automatically displayed through the interpretation of digital images. The statistical summary of percentage changes of any anomalies detected in subsequent years makes it possible to quickly identify tunnel sections concerned by evolving deterioration phenomena. In particular, this software stores and manages surveys performed with the TSS “Tunnel Scanner System” together with the findings of visual inspections performed at different intervals.
This information, updated from time to time and stored, allows creating a database of the evolution of the deterioration of a structure as well as the definition of specific deterioration models according to which the maintenance, repair and rehabilitation (MR&R) can be planned.



Graph of % changes measured on a tunnel over two successive years



Comparative image of the same tunnel section taken in 2005 and in 2006

“B&TMS®” software

(Bridge and Tunnel Management System)

Agencies that manage own infrastructures are required to pursue the best maintenance policies in order to keep civil structures within set standards of safety, functionality and usability. Being aware of this need, SINA has developed a B&TMS management systems based on the AASHTO Pontis code, with the aim of providing agencies with a decision-making support system which, starting from information collected during the monitoring/surveillance activities of the structures, can easily identify the best maintenance policies and optimize the allocation of financial resources.

Surveillance and Management of Railway Infrastructures

Over the years **SINA** has developed automated monitoring services through cutting-edge laser equipment that allow to carry out, quickly and accurately, the geometrical and topographical survey of transportation networks – from the railway platform to the surrounding environment – as well as the inspection of railway tunnels and structures in general.

Thanks to these effi cient technologies, today the Railway Agencies can easily perform, with limited effect on traffic flow continuity and under safe condition , periodical inspections and surveillance of the structures, promptly schedule any maintenance jobs needed for conservatory restoration and ensure compliance with the safety standards set by the regulations in force.

Finally, laser scanner technologies are able to acquire the necessary information of a geometric/topographic type and provide it to engineers in support of design activities for new lines or adaptation of existing ones.

LASER MOBILE MAPPER

Sina has fully integrated vehicles that can perform a 3D geo-referenced laser scanning of railway infrastructures and of the surrounding territory in dynamic mode, also at night-time, reaching operational speeds up to 100 km/h: the Riegl VMX 450 (Fig. 1a) and the Lynx V-200 produced by Optech (Fig. 1b)

Here is a short description of about their operation: 2 latest-generation Lidar sensors, positioned on top of the vehicle, emit laser rays at a variable frequency from 200.000 to 500.000 pulses/second, rotating at a settable speeds up to 24.000 rotations/minute. Laser rays are reflected by objects

Parameter	Value	Parameter	Value
Rotation speed	Up to 24.000 rot/minute	Scanning angle	360 degrees
Measuring accuracy	±8 mm (1 sigma)	Number of shots	> 200.000 per second
Spatial resolution	Up to 1 cm at 50 km/hour	Measurements for each point	Up to 4 simultaneously
Range	>200 metres (with 20% refl.)	Eye safety	IEC/CDRH Class 1, harmless

Table 1 - Laser system specifications

present in a bandwidth of over 200 metres per side and then read by a receiver that measures their distance. The set of points measured as described above reproduces the territory as a high-density "Point Cloud" (Fig.2, 3), each of which is geo-referenced in WGS84 coordinates. The geo-referencing of points is allowed thanks to the interface of laser sensors with a localization system consisting of satellite receivers (GPS), an inertial platform (IMU) and an high precision odometer (DMI).

With an optimal satellite coverage, a planimetric accuracy (X, Y) equal to 0.05 metres can be reached, with an accuracy in altitude (Z) equal to 0.15 metres.

The point density depends on the speed at which the survey is carried out and can range from 1.000 to 4.500 points per square meter of platform surface respectively for a speed of 40 and 10 km/hour. Another important feature of these instrumentations is the class of lasers (Class 1), which guarantee full protection for the eyes, allowing to work in man-made environments such as intermodal hubs, railway stations, etc.

Fig. 1a - Riegl VMX 450 on railway flat wagon

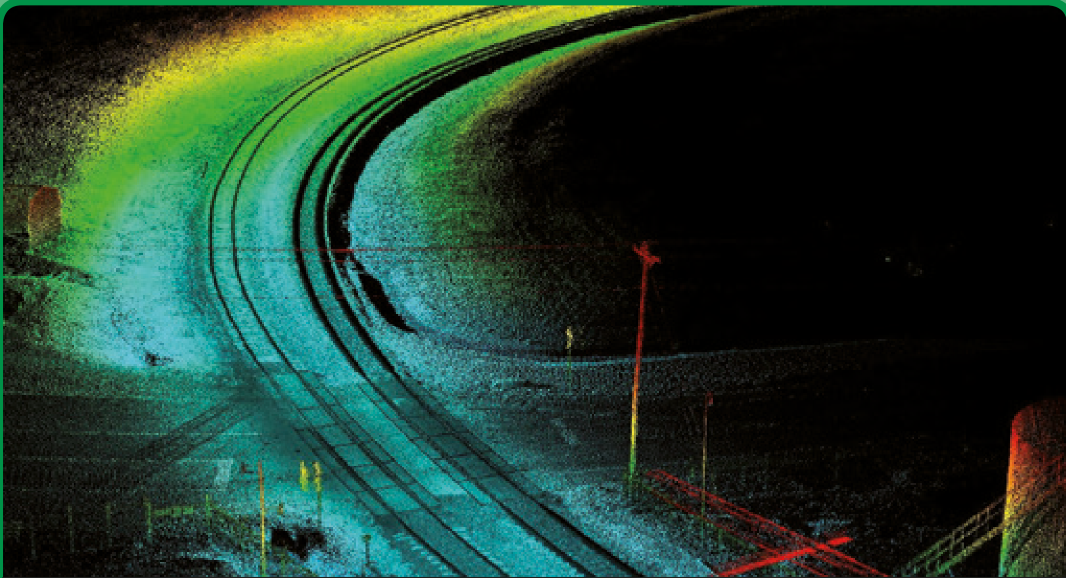


Fig. 2 - 3D point cloud of a railway section

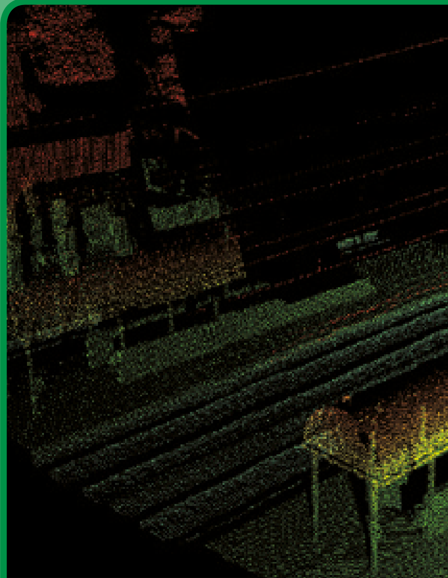


Fig. 3 - 3D

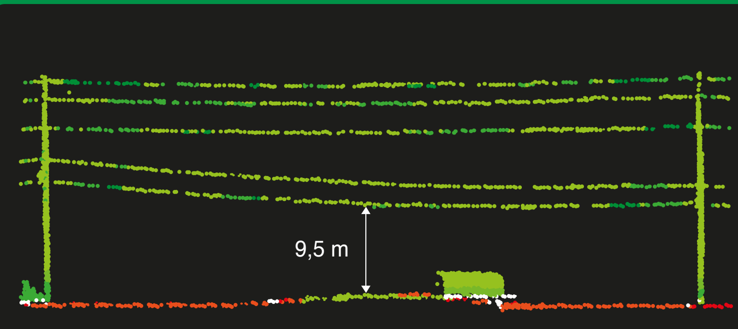


Fig. 4 - Electrical cables/rail distance check

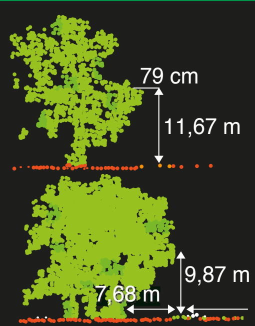


Fig. 5 - Interference check

Fig. 6 - 3D point cloud of a switch

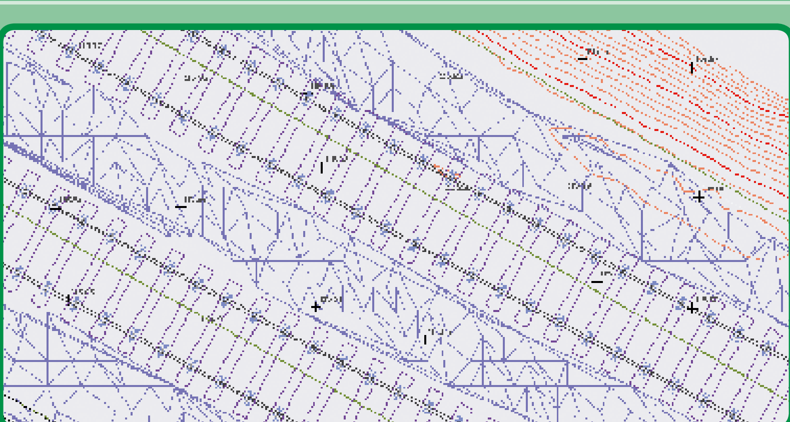


Fig. 8 - 3D model of a railway platform

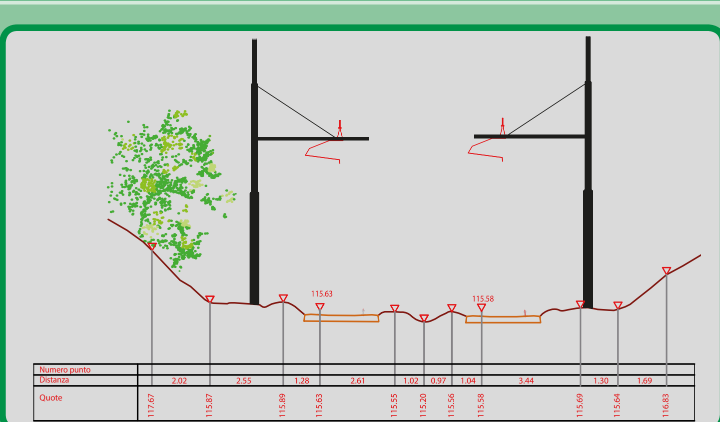
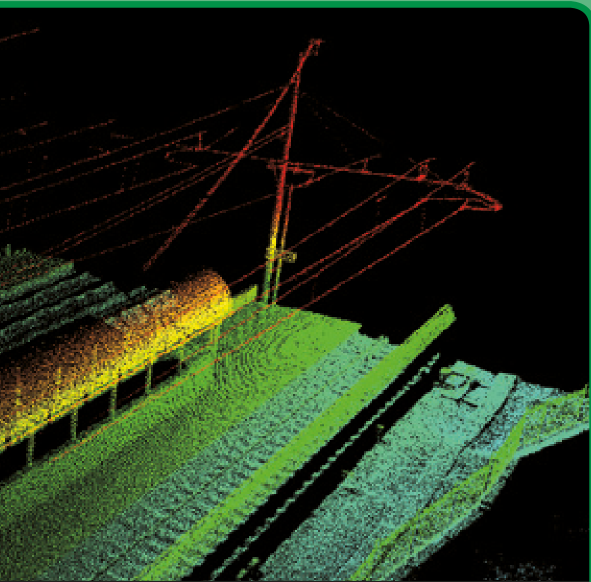


Fig. 9 - Extraction of transversal section

The technical specifications of the Laser Mobile Mapper systems are listed in Table 1.

