
architettura impianti computi direzione lavori BIM visual design infrastrutture strutture
NET ENGINEERING

Imagine Think Design

This book arose with the intention of talking about our projects through the eyes of those who have designed them, built them and perfected them. There are many different, complex projects but they all share a common denominator - they demonstrate how the professionals that worked on them interpreted the principles that have always guided and still guide NET Engineering in a new way, often ahead of the times.

We have worked using system engineering as a work method for decades. This method puts a work or an infrastructure into the context hosting it, trying to assess the impact it generates and that the area will undergo with the greatest attention. This allows optimal answers, possibly a worthy compromise, to be found which take account of all the requirements at play. Therefore, system engineering allows us to look at the future today with critical, attentive eyes and put the PROJECT, and all the topics involving it, at the centre of the work, starting from Vitruvius's obligatory elements (utilitas, firmitas and venustas - strength, utility and beauty) before passing to sustainability through tools like lean design, public engagement and, last but not least, the awe-inspiring digital transformation which will change our whole life, not just the way of designing, building and managing infrastructure. The potential of this change is easy to understand, just think of how BIM methodology, virtual reality or the laser scanner enable us to create sophisticated digital models of the infrastructure and its context. These are tools that were unthinkable until a few years ago but are now spreading rapidly.

It's with great pleasure that I invite you to read the following pages, also considering this point of view.

Have a good read!

Giovanni Battista Furlan

President

We chose to talk about our 50 best projects for NET Engineering's 50th anniversary, i.e. those projects which not only best represent our history but also what we are today and what we want to be in the future. It wasn't an easy choice - every project talks about a part of us, every project was developed with the care and attention that marks us, every project brought experimentation, innovations, tenacity, creativity and the constant commitment that every person in NET Engineering applies to their work. Talking about 50 years in 50 projects means telling the story of everyone who has ever worked at NET. For us, each project goes beyond the engineering work conceived because it represents the people who built it. These projects are what continues to bring us together and makes us a community of engineers driven by the passion for what we do.

Thus the projects are people, feelings and memories. They are parts of our life and, because we chose this profession, they leave a tangible mark on our planet. In itself, this is fantastic - seeing something you worked for over a long period built before you, watching it and actually walking through it, noting its benefits for the community, and seeing yourself in it. However, that's not enough. As engineers, we have to have to act with great responsibility as the footprint of the works we design lasts for decades. Therefore, we're called on to live sustainability not just as an ideal but, first and foremost, as a real fact. Reading this publication from this viewpoint has made me very proud because the projects described highlight the fact that the contents of our manifesto are not words in the wind but the reality that the people of NET Engineering undertake to design every day to leave future generations with a better land than the one we've inherited.

Silvia Furlan

CEO

our manifest

purpose

We leave future generations a better territory than the one we have inherited.

vision

We want to be among the first independent Italian engineering and architecture companies with the ability to read our ever-changing world in order to create excellent projects together with our client.

identity

We are engineering artists, because we want each project to be a work of art.

We are greatly knowledgeable of the different skillsets needed to analyse all of our projects as a whole: from defining the problems to be solved to implementing each project task, without losing sight of our overarching vision that allows us to make each project unique and effective.

mission

We design mobility, urban renewal and industry solutions pioneering impeccable engineering practices in the spirit of excellence.

We protect what the future generations will inherit by designing smart, shared, sustainable infrastructure.

Excellence

Excellent method: We read the market's and clients' needs ahead of time by collaborating with them and identifying the best design solutions. We manage complex projects harnessing our high-level, specialised skillset, and our ability to always enrich it.

Excellent in our projects: We use a creative and innovative approach that leads to avant-garde solutions. We consistently deliver impeccable project results and communicate effectively to benefit all the relevant stakeholders.

Excellent internal structure: We promote an agile work environment based on timely information sharing. We value the unique talent of each team member and constantly invest in their education.

Sharing

Shared method: We promote stakeholder engagement through clear planning, effective communication and complete information since the early stages of each project.

Shared projects: We pay close attention to the way we communicate during our projects; we invest in advanced display tools; we encourage creativity and attention to details; we carefully pick the language so that it is specific for each stakeholder.

Shared internal structure: We believe in and practice a multidisciplinary work style that integrates specialisation with a broad skillset. We internally share what we have done, what we are doing and what we will be doing because our history lays the ground for our future. We ensure that our processes are trasparent and fully visible so that each and every team member can see what the company is working on and always feel part of a team.

Smartness

Smart method: We consider projects as a whole; we manage them by holding all their pieces together and, at the same time, recognising each piece's specific challenges. We effectively embrace and overcome their complex nature, and we produce practical, measurable solutions.

Smart projects: We design infrastructure that seamlessly integrates with what is around it so that the new product is effective, efficient and sustainable.

Smart internal structure: We enable the professional development of each team member by training and empowering future leaders.

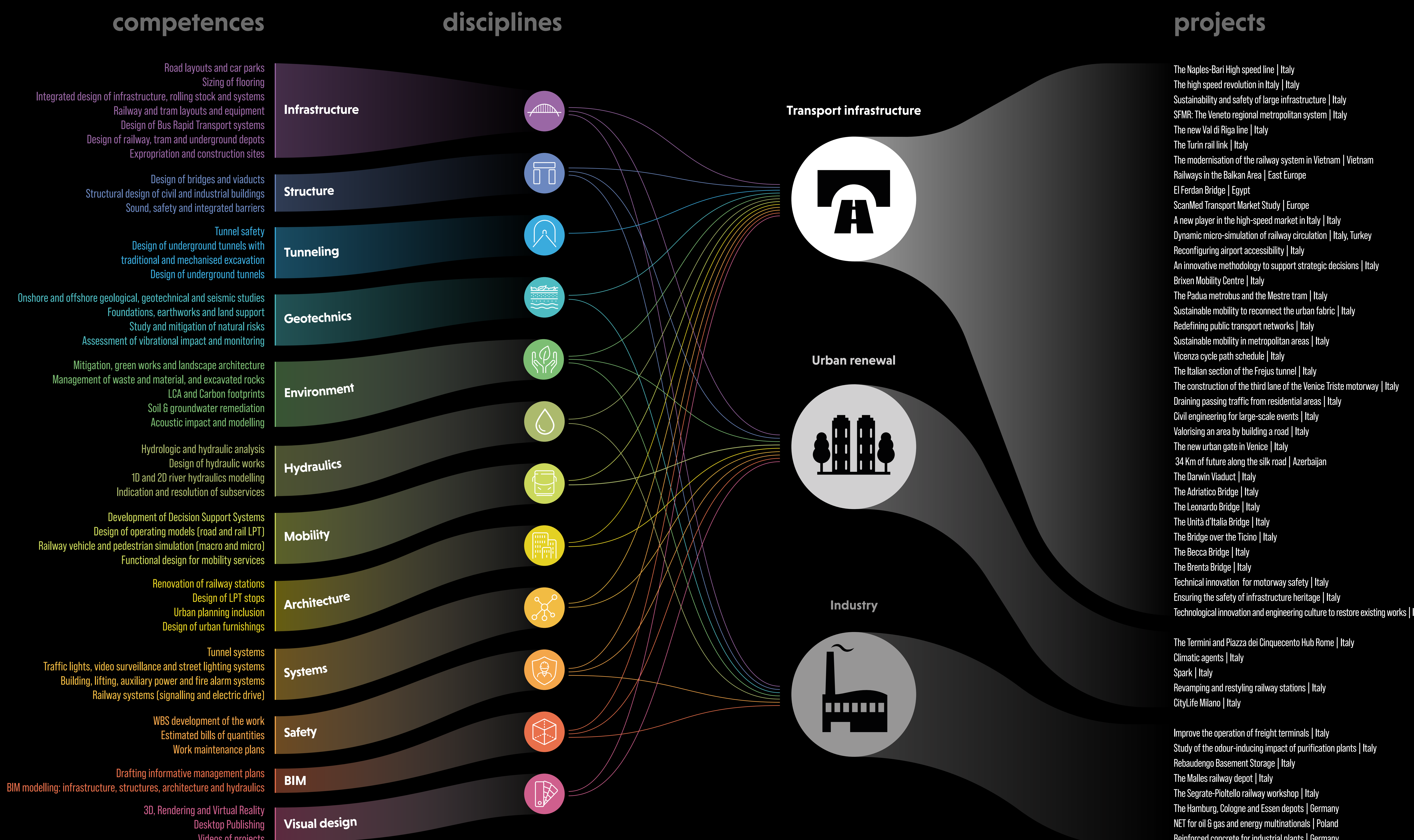
Sustainability

Sustainable method: We treat sustainability as a responsibility – not as an ideal, but rather as a practical criterion. Our method starts with a risk analysis and develops a number of possible solutions, identifying the potential downside to each one of them.

Sustainable projects: We design keeping in mind the whole infrastructure life cycle. We aim to incorporate climate change in the design, reduce maintenance needs, and minimise the environmental impact and energy consumption of the final product. We design with the utmost respect for not only the project location, but also the cultural and social environment and their evolution in time.

Sustainable internal structure: We implement new organisational practices that make our job sustainable on a daily basis.

Our 50 most important projects


competences
disciplines
projects
Road layouts and car parks
Sizing of flooring
Integrated design of infrastructure, rolling stock and systems
Railway and tram layouts and equipment
Design of Bus Rapid Transport systems
Design of railway, tram and underground depots
Expropriation and construction sites
Infrastructure
Design of bridges and viaducts
Structural design of civil and industrial buildings
Sound, safety and integrated barriers
Structure
Tunnel safety
Design of underground tunnels with traditional and mechanised excavation
Design of underground tunnels
Tunneling
Onshore and offshore geological, geotechnical and seismic studies
Foundations, earthworks and land support
Study and mitigation of natural risks
Assessment of vibrational impact and monitoring
Geotechnics
Mitigation, green works and landscape architecture
Management of waste and material, and excavated rocks
LCA and Carbon footprints
Soil & groundwater remediation
Acoustic impact and modelling
Environment
Hydrologic and hydraulic analysis
Design of hydraulic works
1D and 2D river hydraulics modelling
Indication and resolution of subservices
Hydraulics
Development of Decision Support Systems
Design of operating models (road and rail LPT)
Railway vehicle and pedestrian simulation (macro and micro)
Functional design for mobility services
Mobility
Renovation of railway stations
Design of LPT stops
Urban planning inclusion
Design of urban furnishings
Architecture
Tunnel systems
Traffic lights, video surveillance and street lighting systems
Building, lifting, auxiliary power and fire alarm systems
Railway systems (signalling and electric drive)
Systems
WBS development of the work
Estimated bills of quantities
Work maintenance plans
Safety
Drafting informative management plans
BIM modelling: infrastructure, structures, architecture and hydraulics
BIM
3D, Rendering and Virtual Reality
Desktop Publishing
Videos of projects
Visual design
Transport infrastructure
Urban renewal
Industry
The Naples-Bari High speed line | Italy
The high speed revolution in Italy | Italy
Sustainability and safety of large infrastructure | Italy
SFMR: The Veneto regional metropolitan system | Italy
The new Val di Riga line | Italy
The Turin rail link | Italy
The modernisation of the railway system in Vietnam | Vietnam
Railways in the Balkan Area | East Europe
El Ferdan Bridge | Egypt
ScanMed Transport Market Study | Europe
A new player in the high-speed market in Italy | Italy
Dynamic micro-simulation of railway circulation | Italy, Turkey
Reconfiguring airport accessibility | Italy
An innovative methodology to support strategic decisions | Italy
Brixen Mobility Centre | Italy
The Padua metrobus and the Mestre tram | Italy
Sustainable mobility to reconnect the urban fabric | Italy
Redefining public transport networks | Italy
Sustainable mobility in metropolitan areas | Italy
Vicenza cycle path schedule | Italy
The Italian section of the Frejus tunnel | Italy
The construction of the third lane of the Venice Triste motorway | Italy
Draining passing traffic from residential areas | Italy
Civil engineering for large-scale events | Italy
Valorising an area by building a road | Italy
The new urban gate in Venice | Italy
34 Km of future along the silk road | Azerbaijan
The Darwin Viaduct | Italy
The Adriatico Bridge | Italy
The Leonardo Bridge | Italy
The Unità d'Italia Bridge | Italy
The Bridge over the Ticino | Italy
The Becca Bridge | Italy
The Brenta Bridge | Italy
Technical innovation for motorway safety | Italy
Ensuring the safety of infrastructure heritage | Italy
Technological innovation and engineering culture to restore existing works | Italy
The Termini and Piazza dei Cinquecento Hub Rome | Italy
Climatic agents | Italy
Spark | Italy
Revamping and restyling railway stations | Italy
CityLife Milano | Italy
Improve the operation of freight terminals | Italy
Study of the odour-inducing impact of purification plants | Italy
Rebaudengo Basement Storage | Italy
The Malles railway depot | Italy
The Segrate-Pioltello railway workshop | Italy
The Hamburg, Cologne and Essen depots | Germany
NET for oil & gas and energy multinationals | Poland
Reinforced concrete for industrial plants | Germany

transport infrastructure

The Naples-Bari High speed line

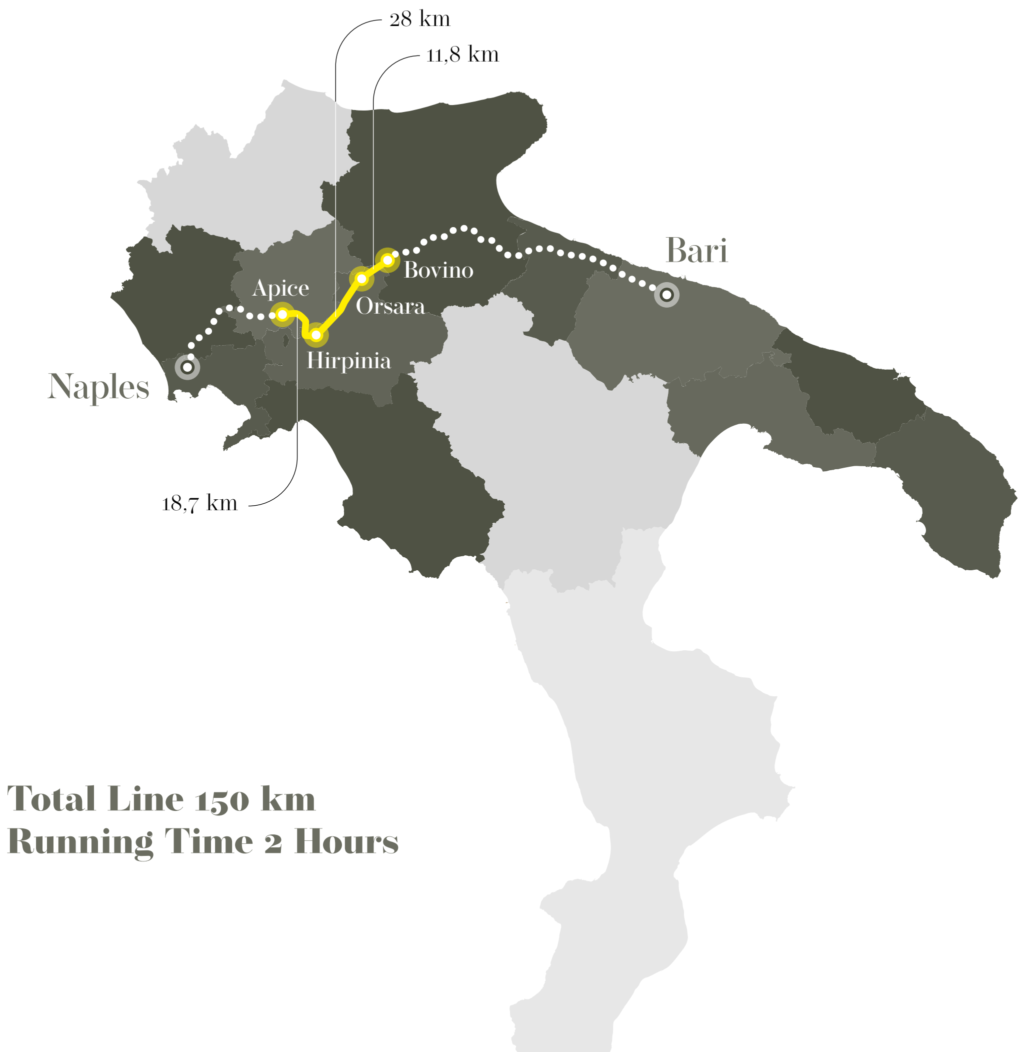
Technological innovation, multi-disciplinary and sustainable - the first large Italian infrastructure developed using BIM.

The High-Speed railway line connecting Naples and Bari is part of the wider redevelopment and optimisation programme for the Rome-Naples-Bari railway network. Functionally and structurally, this section will advance integration of the railway infrastructure of the South-East with the lines connecting to the north of the country and Europe. The project sets out the **doubling of the single line railway sections and the creation of variants to the current scenarios,** pursuing the solutions ensuring that connections will be speeded up and growth in the general railway service offer, at the same time increasing accessibility to the service in the areas crossed. The line, to be constructed in an especially challenging context environmentally, geotechnically and geomorphologically, will **respect the highest safety standards in both the civil works and technology fields,** e.g. by implementing Level 2 ERTMS-type signalling for the whole line.

In this context, NET Engineering took care of the **Executive Plan** for the Apice-Hirpinia, Hirpinia-Orsara and Orsara-Bovino sections, **totally developed using BIM, with a figure for the work of more than Euro 2 billion.** In addition to the planning and design it was responsible for, NET Engineering **carried out co-ordination of the various players involved, created and organised the shared work environment, was the direct interface with the client, collecting and interpreting the requirements, and facilitated the discussions and integration between the different disciplines, setting out the project evolution times.** In addition, NET Engineering also took care of the direct **relationships with the construction company for the Apice-Hirpinia section, already under construction.**

The planned routes

1.



Total Line 150 km
Running Time 2 Hours

The numbers of the Naples/Bari

100 min. travel time saved

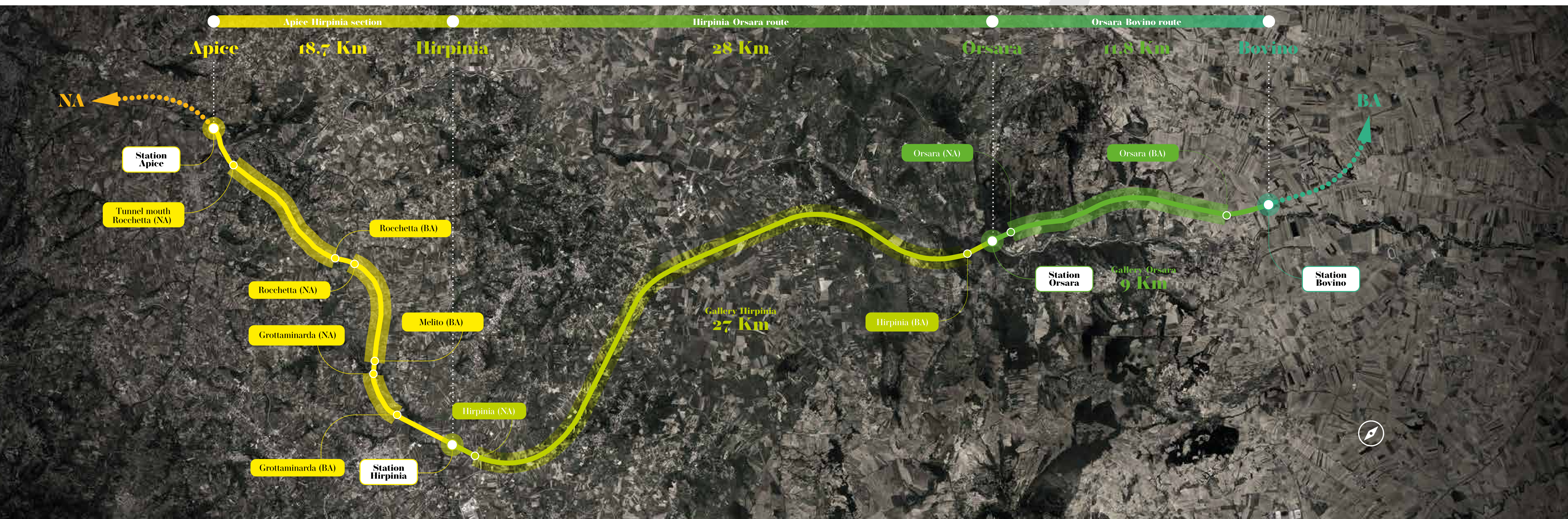
6,2 mld€ of investments

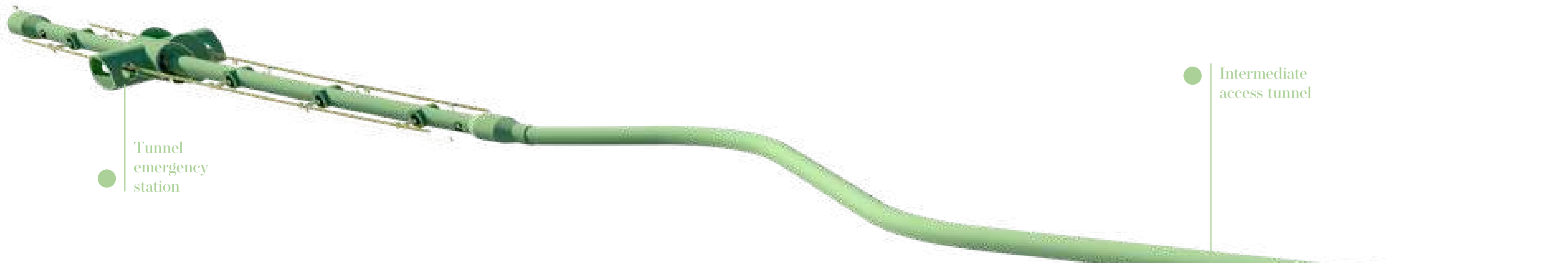
63 km of tunnels

25 new viaducts

14 new stations

250 km/h maximum speed





Apice-Hirpinia section

This section, already Envision Platinum certified, lies in Campania and crosses seven municipalities overall. The route, a complete variant compared to the 'old' line, will see the creation of a new two-track line with an overall length of 18.7 km and a design speed of 200 kph. The project includes not only the new stop at Apice and the new Hirpinia station but also four important viaducts (VI01 - 655 m, VI02 - 205 m, VI03 - 415 m and VI04 - 705 m), 16 new road sections, the building services and systems technologies. The Grottaminarda (1.9 km), Melito (4.4 km) and Rocchetta (6.4 km) tunnels, constructed using only mechanised excavation, will mean that about 70% of the section will be in tunnels.

Hirpinia-Orsara section

This section has an overall length of 28 km with a design speed of 200 kph near Hirpinia and Orsara stations and 250 kph for the remaining section, which is in a tunnel. The most interesting works are certainly the new Orsara station, VI01 viaduct (320 m) over the River Cervaro and the Hirpinia tunnel, 27 km long, which will be the longest railway tunnel in Italy (in a photo-finish with the base tunnel of the Tortona-Genoa High-Speed railway) and the 12th longest in the world. On the Bari side, the tunnel starts as a two-bore and continues in this way until the connecting chamber near the exit on the Naples side. Here, it becomes a single-bore tunnel with two tracks to allow connection to the run tracks of Hirpinia station.

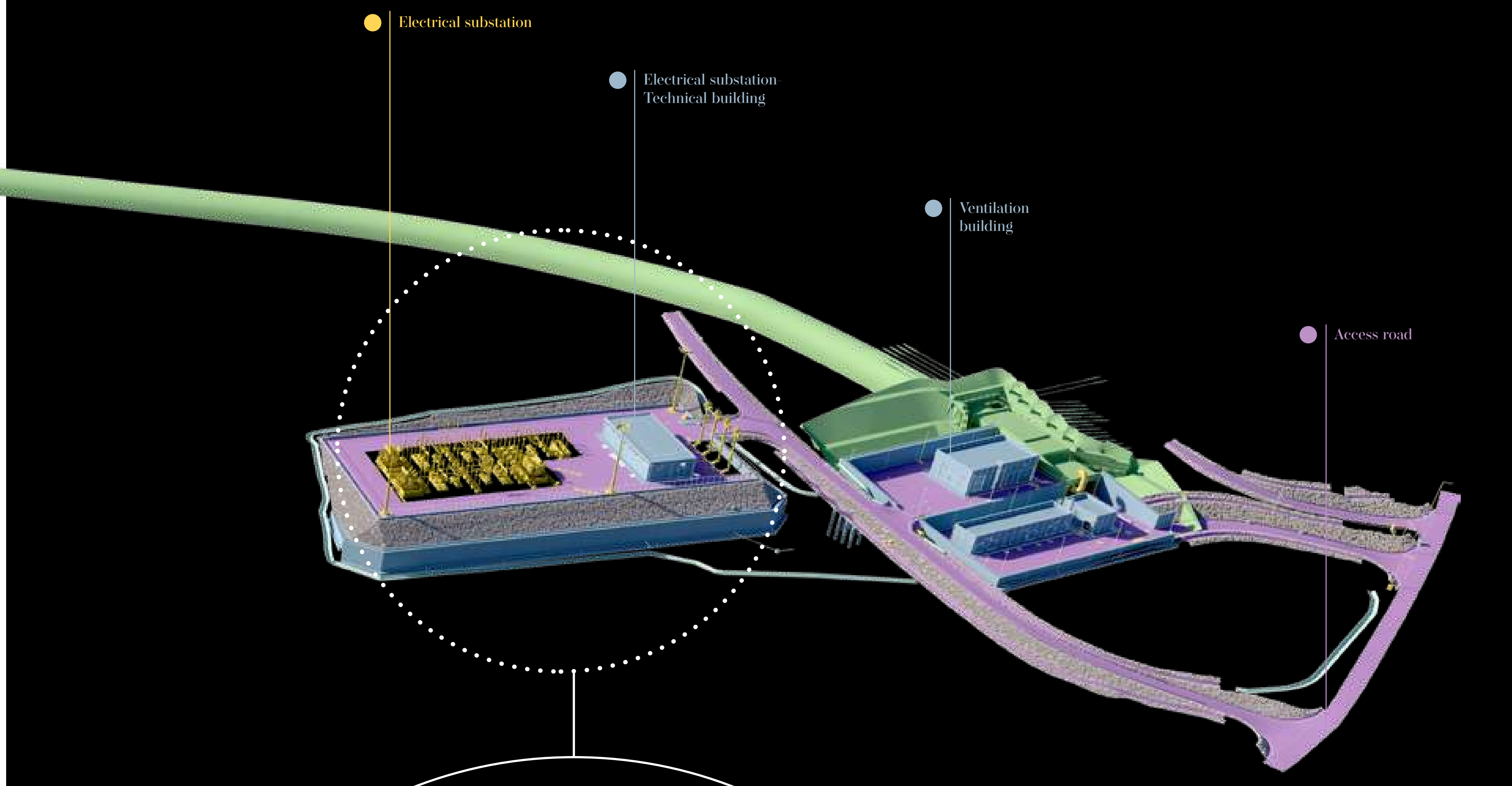
Orsara-Bovino section

This section is mainly in tunnels with a speed of between 200 and 250 kph and an overall length of 11.8 km.

The main work is the Orsara tunnel (9.8 km). On the Naples side, there is a single tunnel with two tracks before reaching a chamber of 320 metres where the tracks gradually lead to a passage of 40 metres. From this point, there are two tunnels which, for geomorphological reasons, continue to diverge up to a distance of 50 metres. The route continues in the open, firstly in a cutting and then on an embankment, downstream from the tunnel on the Bari side.

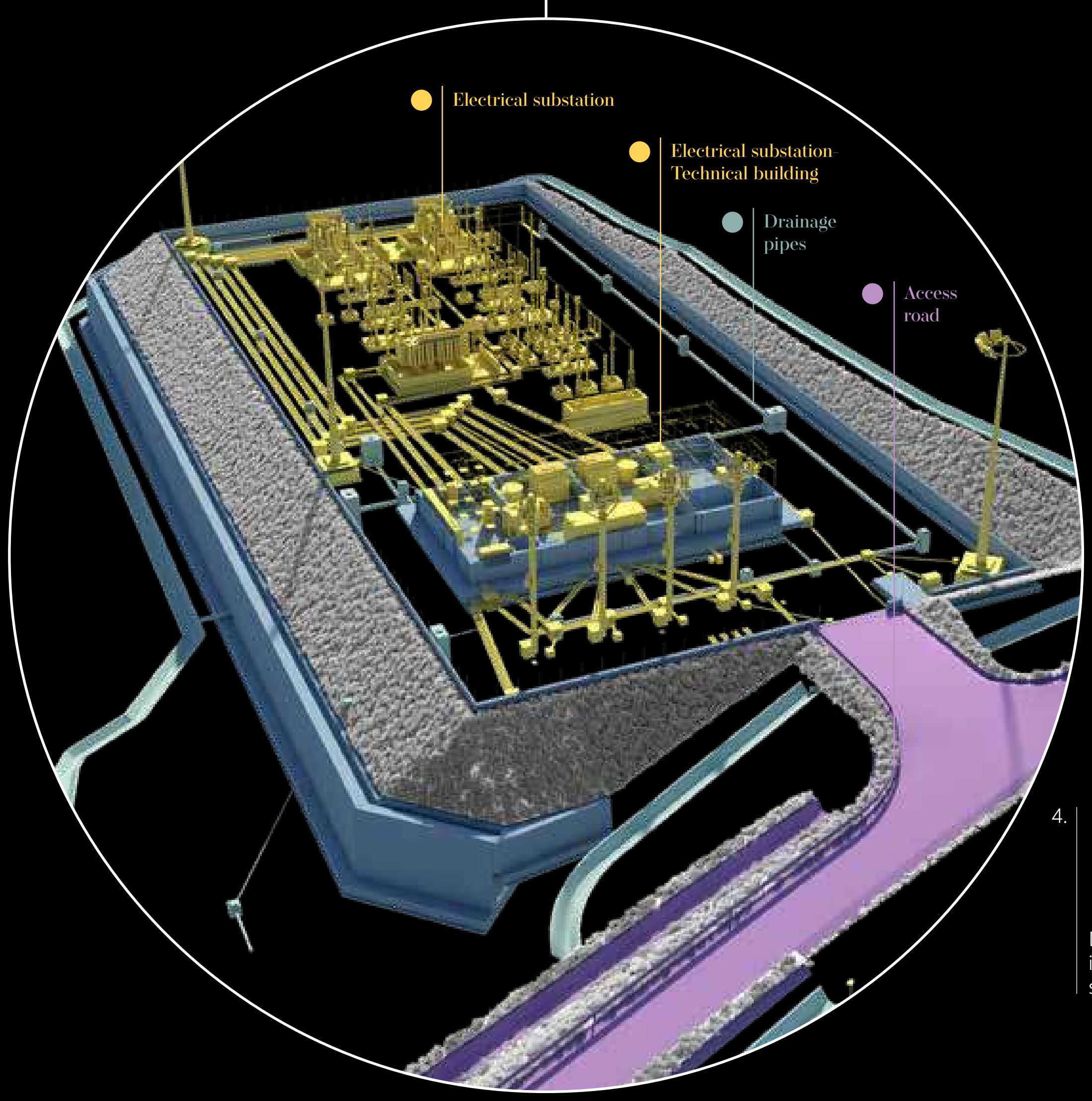
Apice - Hirpinia: reinforced lands of the railway embankment

2.



3.

BIM model: Emergency window access and surrounding technical rooms



Roads

Facilities

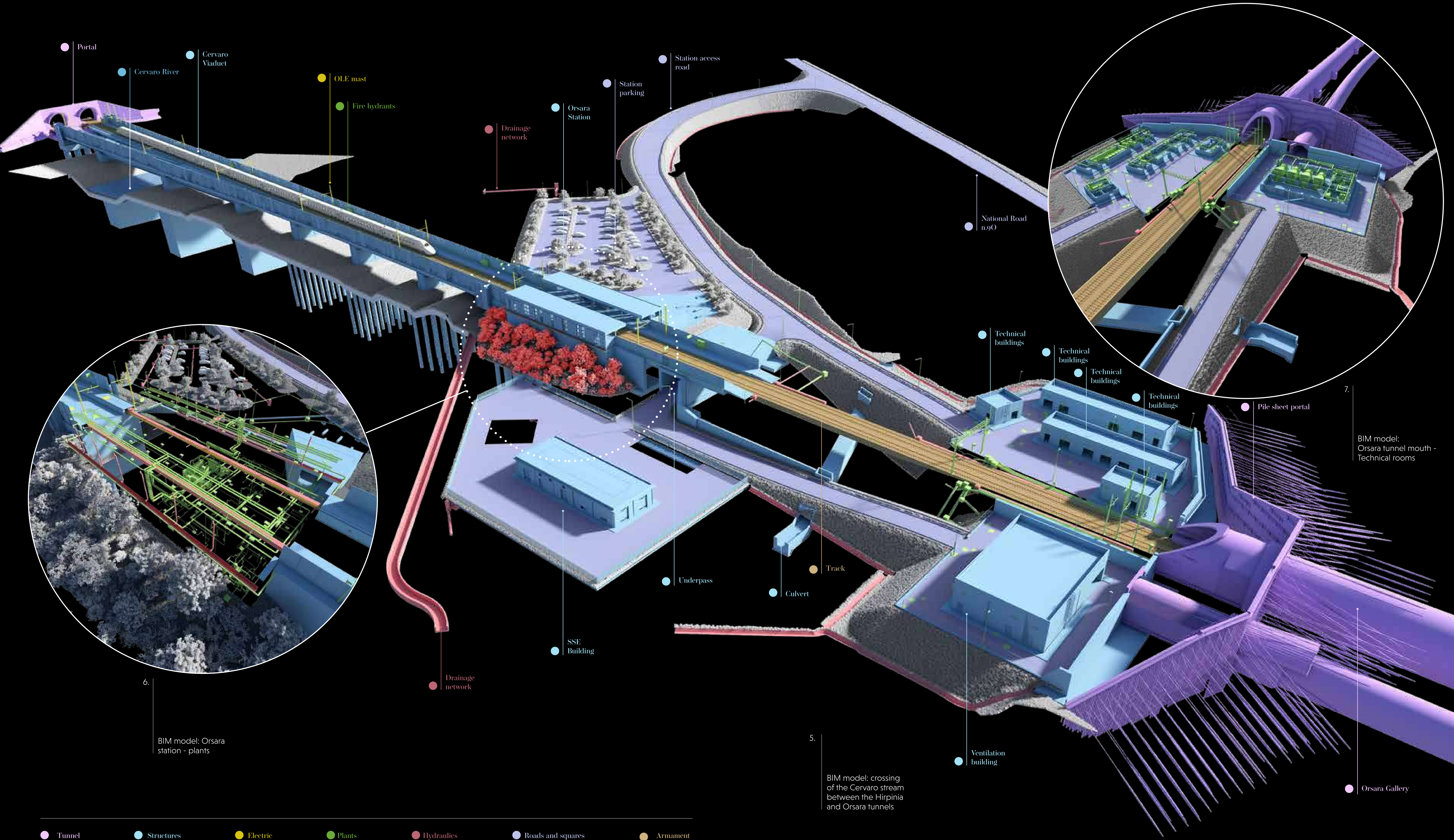
Drainage system

Tunnel

Electric

4.

Detail BIM model including all electrical substation facilities



7.
BIM model: Orsara tunnel mouth - Technical rooms

6.
BIM model: Orsara station - plants

5.
BIM model: crossing of the Cervaro stream between the Hirpinia and Orsara tunnels

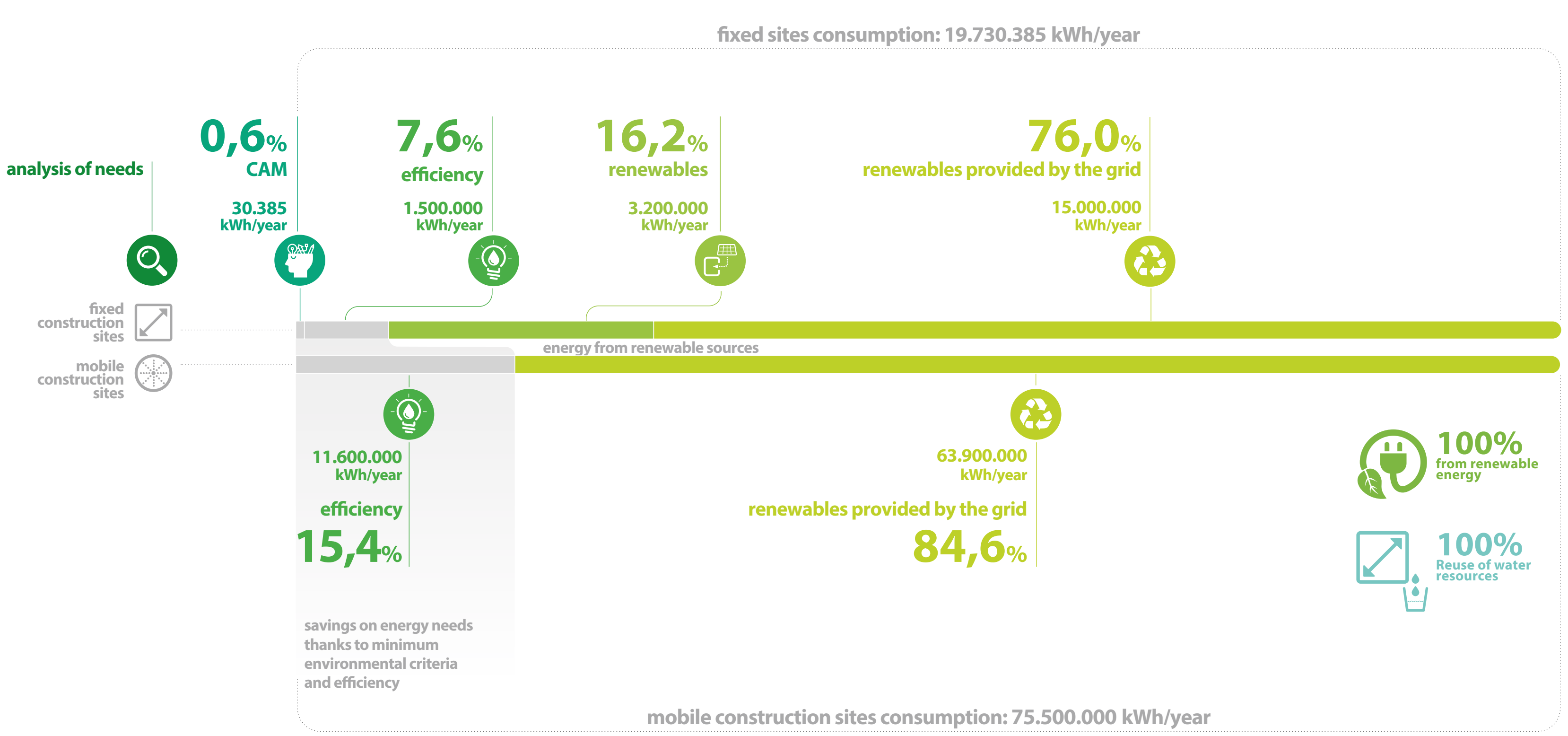
The first large Italian infrastructure developed in BIM

NET Engineering handled **the creation and organisation of the shared work environment** with the aim of developing the design of the three sections with BIM methodology. All the designers involved implemented the same macro-model on the Autodesk BIM360 platform for the best management of the inherent complexity of this type of project. This work method facilitated **the transversal nature, discussion between the disciplines and exchange of information and skills, benefitting the design result.** The BIM model also allowed the creation of the renderings and views necessary not only for the careful development of the project but also **stakeholder involvement.**

Environmental and landscape inclusion

Mitigation measures are mainly based on **recovery of the areas directly involved by the project.** Green areas are used to offer both aesthetic-perceptive redevelopment and reconstruct naturally important elements in a context mainly featuring natural and agricultural vegetation cover. On this point, special attention was given to the crossings of watercourses and the widespread obliteration of the agricultural fabric consisting of the design of the fields and the existing infrastructure. This led to the indication of targeted **mitigation measures to establish a context between the project work and the agricultural landscape it is set into, minimising the superimposition effect.** Another aspect assessed related to the creation of areas where reinstatement of the previous agricultural use was not possible at the completion of the works. These areas were **valorised through the introduction of natural elements.** The choice of the planned system modules was also aimed at achieving some specific objectives – the improvement in the quality of the landscape through the recovery of traditional shapes and screening of degraded areas, and the increase in ecological potential via interconnection.

Energy saving as a result of technological and construction efficiency improvements



Mitigation of construction sites in protected areas

Since some of the construction sites for building the Hirpinia-Orsara and Orsara-Bovino sections will be set up inside the Special Conservation Areas of the Natura 2000 network, NET Engineering took care of the design of specific **mitigation measures setting out the use of plant material for harmonic inclusion with the least possible impact of the site areas in the landscape-environment.** The NET Engineering project was developed based on 4 strategic lines:

• **Landscape inclusion of the site areas :**

Creation of wooded backdrops both internally and along the perimeter of the site areas, visual mitigation of the main systems, etc.;

- **Ecological continuity of the river channel:** Creation of connecting tissue and buffer zones along the perimeter of the site areas, diversification of habitats, use of naturalist engineering techniques, etc.;
- **Mitigation of the impact on the fauna :** Creation of systems-protection barriers for the fauna, environments favourable to the feeding and reproduction of the fauna, new corridors for fauna mobility, etc.;
- **Reduction of the direct impact of site areas :** Reduction of site surface areas, conservation of existing vegetation, repositioning in another site of the planned segment fabrication work, and use of conveyor belts for handling the spoil.

The sustainable construction site

Correct and complete implementation of the sustainable construction site within an infrastructural work can only be made with an overall approach strategy that develops through a succession of steps aimed at **finding the best answers on the environmental impact of the construction site:**

- **Analysis of water and energy needs and indication of the reference legislative framework;**
- **Design solutions and construction methodologies with the least energy and water consumption:** optimisation of work processes through design and construction solutions needing the least energy and water consumption;
- **Water and energy efficiency solutions**: indication of both structural and systems efficiency solutions that will allow the same performance objectives to be attained with a less demanding energy and water balance;

Orsara station: Environmental mitigation with green planting

Simulation of the Acoustic Bang at the tunnel entrances

10.

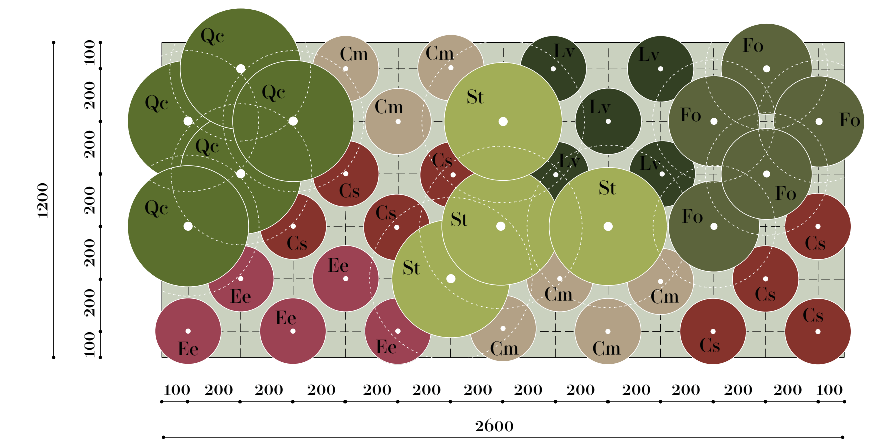
- **Use of in situ water and energy sources**: this will prevent a contribution to the increase of the site's environmental footprint due to supply from fossil energy sources, using (only by way of example) the drainage water from the excavation face for the water requirements of the fully operational site, and solar energy (photovoltaic and solar thermal);
- **Supply of sustainable energy for other needs.**

Sonic boom

The study of the sonic boom carried out by NET Engineering in the sphere of the acoustic study for both the construction site stage and the operational stage is specially interesting. **The sonic boom occurs as trains enter or exit a tunnel; the study further analysed the Hirpinia tunnel.** As the mouth of the railway tunnel is a very complex sound source, two technical-practical methods were compared for the simulation of the emission in the forecasting model – use of the proprietary algorithm in the Soundplan software and the application of a more experimental method derived from the indications in the ISPRA Technical Report of the POD of 2009, a research project on the emissions at the mouths of tunnels on HS/HC lines. The comparison between the results of the two methods showed minimal deviation thus confirming the reliability of the forecasting software algorithm adopted in the operational acoustic study.

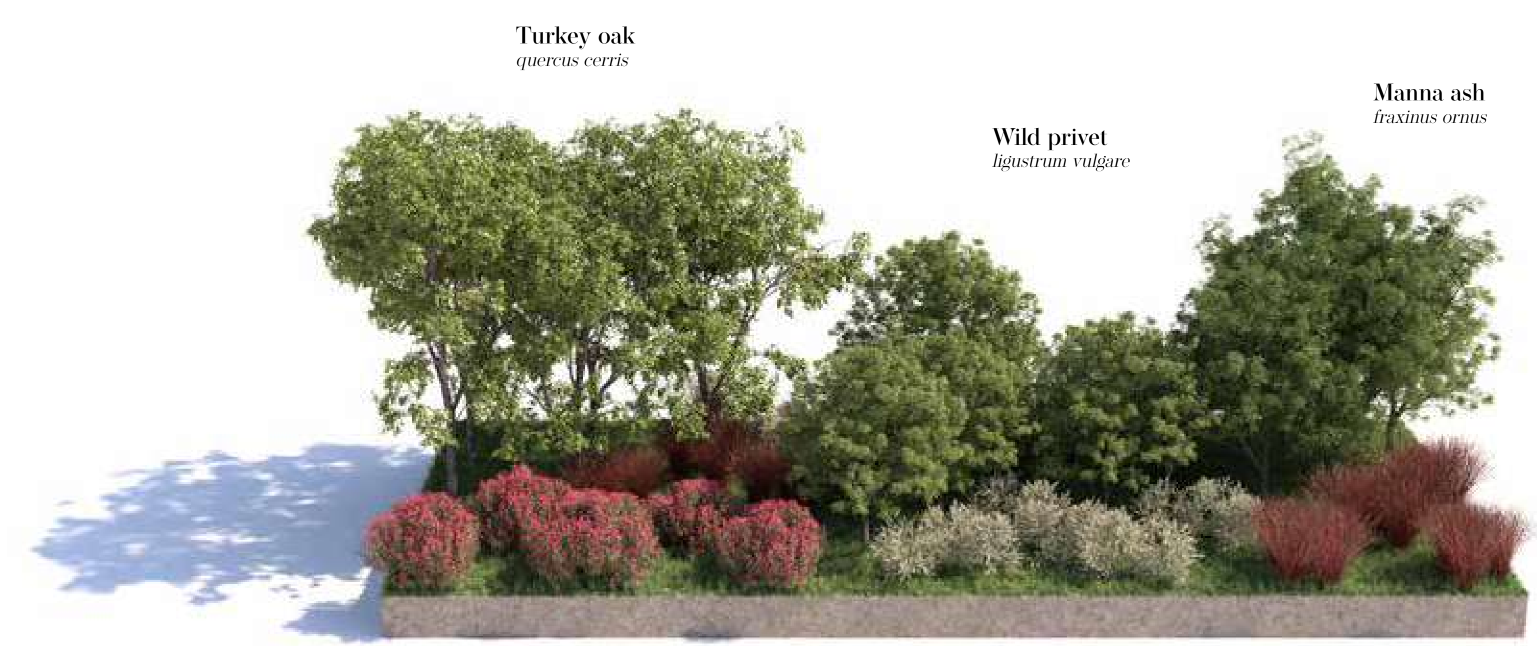
NOISE LEVEL
LeqD in dB(A)

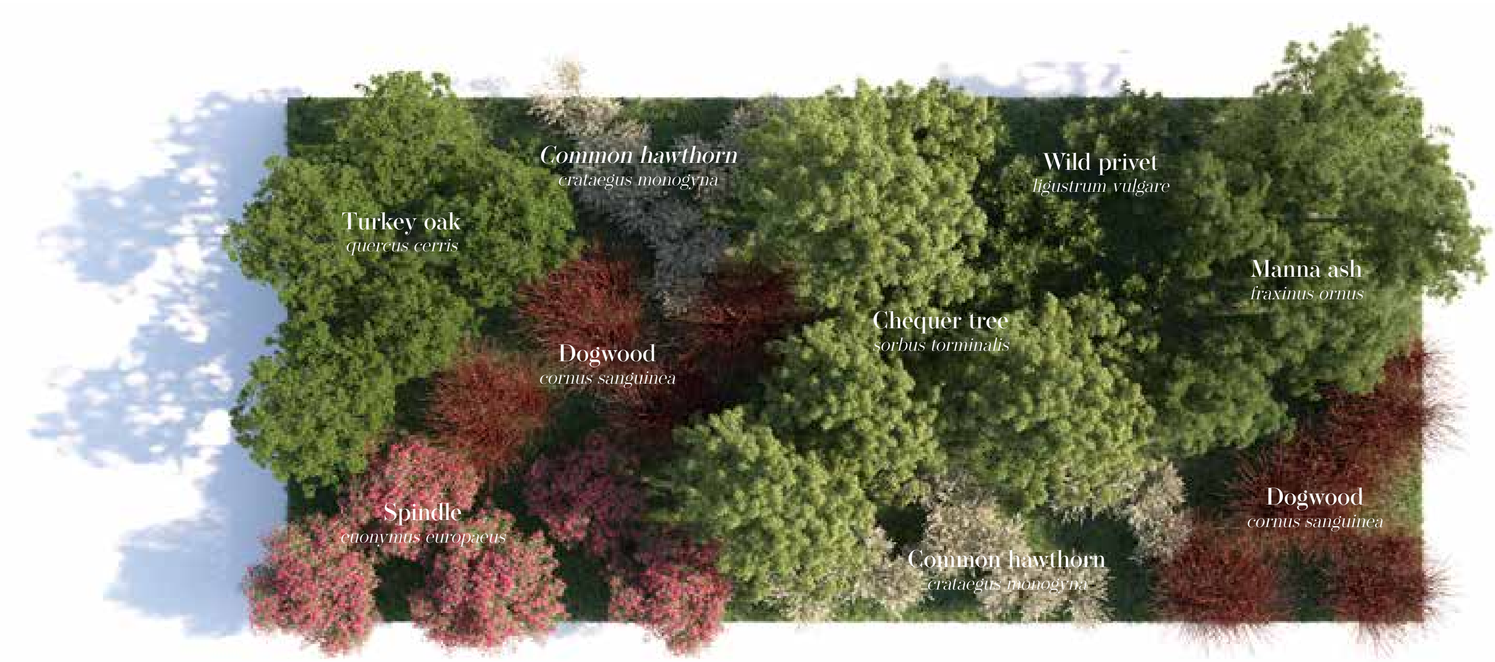
- 45< <=50
- 50< <=55
- 55< <=60
- 60< <=65
- 65< <=70
- 70< <=75
- 75< <=80
- 80<



MODULO F
MIXED PLANTING OF MESOPHILIC SPECIES WITH TREES AND SHRUBS - 312m²

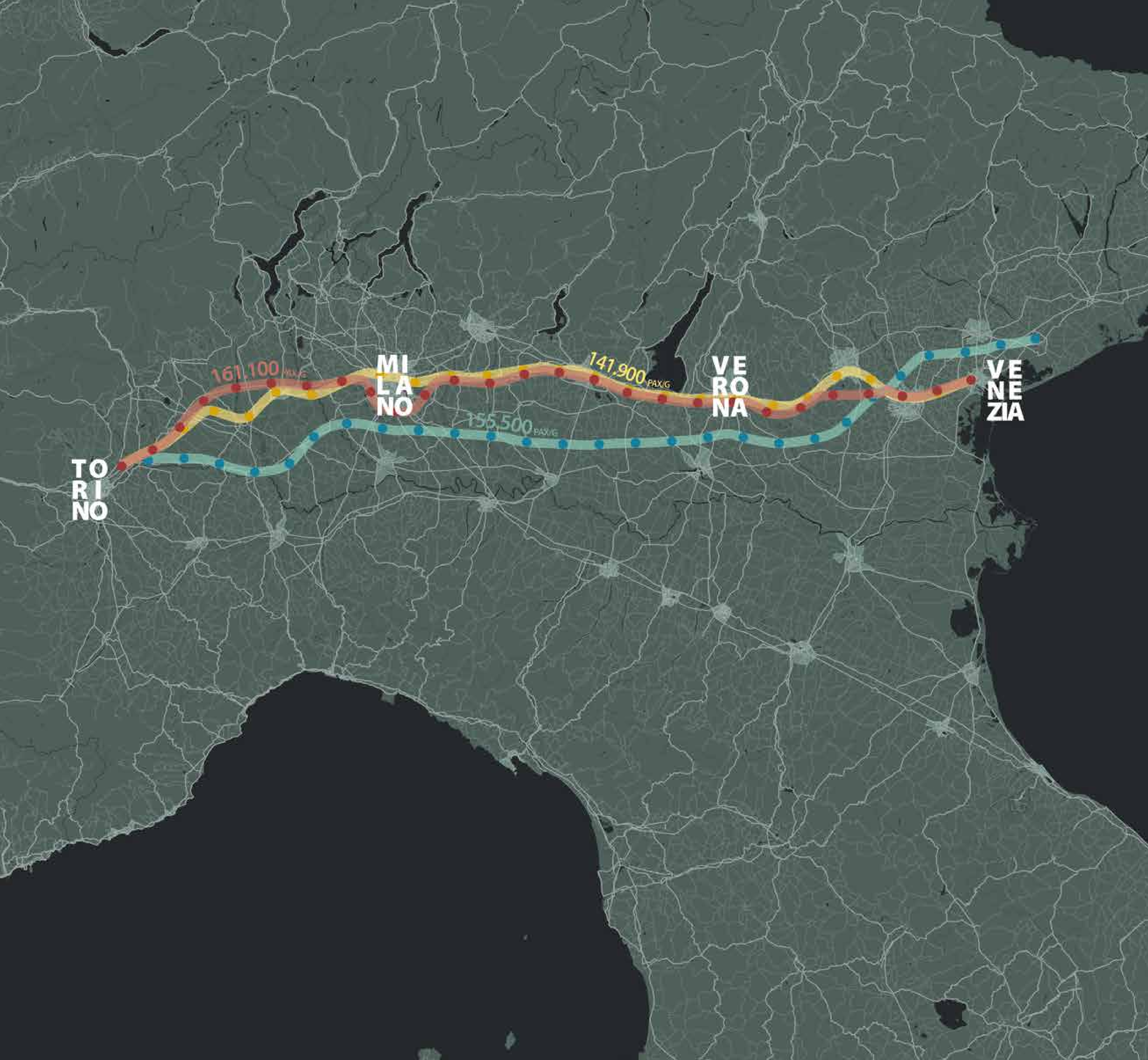
SPECIES	Common name	plants/ ha	plants/ Pattern
TREE SPECIES			
Fraxinus ornus	Manna ash	160	5
Sorbus torminalis	Chequer tree	128	4
Quercus cerris	Turkey oak	160	5
Total		448	14
SHRUB SPECIES			
Cornus sanguinea	Dogwood	256	8
Euonymus europaeus	Spindle	160	5
Ligustrum vulgare	Wild privet	160	5
Crataegus monogyna	Common hawthorn	224	7
Total		700	25





Typological sixth plant for green mitigation of various civil works

11.



The high speed revolution in Italy

The feasibility study and the design of the Turin-Venice line

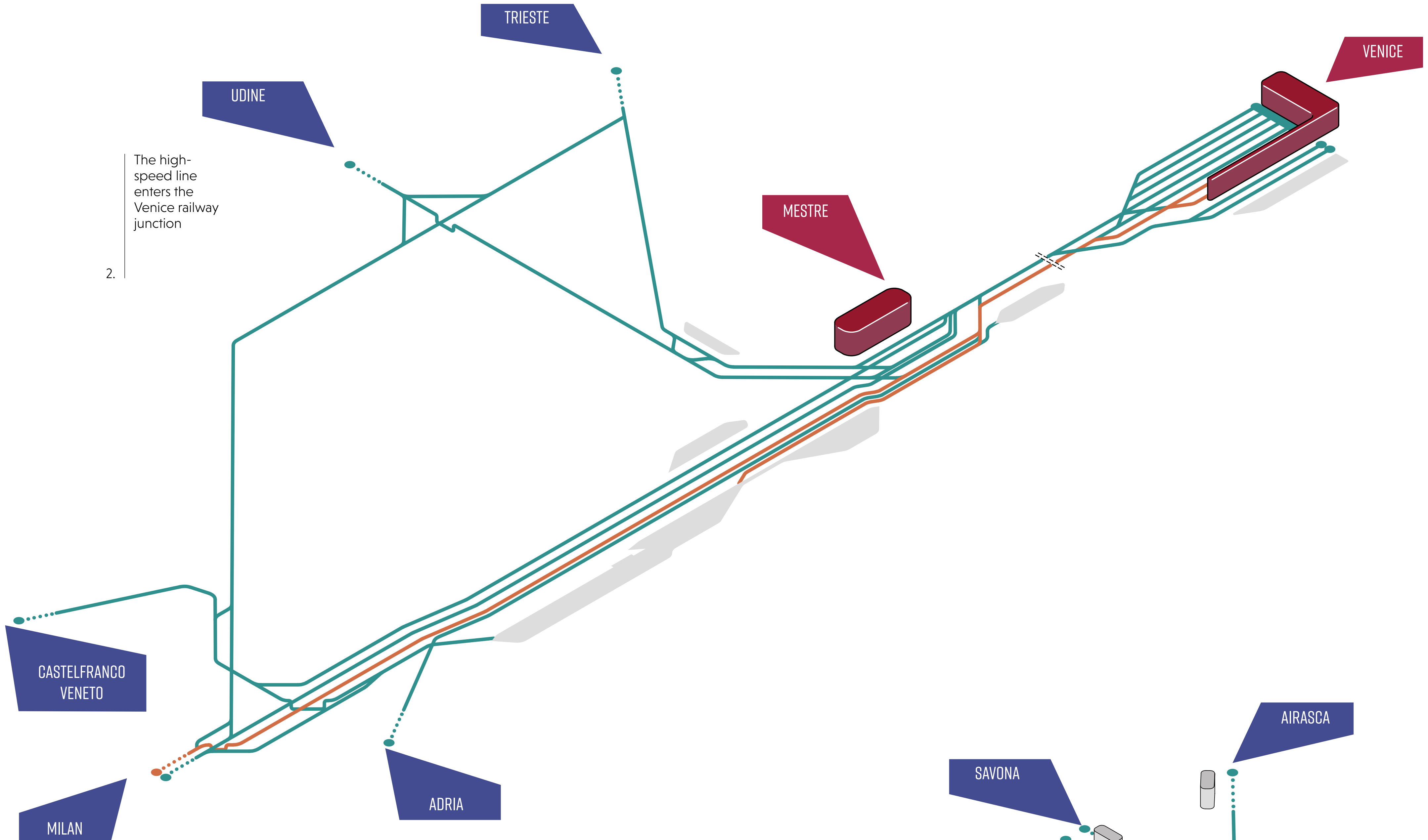
The construction of the High-Speed railway is **one of the most important infrastructure investments in Italy since the end of the Second World War.** The strengthening of the railway network is based on the ambitious aim of increasing the attraction and competitivity of rail transport compared to other transport methods, contributing to modal rebalancing and mobility that respects the environment more. The assignment developed by NET Engineering concerned the technical-economic feasibility study of the whole Turin-Venice line, an overall distance of about 400 km. The High-Speed project crosses national borders and has a European value, being an essential part for the Trans-European Networks – Transport (TEN-T). The Turin-Venice route is part of priority Trans-European Corridor 5 which connects Spain to the Ukrainian border.

The aim of the study was to provide elements for the choice of the physical and functional components of the Turin-Venice HS line, checking the economic and financial convenience of three different possible routes and operation, as well as that of not doing the work, in addition to the design and environmental inclusion implications. The method of work adopted should be emphasised which, through a system approach, saw an analysis made that extended to all the topics influencing the final choice of solution, without neglecting any.

As a result, a complete cost/benefit analysis was produced, with a level of analysis correlated to the design stage, not only from the community's point of view but also that of the managers of the network and services. A pioneering approach since this occurred in 1993, before the creation of the Procurement Codes and their regulations.europee (Transeuropean Networks - Transport, TEN-T).

The chosen route and its environmental analysis

1.



2. The high-speed line enters the Venice railway junction

In detail, the Outline Plan, the Environmental Impact Study and the check on Final Design produced by the General Contractor of the Brescia-Verona (72 km) and Padua-Mestre (25 km) railway sections and the two interconnections of Brescia East and Verona West (10 km) were developed. The complexity of the regions involved made the **planning of many structures, such as bridges, viaducts and tunnels, necessary and required careful analysis of the physical, urban-planning and environmental limitations.**

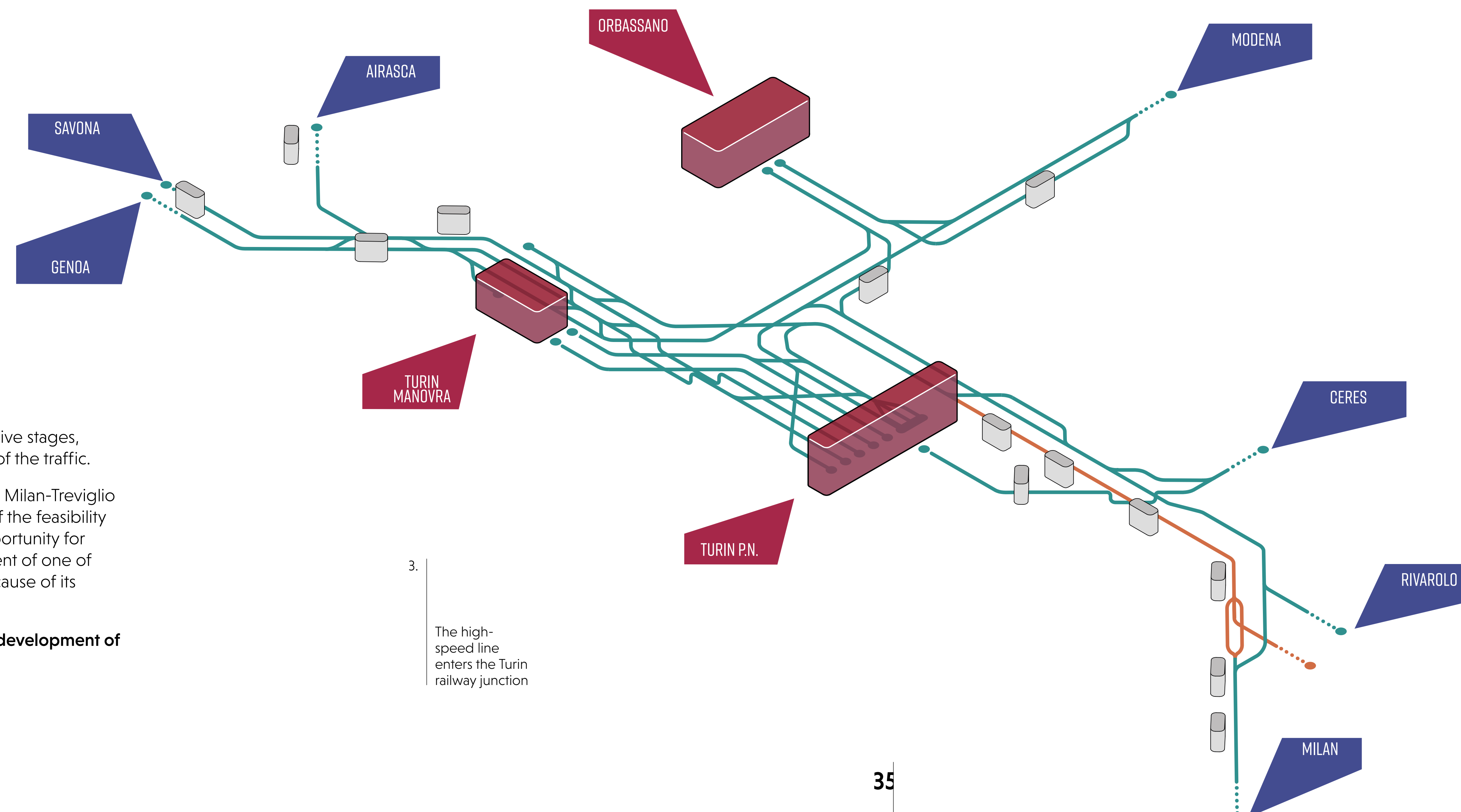
The Padua-Mestre section has been operational since March 2007 and the separation of longer-distance trains from regional ones, through the construction of two new fast tracks (with a maximum speed of 220 kph) has increased the potential of the line taking it from 240 to 350 trains per day, with the expectation that the line will be able to handle up to 500 trains per day.

Design stages

The construction of the High-Speed railway was planned in successive stages, according to the priority needs of reorganisation and fluidification of the traffic.

To date, the line has been partially completed, with the Turin-Milan, Milan-Treviglio and Padua-Mestre sections already fully operational. The drafting of the feasibility study of the new Turin-Venice High-Speed railway line was the opportunity for NET Engineering to make a decisive contribution to the development of one of the most significant infrastructure projects for the country, both because of its constructional complexity and regional extension.

Following the feasibility stage, NET was assigned with the project development of parts of the railway route and the associated civil works.



3. The high-speed line enters the Turin railway junction

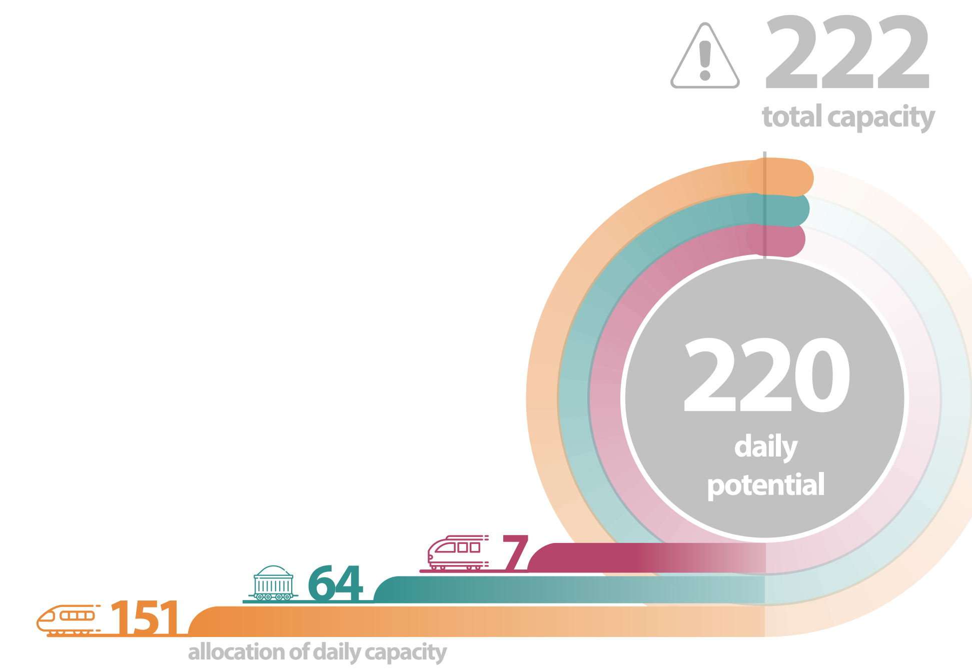
A pioneering method of analysis

The feasibility study developed with the prestigious co-operation of lecturers from the Bocconi University in Milan and Federico II University in Naples, is **the first application of the design approach of system engineering in Italy.** The possible alternatives were analysed and compared in relation to their inclusion in the transport system, the forecast of railway demand (passengers and freight), the economic and financial convenience, and the design, regional and environmental inclusion implications to provide all the useful elements for the choice of the physical and operational components of the new line and the definition of the most suitable route for the environmental and social-regional features of the places it would cross.

The Turin-Venice line was, therefore, designed from the very beginning as an integral element of the national and international multi-modal transport network. When looking for the initial data of the study, special emphasis was given to the need to acquire information on the demand for international transport, also through English and French specialists. In addition, large-scale works such as the construction of the Turin-Lyons line (in progress), the Channel Tunnel, the Milan-Naples HS line and the development of the railway networks of eastern European countries, in an integrated transnational view, were already planned among the fundamental infrastructural prerequisites. This is the correct view with which works of such importance should be assessed and undertaken, thus favouring integrated transport, and abandoning the thought of reasoning on each section in un unconnected way.