The systems are used in a wide range of fields, from 3D Modelling of infrastructures, to the extraction of transversal and longitudinal profiles/sections, contour lines, geometric and clearance analysis and checks on the positioning of the railway platform (Fig. 4,5,6,7,8,9 and 10).

Fig. 1b - Optech Lynx V200 on railway flat wagon



point cloud of railway station

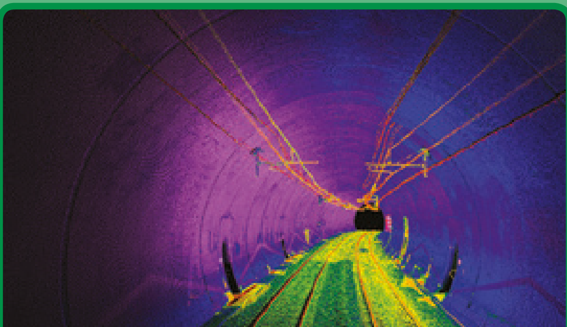


Fig. 7 - 3D point cloud of a tunnel

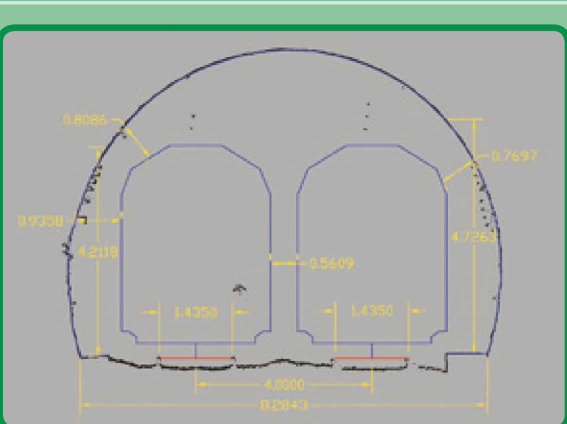


Fig. 10 - Transversal section with clearance for interference analysis

TUNNEL SCANNER SYSTEM

The Tunnel Scanner System-TSS (Fig. 11 and 12) is an instrument used for the photographic, profilometric and thermographic survey of tunnels in order to carry out geometric tests and diagnostic analysis of the conservation of the tunnel surface.

Thanks to the joint use of infrared and laser rays, TSS allows the acquisition, in movement and simultaneously, of a very high-resolution digital images, transversal sections at any point and the execution of a thermographic analysis of the entire tunnel.

Parameter	Value	Parameter	Value
Rotation speed	Up to 18000 rev/minute	Sampling frequency	800 kHz
Measuring accuracy	360 degrees	Translation speed	From 2 to 50 km/hour
Spatial resolution	From 5,000 to 10,000 pixel/rev	Laser class and power	10 mW - Class III B
Range	< 0.3%	Operating temperature	From 0 to 40°C

Tab. 2 – TSS system specifications

Specifically, the power of the system lies in the rotating head “laser scanner”, that can perform up to 300 Hz at a variable surveying speed, in relation to the aims of the survey, from 3 to 5 [km/h]. The technical characteristics of the system allow images from 5,000 to 10,000 pixels per scan to be taken (Table 2).

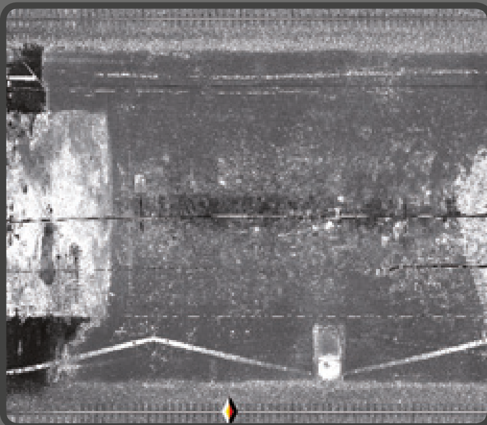


Fig. 13 - Photographic image of the entrance area

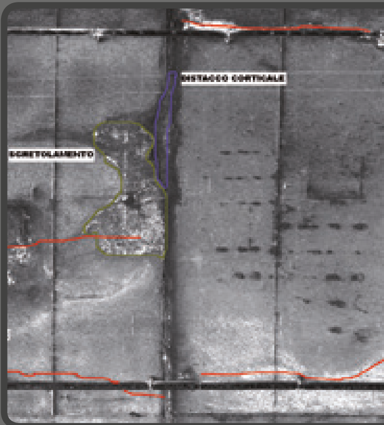


Fig. 14 - Verification of cladding

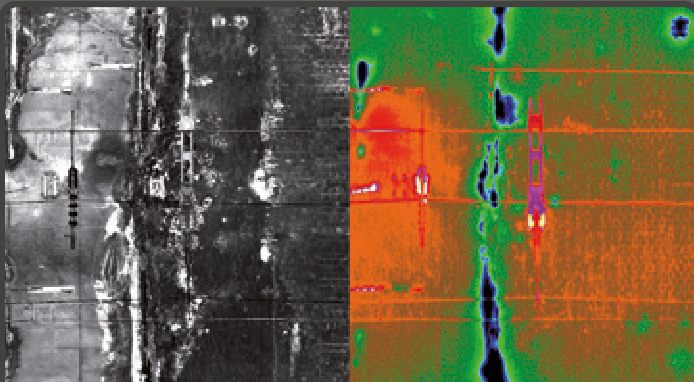


Fig. 17 - Photographic and thermographic image presence of active water seepage on the joint

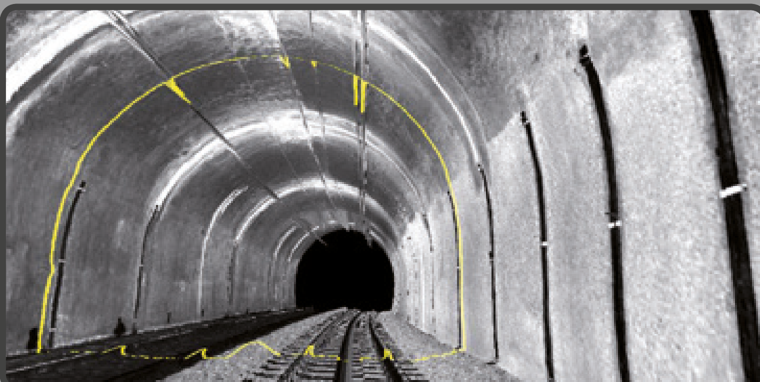


Fig. 19 - Three-dimensional display from the entranceway with geometric section

Visual data

The first result is the high definition image recording (Fig. 13) of tunnel surface, including the railway platform, which allows the user to display, enlarge and print two/three-dimensional images any point.

The detailed visual inspection (Fig. 14) is thus transferred from the construction site to the office, thanks to the possibility of recording and quantifying directly on the image cladding anomalies such as: **cracks, breakaways, presence of salts and/or incrustations**, etc. as well as of easily detecting fittings such as **raceways, lighting, SOS systems, fire systems**, etc. and to obtain an actual inventory of the services installed in the tunnel (Fig. 15 and 16).

Thermographic data

In addition to pointing out special events, such as the **presence of water** or **surface restoration** of the cladding, thermographic information, displayed through a scale of greys or in colour, also allows for a better assessment of tunnel anomalies when used together with the photographic image (Fig. 17 and 18).

Geometric data

It is used to build a 3D model of the tunnel (Fig. 19), thus providing support to the visual analysis of the status quo, showing the presence of any **breakaways** in the facing (fig. 20) or any other geometric anomalies.

Transverse sections of any point can be extracted from geometric data, and **geometric checks** are carried out on "**gabarit**" or on interferences between the limit clearance profile and the facing.

The possibility of extracting transverse sections at any point allows to develope restoration projects of the cladding or of new plant . Analysis of the "gabarit" makes it easier to identify the presence of **under-clearance sections** or to monitor the height after any job is carried out on the cladding. The interference between the limit clearance profile and the facing (Fig. 21) is studied using the **TuView** software, which automatically identifies all possible **contact zones**, representing them on the surface of the facing.

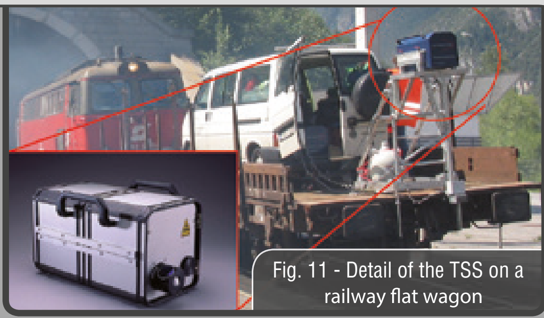
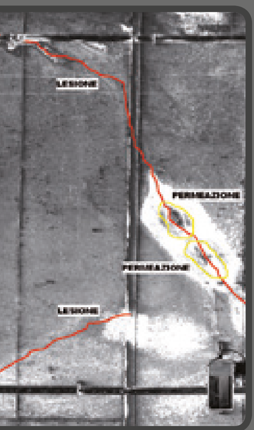


Fig. 11 - Detail of the TSS on a railway flat wagon

Fig. 12 - TSS survey of an underground railway



ng irregularities

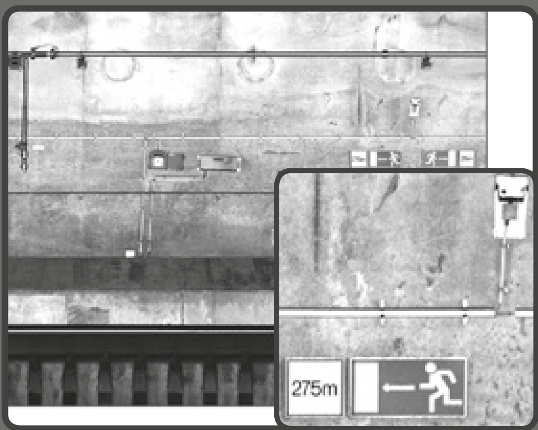


Fig. 15 - Detail of side wall with recognition of track, sidewalk, installation and signs