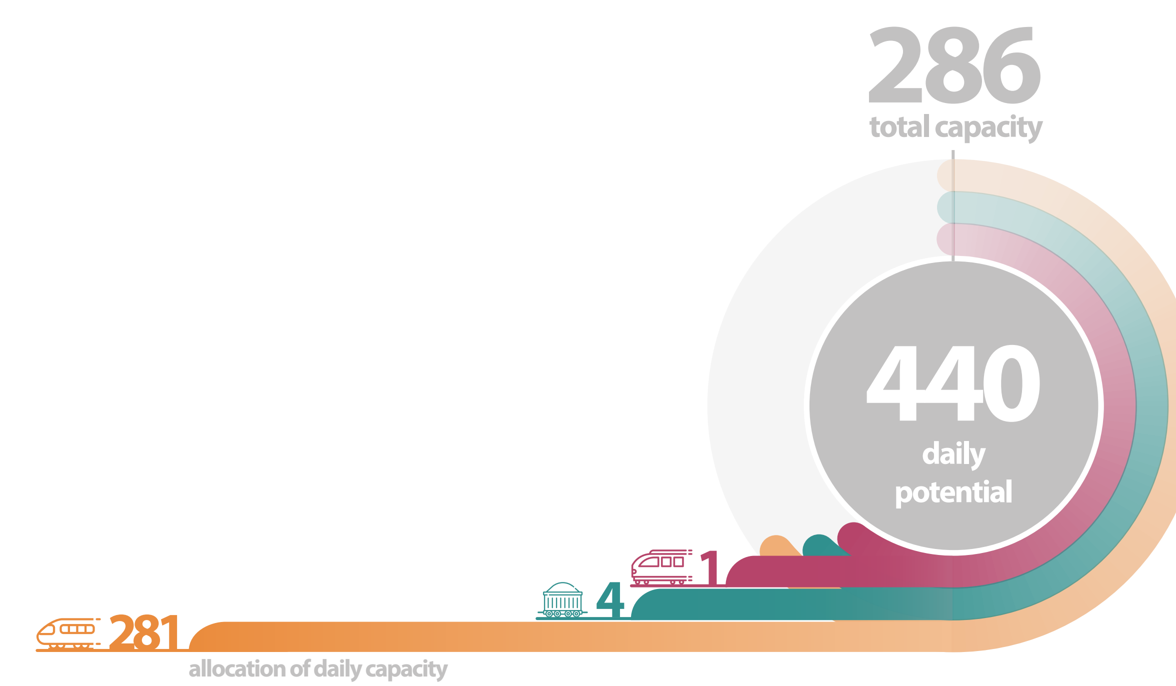
The experience gained has, over time, led to the definition of the role and value that marks NET Engineering in such situations – an independent voice that provides adequate supporting instruments for decisions. In this sense, **the task of engineering is the analysis of the scenarios and accompanying the client** (whether they are a public administration or a private investor) **in the choices they are about to make**, assessing their real consequences, even when the best alternatives from the strictly technical or economic point of view don't coincide with the decision-maker's initial expectations.

4. Potential and capacity of the Turin Porta Nuova-Turin Dora railway section (1991)



Railway junction to be improved

5. Potential and capacity of the Mestre-Venice railway section (1991)



Suitable railway joint

Sustainability and safety of large infrastructure

Geotechnical, geological and hydraulic Final Design for the Verona-Padua High Speed line

The Verona-Padua High Speed/High Capacity railway line is in the Mediterranean Corridor which reaches the Ukrainian border from Spain and is part of the trans-European strategic transport network (TEN-T core network), the preferred itinerary for traffic between Europe and Asia. In Europe, it unites industrialised regions with the developing eastern areas, connecting south-west European countries with East European countries.

The line, designed for a speed of up to 300 kph, is the **first functional lot with an overall length of 44 km and extends from Verona to the fork at the entrance to Vicenza.** The route is divided into two construction lots – from Verona Montebello Vicentino and Montebello Vicentino to Bivio Vicenza, up to the entry to the existing historic line.

In the scope of the **Final Design,** NET Engineering was responsible for the **hydrogeological, hydraulic, geotechnical, geological and seismic aspects** for both the general organisation and the Final Design of the Verona-Bivio Vicenza section and the individual works on the route. NET Engineering's role also includes assistance during the creation and final testing of the works as well as drafting the as-built technical documentation.

Hydrologic and hydraulic studies

The hydrologic and hydraulic studies of the watercourses interfering with the High-Speed line concerned some main crossings and all the secondary ones. The route intersects the River Adige from Verona to San Bonifacio, then continues from Montebello Vicentino to Vicenza and intersects the Brenta-Bacchiglione basin hydrographic system, i.e. the union of the hydrographic basins of the Brenta, Bacchiglione and Gorzone rivers.

The hydrological analysis concerned the study of more than 70 watercourses using traditional methods and mathematical models (HEC-HMS), defined according to the size of the hydrographical basin analysed. NET Engineering calculated the maximum capacity of secondary basins during the construction for the sizing of the professional works, intended to ensure both hydraulic continuity and safety during the execution stage.

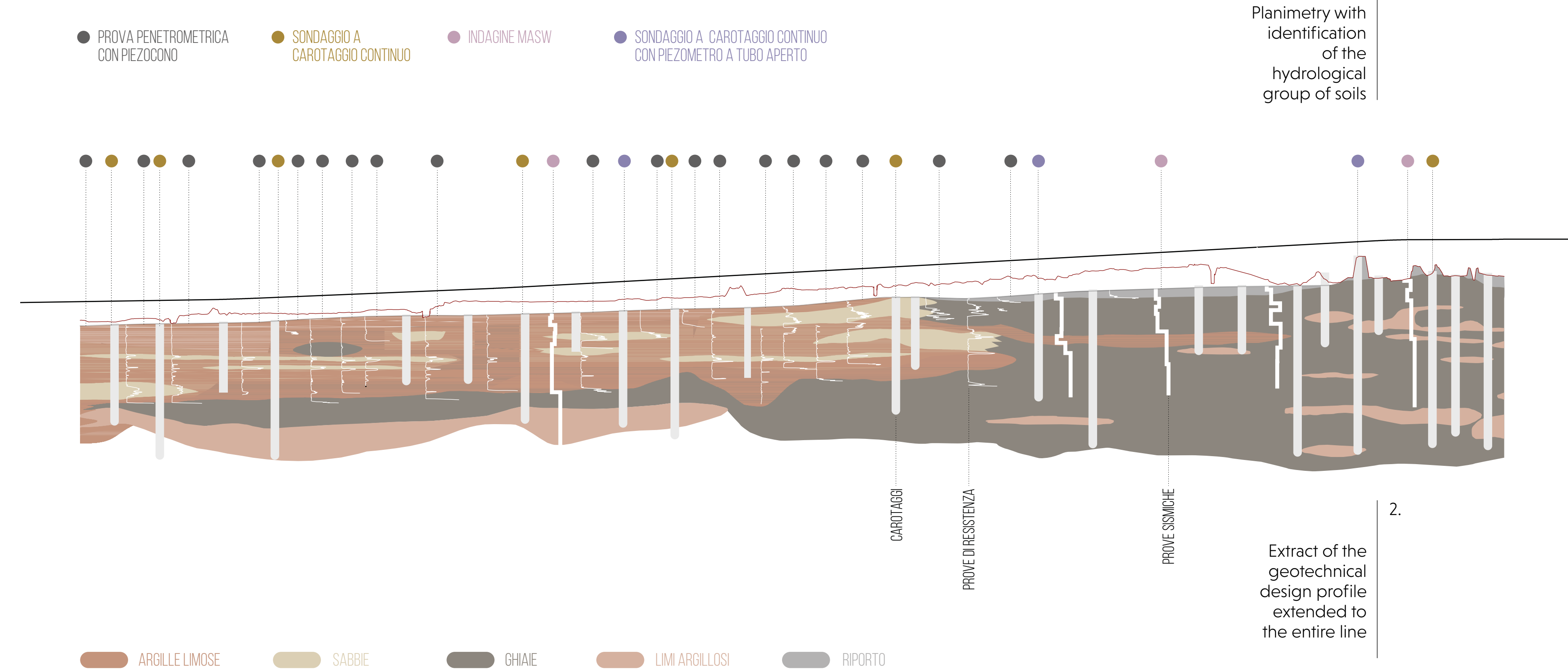
The **hydraulic study** - carried out to check the outflow conditions in the area involved in configuring the current situation, the project configuration and the construction site configuration, was conducted using the uni-dimensional permanent motion calculation program developed by the U.S. Army Corps of Engineers which provides a suitable representation of the situation and can also give the flooding areas in pre- and post-work conditions.

Geotechnical studies

The railway line extends through a large portion of the Veneto region. Along some sections, there are geotechnical problems such as soft soil, confined aquifers, high seismic danger, potential liquefaction of the soil, etc. In addition, the route involves an urbanised area and often runs close to the existing historic line, intersecting the A4 motorway.

1.

Planimetry with identification of the hydrological group of soils



2.

Extract of the geotechnical design profile extended to the entire line

3.

Execution of special foundation works

The design challenge within this framework was also to **minimise the impact during construction on the region and operation of these two essential infrastructures for Italy.** The general geotechnical and geological organisation took a cue from the Final Design to define an integrated campaign of in situ and laboratory research along the whole line. In detail, the **geophysical surveys** conducted enabled the integration of information on the **characteristics of the local seismic** response into the Final Design. Further, confidence on the features of the land increased based on the in-depth analyses carried out for the **geotechnical and geological organisation.** As a result, this **allowed fine-tuning of the design of works on the line** (embankments viaducts and artificial tunnels). **Geotechnical, geological, hydrogeological, geomorphological, lithological and seismic** charts were prepared accompanied by geotechnical and geological profiles. Where necessary, information was augmented through tracing transverse geological-geotechnical-hydrogeological sections with respect to the route. As far as the railway embankments were concerned, the analysis carried out included the geotechnical framework and characteristics, study of the construction stages and calculation of sinking induced on the designed line and the route in operation in addition to long-term stability and seismic checks. NET Engineering developed the **design of land consolidation (rigid inclusions, piles, etc.) and anti-liquefaction** (gravel columns, compacting, etc.) operations to respond to the features of the land.

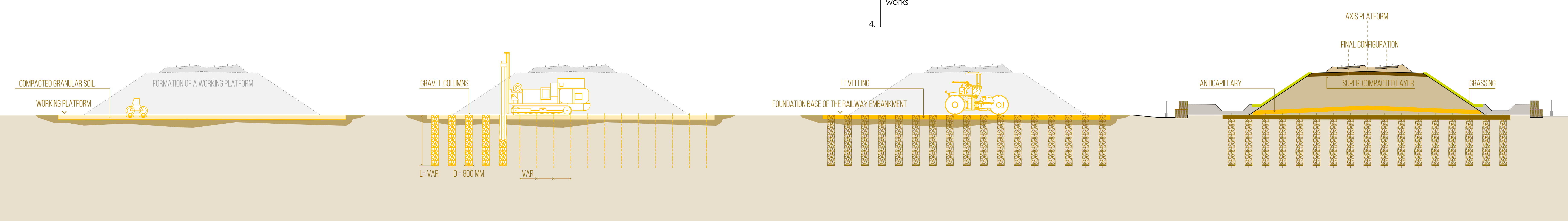
The project for the viaduct foundation system and, at the same time, that for the professional works for the construction of the foundations were also developed. For this particular aspect, the design challenge was to avoid impact on the area and nearby infrastructure, curating the **Final Design of monitoring systems intended to check the integrity, functionality and safety of the works.**

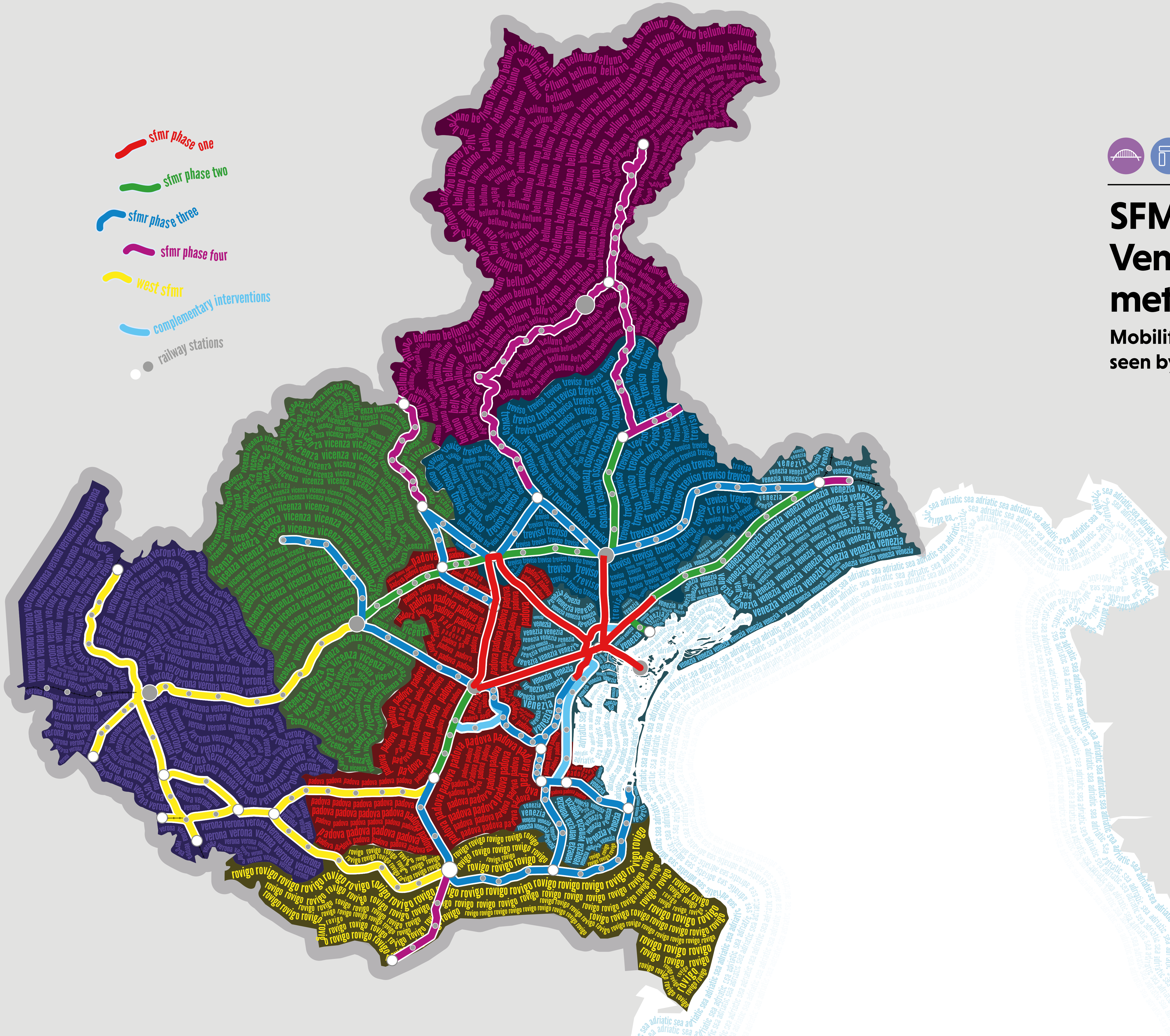
Contributing to sustainability of large works

NET Engineering's work for the Final Design of the Verona-Padua HS/HC line bears witness to how **engineering practice can easily contribute to the sustainability of large infrastructure works.**
One example is the use of gravel columns for the anti-liquefaction of soil. This method has no environmental impact because it entails use of natural elements without any type of 'synthetic' additive. In addition, creation of gravel columns on site involves very dust reduced emissions and silent working, a feature which makes it sustainable in terms of noise pollution. The hydrologic and hydraulic analyses had the same aim; the hydraulic compatibility of the infrastructure in its environment was analysed so that the state of the area could be guaranteed if not improved.

Construction phases of special land consolidation and improvement works and foundation works

4.





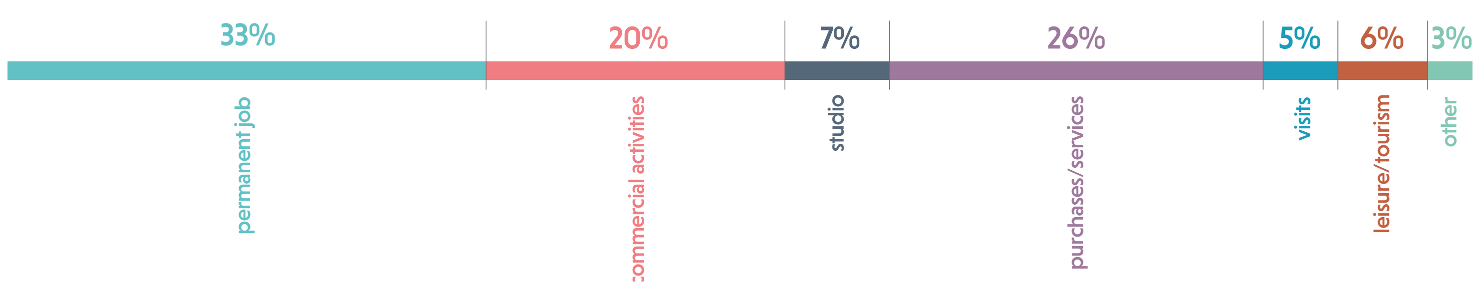
SFMR: The Veneto regional metropolitan system

Mobility, integration and efficiency seen by system engineering

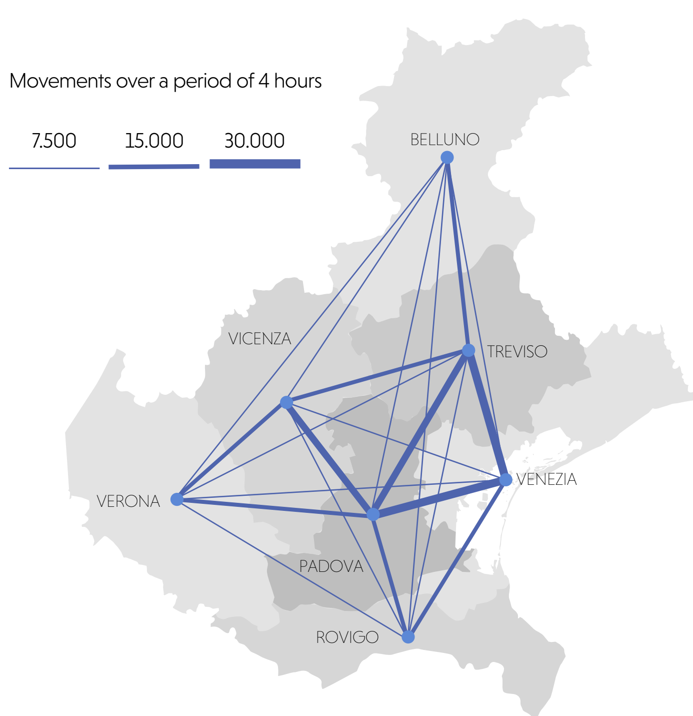
The SFMR – Veneto Regional Metropolitan Railway System is an integrated transport organisation based on the railway extended to the regional area. The aim of the project is to satisfy the mobility requirements in the region at the same time reducing environmental pollution, congestion and the accident rate on the road network, and making travel more comfortable for people.

The main condition necessary to achieve this is the **integration of the road-railway system in terms of public and private transport.** As a result, it was essential to reorganise the philosophy of public transport so that road and rail were complementary and synergic instead of competing. The transport services that satisfy the demand for mobility and the existing infrastructure was assessed to check its compatibility with the new services, to indicate the need in terms of new works, were then designed with these principles. The new works are to strengthen and rationalise the whole of the current and future railway network and the interchange points, updating accessibility to railway stations (roads, cycle paths, car parks and bike racks). Lastly, a checking simulation of the structure of the strengthened infrastructure was made with respect to the indicated future services, assessing all the effects/impacts – social, economic, technical, financial, environmental and managerial. After these checks, the design stage of the works was started.

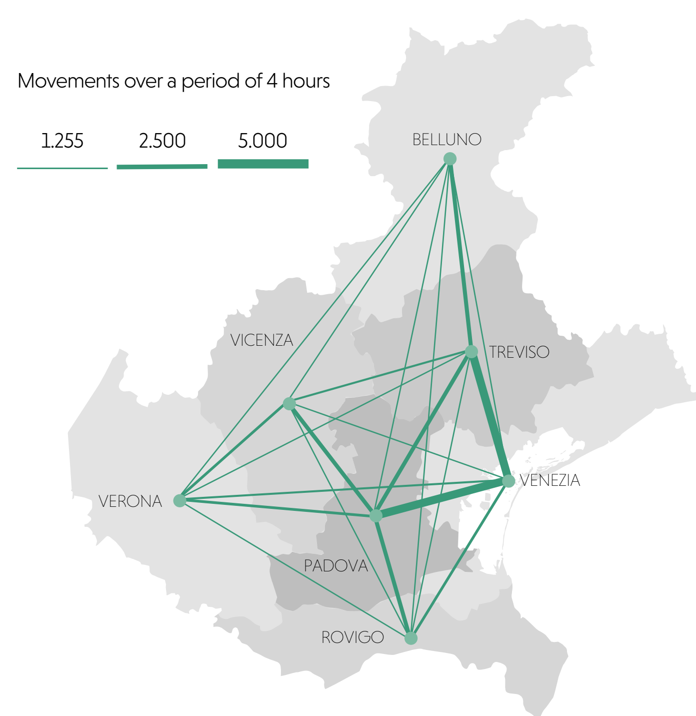
ANALYSIS OF THE DEMAND FOR MOBILITY



TOTAL MOVEMENT IN THE REGIONAL AREA



TOTAL RAIL MOVEMENT IN THE REGIONAL AREA



1. Scavalco ferroviario di Maerne (Venezia)

The work performed

The works making up the SFMR project include the **construction of new sections of railway line and the relative signalling and traction systems, the elimination of level crossings in the whole region replacing them with flyovers or road underpasses and pedestrian subways, the renovation of existing railway stations and the construction of new ones, with car parks, cycle-pedestrian subways and other dedicated facilities.**

In addition to the assessment stage described above, NET Engineering developed the **whole design** – from the preliminary level to the final one – and the **Works Supervision of civil and installation works.**

The construction of subways, after the elimination of level crossings and the renovation of the stations, was one of the most frequent components of the SFMR project.

Therefore, NET Engineering gained notable experience in design and the direction of works of this type, also in highly urbanised contexts and with significant hydraulic and geotechnical problems. The choice of this construction method for the works was directed by the need to **guarantee the continuity of railway operation.** The technique sets out creation off-site and subsequently installation via hydraulic thrust. This construction method, combined with solutions such as Essen Bridges, GUIDO Bridges, twin girders, and rail bundles to support the railways tracks, means that rail traffic can be guaranteed at a speed compatible with service and safety requirements (80 kph) even during any phase of the works underneath or alongside the tracks.

2. Some SFMR data

1100km
verification of the existing railway network

180km
new railway lines

407
level crossings to be eliminated

3. Maerne Railway Station (Venice)

The important works already completed include: the Mestre Ospedale railway station, which was opened in 2018, the railway overpass line in a westerly direction from Mestre station about 6 km long, with a viaduct of 1 km with 41 decks, and the elimination of the level crossing at Maerne (VE) station and the construction of three roundabouts, one on a deck. These works are part of the general scenario of:

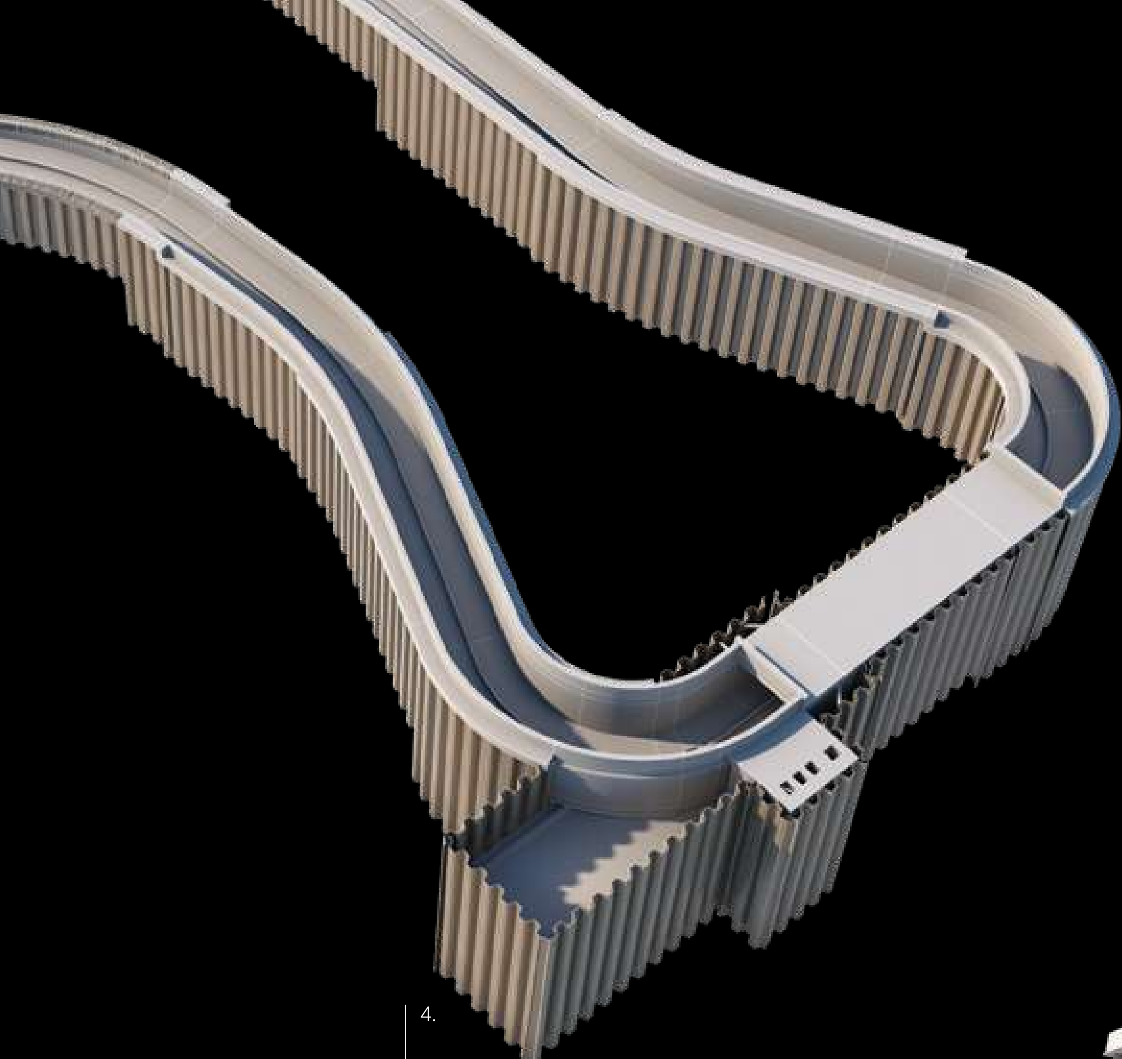
- **1100 Km** of existing railway network checked and made efficient;
- **180 Km** of new railway lines;
- **407 level crossings** to be eliminated;
- **162 railway stations** and stops to renovate;
- **37 new stops** and railway stations;
- **120 new trains** to assign to the SFMR service.

162
railway stations to be renovated

37
new stations

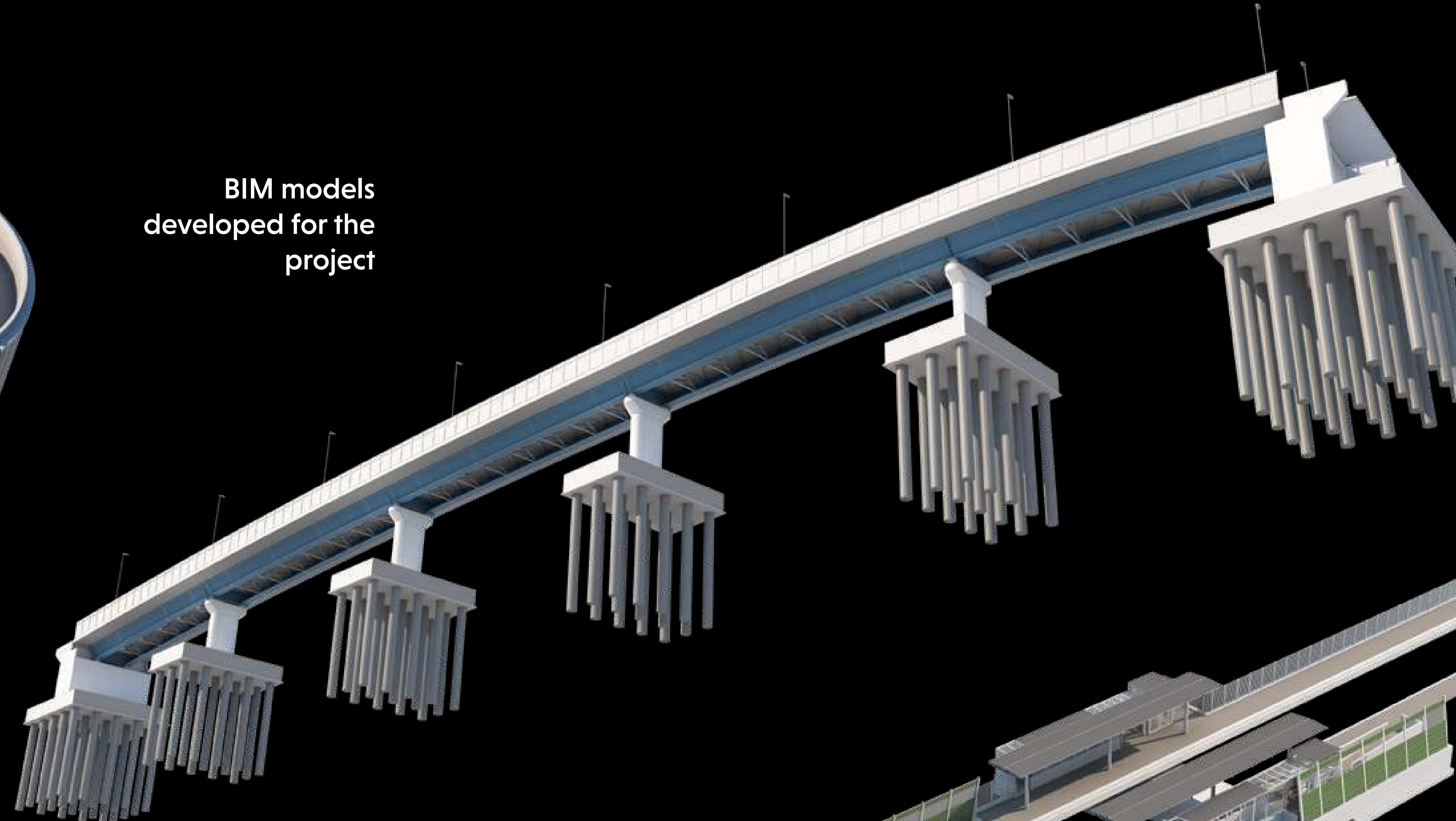
120
new train

BIM models developed for the project



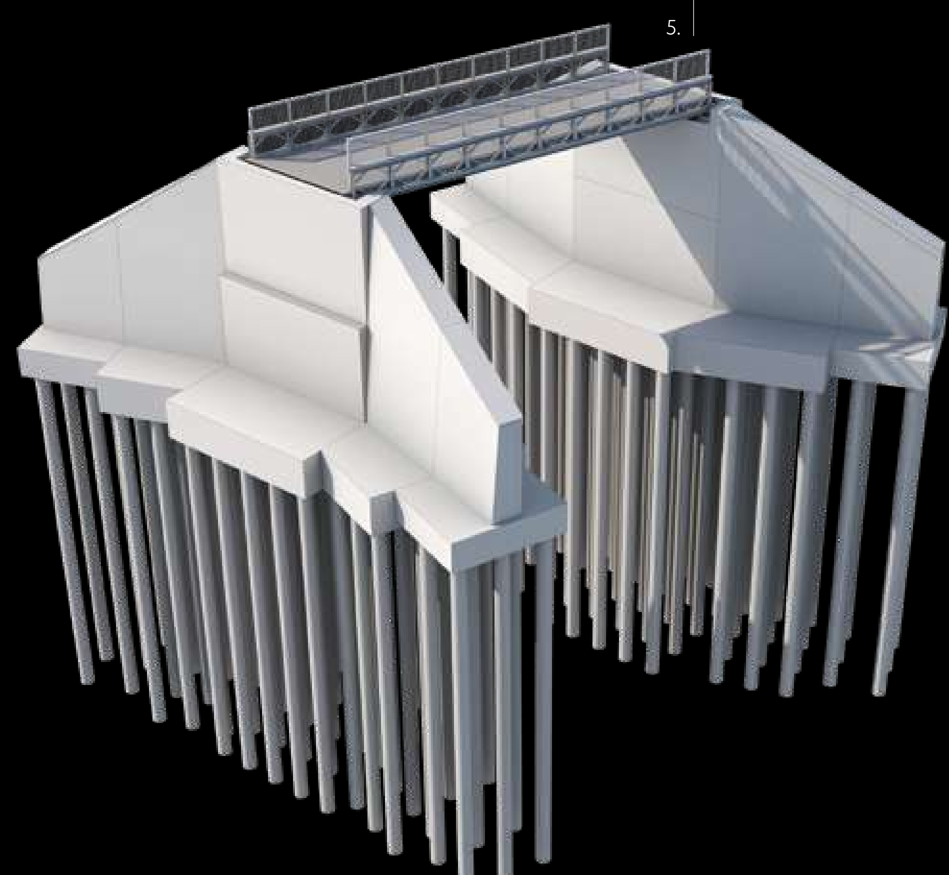
4.

Pedestrian and cycle underpass along Via Boschi, Roncade (Treviso)



6.

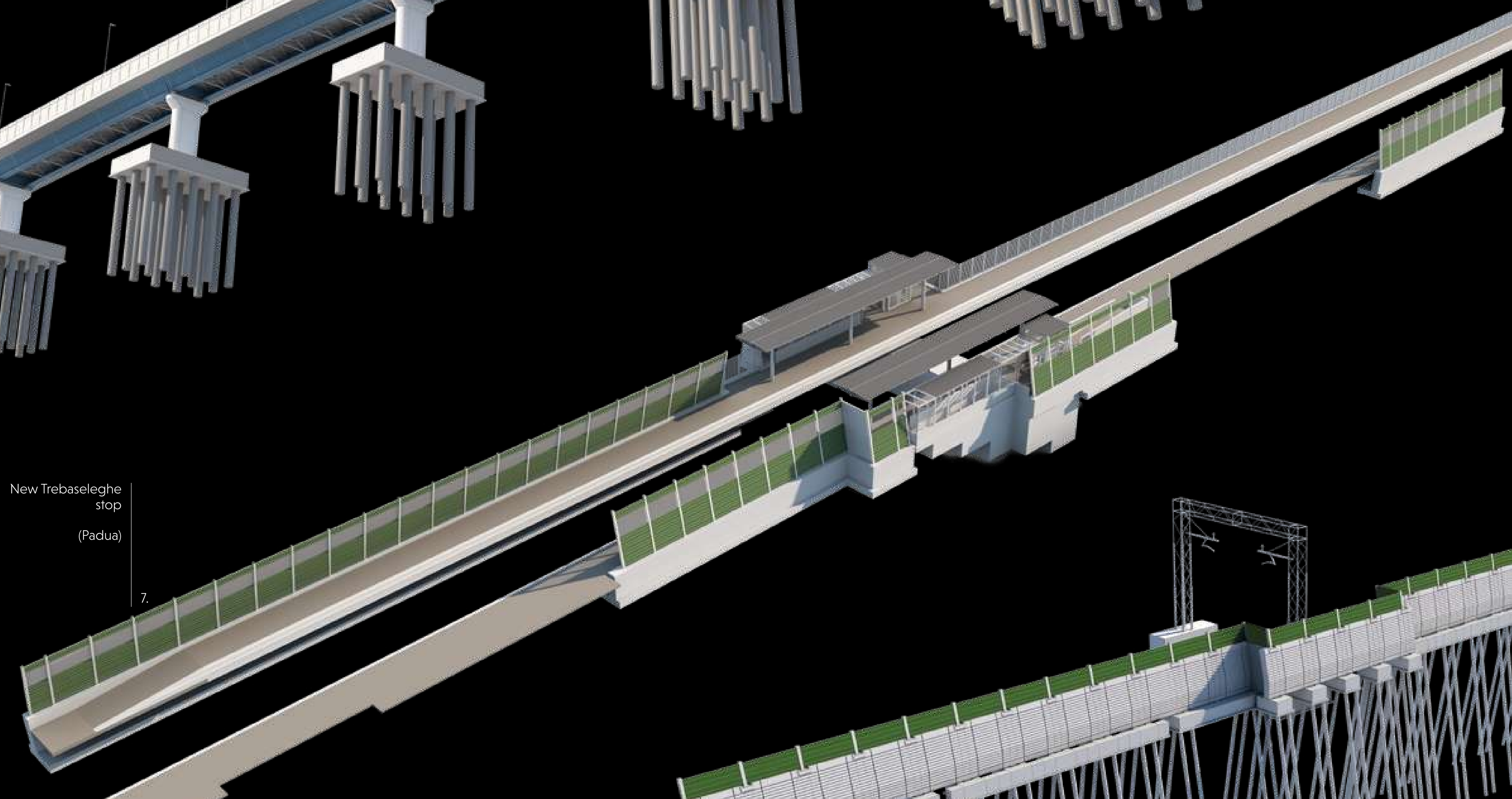
Overpass on the Venice-Trieste railway line



5.

New bridge over the Marzenego river

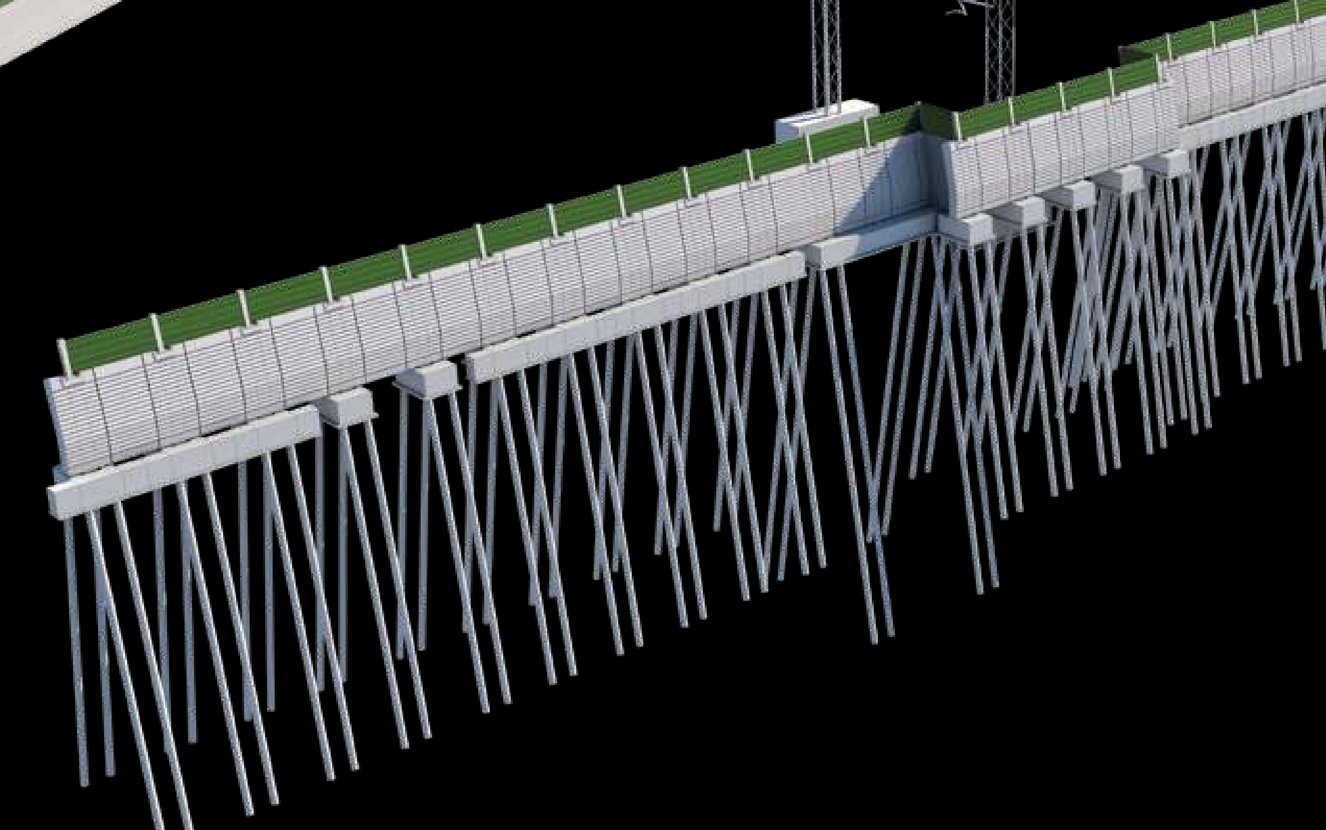
(Venice)



7.

New Trebaseleghe stop

(Padua)



8.

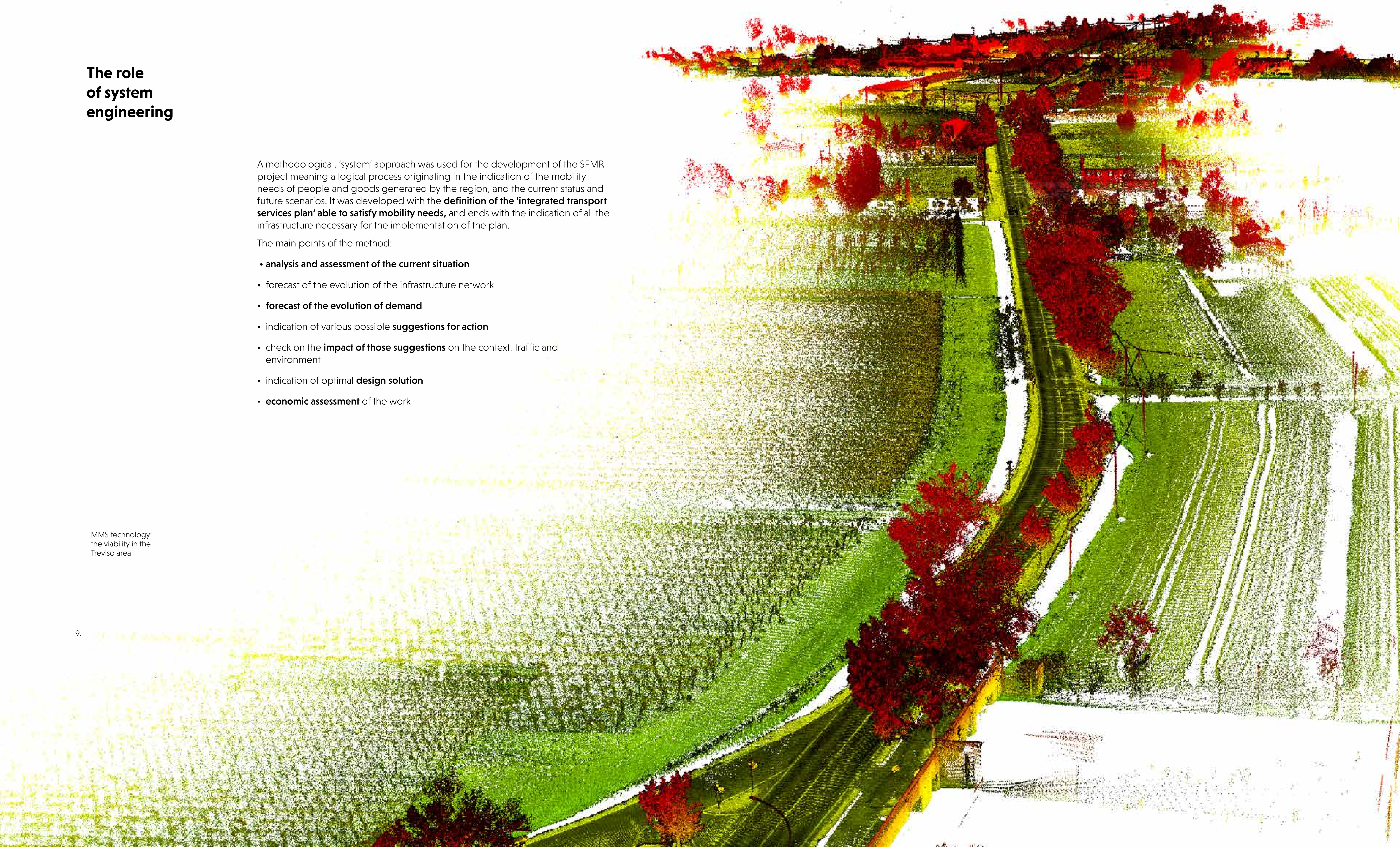
Sound-absorbing barriers along the Maerne-(Venice)-Castelfranco Veneto (Treviso)

The role of system engineering

A methodological, 'system' approach was used for the development of the SFMR project meaning a logical process originating in the indication of the mobility needs of people and goods generated by the region, and the current status and future scenarios. It was developed with the **definition of the 'integrated transport services plan' able to satisfy mobility needs,** and ends with the indication of all the infrastructure necessary for the implementation of the plan.

The main points of the method:

- **analysis and assessment of the current situation**
- forecast of the evolution of the infrastructure network
- **forecast of the evolution of demand**
- indication of various possible **suggestions for action**
- check on the **impact of those suggestions** on the context, traffic and environment
- indication of optimal **design solution**
- **economic assessment** of the work



MMS technology: the viability in the Treviso area

9.

10.

Augmented reality: view of the SFMR project in Roncade (Treviso)

A profound change with respect to the traditional approach that favoured the strengthening of the infrastructure, sometimes without having an adequate idea of what aims to achieve and which operating model was the most suitable to pursue them.

Compared to the years when work for SFMR started (1998), the system approach in Italy to indicate works to construct has made significant steps forward and consolidated the value of its utility. The results obtained are, however, are probably less than expected. Results arrive in a longer time span than many citizens generally consider acceptable for their consent and approval. As a result, perseverance is required in raising awareness of it and spreading knowledge of its undoubted advantages. **This is something that NET Engineering has carried out in a pioneering way from its first applications.**

Currently

It's useful to consider that the large geographic extension of the SFMR and the resulting importance of the economic commitment have induced Veneto Region to plan the implementation in stages, correlated with the available financing.
At present, therefore, there are completed works, others at construction or tender stage, and yet others where projects with different stages of investigation (preliminary, definitive or executive) have been developed; lastly, there are others that are still being assessed by system engineering.

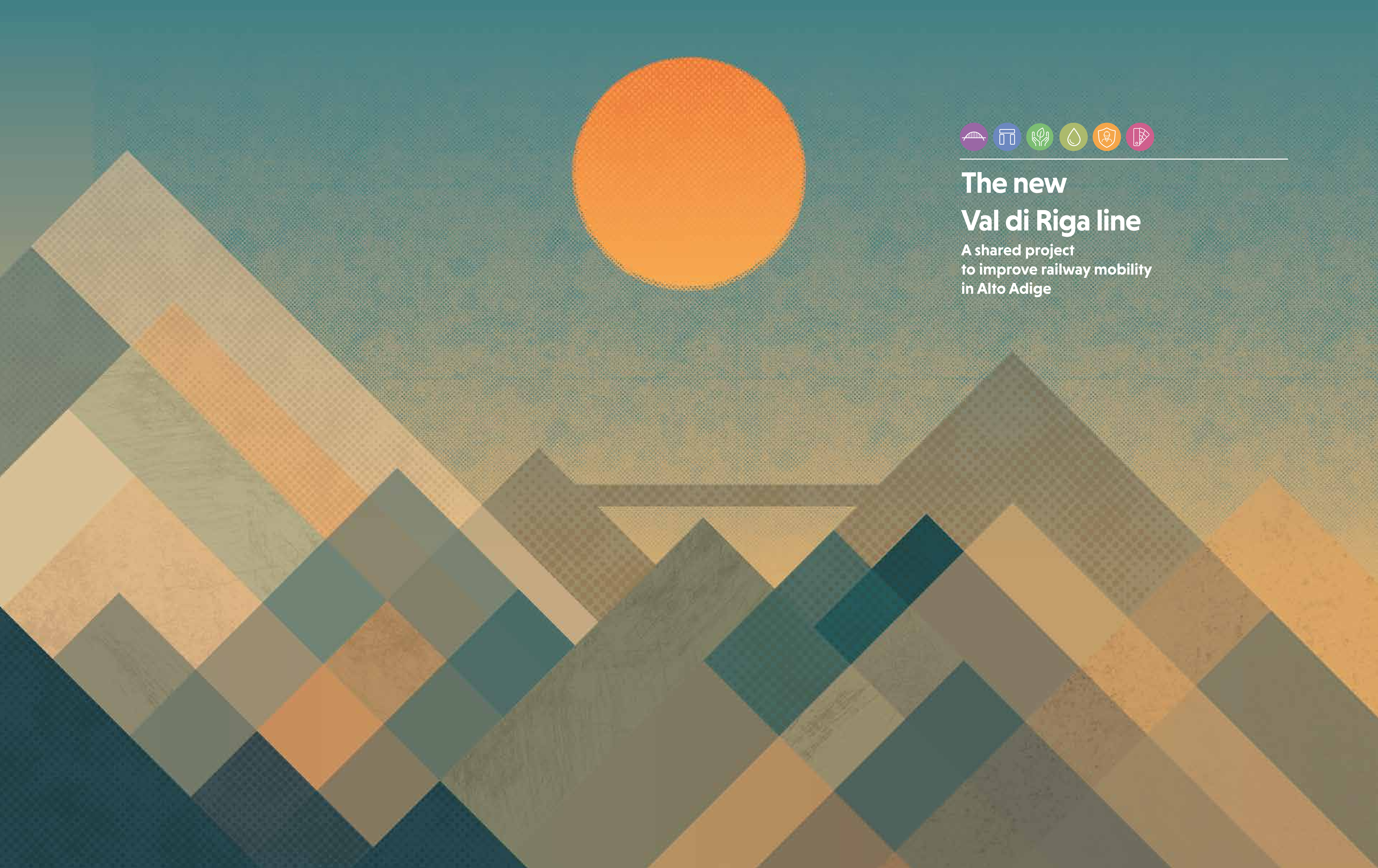
Technological innovations

The advantage of being an essential part of a project under development for almost 20 years is the opportunity, which Net Engineering immediately seized, to **adapt one's engineering approach to the main technological innovations in the market over time.** This firstly concern the reconstruction methods of the orographic/urban planning context where the various project works are placed. The paper and two-dimensional digital drawings, arising from traditional topography, were slowly but surely replaced by point clouds generated by land-based laser stations or drones. The field work of the technicians was integrated with the chance to exploit vehicles and/or trains as a support for the installation of laser/video integrated instrumentation, thus obtaining an instant, dynamic photograph of the infrastructure undergoing modernisation.

The desire to **increase the quality of the services offered** was mainly aimed at reducing problems in construction sites as much as possible and drove **Net Engineering to implement BIM methodology in its processes, thus creating digital computer models useful not only at the design stage but also in the subsequent management and operational stages of the infrastructure.**

SFMR station of Terraglio (Angelo Hospital) Mestre (Venice)

11.



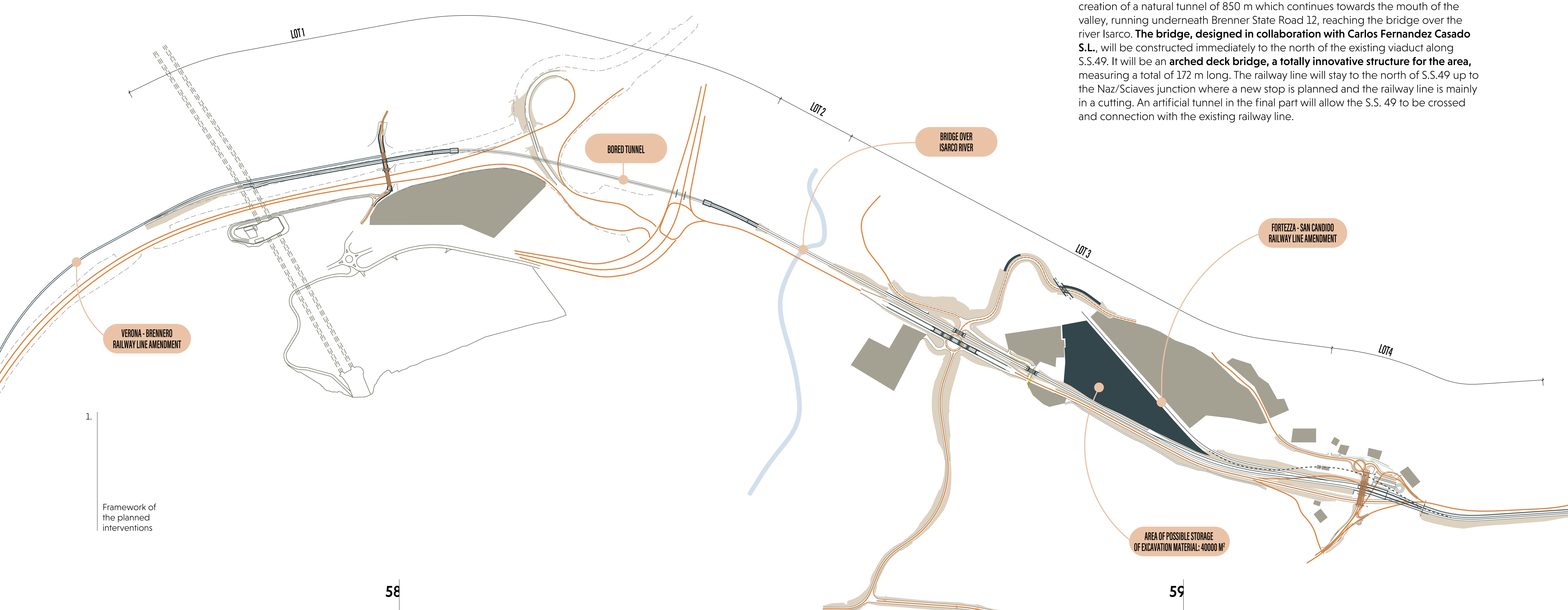
The new Val di Riga line

A shared project to improve railway mobility in Alto Adige

Feasibility study

The new Val di Riga railway line is a link between Rio Pusteria and Brixen (BZ) which will directly connect the San Candido-Fortezza line to the Verona-Brenner line in a southerly direction. The general aim of the operation is to achieve a significant reduction in travel times between Brixen and Rio Pusteria through the construction of a straighter railway connection than the current one. NET Engineering was responsible for the Feasibility Study and Preliminary Design on behalf of Strutture di Trasporto Alto Adige (STA – Alto Adige Transport Structures). Many alternative projects for each of the four lots of the operation developed from the Feasibility Study. In detail, there were 7 variants, differing for the position and type of crossing of the A22 motorway and the approach to the River Isarco, for the section joining the existing Fortezza-Brixen railway line to the projected bridge over the River Isarco; 5 different solutions were devised for the type of bridge to cross the river and there were 3 alternative projects on the portion di line connecting the bridge over the Isarco to the Naz/Sciaves stop; they were differentiated for the position of the line with respect to Strada Statale (State Road) 49. Lastly, there were 4 different hypotheses for the new Naz/Sciaves railway station. The design alternative was found from not only comparing the various solutions but also taking into **consideration the human-based and natural constraints.**and the indications of the bodies and municipalities involved which had the opportunity to make their requests in intense stakeholder engagement.

The route chosen is about 4 km long overall and the first 700 metres lies alongside the historic Verona-Brenner line and the A22; the motorway is crossed through the creation of a natural tunnel of 850 m which continues towards the mouth of the valley, running underneath Brenner State Road 12, reaching the bridge over the river Isarco. **The bridge, designed in collaboration with Carlos Fernandez Casado S.L.**, will be constructed immediately to the north of the existing viaduct along S.S.49. It will be an **arched deck bridge, a totally innovative structure for the area,** measuring a total of 172 m long. The railway line will stay to the north of S.S.49 up to the Naz/Sciaves junction where a new stop is planned and the railway line is mainly in a cutting. An artificial tunnel in the final part will allow the S.S. 49 to be crossed and connection with the existing railway line.



1.

Framework of the planned interventions

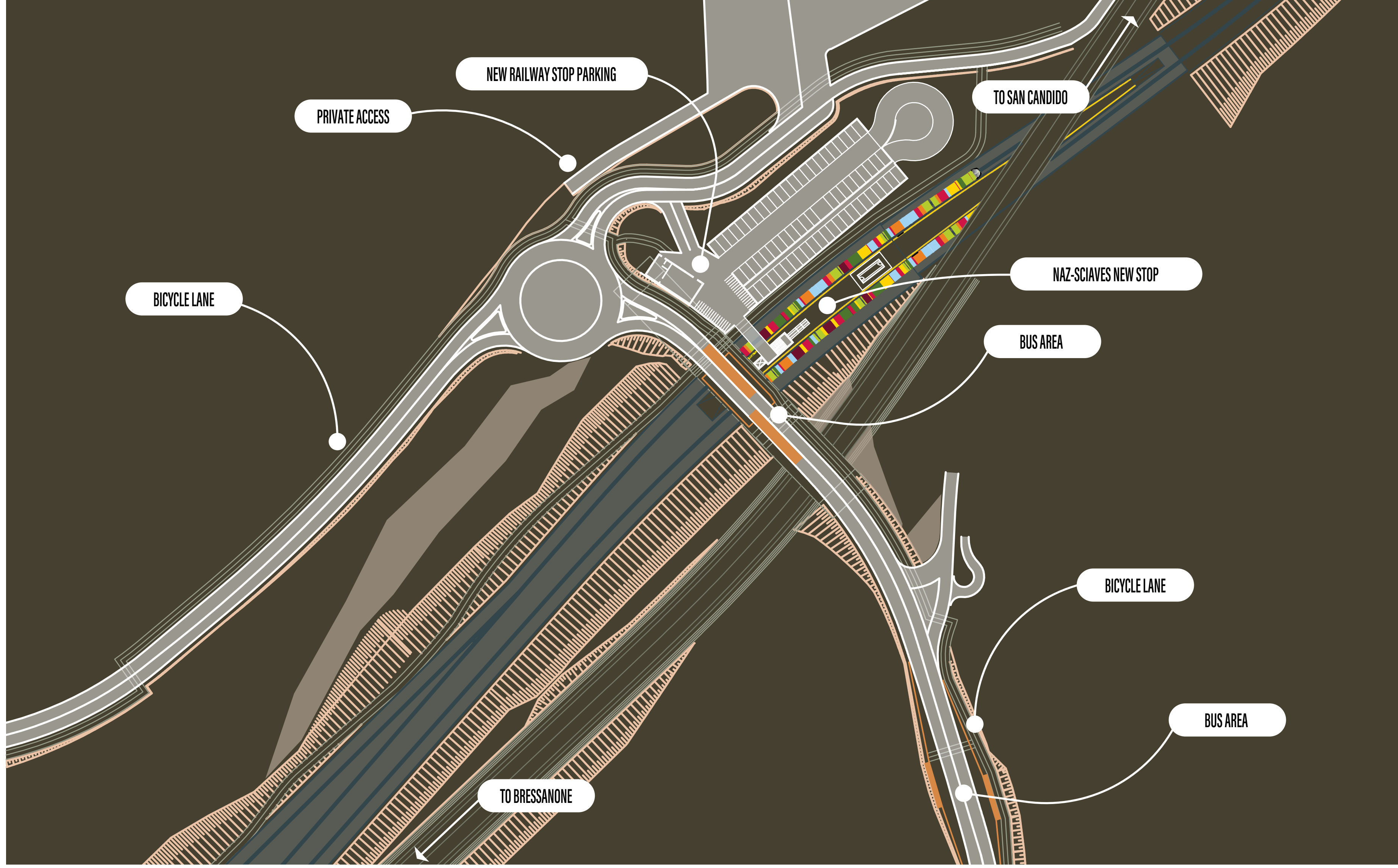
Preliminary Design

The preliminary design of the alternative project chosen not only dealt with aspects of the new railway infrastructure but also topics connected to it, such as the reinstatement of the road systems crossed, safeguard of the general hydrographic network, resolution of interference with network services, the construction site and, last but not least, the adaptation of the PRG (Piano Regolatore Generale – General Zoning Plan) and related buildings in Brixen station.

As the new railway route is in an area featuring considerable geological, naturalistic and landscape variability, NET Engineering was also concerned with the **development of the environmental pre-feasibility study with the intention of not changing the aesthetic-perceptive historic-cultural and natural value of the landscape**. The choice of using a tunnel to cross the A22 enabled, amongst other things, the wooded area on the right of the Isarco to be continued, just as the section in a cutting has preserved the perception of the valley. The bridge over the Isarco, the largest landscape work in the project, was designed to preserve the perception of the landscape from various points of view both through low impact choices and also in relation to its position alongside the existing bridge of the S.S.49.

Another of the important aspects concerning the Preliminary Design was the updating of the Brixen railway station PRG, i.e. the change to the structure of the track level with the creation of new pavements and related underpasses and a preferential track of 650 m for goods traffic.

2. 3D rendering of the new bridge over the Isarco river



3. Planimetric excerpt of the junction and the new Naz-Sciaves stop

Stakeholder engagement

The Feasibility Study and Preliminary Design for the new Val di Riga line were developed in constant, intense discussions with the client and then with all the main stakeholders – the Autostrada A22 (A22 motorway), municipalities of Varna and Naz/Sciaves, and private citizens.

The involvement of all the players concerned with the project from the very beginning, the in-depth study of the problems found and the development of many alternatives responding to the needs presented through valid technical solutions aided the establishment of trust in the designers by STA and the municipalities. As a result, stakeholder engagement led to the development of a project that offered an answer to the client's needs and in which, at the same time, everyone could recognise their contribution.

The Turin rail link

Strengthening of transport and repair of the urban fabric

One project, two complementary results

From the late 1970s, Turin has reflected deeply on its urban structure – the railway infrastructure, built when Turin was the capital of Italy and around which the city of the industrial boom developed, started to be seen as a separation. The railway line was increasingly perceived as a barrier, a functional and perceptual obstacle where abandoned areas and low quality architecture developed. It was in this context that the ambitious Rete Ferroviaria Italiana (RFI) project, for the **quadrupling of the railway in the city centre, was conceived through the construction of an underground rail link** between Lingotto in the south and Stura in the north. The project was a particularly difficult technical challenge, setting out up to **four underground levels** of flow but, at the same time, was the opportunity to build a new urban penetration route right in the city centre.

1. Turin Porta Susa underground station

In essence, the project had two main aims. Firstly, the strengthening of the railway junction (adding two lines and new stops) with a view to the new operation model of regional railway services and the entrance of the High Speed lines from the east (Turin-Venice) and west (Turin-Lyons); secondly, to seize the opportunity of putting the urban railway section underground and eliminating the physical separation of the city it generated, so that, overall, the areas previously penalised by the railway could be rejoined and redeveloped. The urban transformation also included targeted operations to fluidify road traffic through the elimination of road/railway level crossings and new sections of cycle paths and urban road on the surface, above the railway underground.

The technical challenge for the engineers was to design the works so that the railway circulation remained unchanged and there was as little interference as possible with road circulation, businesses and residents' lives. Therefore, the sequence of construction sites was divided into time portions small enough to analyse the accessibility conditions to each building at all times. This was done through the **planning of suitable spaces and the temporary reorganisation of circulation directions in the various groups of streets behind the area of work.** The analysis allowing the emergency services (ambulance, fire brigade and police/carabinieri) access to the front of all the buildings was particularly important.

The principle of dealing with the construction sites in the final project initially and then fully and in-depth in the working drawings was brought about by the, at the time, recent introduction of the legislation on the 'practicable working drawings', i.e. at a level of detail that leaves the contractor with no uncertainty or degrees of discretion. **Forecasting suitable spaces and temporary reorganization of traffic directions in the various blocks behind the work area.** This methodological line for the project has, over time, become a standard for NET Engineering, which has gradually refined it through the feedback heard during the management of works the company has designed.

The works design

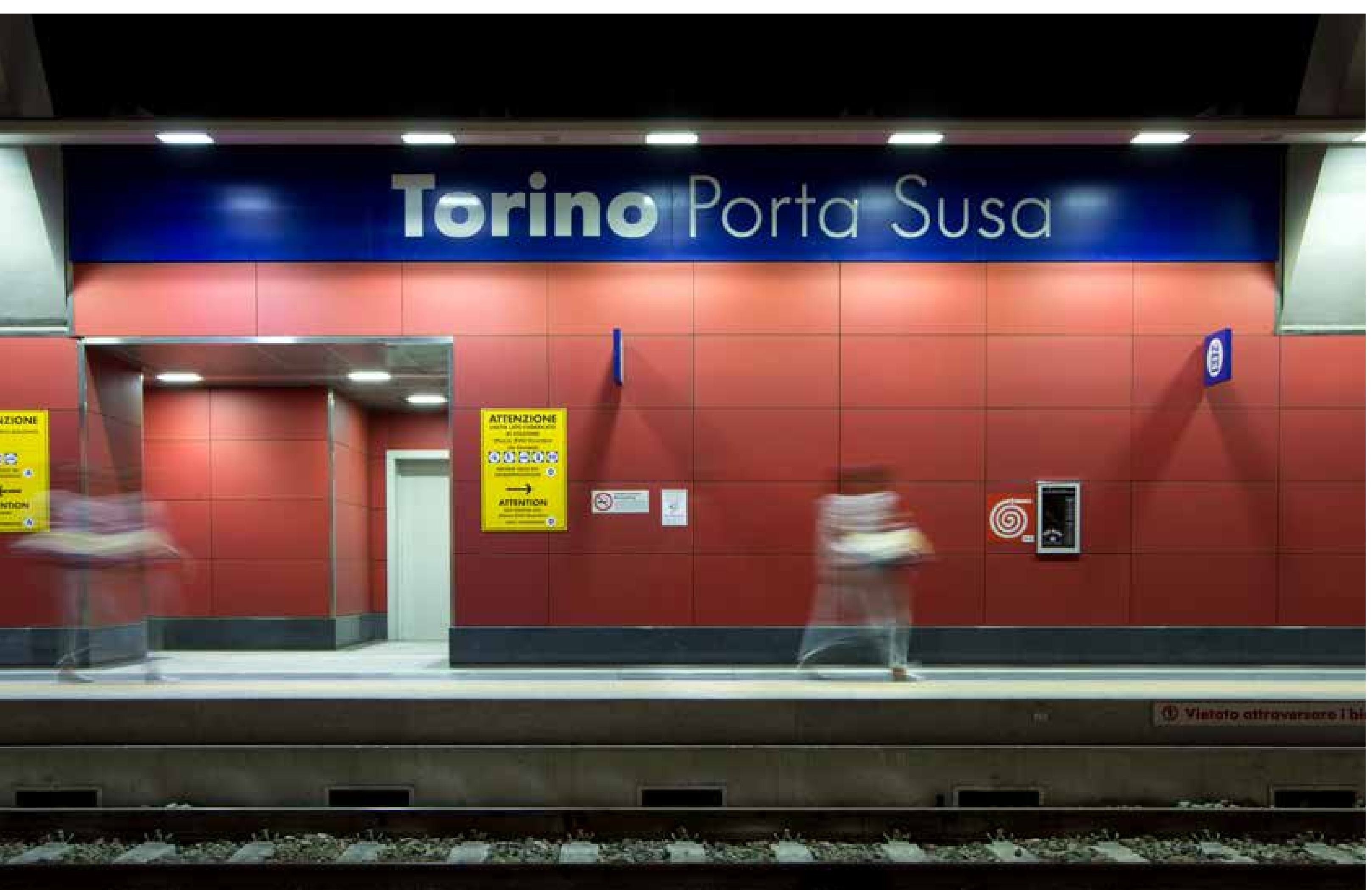
NET Engineering developed the final detailed design of the northern section of the rail link, from the new station of Porta Susa, currently being completed, to the Corso Grosseto junction, and further the Stura area.

The suggestions made for the Turin Rail Link project were the summary of a complex decision-making process.

The activities planned the design of the following works:

The following actions are planned for the infrastructure projects:

- Two artificial tunnels side by side with a length of 4.5 km;
- An underground intersection building on two basement levels between the railway tunnels and the underground (Tube-style) railway;
- The new underground stations of Porta Susa and Rebaudengo;
- The stations of Dora (covered) and Stura (open);
- An avenue for the urban penetration along the whole length of the underground construction (4.5 km);



2.

Turin Porta Susa: Pillars framework

- Two sewers 2.3 km long;
- The new bridge on two levels over the Dora Riparia, with three spans and an overall length of 42 metres;
- A road junction between Corso Grosseto and the by-pass for Caselle Airport;
- The urban redevelopment of the areas.