Fig. 16 - Detail display: vault cladding and lamps

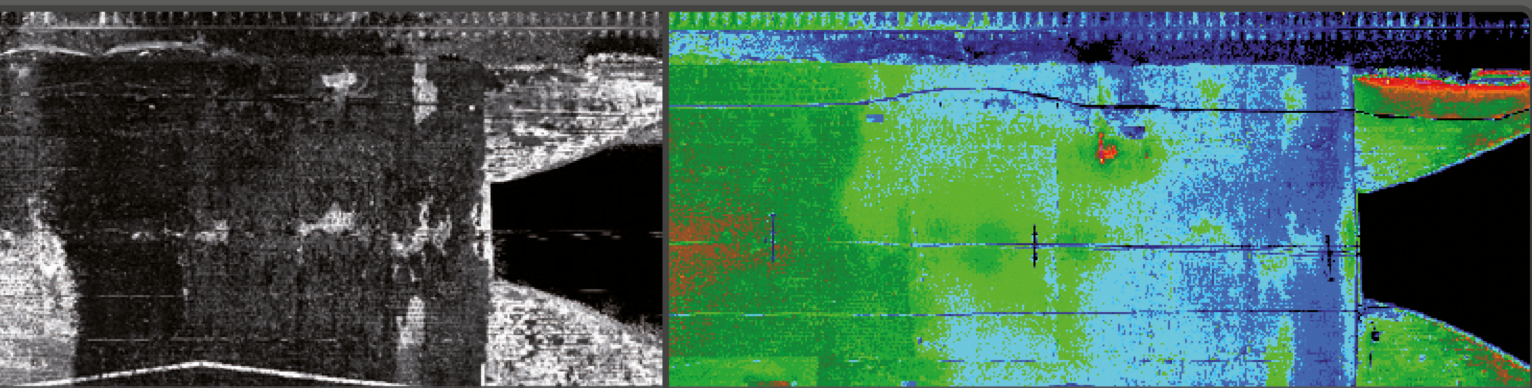


Fig. 18 - Photographic and thermographic image of a tunnel section: presence of seepage from point 81+043 to point 81+065

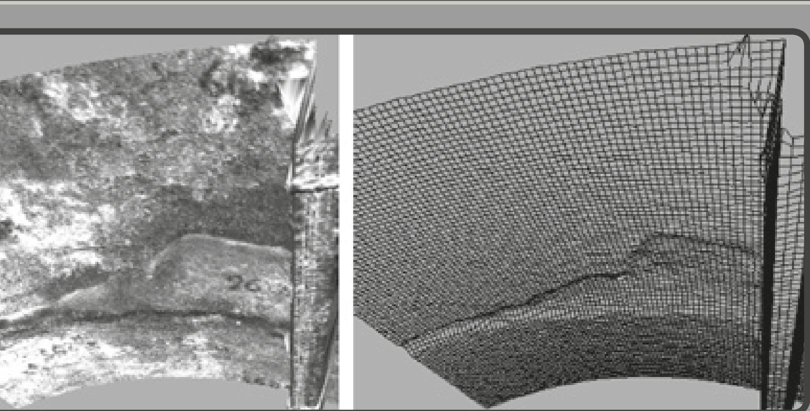


Fig. 20 - Three-dimensional detail of a separation in the vault

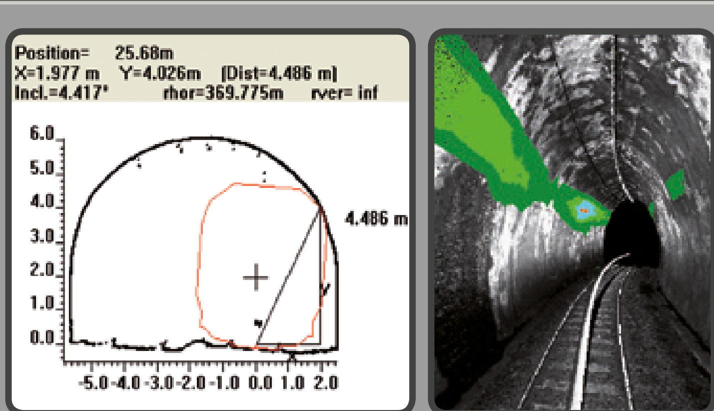
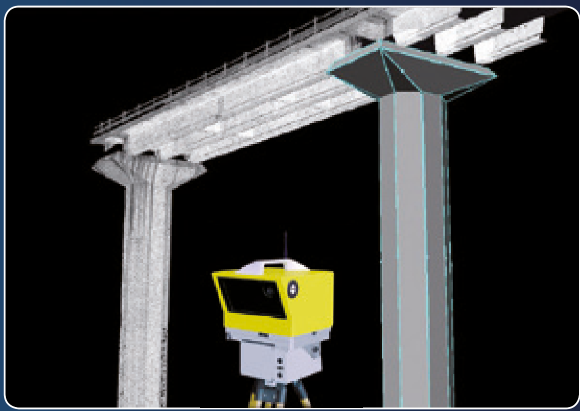


Fig. 21 - Theoretical shift of track axis and corresponding interference analysis of the theoretical clearance profile

INSPECTION OF BRIDGES AND OTHER WORKS

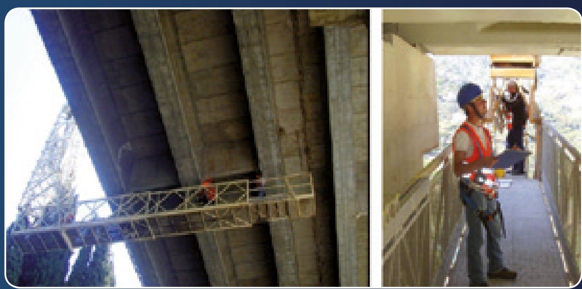
SINA can perform inspections aimed at verifying the state of preservation of the structure, guaranteeing the Railway Agencies prompt information, constant specialized technical support and all the consulting it needs to set up scheduled maintenance management.
The inspection methods applied by SINA entail three different phases which consist in:

Preliminary phase



Collection of general/geographic data concerning the work, if possible supplemented by geometric surveys by means of static laser scanners (ILRIS 3D) and environmental surveys.
The activity aims to recognize the structural types and to group them together in similar sets (piers, dosserets, beams , transverse-beams, etc.).
A list of anomalies is compiled for each type of structure or structural component, and a class coefficient with the relevant degrees of gravity is assigned to each anomaly.

Inspection phase



This activity is carried out by qualified inspectors, using by-bridges, elevators and ladders to access the structures. Irregularities are classified by looking at the visible surfaces of structural elements (piers, dosserets, beams, etc.), noting them down on graph diagrams prepared in advance and assigning to each one the gravity class with the help and the instructions of the reference books.

Execution of tests and samplings

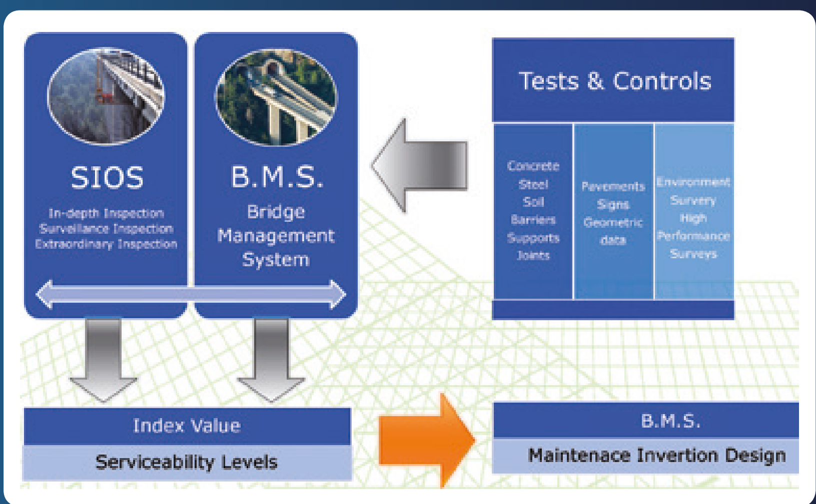
Inspection activities are usually supplemented by non-destructive tests **such as ultrasonic and/or sclerometric tests, pacometric tests, pull-out tests**, etc.
If needed, more complex tests can also be carried out such as, for example, potential mapping and corrosion of steel in concrete, grip tests for mortars, residual traction resistance of steel rebars, **load tests, convergence measurements, geo-radar analysis, remote surveys and vibration tests**.

Post processing phase

This phase is assisted by the **SIOS** software, which separates anomalies into different levels according to the class of severity and gravity. The software then calculates the actual area of the anomalies discovered and calculates the **Index Value** to a specific computational algorithm.
All index values thus calculated are entered in a database used to carry out groupings, averages, statistical incidences, maximum/minimum values, etc.

Engineering and BMS (Bridge Management System)

Based on the findings of diagnostic activities, SINA can then design and develop structural requalification projects aimed at re-establishing suitable performance and safety standards with regards to the structure.
These activities include seismic checks, checking the tension-deformation status under ordinary or special load conditions, and lastly, the planning of **Bridge Management System** maintenance activities, which, in the specific case, is carried out by SINA using several codes (**AASHTO Pontis** software, **Atkins** etc.).



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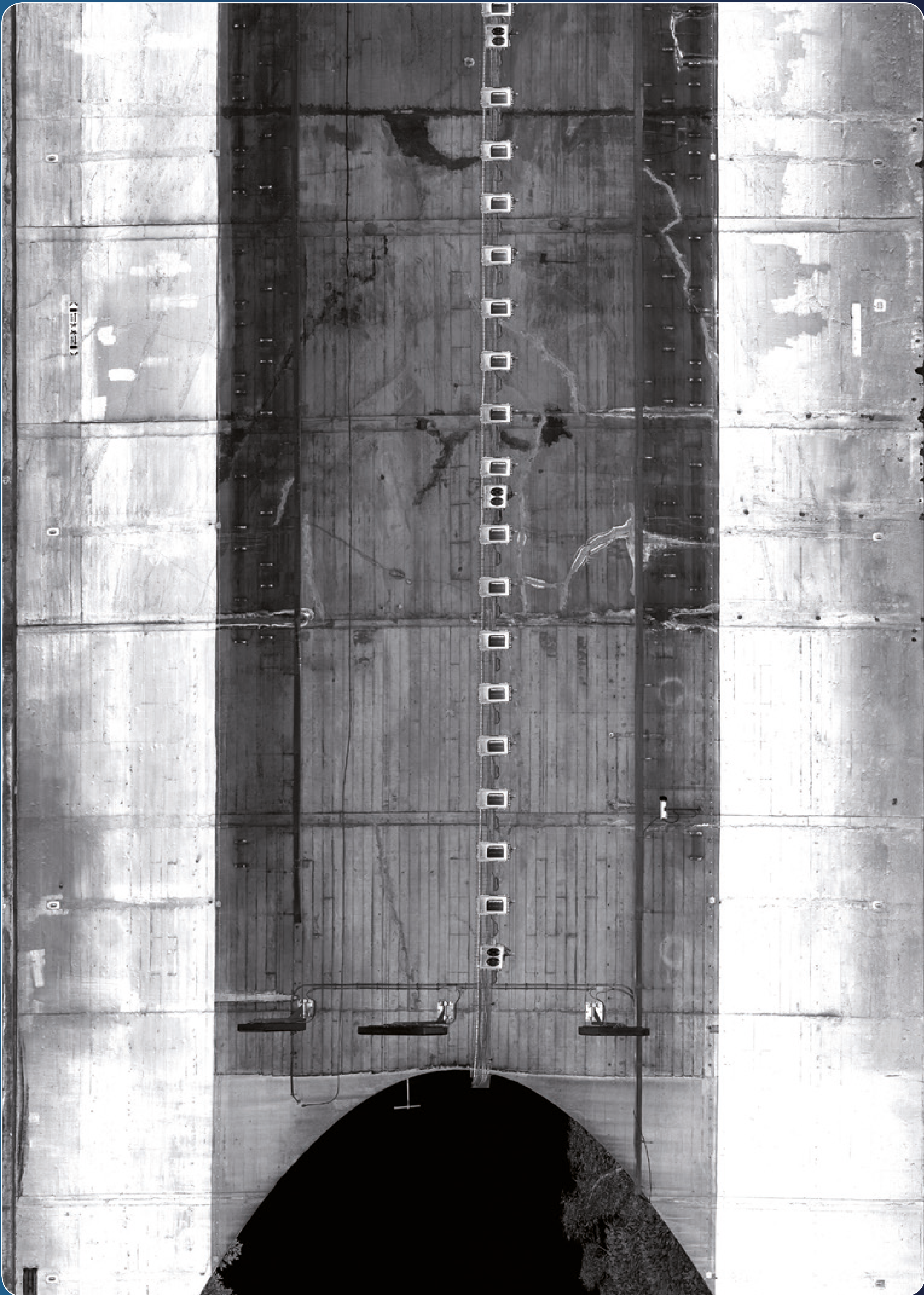
TUNNEL SCANNER SYSTEM



High definition image (10.000 pixels) of the entrance area tunnel

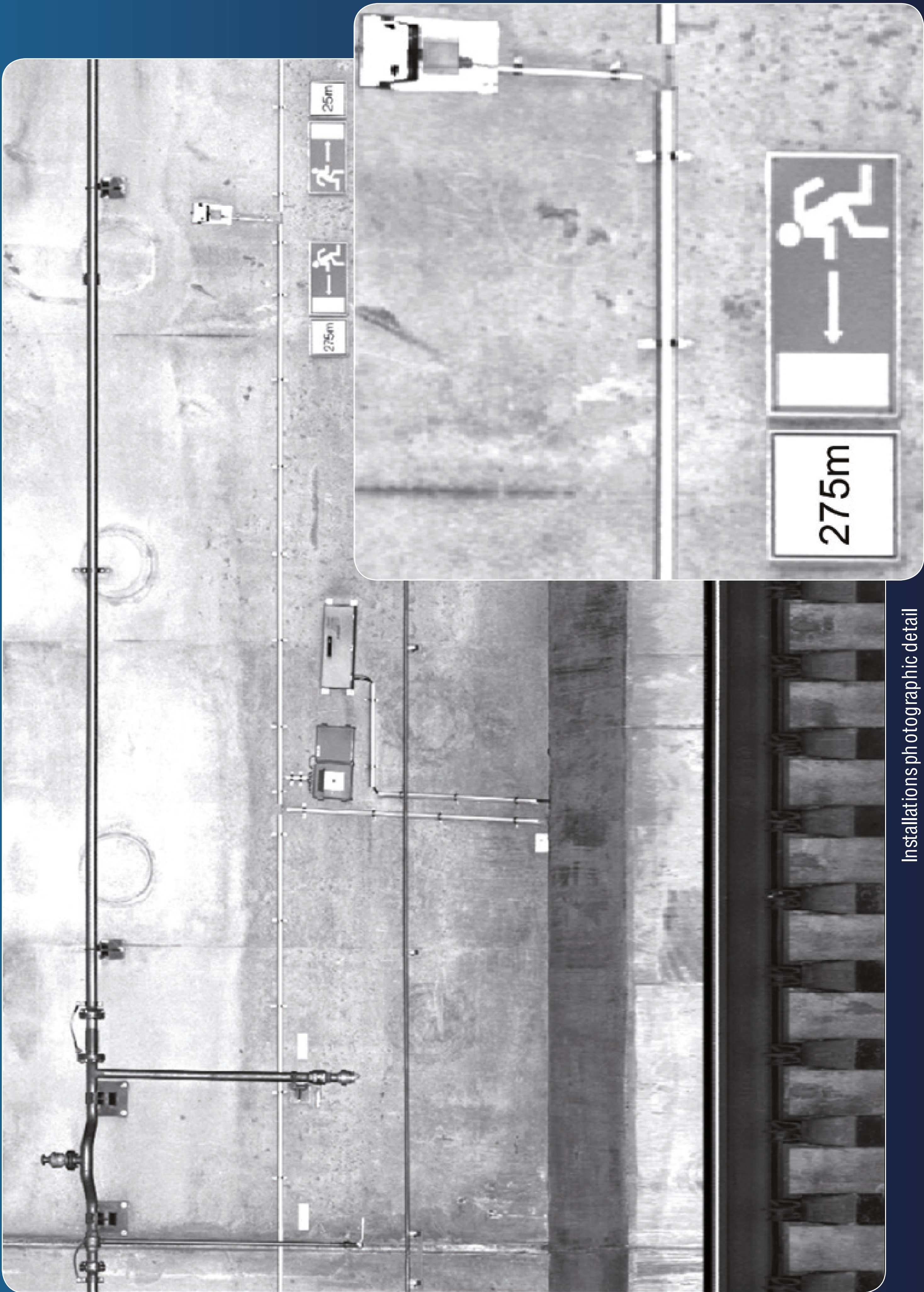
TUNNEL SCANNER SYSTEM

3D visualization of the tunnel entrance with transverse section

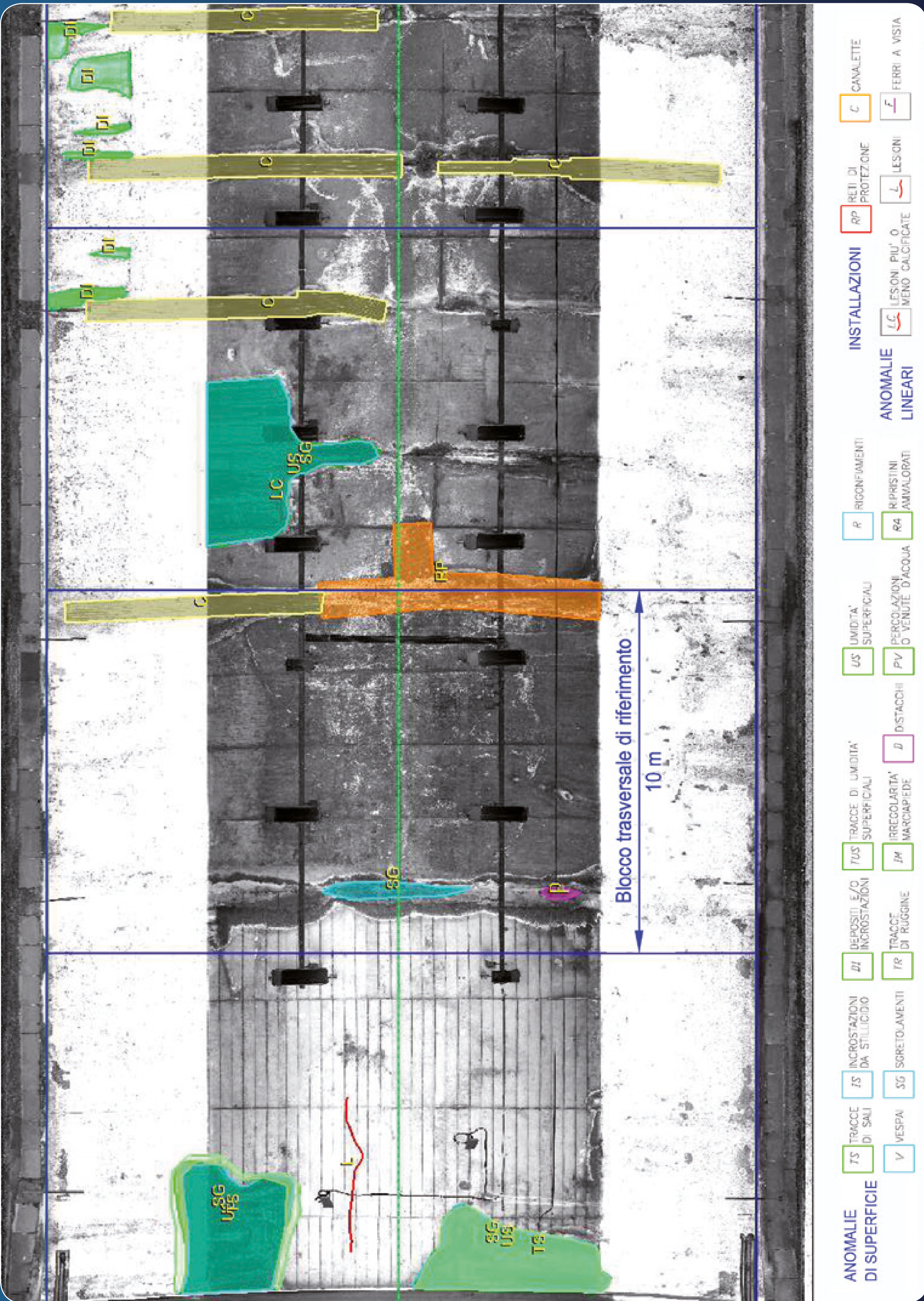
TUNNEL SCANNER SYSTEM

Photographic detail of the tunnel cladding

TUNNEL SCANNER SYSTEM

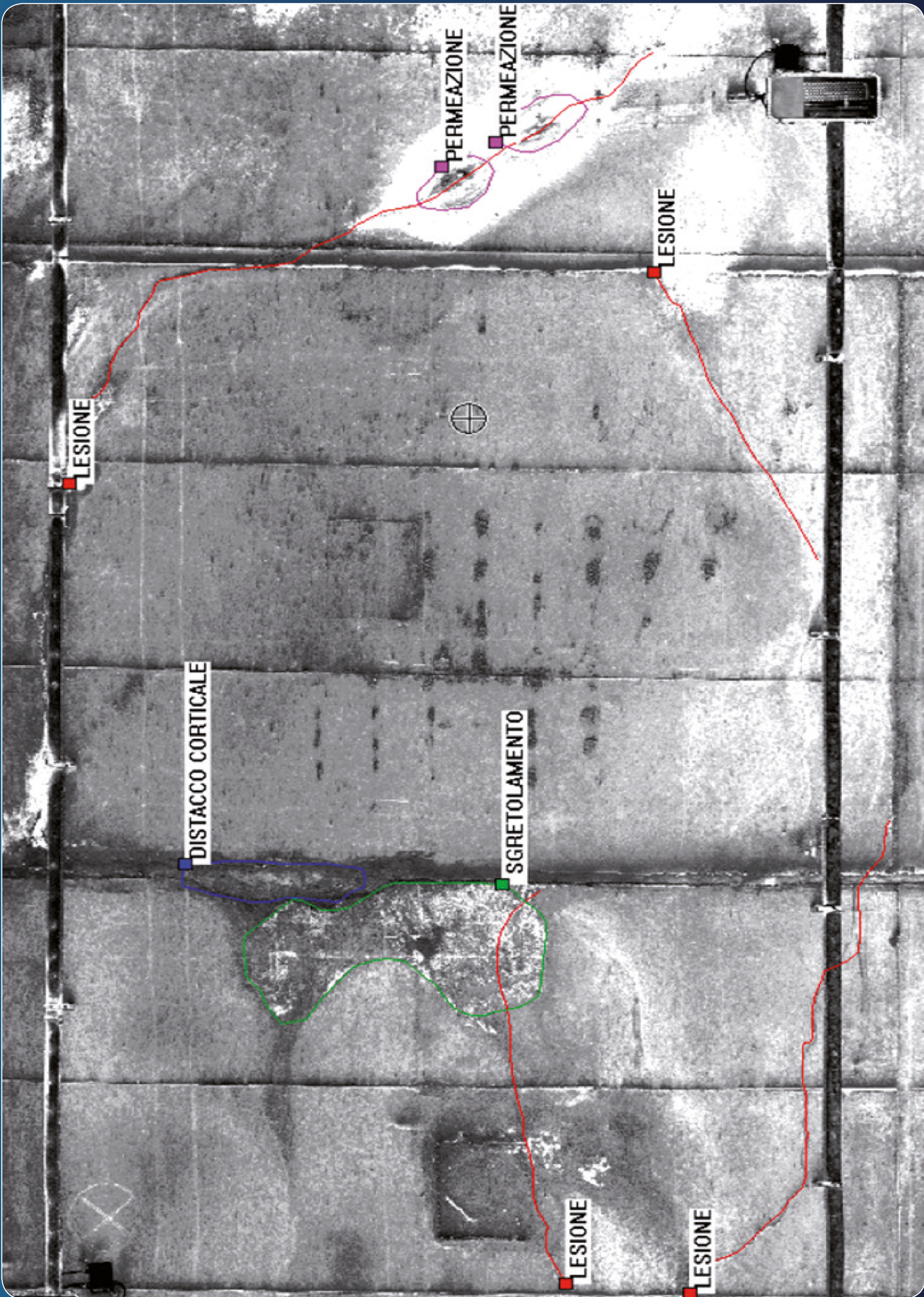


Installations photographic detail



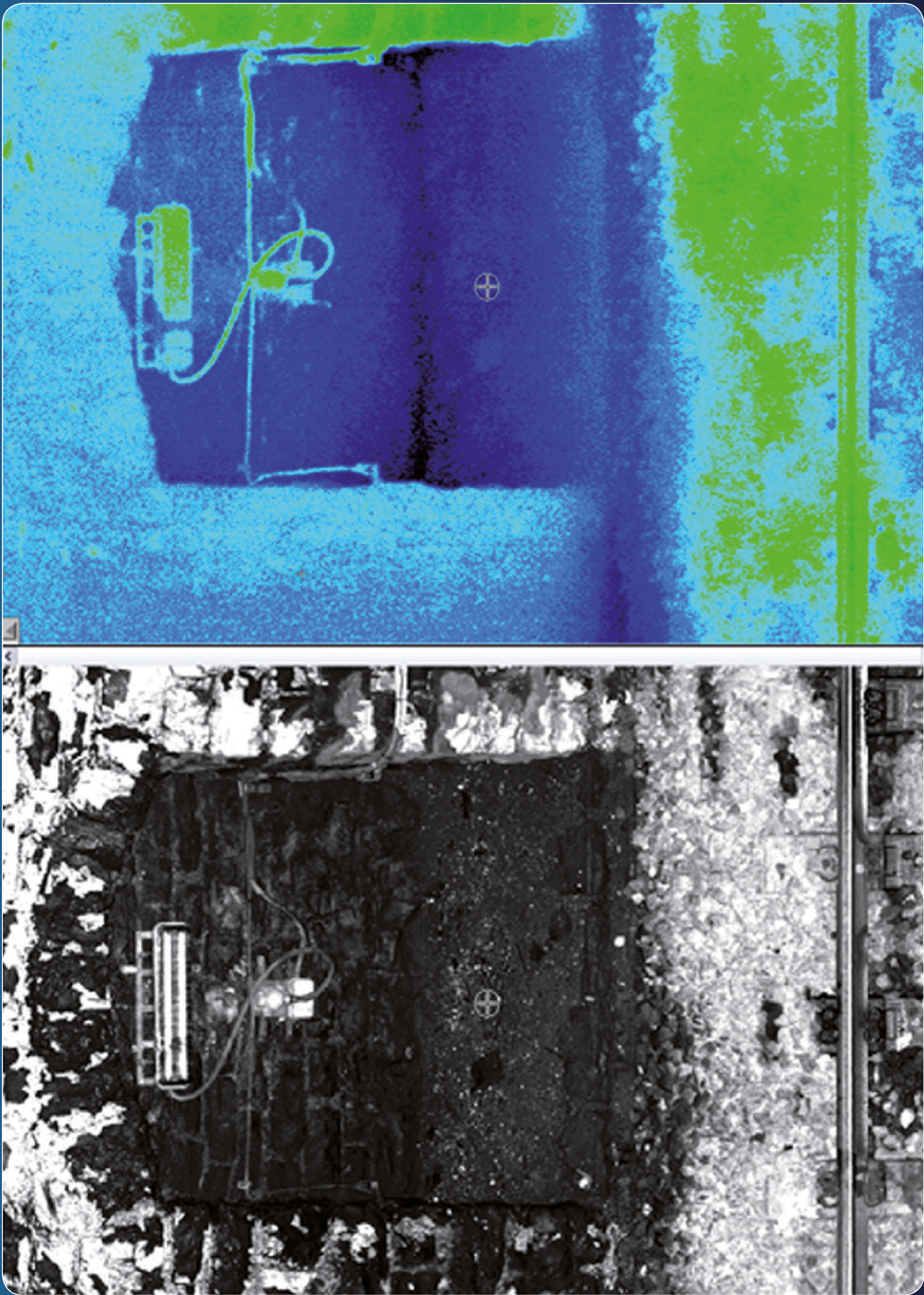
Inspection sheet obtained by "Tunnel Inspector" software reproducing the main anomalies in the tunnel