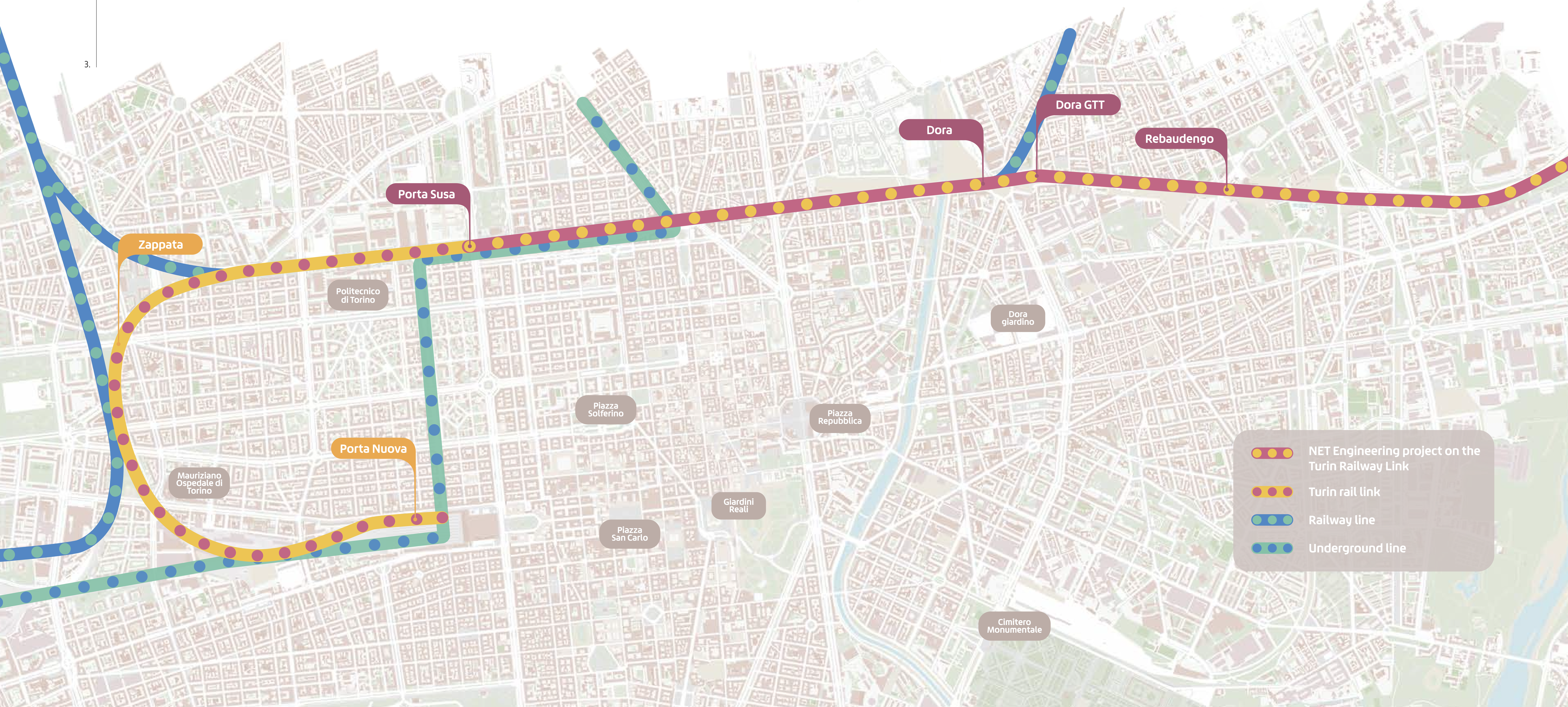
In addition, the project set out a **meticulous environmental arrangement**, with specific, innovative design of particular furnishings such as the type of paving of the roads and pavements, differing according to the kind of road and built environment, the surfaces of the road ramps, elements recalling the stylistic features of the pre-existing architecture, lighting, soundproofing at the most critical areas, and planting and arrangement of green areas. **The environmental arrangement was developed for both the final configuration of the works and the protection of the construction sites** during the building work, analysing different types of fencing with panelling and decorations and their precise application in the various places.

It can be seen ho the urban structure was the result of the work necessary for the reorganisation and development of the potential of the revitalised urban spaces including the elimination/reduction of the disturbance caused to other infrastructures, at the same time thus ensuring the greatest use, availability and attraction.

A consideration

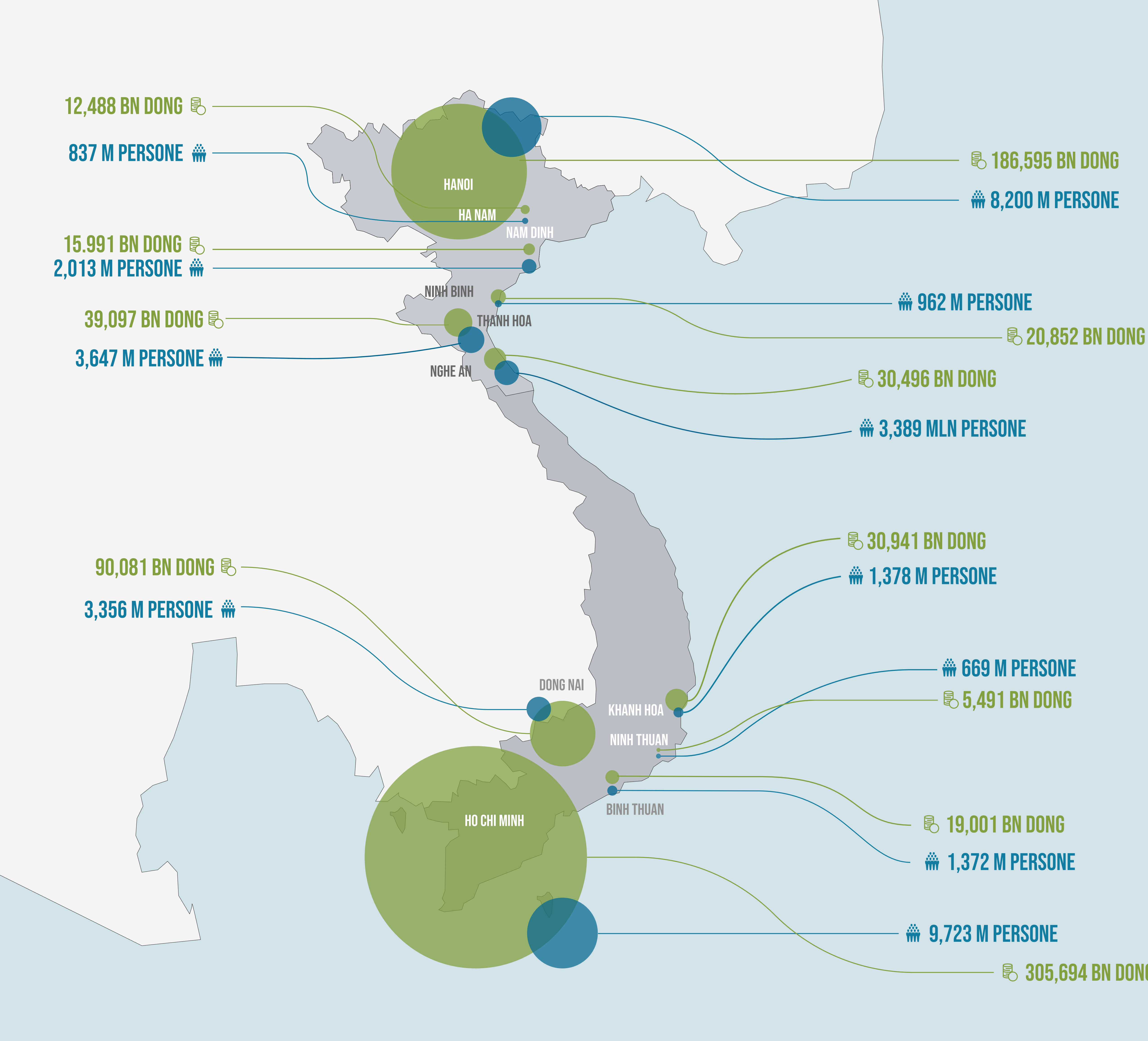
The Turin rail link project invites reasoning on the evolution of the role of the railway in urban centres. In the initial stage of building railway infrastructure in Italy, the station was often outside the urban agglomerate in suburban areas without buildings. However, the distance from the town centre progressively stimulated the construction of access roads, buildings for the work connected with transport services and those for travellers, and also residential buildings. The new urban fabric, generated by the station, therefore expanded until it joined the pre-existing historical one, causing these initially separate contexts to become 'town'. As a result, the positive feeling of "being what is connecting towns" that the inhabitants of railway tracks experienced became progressively imbued with negative feelings of "being what is dividing the town". At times, this became so marked that the previous, positive feeling, was cancelled. **Today, there is a growing demand from town and country to put the railway 'underground' to solve urban planning and local mobility aspects and eliminate level crossings.** However, the impact of such work is now enormous and the associated costs often discourage the idea of undertaking it.

3. Project layout



Porta Susa
Station

4.



The modernisation of the railway system in Vietnam

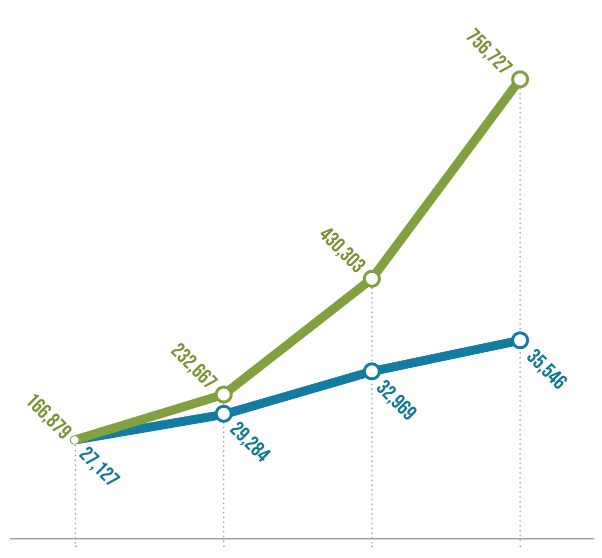
A strategy for the accessibility and integration of mobility for passengers and freight

Vietnam is a long country of not much more than 300,000 km2, about 80% of which is hills and mountains. It has two main cities – Hanoi, the administrative capital, and Ho Chi Minh (the former Saigon), the economic and financial capital, more than 1600 km away.

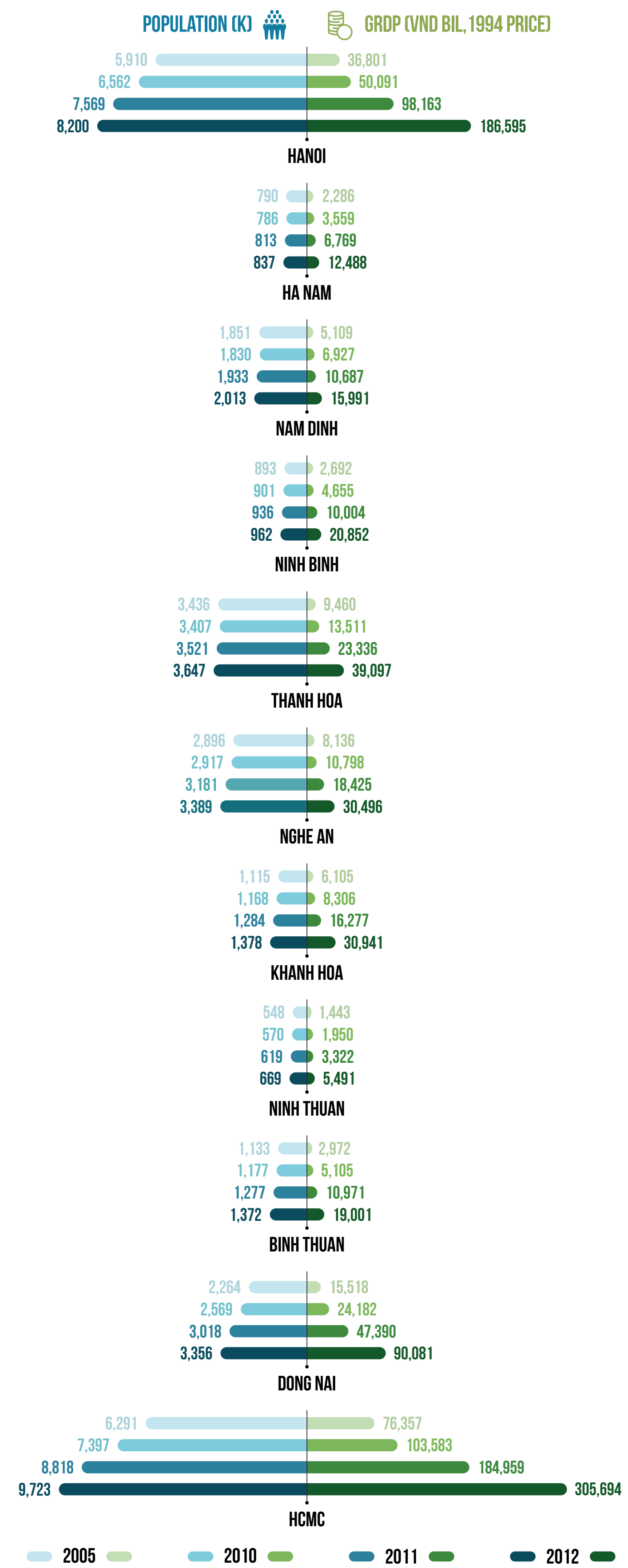
"From certain points of view, it has many features in common with Italy, especially if we think of the networks of national connections, the orographic difficulties and, for goods, the need for fast and frequent connections between the two 'capitals', also with the commercial ports along Pacific coast, a strategic relevance as a 'logistics platform' for the neighbouring inland countries. The tale of a pre-HS Italy."

From the infrastructural point of view, the railway system is the main national distributor and, for transport services, one of the potentially most relevant assets for promoting social-economic development in the interests of modernisation, ensuring international integration and strengthening regional cohesion. In this sense, the history of HS in Italy is a real experience with various similar elements.

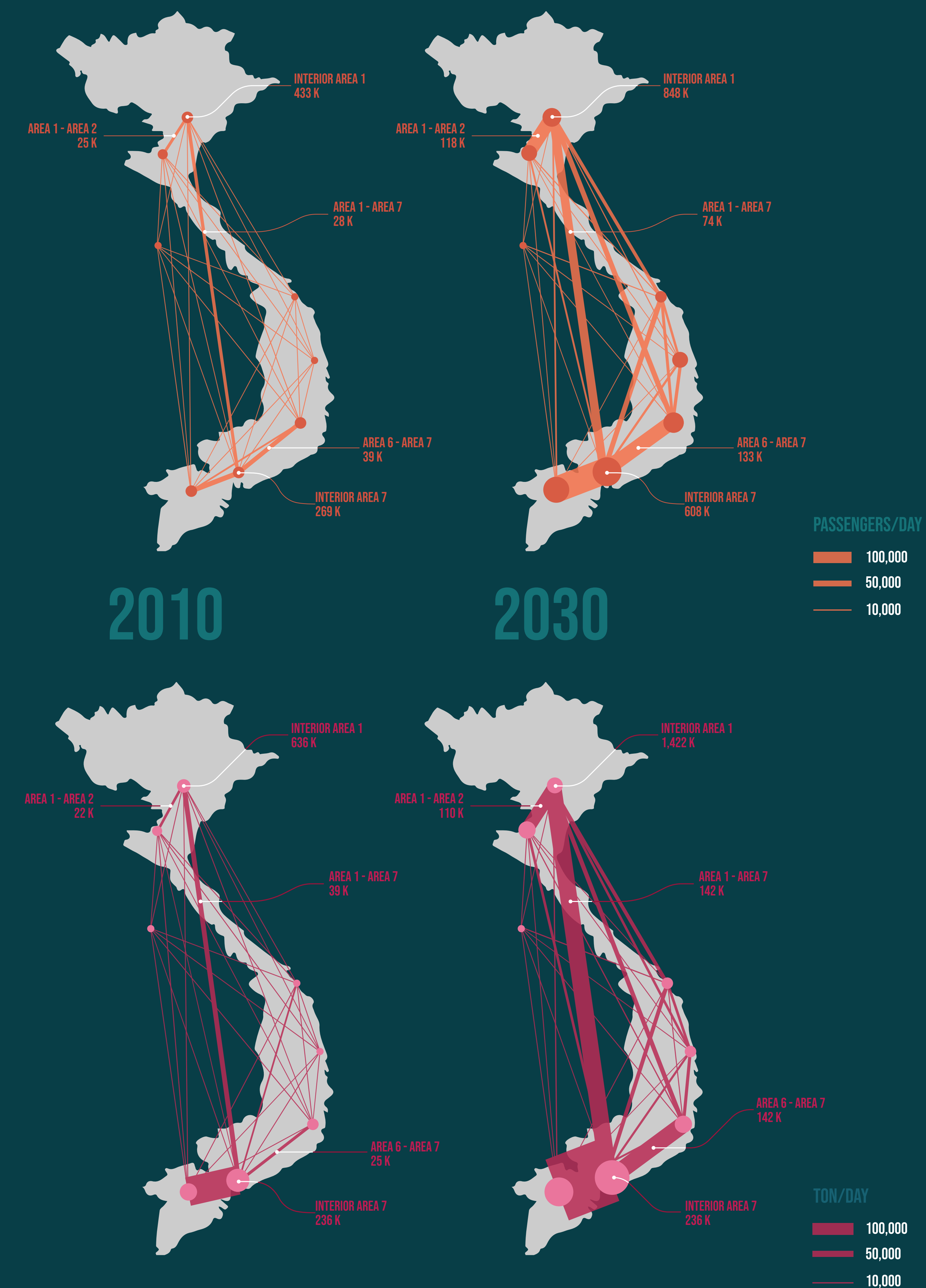
In this setting, the Vietnamese government set the aim of strengthening the **existing railway network in terms of increasing the revenue speed of passenger and goods trains, also with a view to efficiency and transport safety. This was why a specific technical-economic feasibility study that evaluates the optimisation, development and modernisation of the national railway network to sustain the achievement of these objectives in the medium period was needed.**



TOTAL SOCIO-ECONOMIC INDEX FOR MAJOR CITIES



SOCIO-ECONOMIC INDEX FOR MAJOR CITIES
LEFT-POPULATION (THOUSANDS)
RIGHT - GROSS DOMESTIC PRODUCT (VIETNAM DONG)



NET Engineering was concerned with developing the study within the scope of the co-operation between the Ministry of Infrastructure and Transport of the Republic of Italy and the Ministry of Transport of the Socialist Republic of Vietnam, as stated in the protocol of agreement signed in Rome on 22 November 2016. The initiative is in line with the decisions of Nguyen Tan Dung, the Vietnamese Prime Minister, on railway transport development strategies and general planning until 2020, with a time-frame projected to 2030-2050.

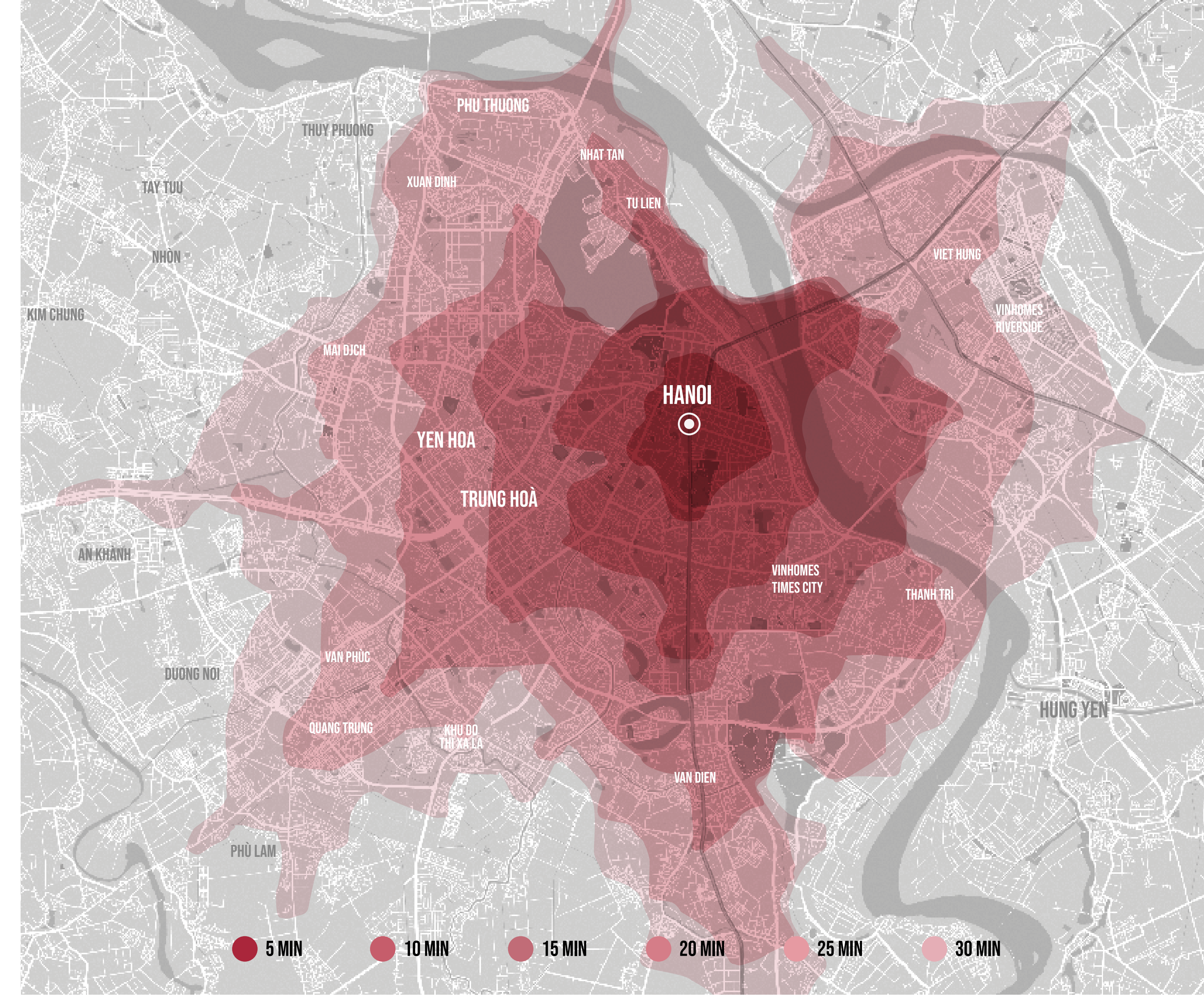
There were obviously many topics to consider with little space to deal with them:

- **Analysis of the context**, starting from a social-economic and geographical analysis providing solid elements on the estimate of the potential travel demand with respect to future time frames;
- **Assessment of** the most attractive **sections and services**;
- Study of the **new role of the main stations** of Hanoi and Ho Chi Minh as drivers for urban regeneration and motors for the increase in accessibility;
- **The new Hanoi railway station;**
- The analysis of the **proposals** for the new high-speed train station in Hanoi **in terms of supply and expected traffic.**

"Walking with difficulty through the streets of Ho Chi Minh, there are swarms of mopeds, an obvious, evident 'symptom' of an urban transformation that remains 'accessible' at the cost of being 'unsustainable'. A transformation which impacts everyday life and, clearly, mobility. A transformation which rapidly changes the 'shape' of the city.".

Traffic congestion in Hanoi: motorbikes waiting at a level crossing

1.



2.

Hanoi Main Station Accessibility: Public Transportation Network Isochrone map (min)

Effectively, the **feasibility study reconstructed the precise reference framework of the railway network structure from the technical, technological and infrastructural points of view**, checking the actual performance and assessing the feasibility and opportunity of some targeted operations. In addition, it investigated further the strategies for the **accessibility of the stations and the integration of mobility systems** and services with the railway system in the two main centres of the corridor, i.e. Hanoi and Ho Chi Minh.

However, above all, it created a 'common playground' for thinking about the north-south railway corridor, more oriented to passenger traffic (in competition with the current air traffic), and that from east to west, from Hanoi to the sea, which satisfies the requirements of demand for goods towards the port of Haiphong, both from the productive areas in the north of the country and the neighbouring China.

Railways in the Balkan Area

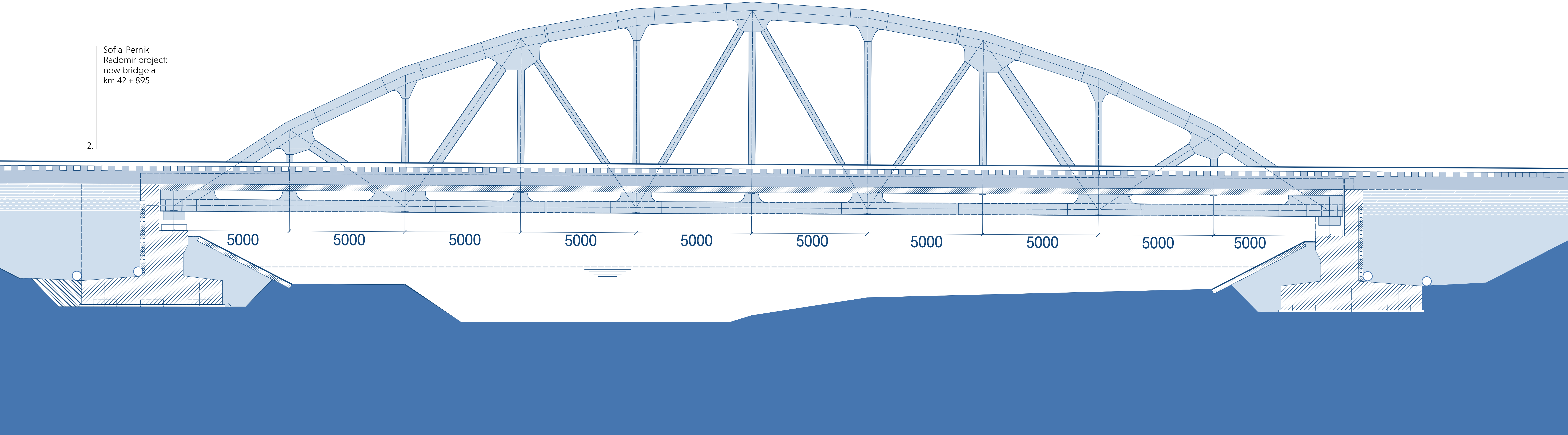
Where the mobility routes meet

The geographic area of the Balkans is particularly affected by new infrastructure that, for the railways, are part of the European Community programme for the development of a corridor system (Trans-European Network – Transport, TEN-T) able to make widespread connections between regions of the continent with highly varied technical and development features. In this context, NET Engineering was involved in the **construction of competitive railway infrastructure for Bulgaria to enable the country to deal with the EU challenges relating to the development of an overall Trans-European transport network** (railway, road, sea, river and air transport) aimed at ensuring the correct operation of the internal market and strengthening economic and social cohesion.

A far from secondary aim for 2014-2020 was to obtain complete interoperability of the different transport corridors that will help to attract more goods traffic and develop an international passenger transport service in the Republic of Bulgaria. Looking to what has been done for the Serbian city Niš, on the border with Bulgaria, with a particularly complex situation concerning the railway route which unites the city with the Bulgarian border, provides an excellent guide.

1.
Sofia railway station

2.
Sofia-Pernik-Radomir project: new bridge a km 42 + 895



The operations

NET Engineering was involved on three fronts in Bulgaria:

- The modernisation of the Sofia-Pernik-Radomir line;
- The modernisation of the Sofia-Plovdiv line – Sofia-Elin Pelin and Elin Pelin-Septemvri;
- The operational reactivation of the Ruse-Varna railway line.

The Sofia-Pernik-Radomir railway section is part of European Corridor 4 and is an essential section of the longitudinal route connecting Vidin, on the border with Rumania, the capital Sofia and the border with Greece. The project work concerned a series of operations to **strengthen the functional conditions of the railway infrastructure** (equipment, power supply network and civil infrastructure) **for a section of about 40 km.** In terms of local planning and design, the Sofia-Pernik-Radomir project had the absolutely new elements of a **TBM-excavated double-barrel railway tunnel of about 5 km and steel bridges with a significant span.** The tunnel, in particular, was accompanied by a significant, differentiated design of the safety and fire prevention systems respecting the legislative framework, international benchmarks and local regulations.

Another salient aspect of the project was the attention paid during both the analysis of the alternatives and the subsequent design stage to the **reduction of the environmental impact of the infrastructure** and the impact on the fabric of the existing settlement. Long stretches of the route are in urban contexts in the suburbs of Sofia and the industrial centre of Pernik.

In detail, the project sets out the creation of about 32.5 km of railway noise barriers localised and sized using a detailed acoustic forecasting model extended to an band of 1000 m around the new railway route to alleviate the noise caused by the operation of the line.

The work on the line introduced the changes necessary to allow railway services that satisfy the requisites for the TEN-T network. NET Engineering's project is part of a wider investment programme which includes the creation of the Sofia-Dragoman railway and the railway hubs of Sofia and Burgas planned by the European Commission.

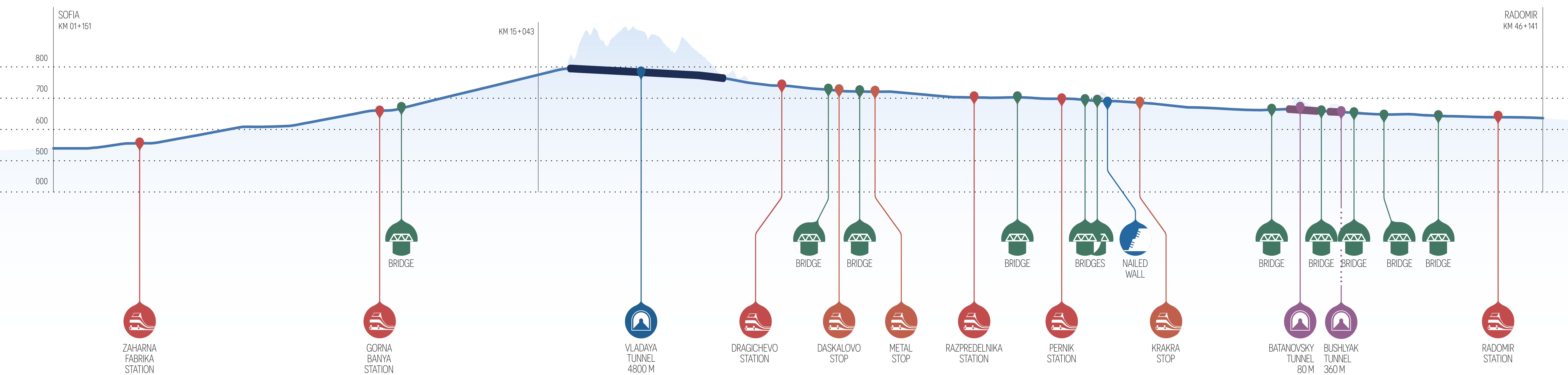
A similar enhancement operation is also in progress for the **Sofia-Elin Pelin and Elin Pelin-Septemvri sections of the Sofia-Plovdiv line**, which are part, respectively, of European Corridor 4 from Dresden/Nuremberg to Istanbul and Corridor 8 from Durazzo/Valona to Varna/Burgas. The modernisation was a priority of the operational programme for transport 2007-2013.

The existing Sofia-Septemvri railway line was already electrified for approximately 103 km. The consortium, led by NET Engineering, is providing the technical, administrative and procedural support on behalf of the customer in relation to the assignment of the technical design services and the construction work managed in six different work contracts. In the north-eastern area of Bulgaria, NET Engineering led the operational reactivation work of the **Ruse-Varna line** with an extension of about 230 km. This is strategically essential both nationally and at European level and the route will make transport fluid and effective on the railway line that is the shortest connection between the Black Sea area and bordering member states in Central and Eastern Europe, connecting Pan-European Corridors 7, 8 and 9.

In detail, Ruse station is a leading railway hub for south-east Europe as it not only connects the Danube river port of the city to the sea port of Varna on the Black Sea but also manages the national connections with Sofia and Plovdiv and the international ones with Bucharest, Istanbul and Rumania.

Longitudinal profile with indication of the design interventions

3.

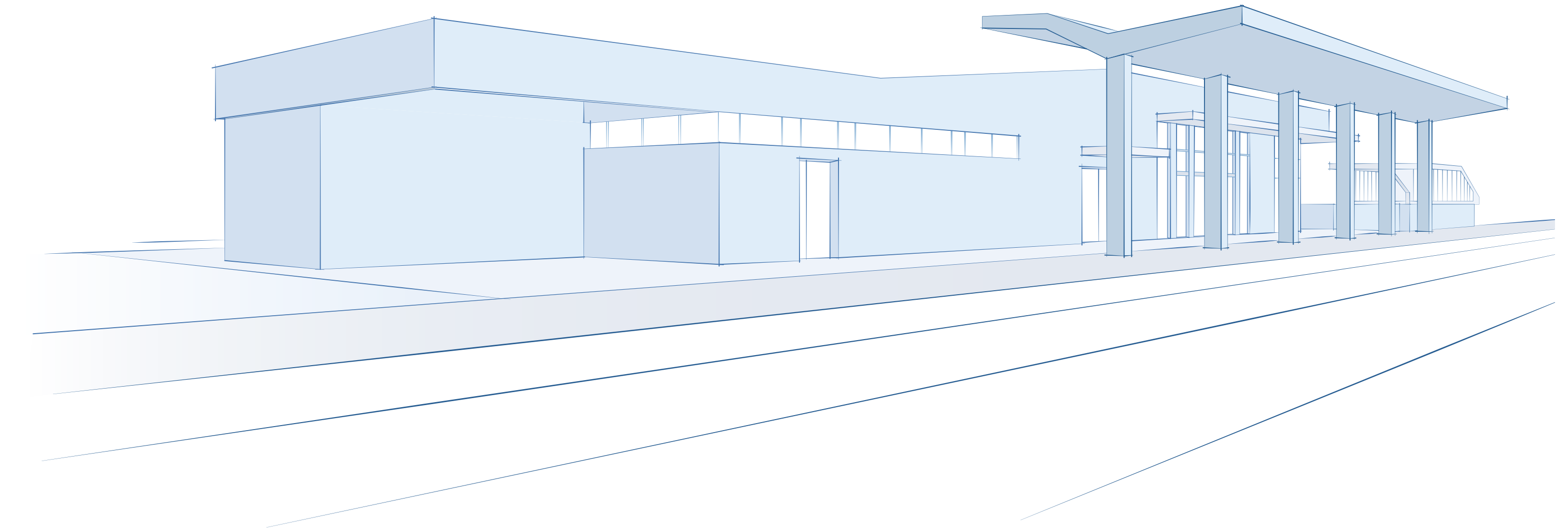


NET Engineering in Serbia with the Nis Railway Loop

The Nis transport system had a problem of increasing traffic that the railway network of 2015 was no longer able to sustain because of its infrastructure limits. The city is crossed by 8 railway lines with more than 260 trains a day of which 68% are freight trains. This situation is very complex and constantly evolving – the traffic will increase by 57% by the end of 2020. Niš is also crossed by Corridor 10 of the TEN-T network made up of the international E-70 and E-85 lines connecting Paris with Istanbul and Budapest with Athens.

The lack of investment for the development of an adequate road and railway infrastructure network had led to 51 level crossings which caused traffic congestion that reduced the average speed of vehicles. All this translated into inefficient road and railway transport services and an increase in the 'black spot' critical points with an accident risk. Over time, this had a negative influence on the performance of the Serbian railway network, no longer competitive compared to other methods of transport (both freight and passenger). Further, considering the expansion of the city into areas near to the existing railway lines, space and functional conflicts had been generated with resulting negative effects on the environment and population.