TUNNEL SCANNER SYSTEM



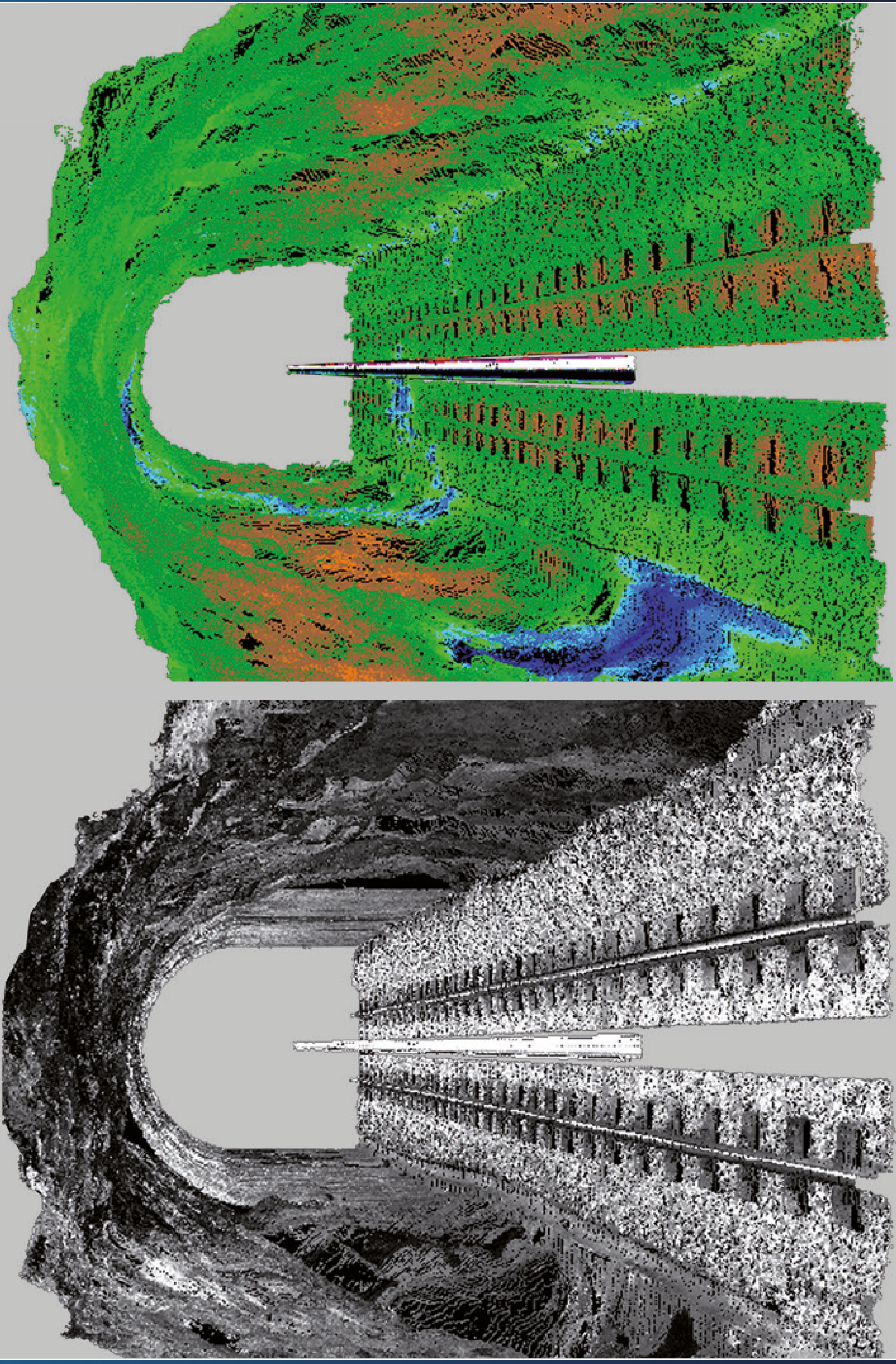
Inspection sheet detail with anomalies

TUNNEL SCANNER SYSTEM



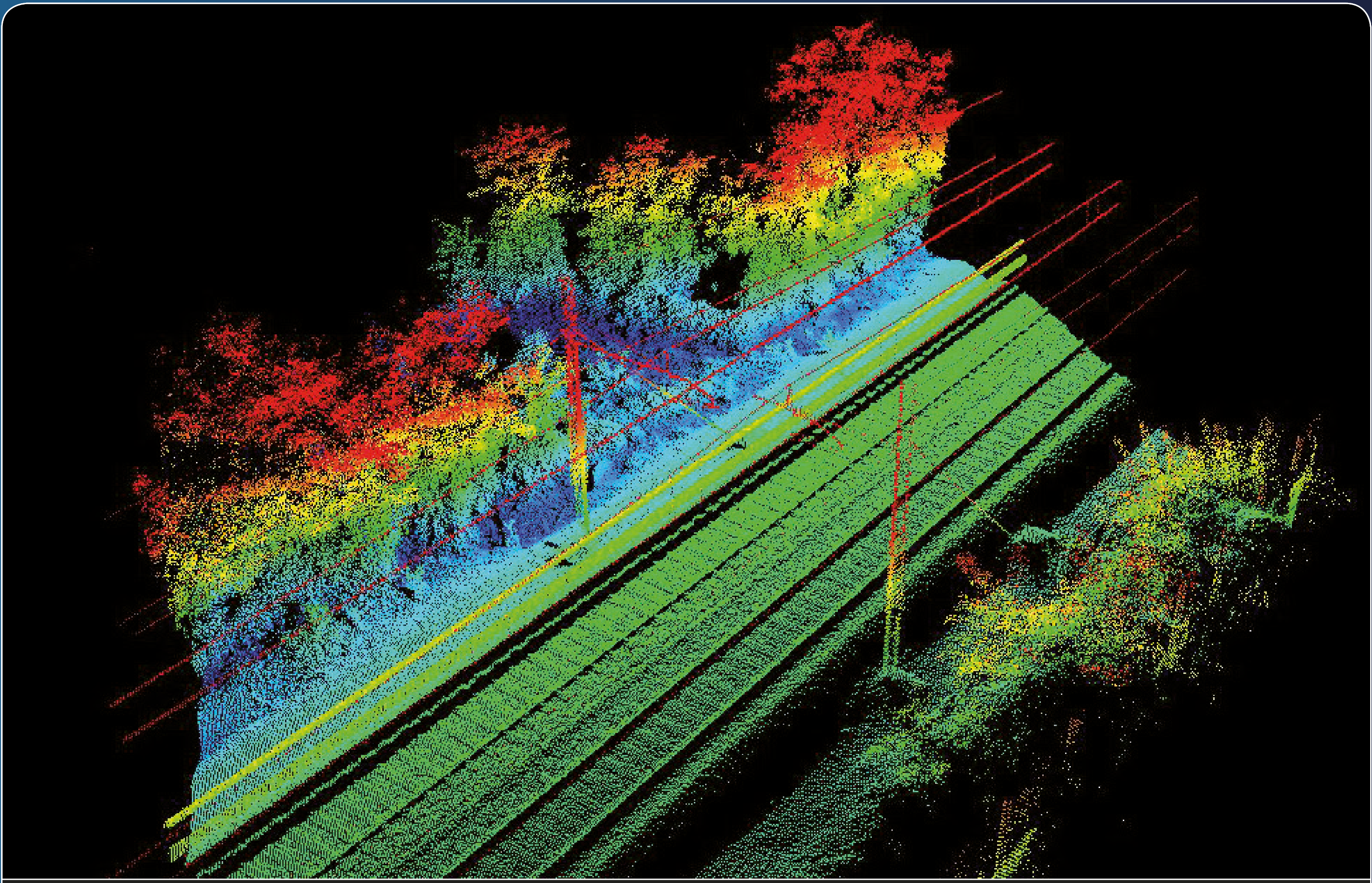
Photographic and thermographic detail of a tunnel niche