The project developed by Net Engineering for the European Delegation to the Republic of Serbia set out **the creation of a new railway loop around the city able to ensure greater efficiency of public transport and a consistent reduction of private traffic.** The new railway bypass was designed to absorb all the freight traffic on one hand, to relieve the town centre of the current problems of congestion, noise and pollution, and, on the other, promote the high development potential of Niš and its neighbouring areas.



5.

Architectural design of the Niš station

It was decided at the planning stage to examine alternative routes, including some outside the corridor set out in the planning documentation from Niš, so that the high construction costs caused by the importance of some of the works could be reduced.

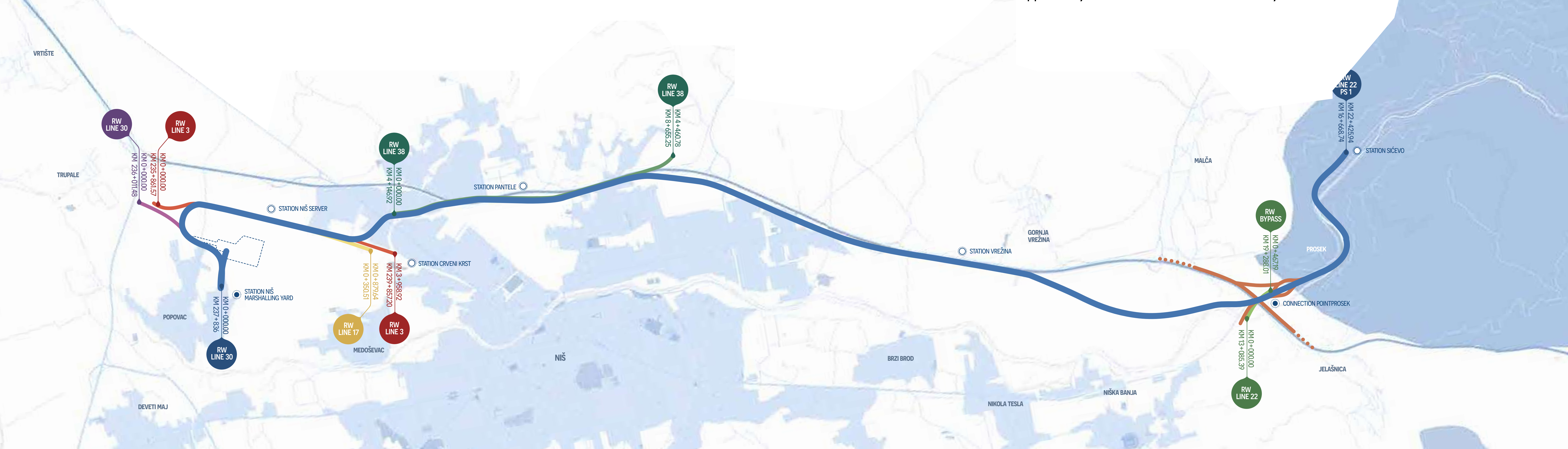
Thus NET Engineering was called on to **develop an alternative plan with fewer works which, as a result, was more economic.** As the new route proposed was outside the planned corridor in its final part, Niš had to update the planning documents and submit the new design idea to the townspeople. **Public engagement** is a standard process in the Serbian Republic.

Round tables open to the public **were conducted for the presentation of the new route. As a result of these, a design idea was outlined, and then created, that was shared and unanimously approved by the municipal administration and the townspeople.**

Prior to the assignment of the work, the design process had been suspended several times due to significant disagreement between Niš and the Serbian railways; over the years, this had caused the interruption of the project. The presence of NET Engineering and the other companies involved enabled **constructive talks to begin between the disputing parties and a shared choice to be reached approved by both the administration and the railways.**

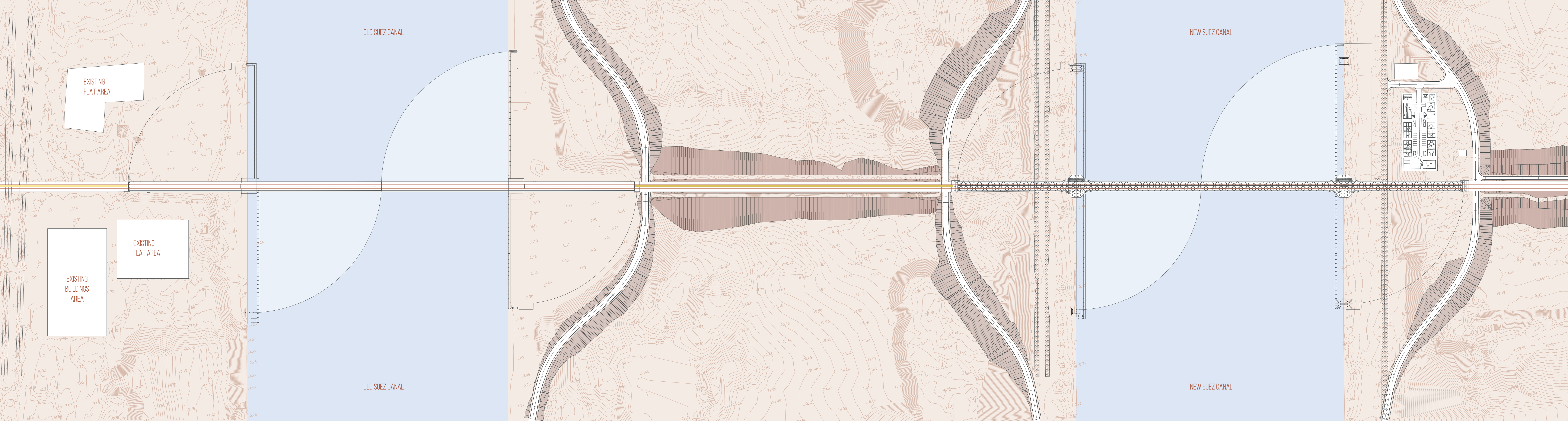
4.

General arrangement of the railway ring road around Niš



El Ferdan Bridge

Refurbishment of the railway line over the Suez Canal



1.

Intervention
area

El Ferdan Bridge, the longest railway swing bridge in the world, was built over the Suez canal in 2001. It fell into disuse in 2015 after the Canal was doubled. Today, it is undergoing important structural strengthening – loans obtained from the Egyptian government have enabled the refurbishment of the railway line due to the construction of a twin bridge and the doubling of the line. It is a very important project for the Egypt as the railway line using the El Ferdan Bridge is the only railway connection between Egypt and the Middle East.

The line could connect with the Jordanian railway network by crossing the Sinai, thus arriving in Saudi Arabia and then the United Arab Emirates and is part of a much wider project that aims at connecting all Arab countries together.

The project also has an important **impact on the social and environmental aspects** of the area. The Sinai peninsula is the poorest Egyptian region. Refurbishment of the railway would allow low-income families who without a car to travel long distances, promoting the start of local commerce. Therefore, refurbishment of the railway could encourage the population of the area, new businesses to prosper and so the development of the region.

Planning the railway line

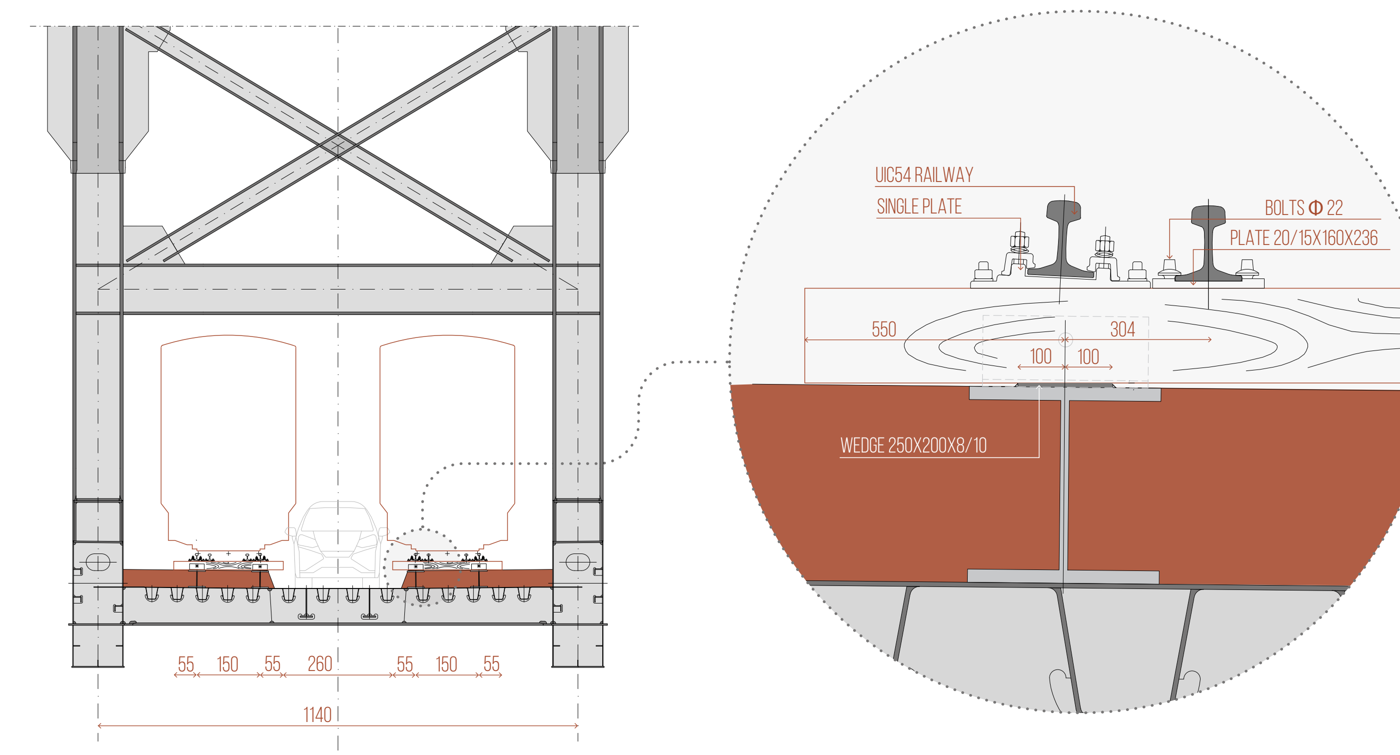
Reactivation of the line would also generate significant environmental benefits. Since 2015, the Suez Canal has only been crossed by roads and therefore all goods moving from Egypt to the Arab peninsula and vice versa only move by road or by ship. **The railway would, therefore, be a specially important alternative for the more sustainable movement of goods over long distances.**

In this context, NET Engineering **designed the railway line that crosses the Suez Canal using both the new and old bridges** as well as the refurbishment and modernisation of the sidings for waiting trains. As they have been unused for a long time, they need to be renewed and the capacity increased. As there are often important time restrictions on use of the bridge, freight trains wait in the sidings east and west of the Canal in the hours before the opening ready to cross it.

NET Engineering also took care of the updating of the railway tracks of the existing bridge with the aim of planning a passable route with the two tracks and the optimisation of the structural reinforcement of the deck.

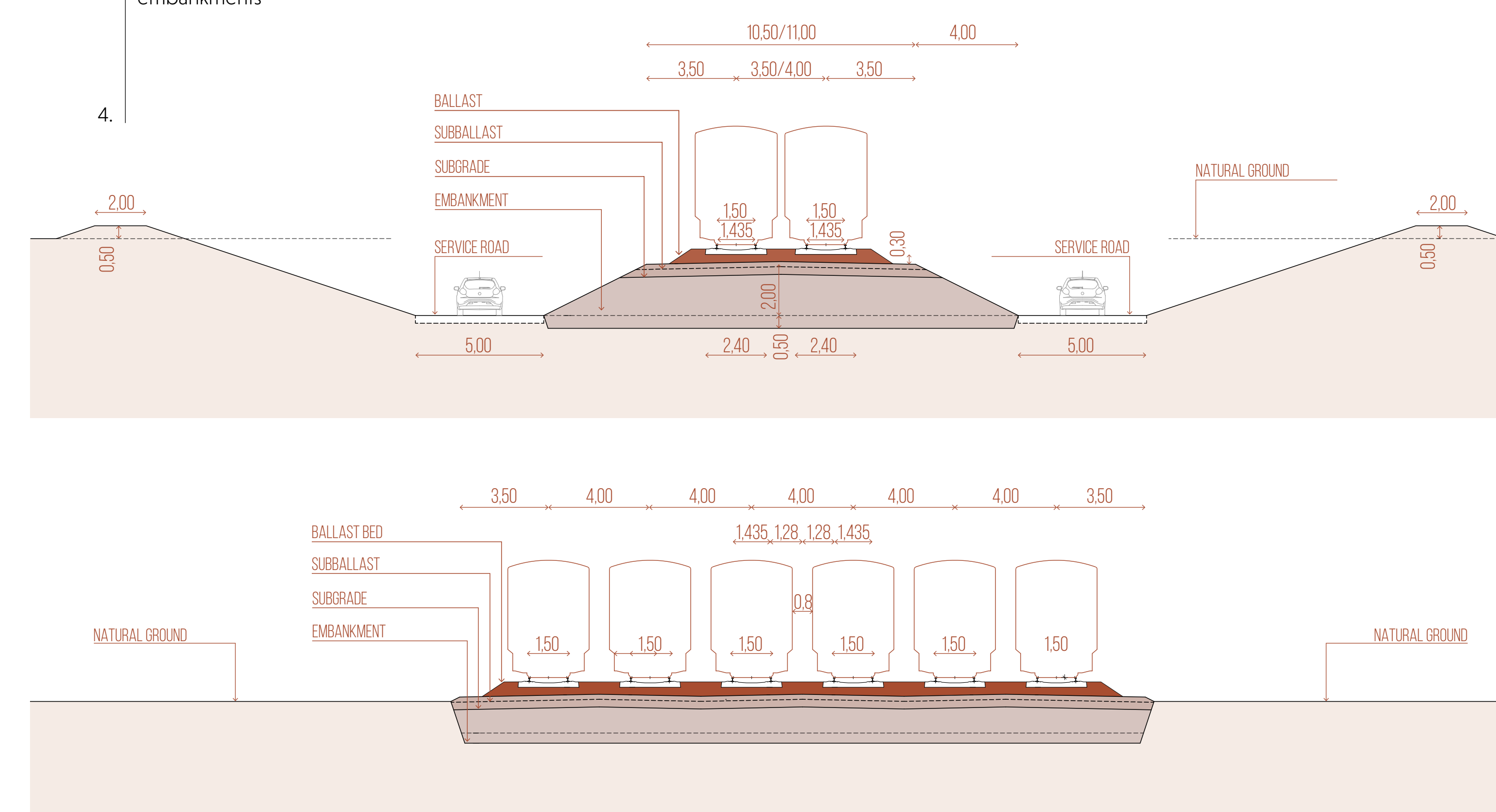
In detail, NET Engineering's work concerned the detailed design, railways tracks, earth movements, significant geotechnical operations and also assistance while the construction site is active (ongoing) until the work is completely finished. The study of the railways tracks on the two bridges was especially challenging – **the decks, designed according to specific Egyptian regulations integrated with the Eurocodes, are not conventional and different from each other.**

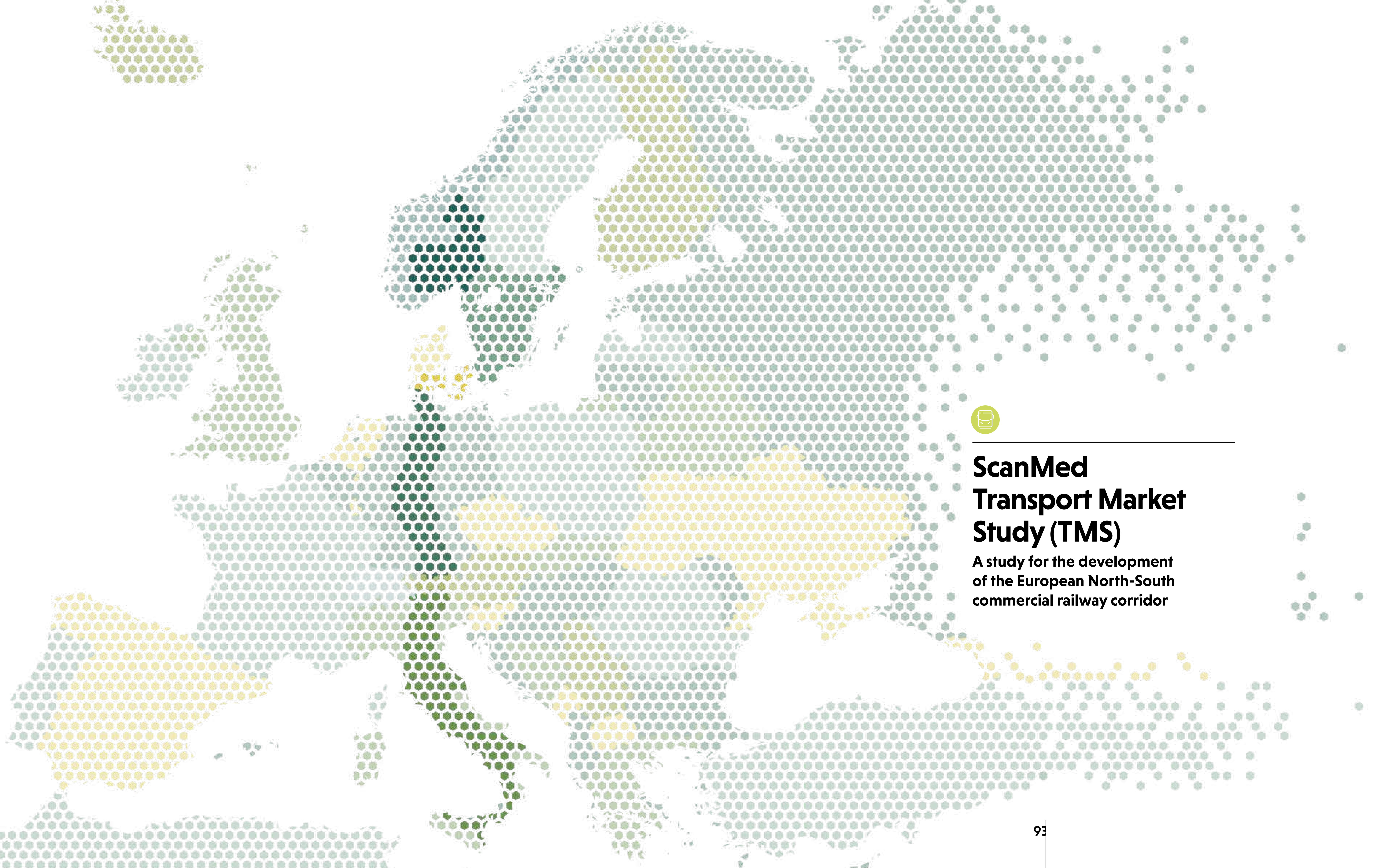
2. The old Suez Canal



3. Existing swing bridge equipment

4. Typical sections in trenches and embankments





ScanMed Transport Market Study (TMS)

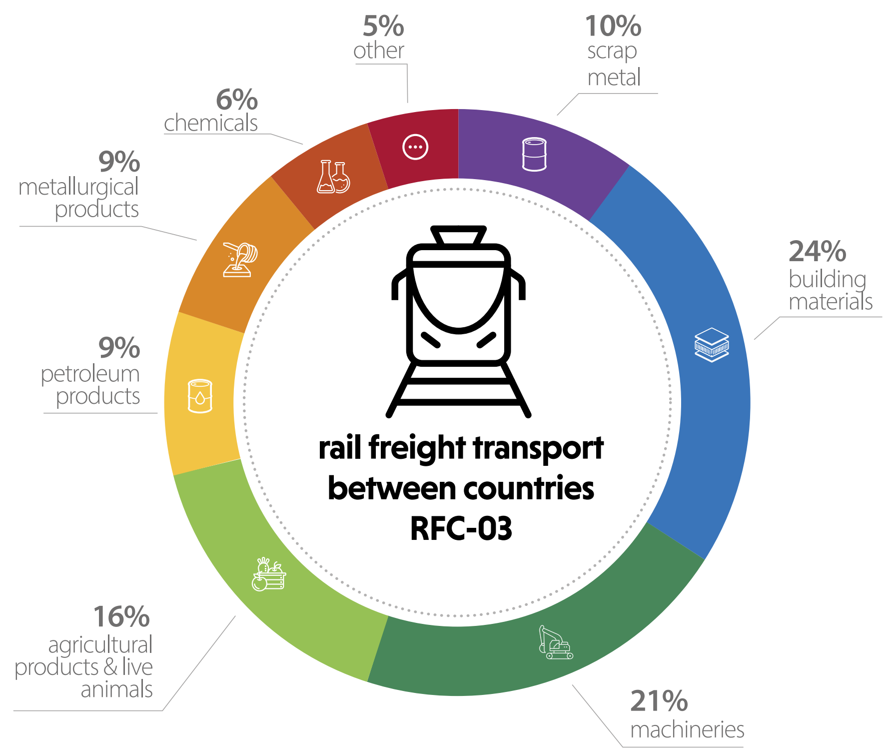
A study for the development of the European North-South commercial railway corridor

After recognising the relevance of the system of railway services for sustainable growth, the European Union implemented the first nine railway corridors for freight transport and a package of measures to improve the competitivity of railway freight transport on these corridors with Regulation EU 913/2010. The measures concerned technical, technological, infrastructural, legislative and regulatory aspects intended to facilitate the exchange of goods reducing the costs of movement, times and procedures.

The Transport Market Study is a tool that enables the analysis of the demand needs of the various stakeholders in the countries crossed by the corridors, the indication of the critical points from the technical, economic, social and political (meaning transport policy) points of view, the current system performance to be checked and new estimates made in relation to the reference time frames or when many of the large-scale works in progress have been completed.

Against this background, and in the sphere of an international group of sector experts, NET Engineering developed the market study of one of the most relevant, longest and most complex corridors, that also has more critical points – **Rail Freight Corridor no. 3 (RFC 3) 'Oslo/Stockholm-Malmö-Copenhagen-Hamburg-Innsbruck-Verona-Palermo'.**

Consistent with the requests of the tender, the group consisted of experts from each of the countries crossed – a German (who was also concerned with the Austrian section), a Dane, a Swede and an Italian. A unique discussion experience with different approaches, different methods and different ways of relating to others.



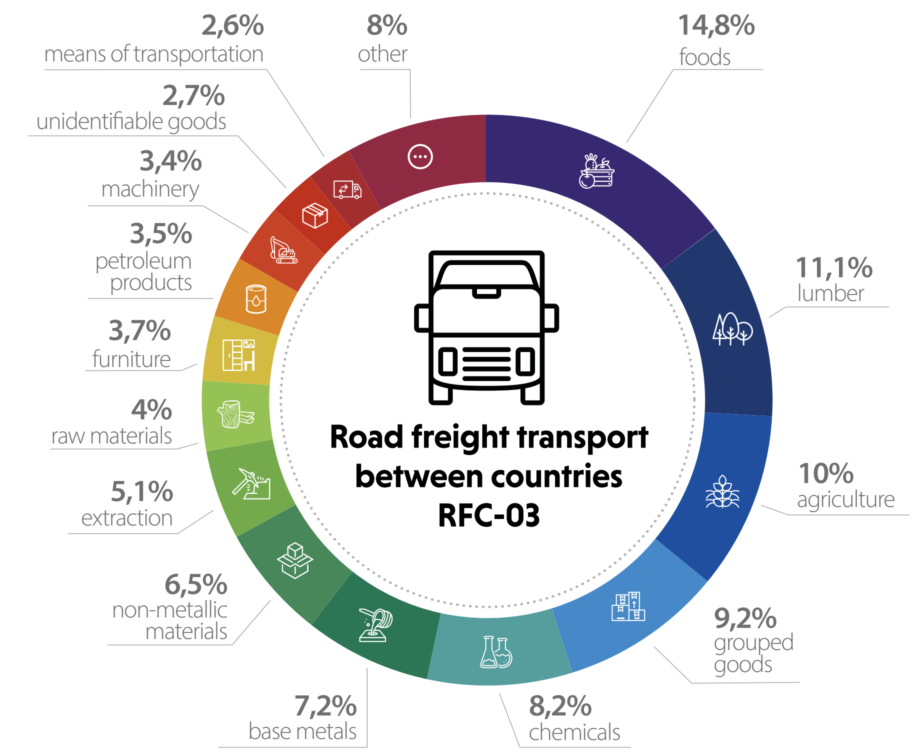
The study was essentially divided into various key topics:

- An assessment of the **current situation in the freight transport market and the forecast of development** for all methods of transport based on annual Eurostat data and social-economic trends (please note that the freight transport market, especially in Italy, is extremely fragmented and there are no sources of official data with enough detail for an in-depth study);
- Analysis of the strong and weak points, the opportunities and threats **(SWOT) of railway freight traffic in the corridor relating to how the implementation of alternative intervention scenarios could have marked railway freight traffic along it;**
- Definition of operational and **organisational action for railway freight traffic to improve the competitivity** of the railway sector and adequately satisfy the demands of the market.

The heart of the project was the organisation of **interviews** adapted to the stakeholders (logistic centres, port authorities and port operators, large production centres, logistic companies, railway companies, etc.) to understand their problems, needs and expectations. The interviews not only concerned aspects relating to current movement requirements and the needs and expectations for future time frames but also enabled a 'geography' of the choices, reasons, elements and criteria behind the dynamics of movement to be reconstructed.

These dynamics go far beyond the statistics and enable the numbers to be read from a new, wider standpoint which not only goes beyond national boundaries but sees the whole movement from the origins in the production sites of the Far East.

This was a profoundly Community project which explored the important topic of European mobility corridors including their dynamics, critical points and prospects for the future from the quality and quantity points of view.



Freight transport demand by road, rail and sea between RFC-03 countries (tons/year)

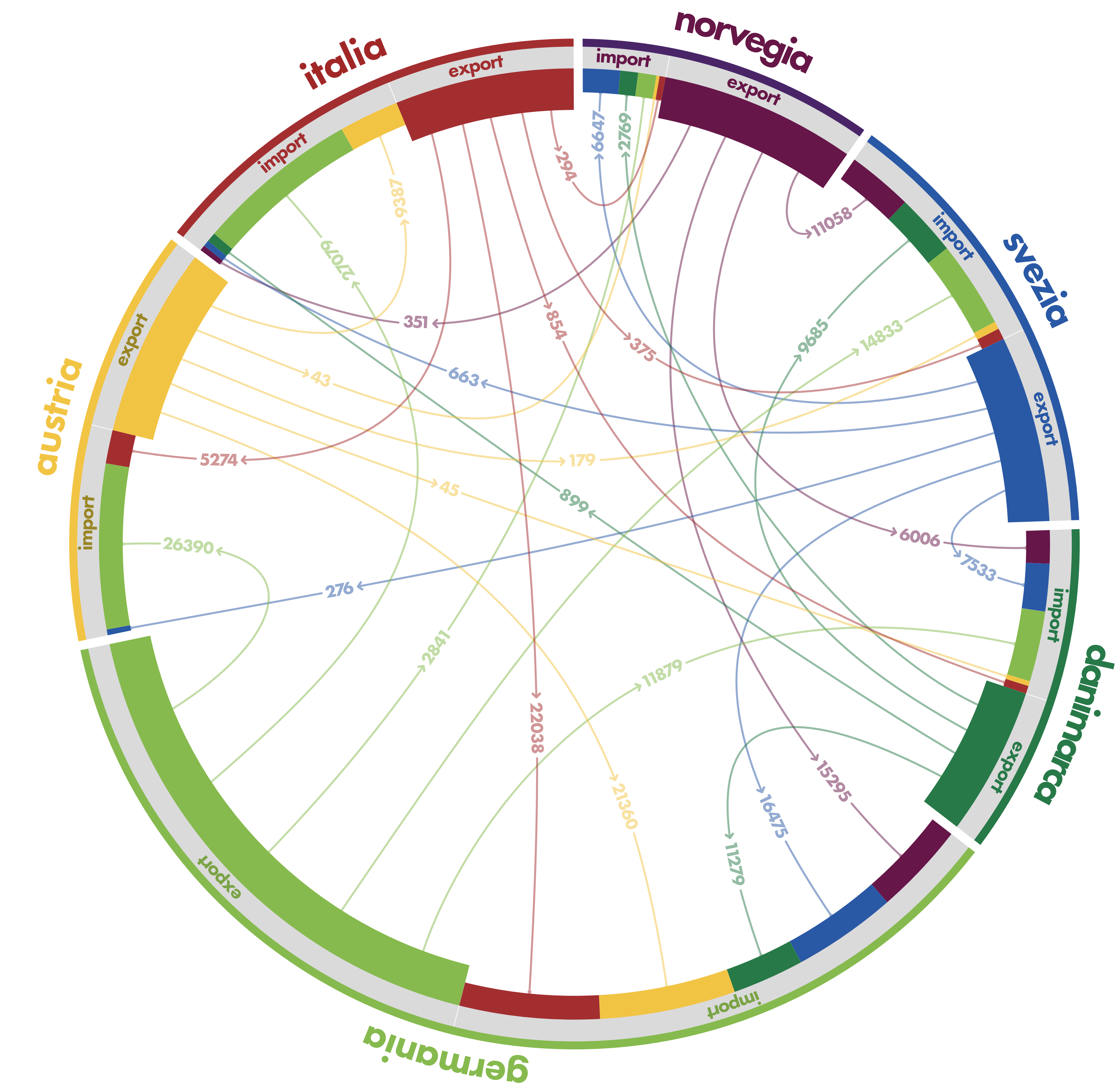
countries of discharge

loading countries	norvegia	svezia	danimarca	germania	austria	italia	total	shared
norvegia	•	1.738	1	26	0	16	1781	3,1 %
svezia	342	•	118	2.497	168	398	3.523	6,1 %
danimarca	1	39	•	84	n/a	693	817	1,4 %
germania	85	2.346	631	•	8.370	16.652	28.084	48,4 %
austria	12	135	n/a	7.083	•	3.256	10.486	18,1 %
italia	31	242	503	10.968	1.541	•	13.285	22,9 %
totale	471	4.500	1.253	20.658	10.079	21.015	57.976	100 %
condiviso	0,8 %	7,8 %	2,2 %	35,6 %	17,4 %	36,2 %	100 %	

loading countries	norvegia	svezia	danimarca	germania	austria	italia	total	shared
norvegia	•	3.767	539	290	n/a	n/a	4.596	5,2 %
svezia	4.168	•	1.299	1.173	108	92	6.840	7,7 %
danimarca	714	1.681	•	5.279	0	122	7.796	8,7 %
germania	375	1.350	5.839	•	18.020	9.538	35.122	39,4 %
austria	31	44	45	14.277	•	6.131	20.528	23,0 %
italia	n/a	n/a	110	10.470	3.733	•	14.313	16,0 %
totale	5.288	6.842	7.832	31.489	21.861	15.883	89.195	100 %
condiviso	5,9 %	7,7 %	8,8 %	35,3 %	24,5 %	17,8 %	100 %	

loading countries	norvegia	svezia	danimarca	germania	italia	total	shared
norvegia	•	5.553	5.466	14.979	335	26.333	31,1 %
svezia	2.137	•	6.116	12.805	173	21.231	25,1 %
danimarca	2.054	7.965	•	5.916	84	16.019	18,9 %
germania	2.381	11.137	5.409	•	889	19.816	23,4 %
italia	263	133	241	600	•	1.237	1,5 %
totale	6.835	24.788	17.232	34.300	1.481	84.636	100 %
condiviso	8,1 %	29,3 %	20,4 %	40,5 %	1,7 %	100 %	

Total freight demand between RFC-03 countries per year



A new player in the high-speed market in Italy

Study forecasting the passenger demand for the NTV S.p.A. service

In 2011, a great revolution in the transport world was about to take place in Italy – the network of High-Speed railway services was opening to the market in the light of the evolution of the European regulatory framework on transport services.

In this situation, Net Engineering was called on to **support the new service company Nuovo Trasporto Viaggiatori (NTV) in understanding the 'attackable' share of the railway market so that economic-financial objectives could be set and the strategies to achieve them established.** The aim of the study, which lasted several years, was to estimate the demand for mobility potentially interested in the services offered by NTV, and so its earnings, in terms of quality, service on board, timetable, pre- and post-journey accessory services. Basically, an ambitious, complex project in a situation very different from the current one where there was no private High-Speed service (Trenitalia operated in a substantial monopoly), fare-setting wasn't subject to market logics and the performance of the system wasn't yet 100% (the Florence-Bologna section was still incomplete). It was a project that should have provided answers to essential questions – who would change companies for better services by moving from Trenitalia to NTV? What was meant by 'better services' – better passenger reception, tastier meals on board, more pleasant, comfortable spaces in the station, more functional timetables, more accessible railway stations? And what fares?

The project was set in the wider context of multi-modal connections where, referring specifically to movements between Rome and Milan, flying had a significant role and the car was a valid alternative on some short-medium range motorway sections (Rome-Naples, Rome-Florence, Turin-Milan and Florence-Bologna). Therefore, there was also the assessment of the trade-off between the train and alternative methods of transport, particularly engrained in users' habits – who would leave flying for NTV and who would leave their car at home to climb onto a new train?

Lastly, the project also had to understand how passengers would have reacted to the new brand, a new train that had never been seen before, and pricing policies that no-one could imagine with any certainty. In particular, what countermeasures would the other transport providers (railway, air and road) have taken in terms of service, fares and sections managed?

However, **the greatest challenge of the project was to succeed in estimating the number of passengers of a rail service that had never existed in a competitive situation that still had to be understood and quantified.**

Speaking strictly technically, **the analyses were conducted by developing a system of mathematical models,** appropriately calibrated based on mobility surveys (interviews and counts) which, starting from the estimate of the origin-destination movement matrices for the various means of national transport, enabled the number of passengers on individual trains to be estimated in relation to alternative scenarios in terms of timetable, stops, fares, quality of the services offered, accessibility to transport terminals (stations and airports) for both public and private transport, and competitors' marketing policies.

"In such a large, complex city as Rome, for example, stopping at Tiburtina or Termini stations meant being attractive, or not, for a part of the city. Stopping at Ostiense could even influence competition with flying as it serves an area of the city closer to Fiumicino airport."

The methodological approach was rigorous, complex and effective, so much so that it earned publication in the "Ingegneria Ferroviaria" magazine (Railway Engineering, the official organ of the Collegio Ingegneri Ferroviari Italiani – Board of Italian Railway Engineers) **as well as various presentations in Italy and abroad.**

1. Treni Italo

The study was developed under the supervision of an International Scientific Committee made up of the top names in world transport planning, including Prof. Ennio Cascetta and Prof. Moshe Ben-Akiva of MIT, Boston.

For NET Engineering International, taking part in the NTV project meant being among the key players in the great HS revolution, a historic event which has profoundly changed the face of the national transport system and the Italian economy.

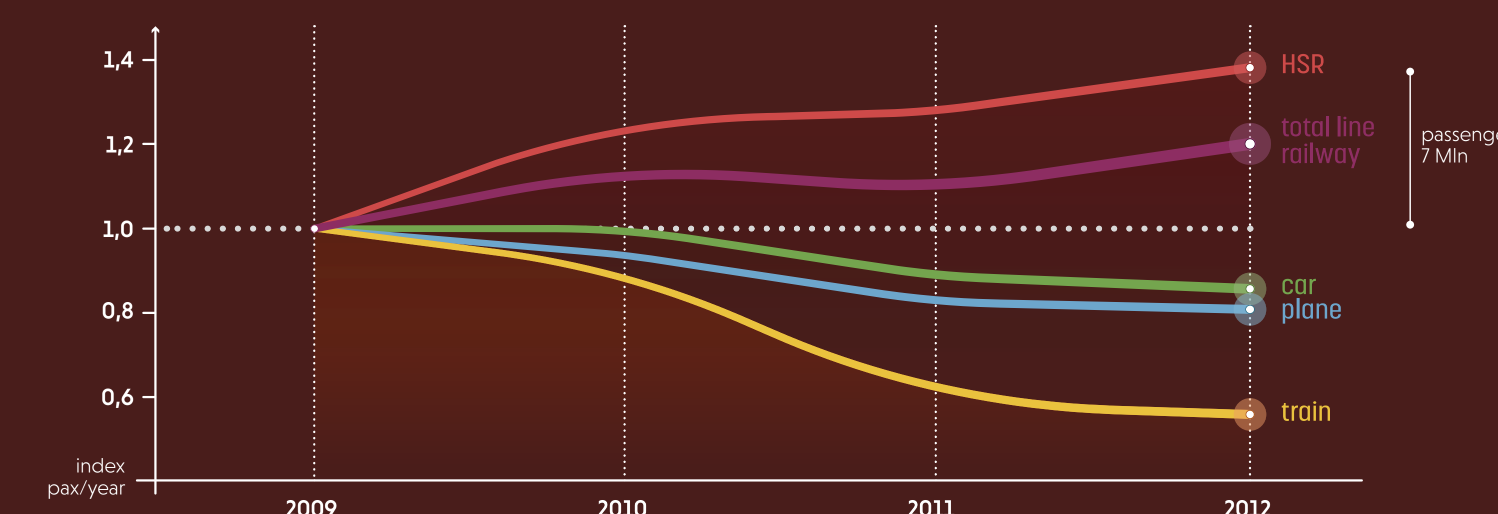
2. Estimated NTV train service: number of trains/day (pairs) on each route

High Speed Rail Market Study

Passenger-km in the core network

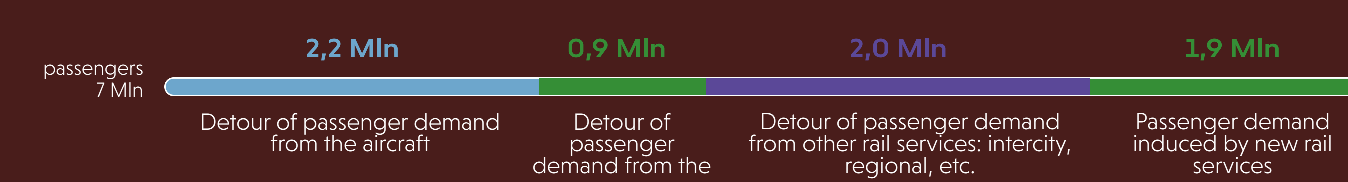
Passenger-km Roma-Milano

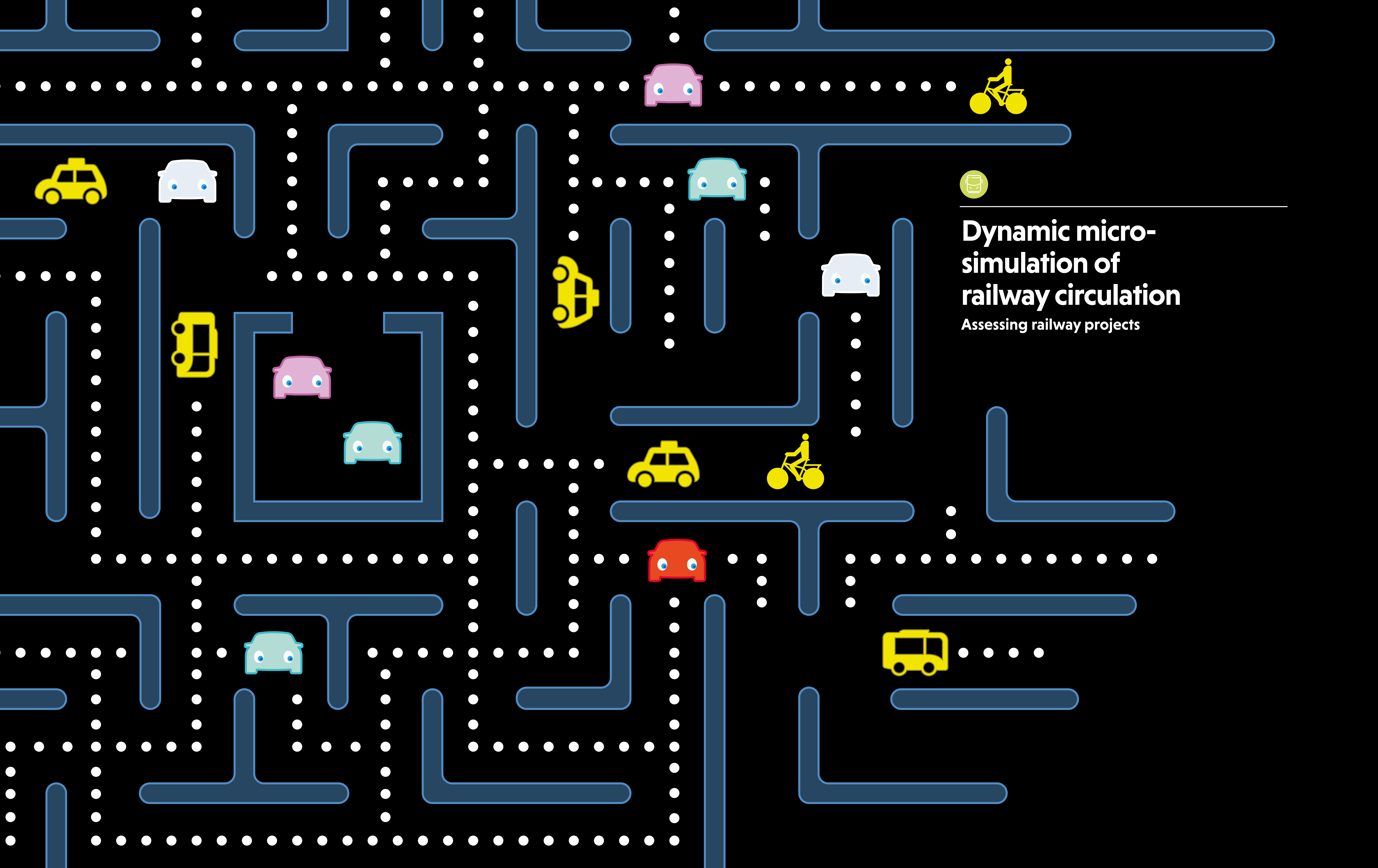
Estimated evolution of modal share due to new HS rail service (2009 - 2012)
Index number based on the year 2009



In the "core" network

HS rail service passengers to 2012
detour mode and induced demand





Dynamic micro-simulation of railway circulation

Assessing railway projects

Dynamic micro-simulation of circulation is a support for railway planning and design. It can be used for both infrastructure design and the definition of operating programmes, allowing checks to be made, bringing out any problems in achieving the planned functional and performance aims, suggesting possible optimisations and restoring an ex ante evaluation to the proposed design.

OpenTrack, the software used for micro-simulation and one of the most used internationally, gives a detailed reproduction of the dynamic behaviour of all the railway system elements like their mutual interaction, allowing analysis of all the technical-operational aspects of the railway circulation simulated.

Defining an operating programme

NET Engineering was responsible for the definition of a challenging operating programme, able to respect not only the client's requirements, mixed traffic with the overlapping of long-distance services with high frequency metropolitan ones but also the various constraints dictated by the specific nature of the infrastructure, in the sphere of the Marmaray suburban railway line (Istanbul, Turkey) project.

The result was an operating programme able to bring together the different requirements and circulation methods (mobile block for metropolitan services, fixed for long distance), achieve the planned frequencies (one train every 2'20'' in the central part of the rush hour), with a clock-face scheduling with frequency diversified between the rush hour and other times, and able to deal with the constraints of the infrastructure (uneven distribution the vehicle depots) and the operational requirements (fixed start-up and close-down times).

Development of the project with the support of the dynamic micro-simulation tool brought out the critical points underway, indicating and checking the corrections and suggesting optimisations. In addition, it provided analytical data at all steps on which to develop discussions with Turkish Railways, the ultimate client.

Comparison between design alternatives

For the Technical-Economic Feasibility Plan on doubling the track of the Bologna-Portomaggiore Servizio Ferroviario Metropolitano 2 (SFM2 Metropolitan Railway Service) line in the section between the Bologna via Larga and Budrio station stops, NET Engineering applied micro-simulation for an effective comparison of function and performance in the proposed alternative designs. A simulation model for each alternative was built in the software environment offered by the OpenTrack tool. The features of the infrastructure in the different project scenarios were created, assessing the effects on railway circulation using simulation models. In detail, an operational model was developed for each solution compatible with the specific project infrastructure scenario and as consistent as possible with the forecasts of the Bologna Metropolitan City Piano Urbano della Mobilità Sostenibile (SUMP - Sustainable Urban Mobility Plan) and the Metropolitan Railway Service (SFM), thus based on synchronisation and intensification in rush hours. **In this way, the most efficient and effective alternative was found, both quantitively and qualitatively, to make possible the levels of service set out by the planning tools, also indicating the essential integrations to optimise the project.**

Reconfiguring airport accessibility

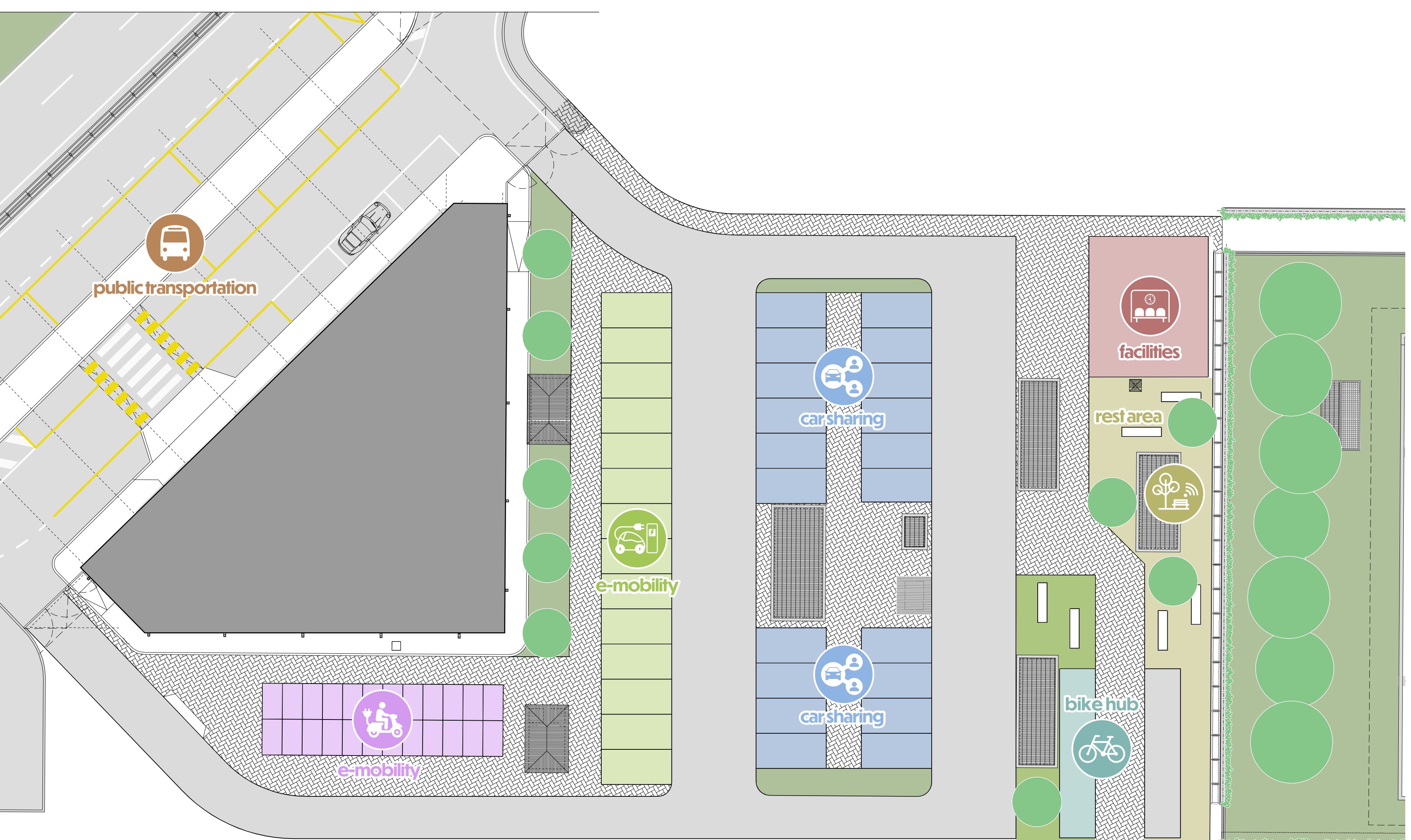
The system study for
Milano Linate

Milano Linate is one of the main Italian city airports able to react to the challenge launched by the great High-Speed revolution. Today, the airport is called on to respond to new challenges and new opportunities in a rapidly evolving reference economic, regulatory, transport and technological scenario, referring to both accessibility to the Milanese metropolitan and regional areas and the offer of innovative services that can answer the new requirements that future users may generate. In the future, the airport will not be just an access terminal to air services but it will be part of a wider regional setting featuring new manufacturing, commercial and residential sites. It will also be the access point to the city upon completion of Line 4 of the underground, whose terminus will be directly connected to the airport.

As a result, SEA (the group managing Milanese airports), in collaboration with NET Engineering, underwent a **system study with the aim of creating a support tool for strategic and planning decision-making processes ranging** from the analysis of the new short- and medium-term scenario, with the construction of the new underground line M4, and the technological scenarios that will have a direct influence on the innovative mobility services, people and goods. The aim of the study was, therefore, to **increase accessibility to the airport by the various transport methods, promoting sustainable mobility, ensuring safe pedestrian mobility inside the public land of the airport, supporting the section of mobility not strictly related to the airport but of interest in the regional context of Linate.**

Proposed layout of the Smart Mobility Hub and allocation of functions

1.



2.

Bike station example

A system approach

The system approach adopted by NET Engineering allowed the development of a project able to make two essential elements converse. First of all, the **real mobility needs that the design layout had to respond to.** Analysis of the floating car data, to understand how the parking areas are used, in addition to users' origins and destinations, enabled the effective decision on and organisation of the airport access roads. Secondly, **integration** of wayfinding, designed by Paul Mijksenaar, one of the leading wayfinding experts worldwide, **within the design process from the very beginning.**

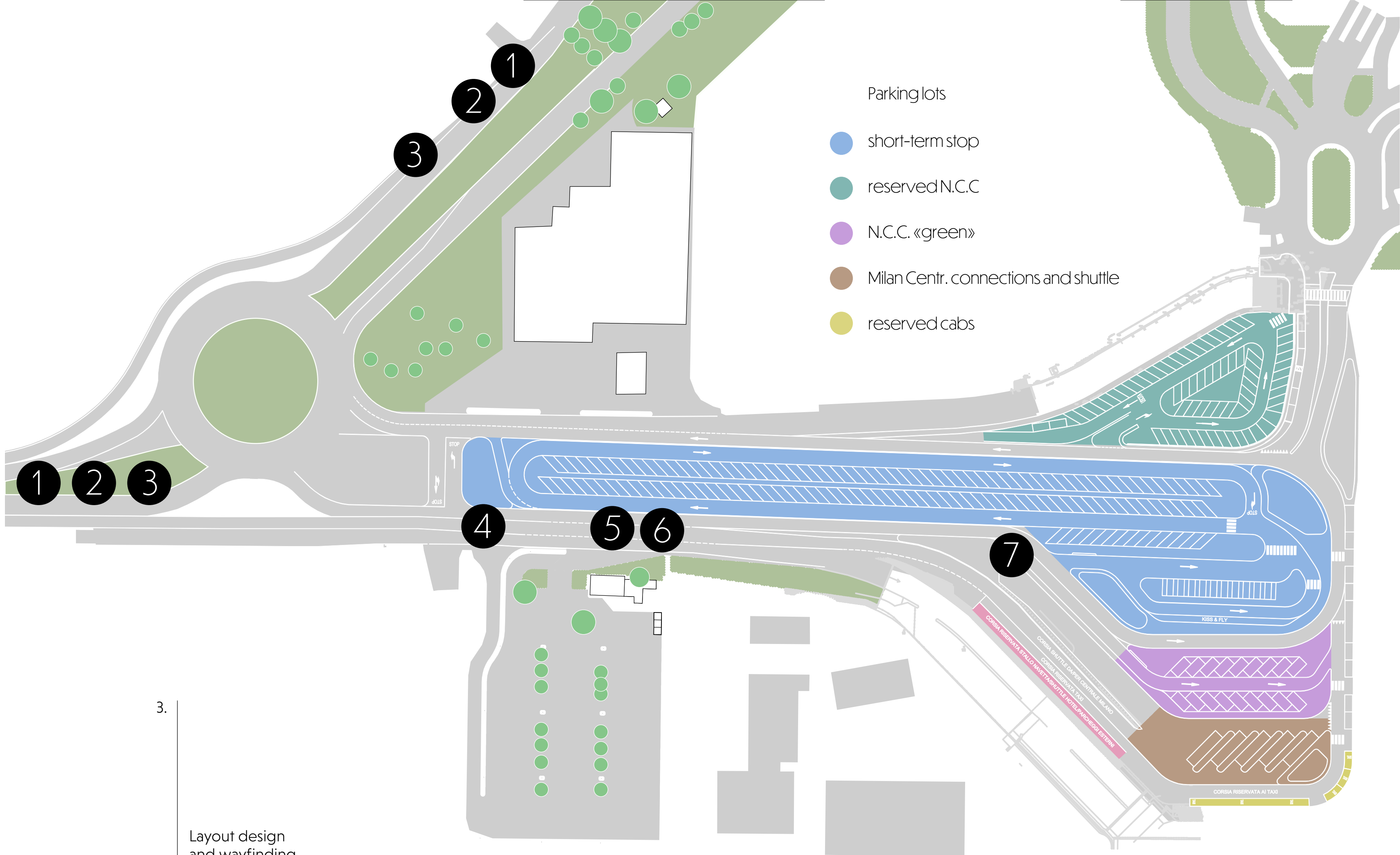
The signs were not designed after the mobility project, as often happens; on the contrary, the two design elements were developed together, integrating and thus generating a final layout with an optimal response to users' needs. Thus, the internal layout project, with the circulation diagrams, led to an integrated design of the airport access points, currently linked to the area of origin and not efficient for the internal road network.

Instead, the new layout sets out access roads differentiated according to the final destination in the public area (Drop off/Pick up points), modifying the plan of possible manoeuvres on access, rationalising internal routes and increasing safety for vehicles and pedestrians alike.

Smart Mobility Hub

The project interpreted Linate not only as a transport terminal but also a true **Smart Mobility Hub** with the aim of increasing its multi-modal accessibility. **A mobility platform with all the transport services** to and from the airport – taxis, public transport, car and bike sharing, electric mobility stands and, last but by no means least, the new underground. 'Linate' station of the M4 will not only facilitate rapid, sustainable mobility to the airport but will also become an intermodal centre for future residents of the area and Milanese who choose to use it in their free time, exploiting the nearby Idroscalo (seaplane base).

The planning of the Milano Linate Smart Mobility Hub led to the design of a layout not only able to meet the needs of current mobility services but also with the **necessary flexibility to host future forms of transport, thinking in the long-term.** Just to give an example, the layout of the Smart Mobility Hub can already welcome flexible, scalable, shared, autonomous and green mobility services or intelligent transport systems based on modular electric vehicles. As a result of discussion between the different engineering disciplines, the Milano Linate system study has enabled **redesign of the transport terminal, facilitating its accessibility and increasing the sustainability** through the adoption of design solutions that allow the maximisation of the benefits arising from existing projects and the extensive amplification of future ones.



3.

Layout design and wayfinding policies

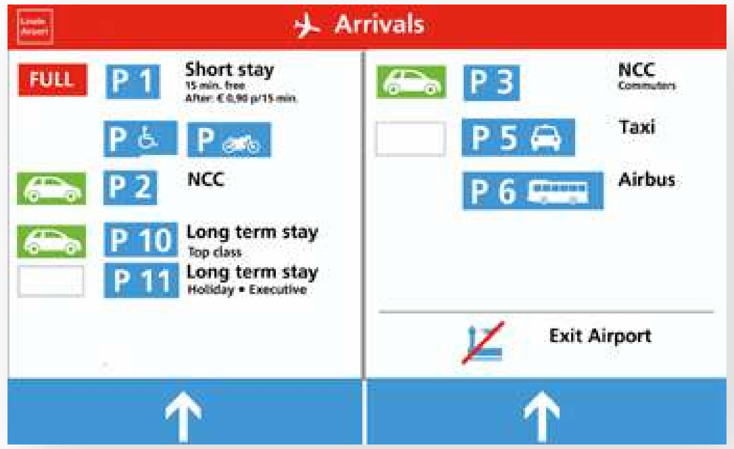
1. At the border between public roads and private airport territory

2. Information about the availability of parking spaces

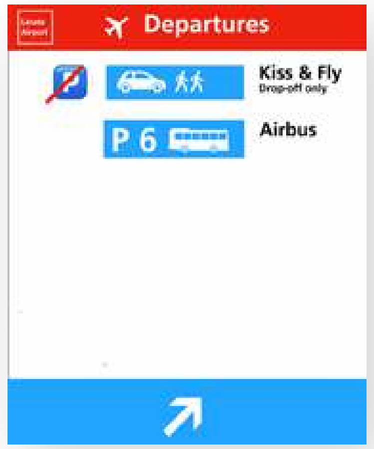
3. Roundabouts needs overview (map type) signs

4. Main decision points

5. Main decision points



6. Main decision points



7. Destination signs with parking space availability information

An innovative methodology to support strategic decisions

The accessibility study at Milan Malpensa airport

Air accessibility is an essential factor for the development of any advanced economy – the globalisation process has extended the social and economic context making maintenance of stable and significant contacts necessary to most of the world. The air accessibility of an airport is inescapably linked to landside accessibility, which is also a decisive element for its development prospects. From this perspective, the fulfilment of infrastructural operations moving towards guaranteeing better accessibility to airports and the strengthening of airports in extensive consolidated basins of traffic are an element that generates benefits to the system, causing significant growth in both passenger and goods traffic. In other words, **landside** accessibility is a qualifying element in the development of every airport and the growth of its air accessibility.

The general aim of the study developed by NET Engineering and the Politecnico di Milano for Milano Malpensa airport was to create **a support tool for decisions assessing the impact that work on the carrier traffic network may have on accessibility to Malpensa airport** compared to competitor airports and the three sectors of demand – long-distance passengers, medium-short distance passengers and goods. Therefore, the tool is a formidable database for careful analysis of the impact that the construction of the individual infrastructural works, or their functional adaptation, may cause to accessibility in a study area of Northern Italy, Southern France and Switzerland. The study deals with the topic on three timelines – 2025, 2030 and 2035 – for which the **evolution of the demand for movement was estimated, also correlated with the increase in the capacity of the airport.**

The innovative methodology marking the project was developed with the scientific co-ordination of the Politecnico di Milano, applying evolved algorithms estimating incoming and outgoing accessibility based on socio-economic indicators and network performance referring to extremely detailed zoning. The development of the analysis was divided into three stages, referring specifically to the indication of the reference context and its characterisation:

• **Identification of the study area**, with an extension to circumscribe the relevant airports (Bergamo, Bologna, Brescia, Geneva, Genoa, Milan Linate, Nice, Turin, Venice, Verona and Zurich) and correctly represent the mobility aspects in the study;

• **Analysis of programmatic framework**, A reference for the division of the scenarios following timelines and the type of operation in terms of conformation, maturity of the project, financing, etc.;

1 Identification of study area based on air market

Analysis of airport supply and selection of "relevant" competing airports based on demand segments;

Identification of current catchment area intersections based on access/entry times.

2 Context reconstruction and planned network interventions

Documents analysis of Plans, Programs and projects in the study area;

Identification of time horizons of interest and respective infrastructure development framework;

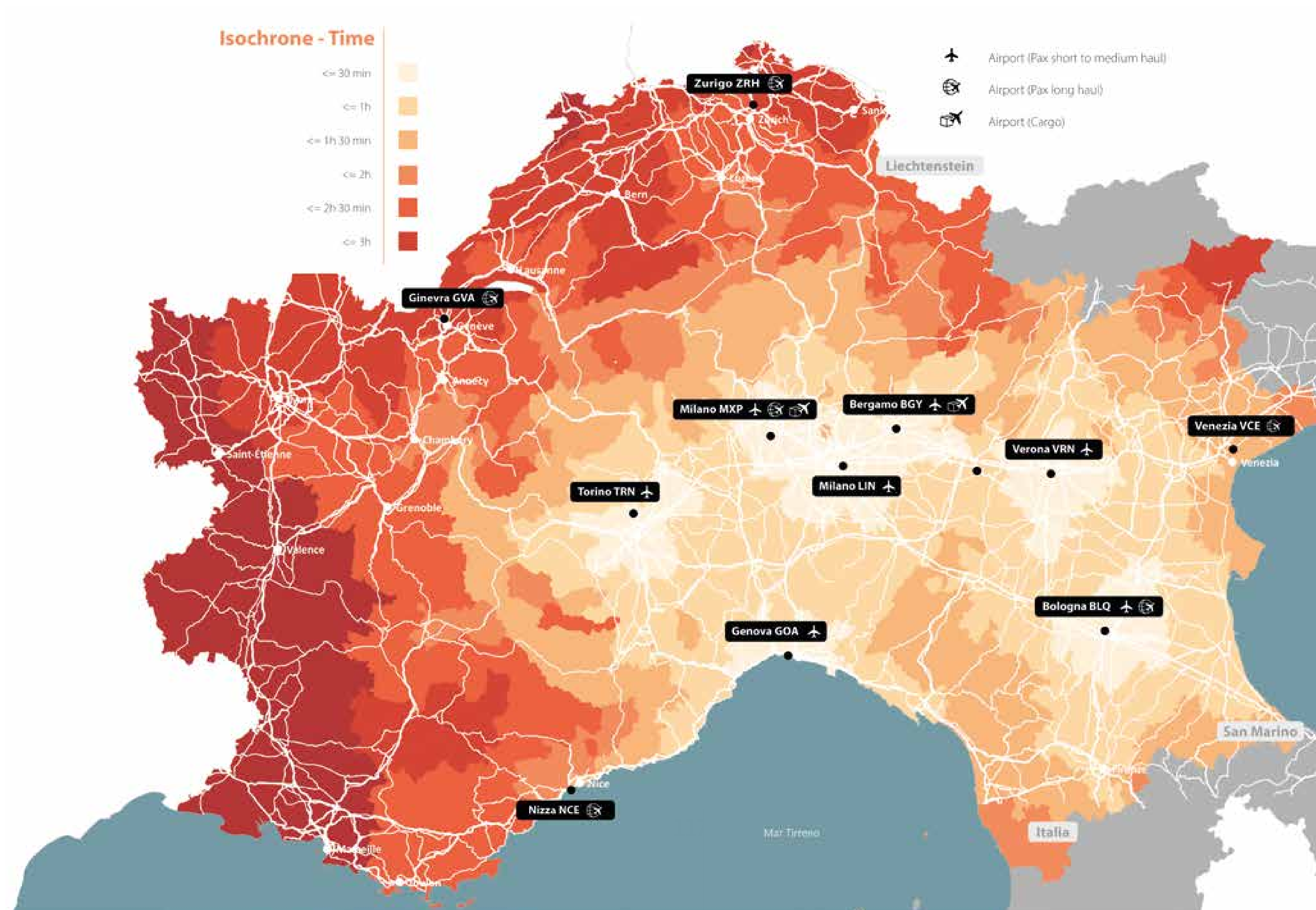
Definition of analysis scenarios.

3 Scenario analysis and identification of investment priorities

Calculation of (passive) accessibility indicators on the network for the airport selection for each scenario;

Assessments of impacts on accessibility as the basis for subsequent insights.

1. Envelope of isochrones for relevant airports: passenger segment short- to medium-haul

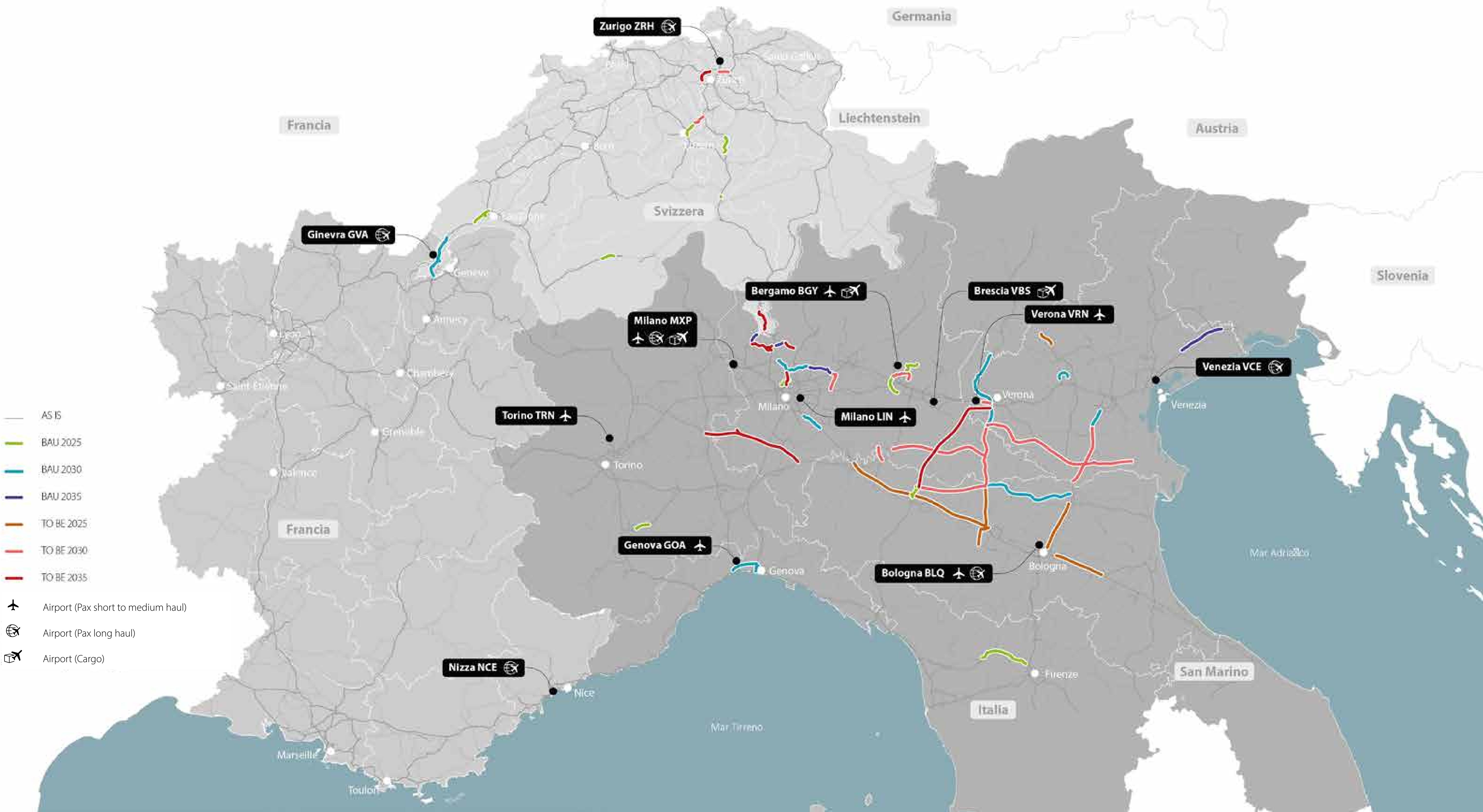


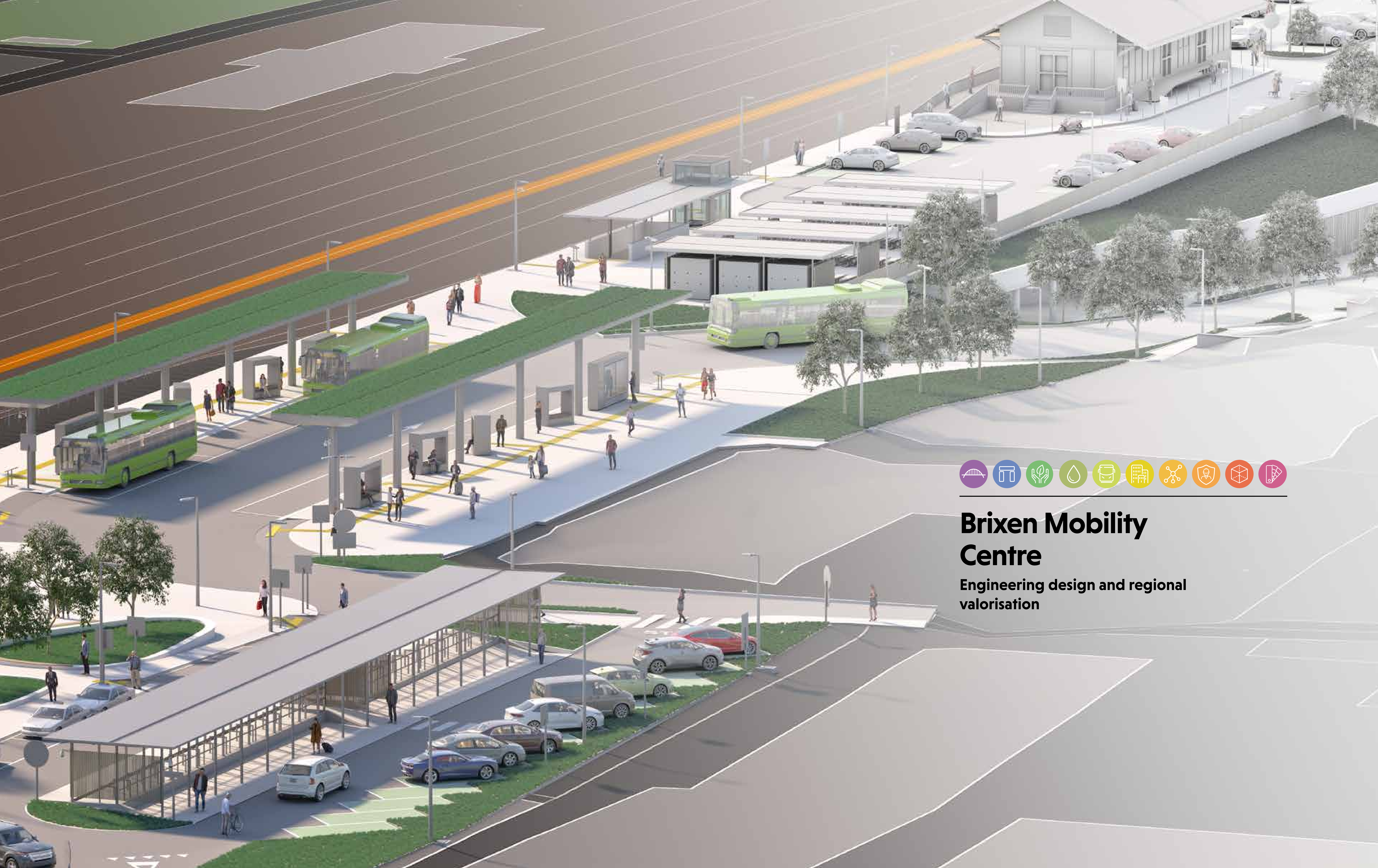
• **Definition of the relevant operations,** selection of only the modifications to the current road network that, based on proximity criteria, hierarchic level of the road concerned and level of financing reached, could have an effectively relevant impact on the accessibility indicators studied.