TUNNEL SCANNER SYSTEM



Photographic and thermographic 3D image of a tunnel stretch

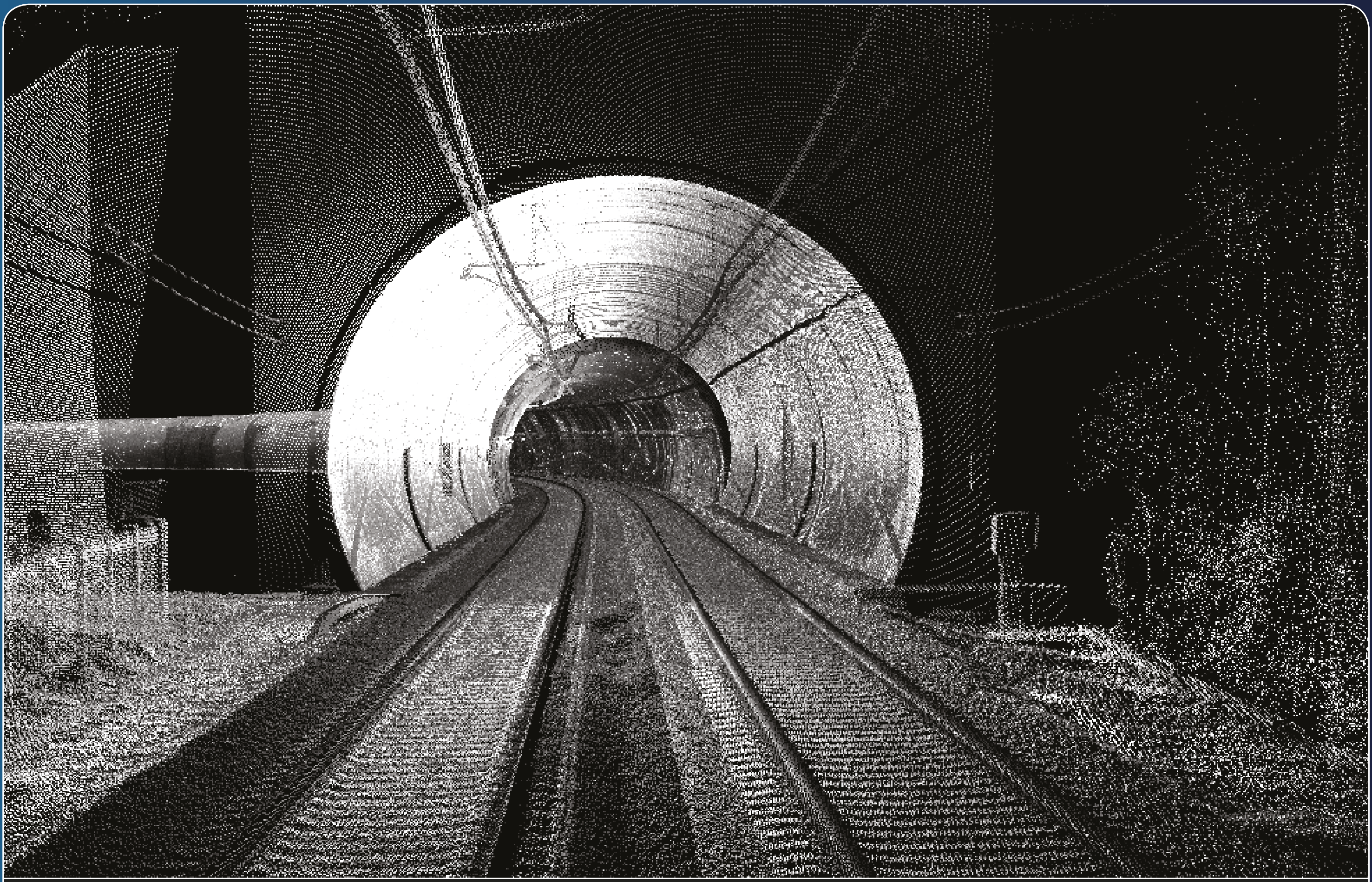
LASER MOBILE MAPPER



3D Point Cloud: Representation in heights

3D Point Cloud: Laser echo intensity representation

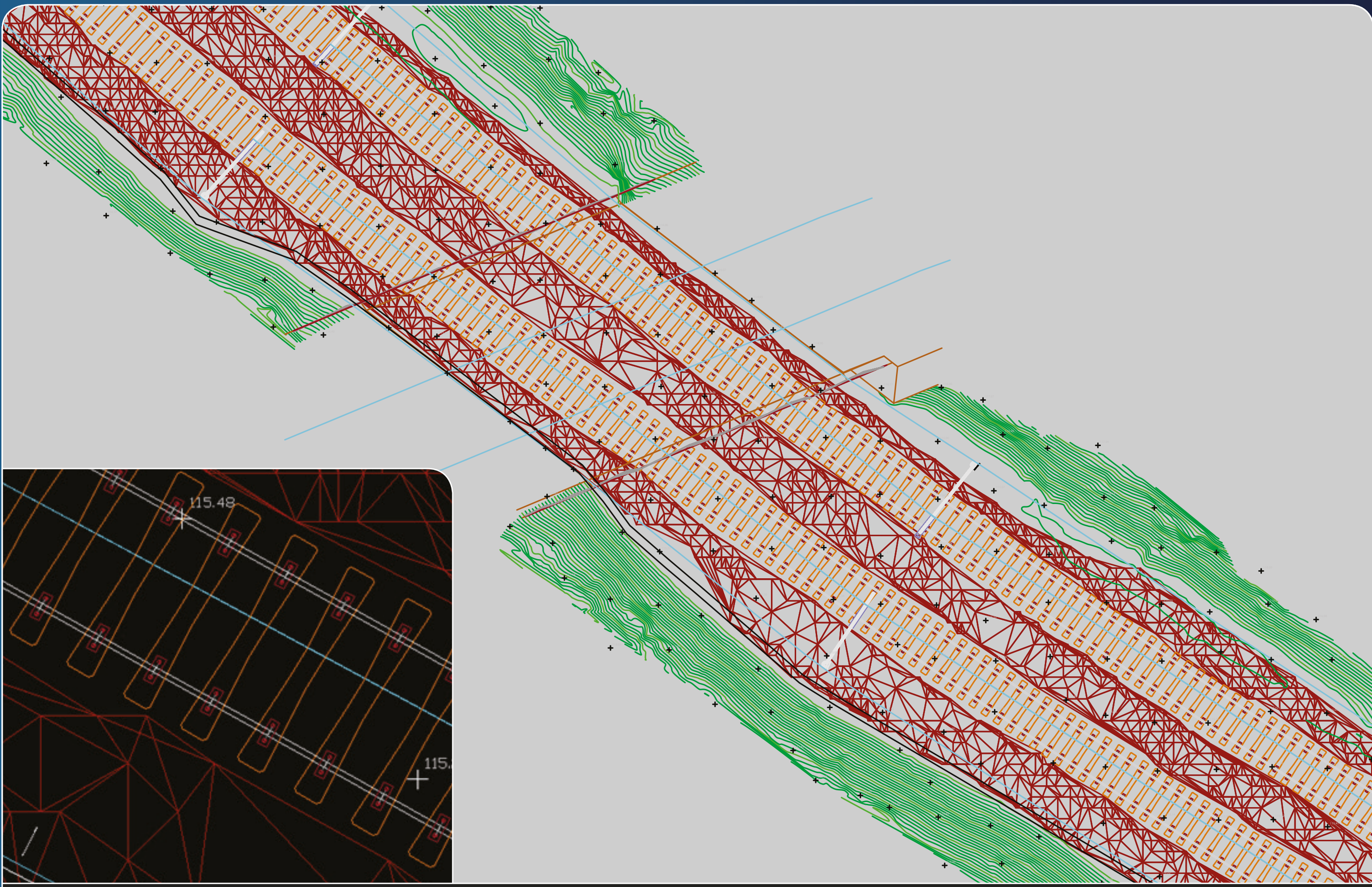
LASER MOBILE MAPPER



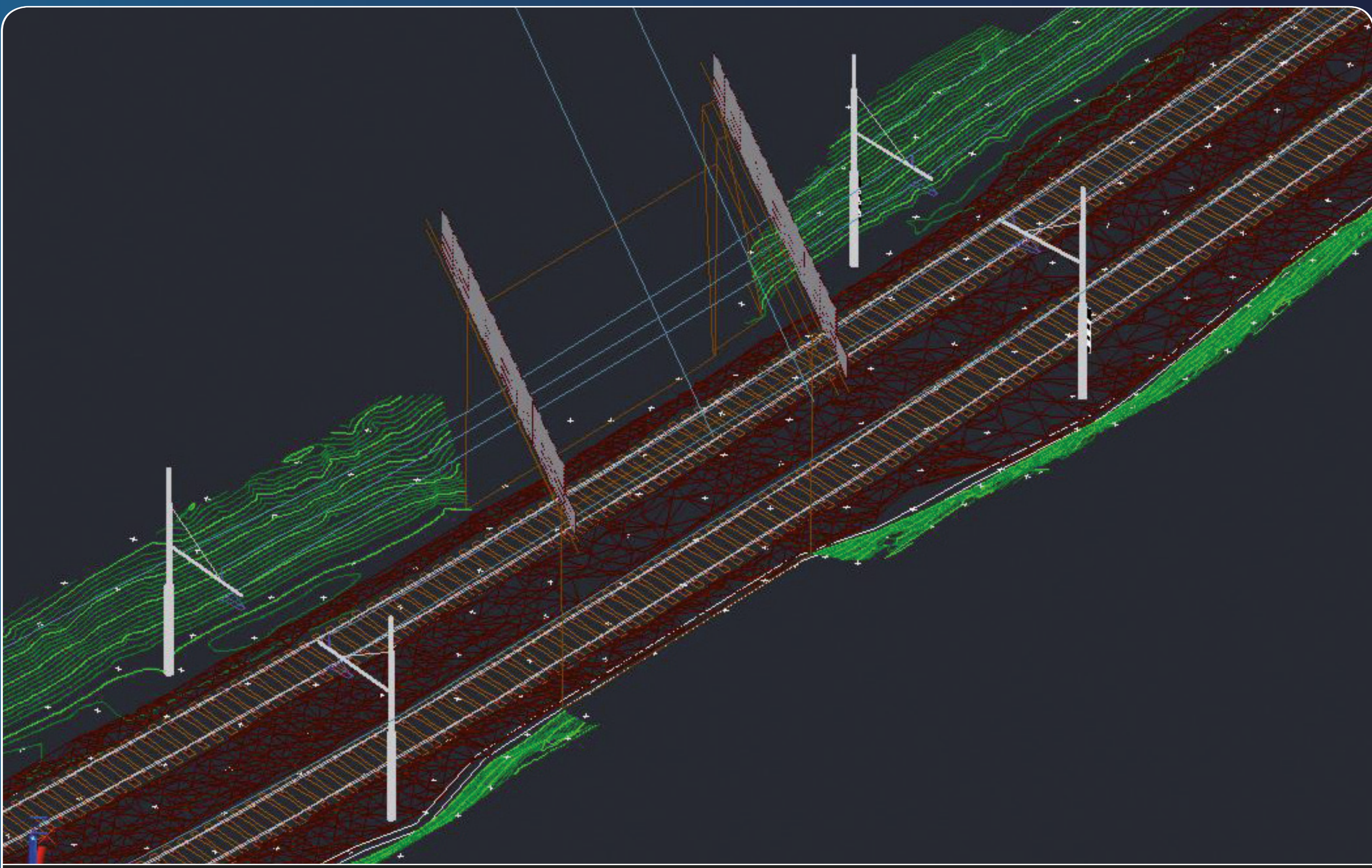
3D Point Cloud: Bologna-Florence Railroad; Entrance of the Gabbolana Tunnel

3D Point Cloud: Bologna-Florence Railroad; Inside of the Gabbolana Tunnel

LASER MOBILE MAPPER

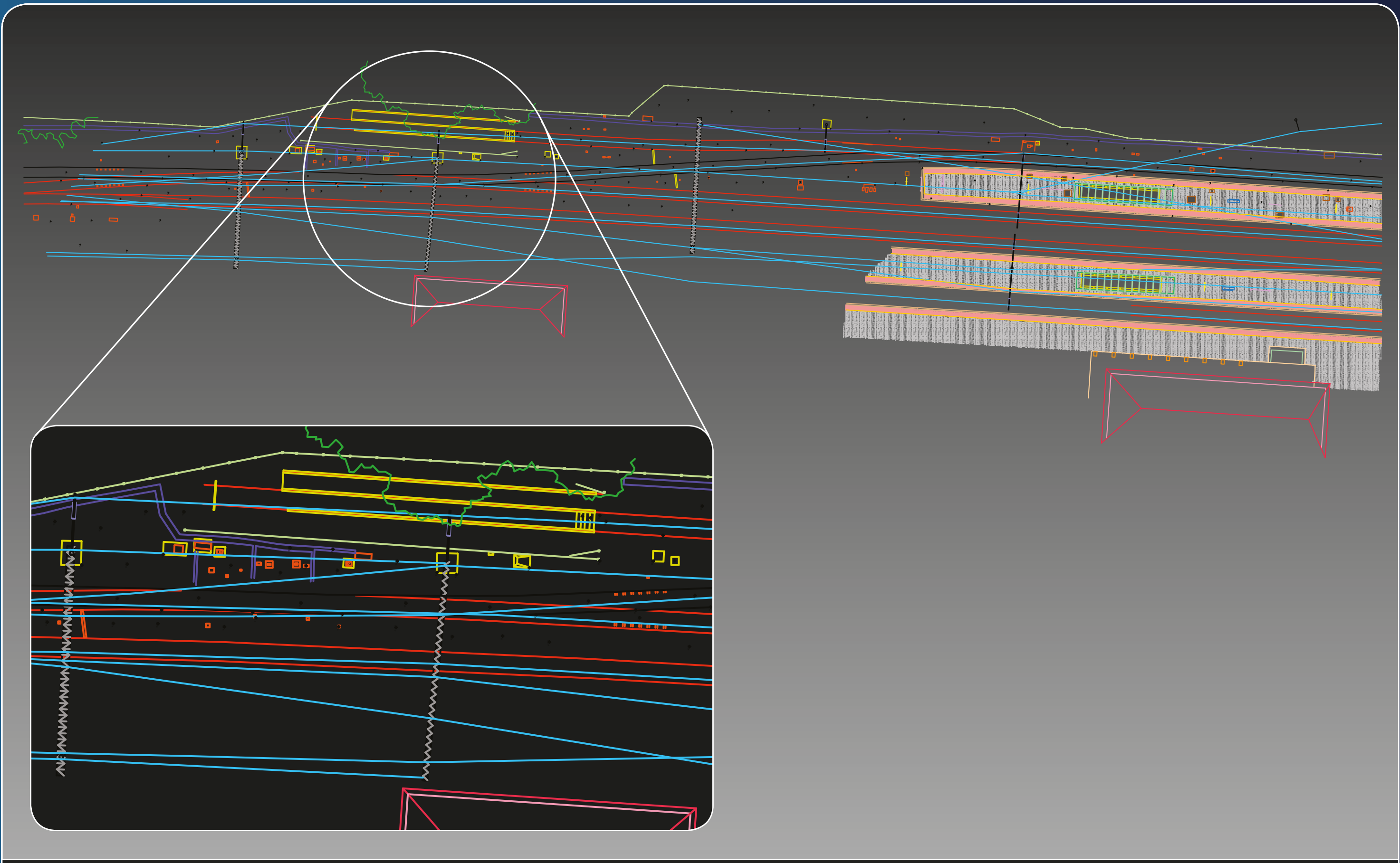


TIN and Contour Line model of a railroad line

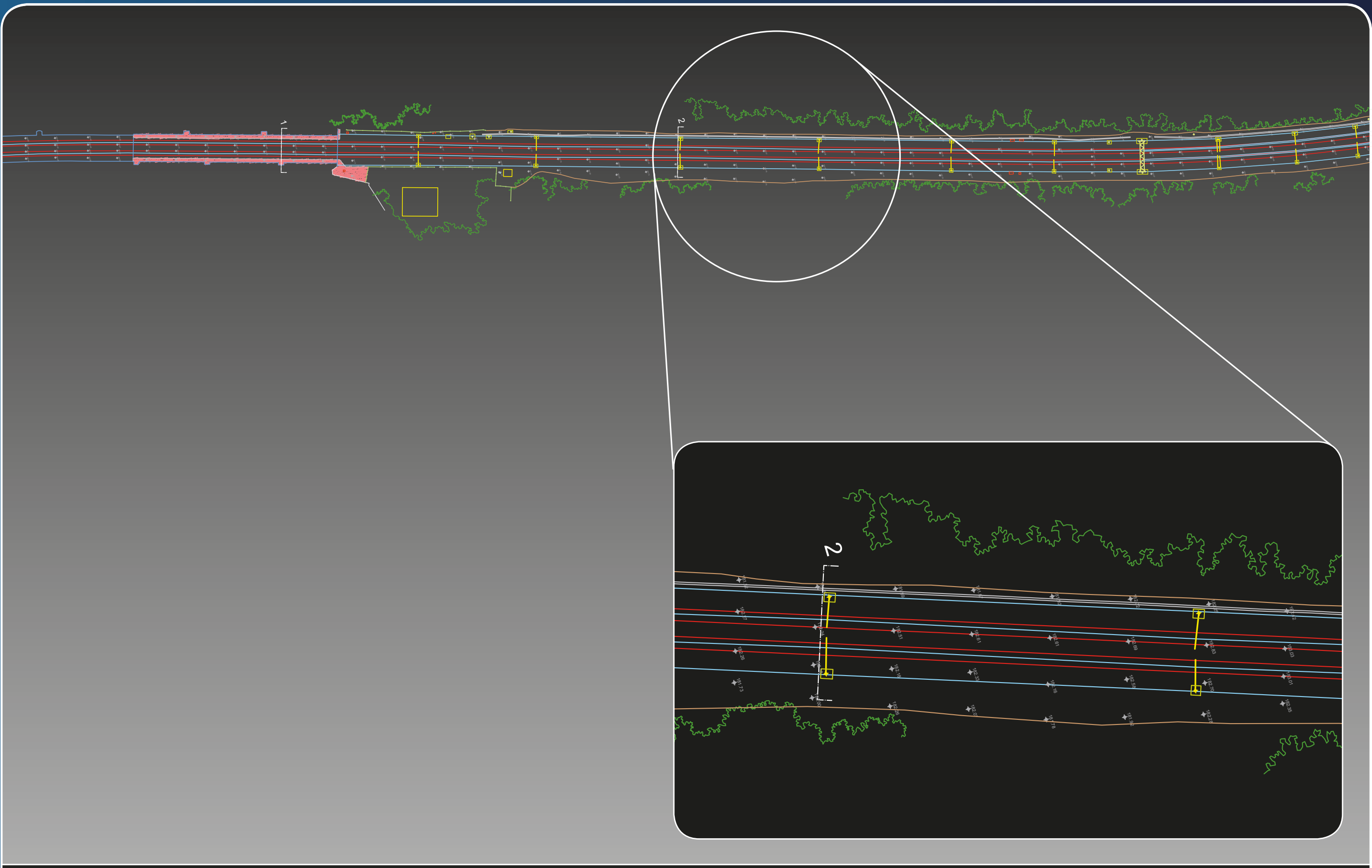


3D Model of a railroad line

LASER MOBILE MAPPER

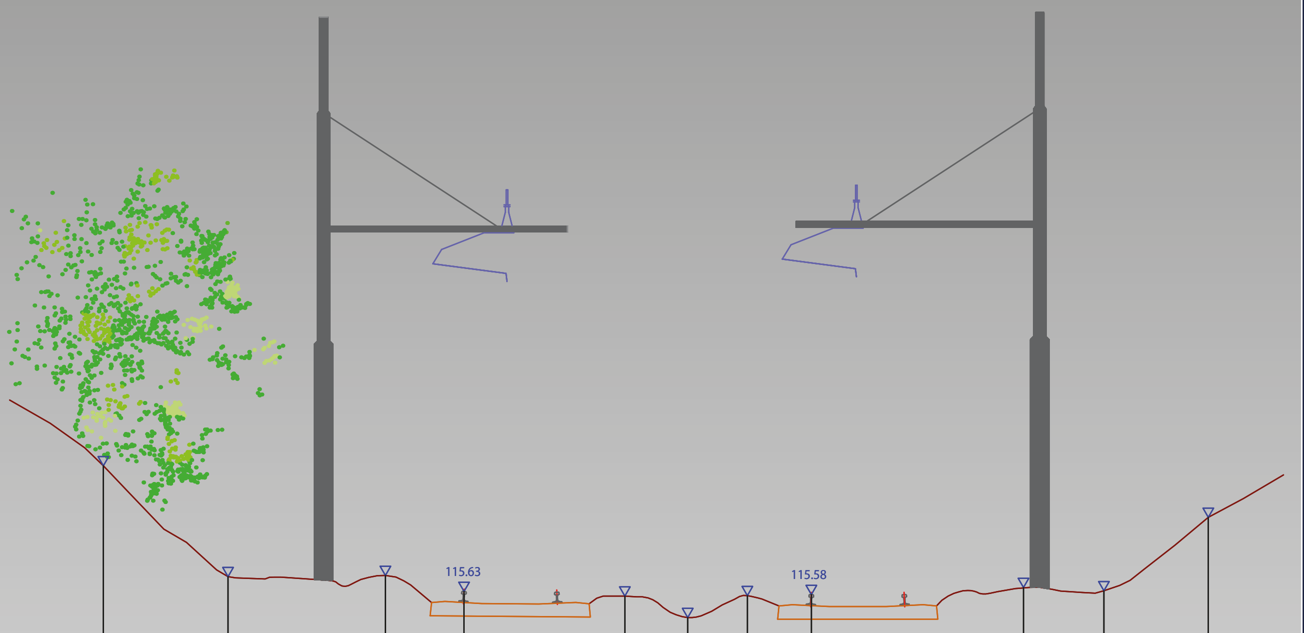


Vectorized planimetric features of the Domegliara train station



Vectorized planimetric features of the Bologna-Prato railroad line

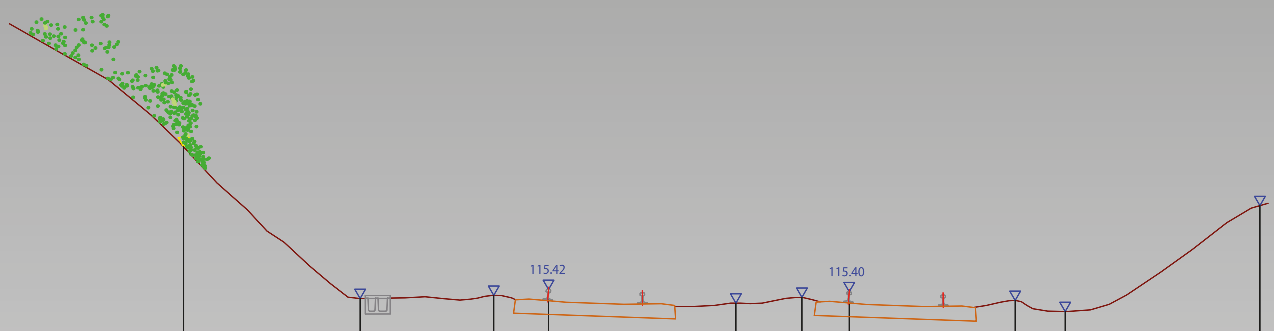
LASER MOBILE MAPPER



Numero punto										
Distanza	2.02	2.55	1.28	2.61	1.02	0.97	1.04	3.44	1.30	1.69

Quote										
117.67	115.87	115.89	115.63	115.55	115.20	115.56	115.58	115.69	115.64	116.83

Dimensioned cross section with an electric portal

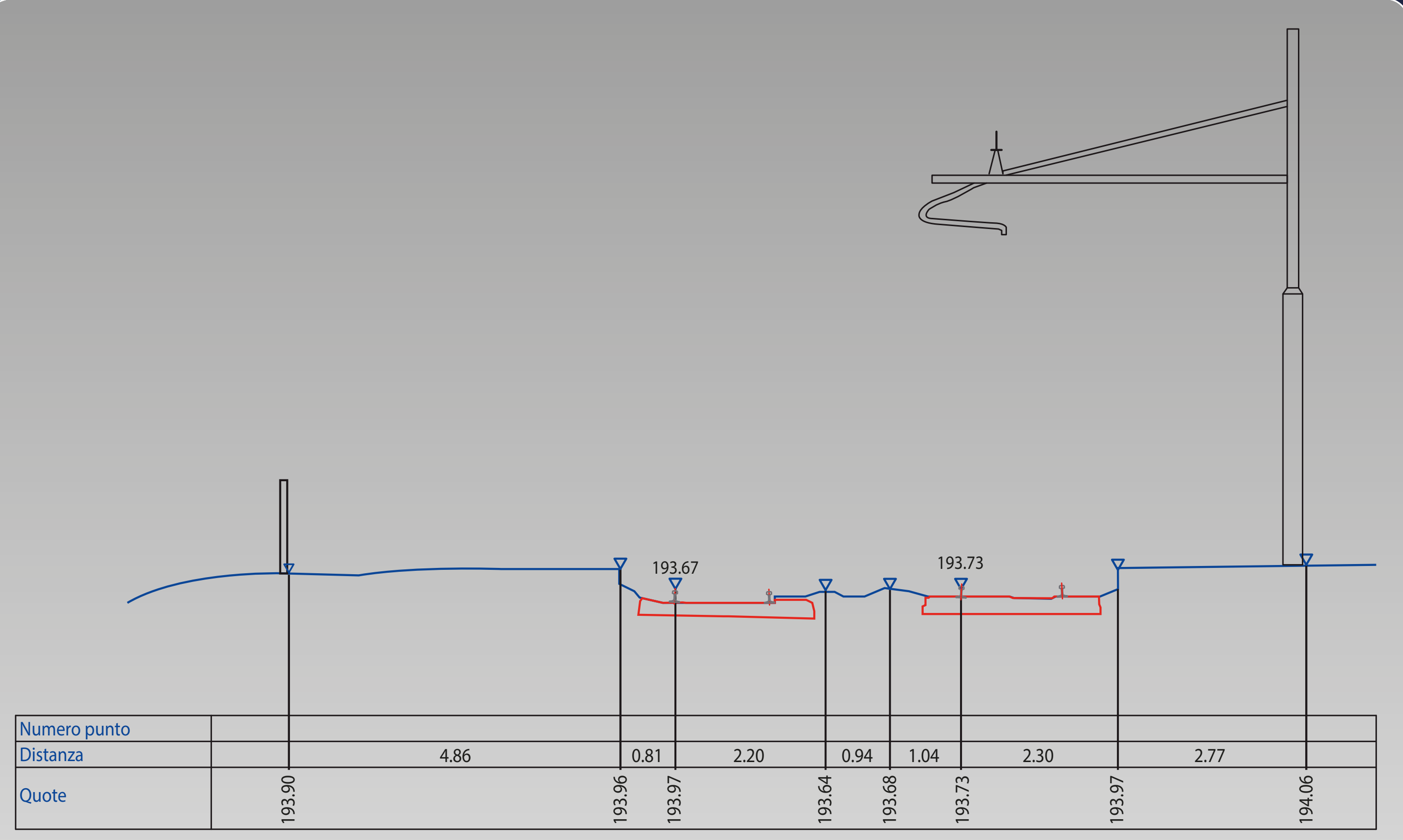


Numero punto									
Distanza	2.83	2.14	0.88	3.00	1.06	0.76	2.66	0.80	3.12

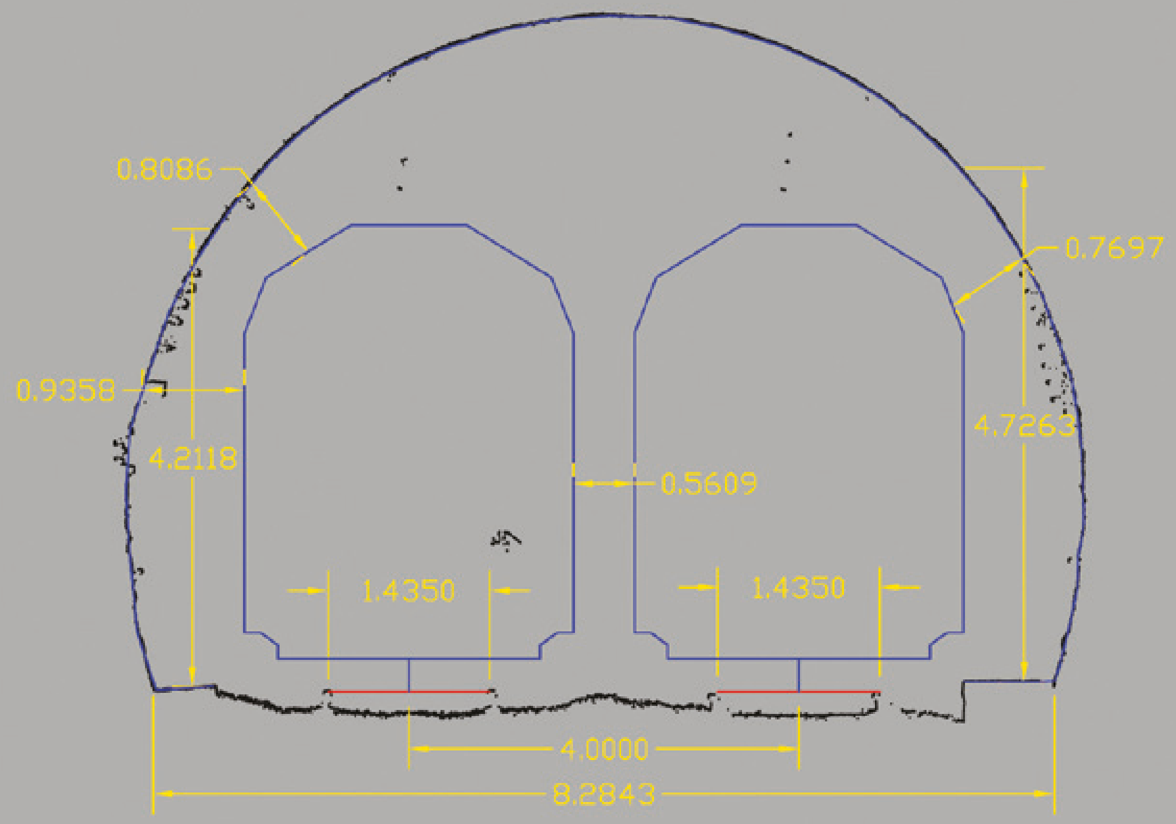
Quote									
117.77	115.30	115.36	115.42	115.21	115.33	115.40	115.28	115.06	116.81

Dimensioned cross section in a catting stretch

LASER MOBILE MAPPER



Dimensioned cross section with sidewalk



Transversal section with clearance for inte rference analysis