Thus, the project saw NET Engineering work with the client in the delicate process of **stakeholder engagement.** The discussion with the municipal and regional administrations, the collection, study and understanding of their doubts, finding an answer and a solution to those problems, and constant sharing of the planning choices and led to the **definition of a specific management approach and project management** appreciated by both the client and the other parties involved.

2.

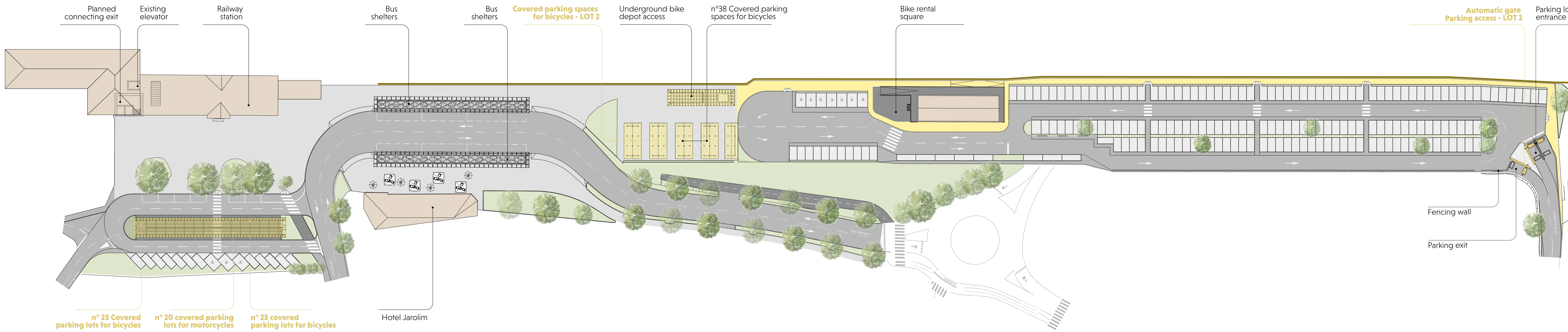
Overview of overall interventions: Time horizon 2035





Brixen Mobility Centre

Engineering design and regional valorisation



1.

Floor plan of the area

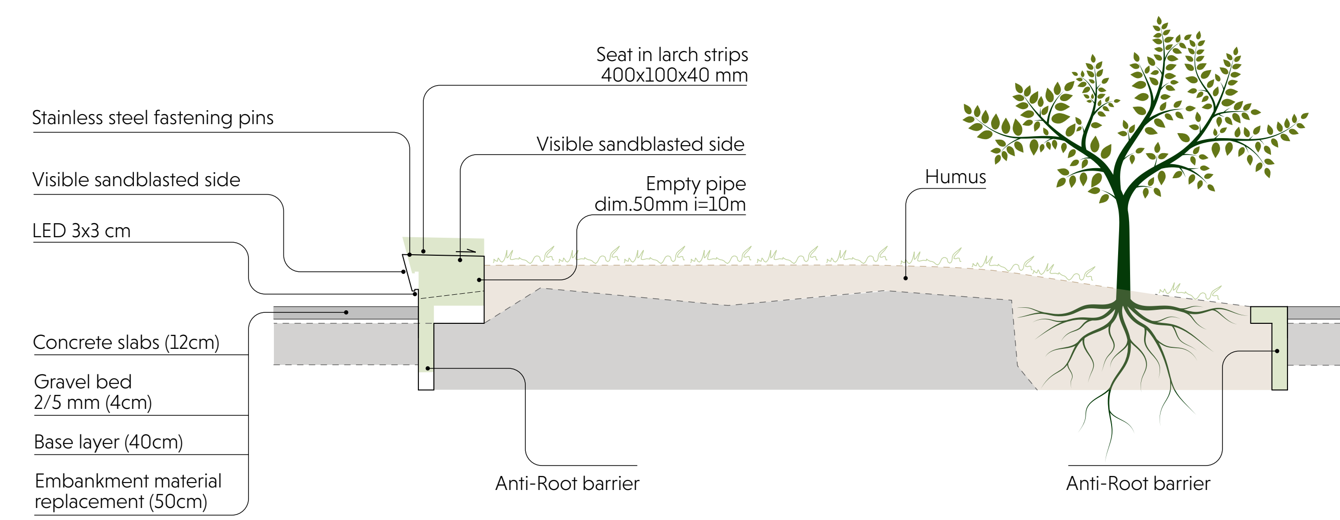
Bringing citizens closer to public transport as a real alternative to using private cars has been the target in Alto Adige for several years. As a result, there has been considerable investment to create and improve infrastructure throughout the province and implement a logistics concept which is easy for the citizen to use yet is also sophisticated.

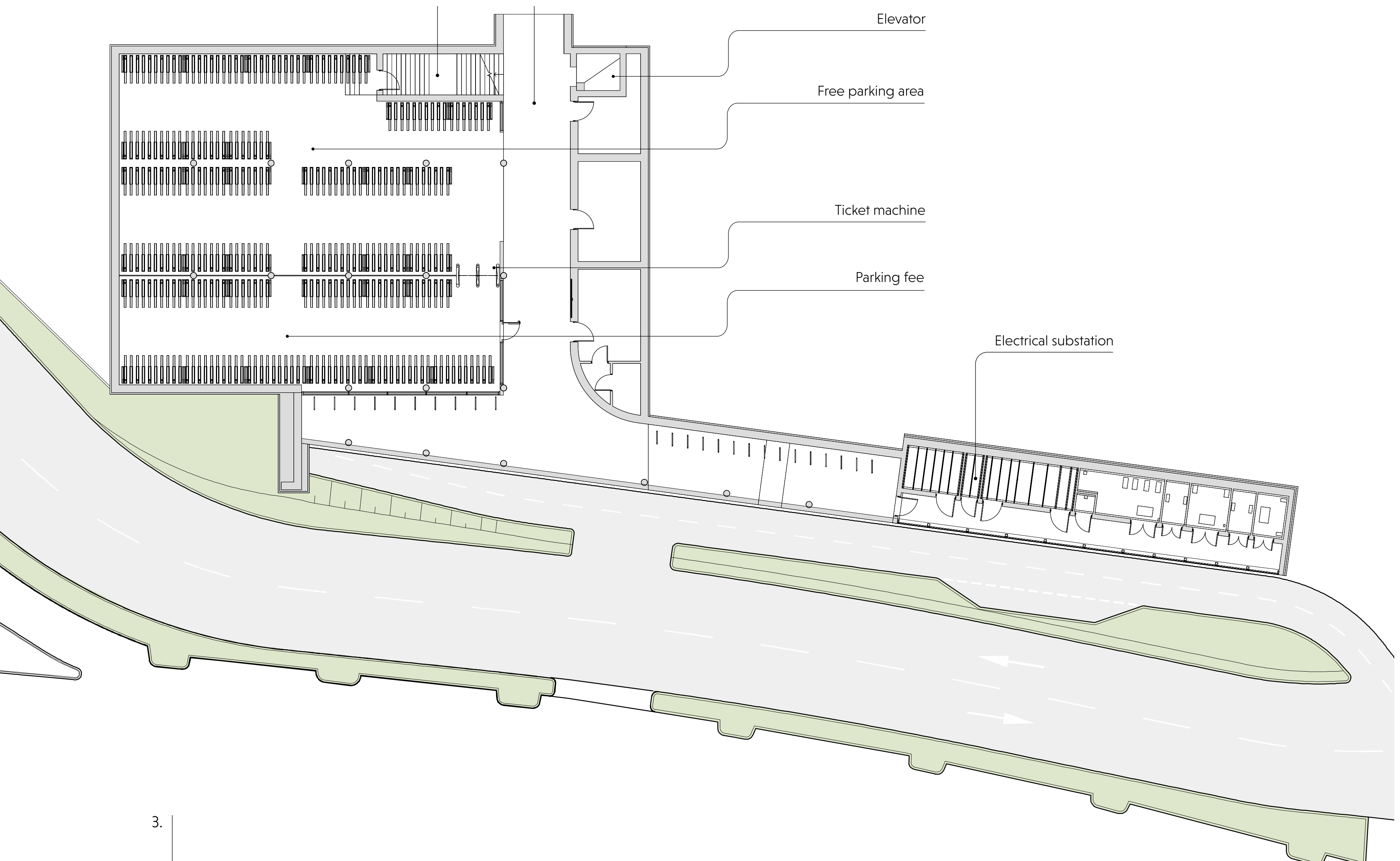
To simplify the change from private to public transport, the creation of an intermodal centre was planned for the most important local stations with the aim of ensuring movement between types of transport as fluid and simple as possible..

This was the direction followed for the development of the **Technical-Economic Feasibility Project, the Final Design, Working Drawings and Works Direction of the new Intermodal Centre at Brixen (BZ) railway station, conceived not only to strengthen the public transport offer but also, and mainly, to considerably improve the**

Green area detail

2.





3.

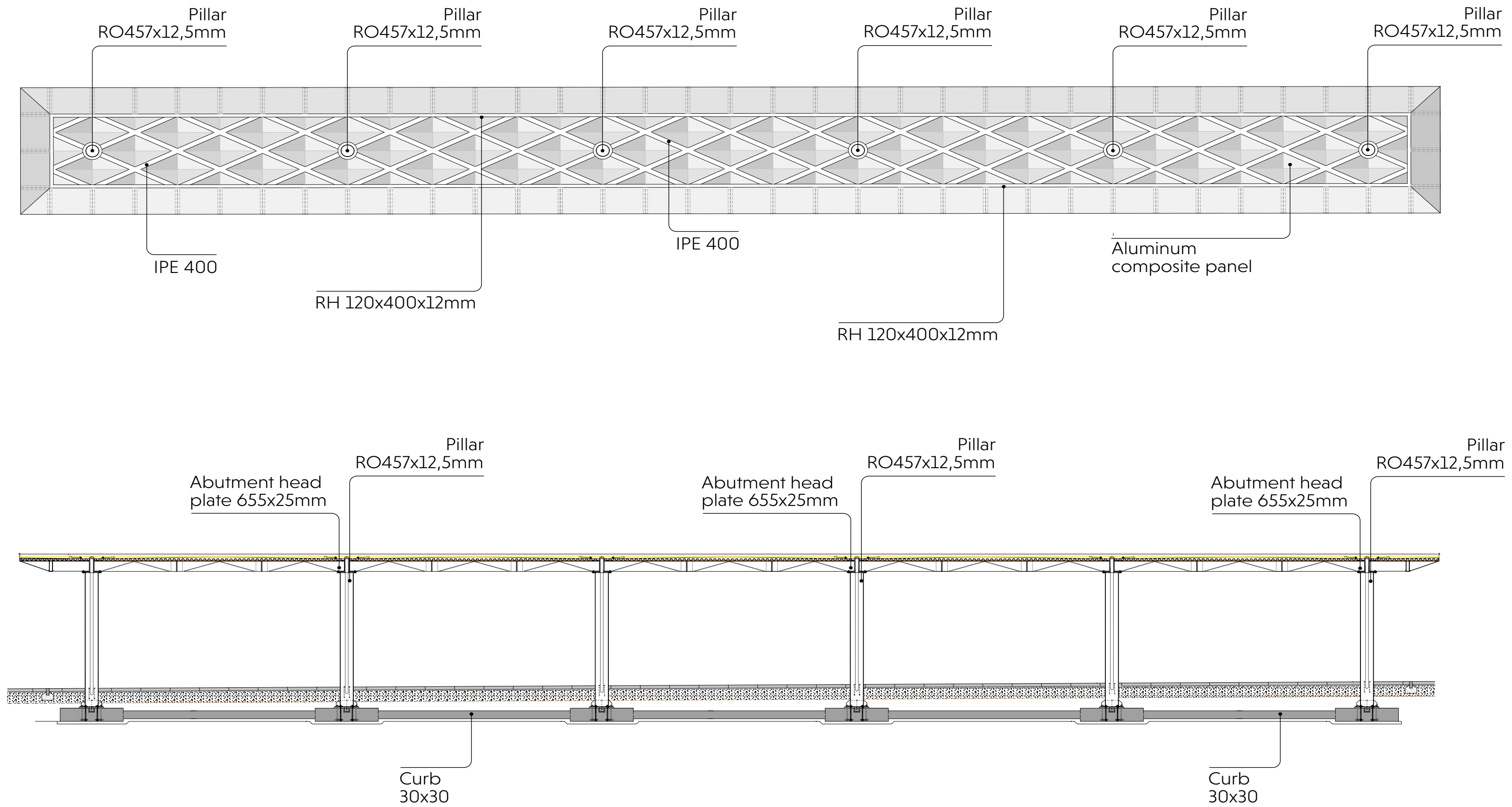
Layout bike storage underground

integration and interaction between the different types of mobility.
At the same time, and from the very beginning, NET Engineering, as designer, together with the provincial and municipal administration also STA – Structure Transportation Alto Adige SpA, turned the project into an **opportunity to understand what was required by the context and users' demands, suggesting a design that was specific, able to generate the expected innovation and also enhance the current situation.**

The Intermodal Centre designed by NET Engineering has the infrastructure necessary to ensure efficient exchange between public transport and private mobility, integrating services that increase the quality of the travel experience for both tourists and citizens (ample covered parking for bikes, family parking, kiss&ride area, 'smart' disabled parking connected to a specific app that allows availability to be checked in advance, and floor routes for the visually impaired co-designed with stakeholders). The most important architectural work of the working drawings is the **bike storage area, on a basement floor** corresponding to the historic bike park in the service area which it is connected to by a ramp, a staircase and a lift; both the latter are equipped for bike access. The project also plans the creation of an underpass, auxiliary and technological areas, bus shelters, **restoration of the historic depot** (a protected architectural asset) which is intended for the bike rental services, and the complete **redevelopment of the square in front of the station**, which many people consider a true gateway to the city. The aim is to create a wide open space encouraging pedestrians through the use of urban furnishing including trees, green areas and seats uniting modernity with historic elements such as the old stone fountain restored to its function, including its social function, after cleaning and restoration.

A system view

Taking care of just the technical details is not enough to maximise the potential of an intermodal hub. **The attractive, aesthetic and functional features and forward-thinking design must also be considered but, first and foremost, ability to co-ordinate the many stakeholders, constantly and effectively facilitating their discussion.** Representatives of local mobility systems were called to discussions so that the Brixen Mobility Centre could function in the best way offering users a useful, high-performance service. A service that doesn't simply plan alignment between the railway and bus timetables but also **considers the needs and potential of all the players concerned.** Design ideas able to **increase the quality of the service offered** can only emerge through specific discussion and co-ordination. Just one example, the bike rental service in the historic depot near the hub will ensure the chance to rent even high-performance bikes suitable for the cycle paths starting in Brixen. Therefore, it is essential to maintain a system view throughout all **stages that enables coordination of the players and disciplines** involved in the same project.



4.

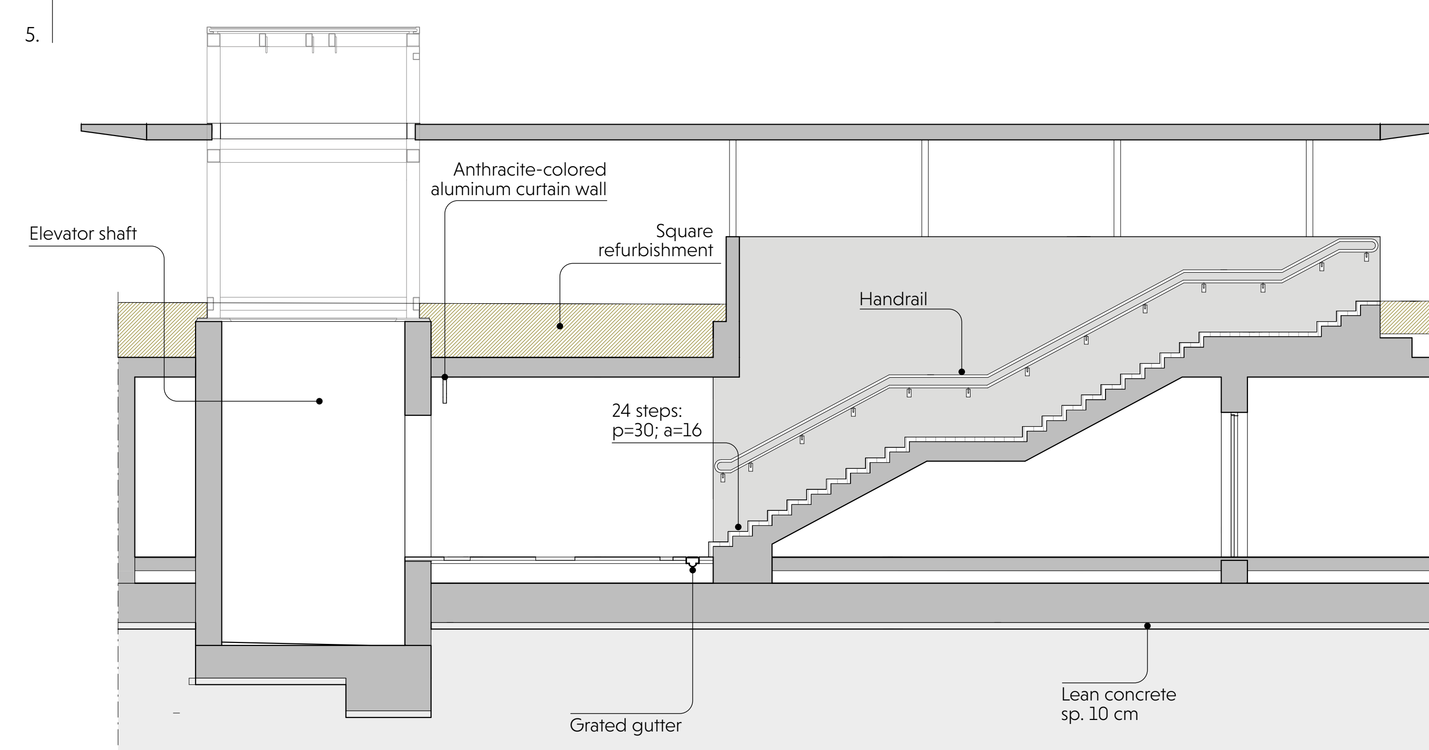
Bus shelter details

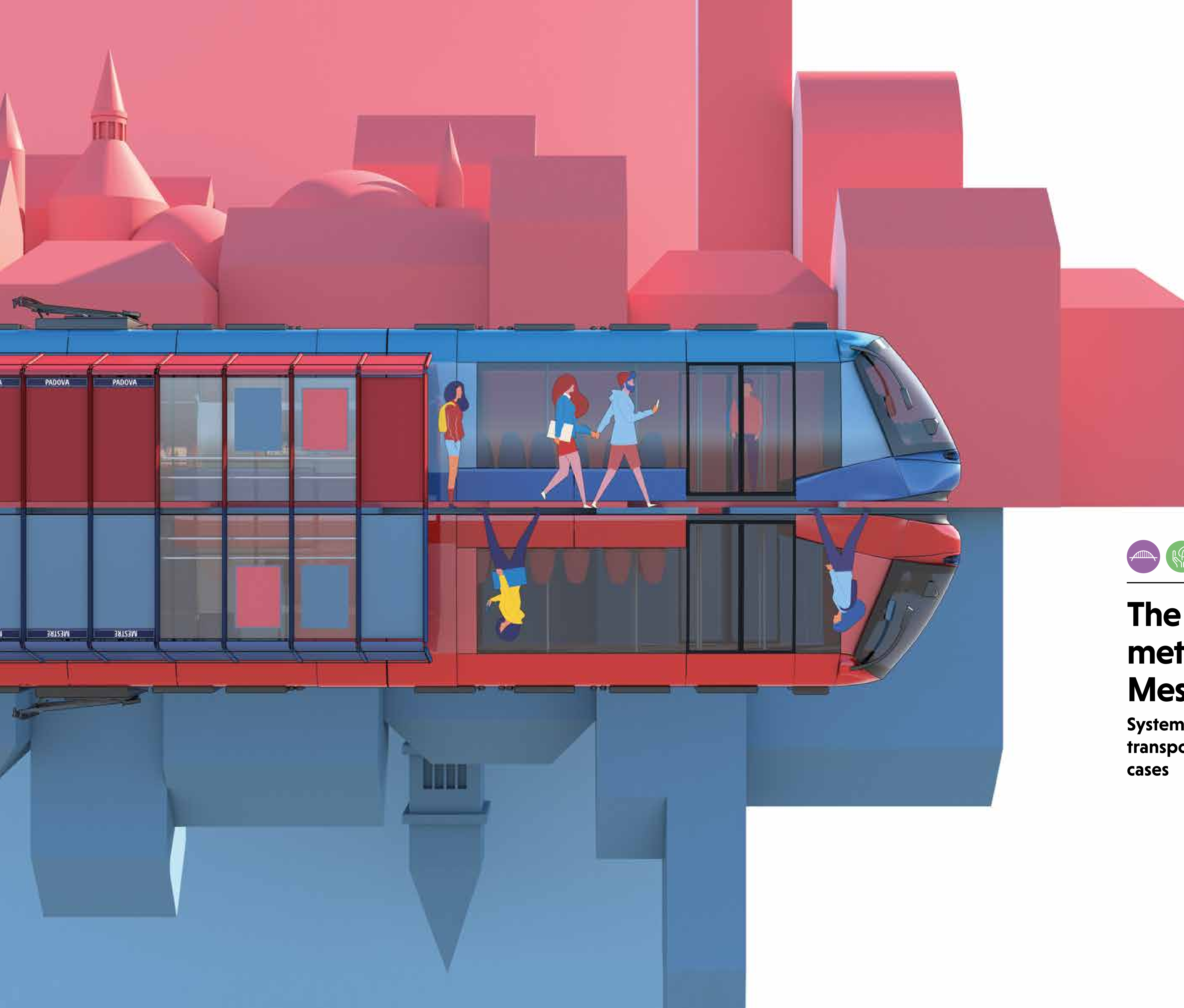
BIM: planning, works direction and operating stages

The project was entirely developed with BIM methodology to **facilitate discussions between disciplines and ensure continuity between the design stage**, construction of the work and its subsequent operation, **allowing structured organisation of development of the work thus enabling adoption of innovative tools and the introduction of an optimal flow of operations and information management.** In detail, BIM is not only an efficiency and process control tool but also facilitated the work of the construction company and the works direction stage, also under NET Engineering, and co-ordination with the other works being constructed by RFI (a station underpass and sound barriers, also designed by NET). This approach **facilitates a check on progress and enables the builder** to deliver to the final client with a model that can be used for checking and planning the necessary maintenance and subsequent operations.

Bike storage section

5.





The Padua metrobus and the Mestre tram

System engineering for urban transport - two enlightening cases

The Padua Metrobus and the Mestre Tram are two examples of the application of system engineering: a methodology of 'doing' which NET Engineering has always pioneered and is now a distinctive element in the Group's operating style. It is a logical process generated by the **qualitative and quantitative observation of the present and future mobility needs of people and goods.** It determines the definition of the 'integrated transport service plan' and is perfected with recognition of the infrastructure complex for the implementation of the plan. The system analyses and assesses the current situation, forecasts the evolution of the infrastructure network and that of the demand for transport, finds the possible proposals for action, checks their impact on the context, traffic and environment, indicates the optimal design solution and carries out an economic assessment.

The system approach used led to the design of two civil infrastructures in accordance with the needs expressed by the operating model developed on the basis of in-depth transport assessments. This design approach **contributed to making the Padua Metrobus (SIR) and the Mestre Tram (STG) real 'integrated' transport projects intended to minimise the impact on traffic circulation and maximise the potential for access to the new service** through the reasoned transfer of exchange car parks and stops. The approach also implied in-depth analysis of transit points, necessary for achieving the best urban-planning integration, also through perceptive physical simulation techniques.

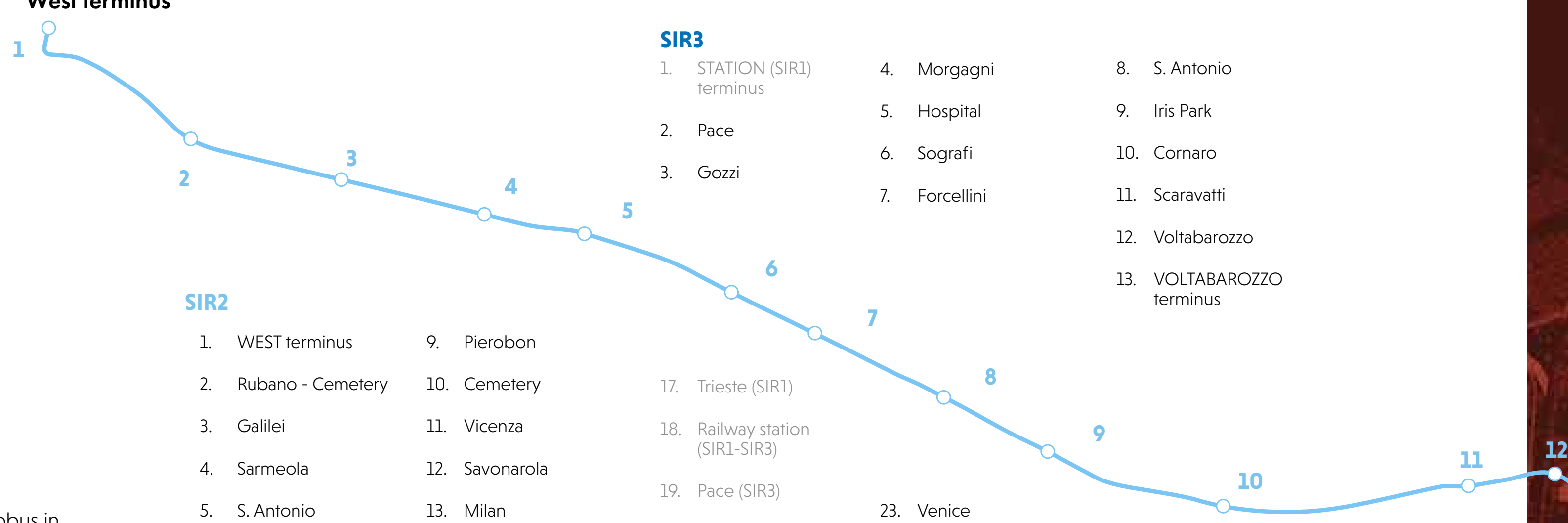
Metrobus in operation in Padua

1.

The Padua Metrobus

Intermediate guided transport system

For Padua, the 'SIR' system, also known as 'Metrobus', is the new collective public transport system in the city and has three long tramways – north/south, east/west and centre/south-east. Let's have a look in detail.



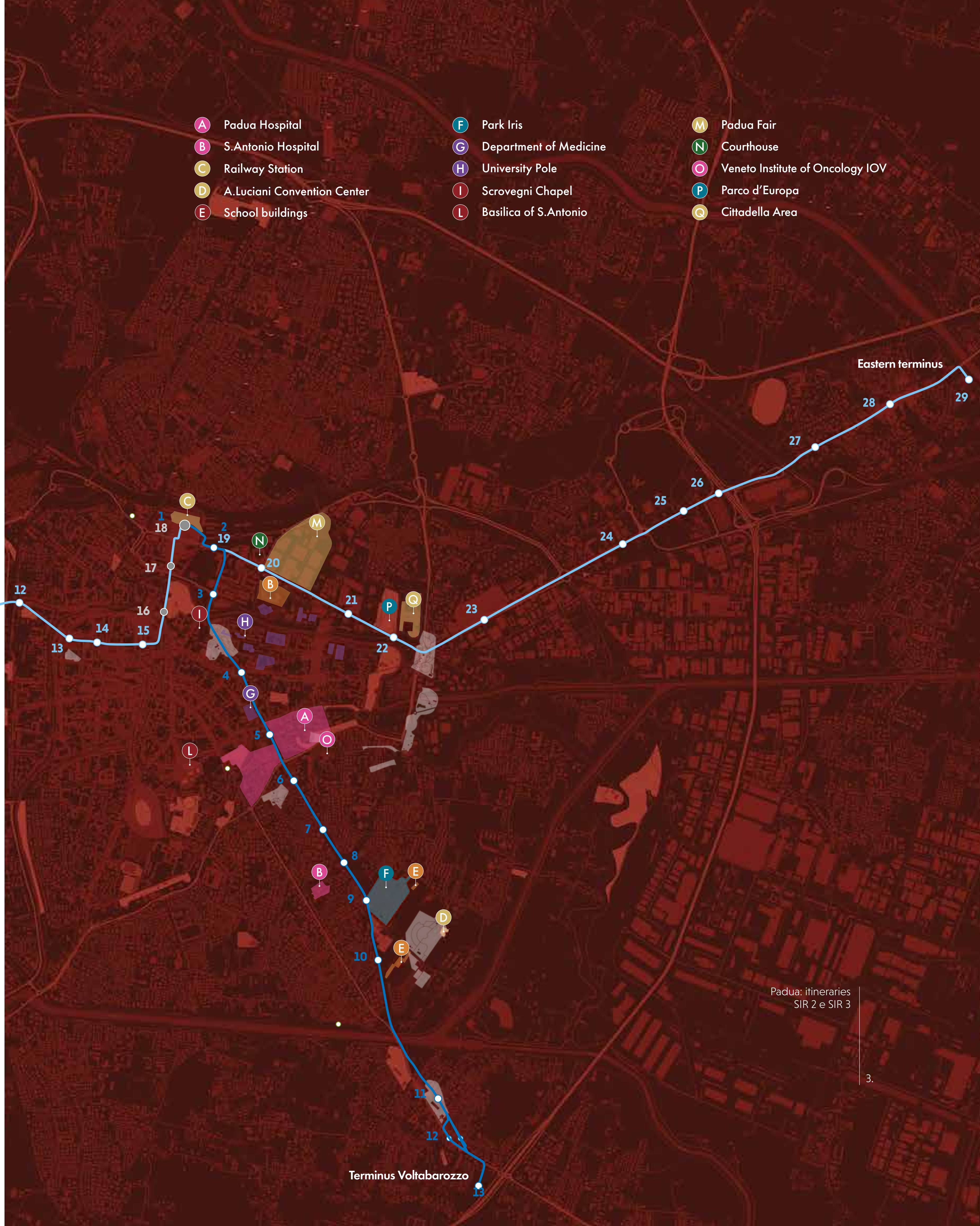
SIR3

1. STATION (SIR1) terminus
2. Pace
3. Gozzi
4. Morgagni
5. Hospital
6. Sograf
7. Forcellini
8. S. Antonio
9. Iris Park
10. Cornaro
11. Scaravatti
12. Voltabarozzo
13. VOLTABAROZZO terminus

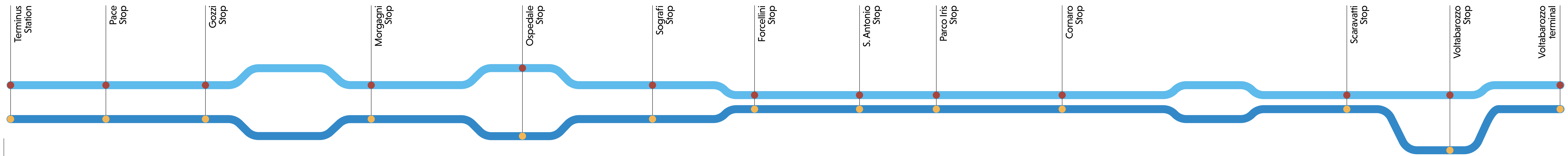
SIR2

1. WEST terminus
2. Rubano - Cemetery
3. Galilei
4. Sarmeola
5. S. Antonio
6. Brentella Ovest
7. Brentella Est
8. Chiesanuova
9. Pierobon
10. Cemetery
11. Vicenza
12. Savonarola
13. Milan
14. Dante
15. Garibaldi
16. Eremitani (SIR1)
17. Trieste (SIR1)
18. Railway station (SIR1-SIR3)
19. Pace (SIR3)
20. Tribunal
21. University
22. Stanga
23. Venice
24. Net-center
25. Palasport
26. S. Marco
27. Hippodrome
28. Ponte di Brenta
29. EAST terminus

Metrobus in operation (SIR 1)



Padua: itineraries SIR 2 e SIR 3



4.

Map of SIR3 itinerary stops

NET Engineering was assigned to design the line system for SIR2, covering 14.6 km, with a total of 29 stops, and SIR3, which with 12 stops on a route of about 6 km to serve the Trade Fair and the hospital district. **For the infrastructure, the system has a central monorail on a platform wide enough to hold the wheels of a road tram, also known as 'Metrobus'.**

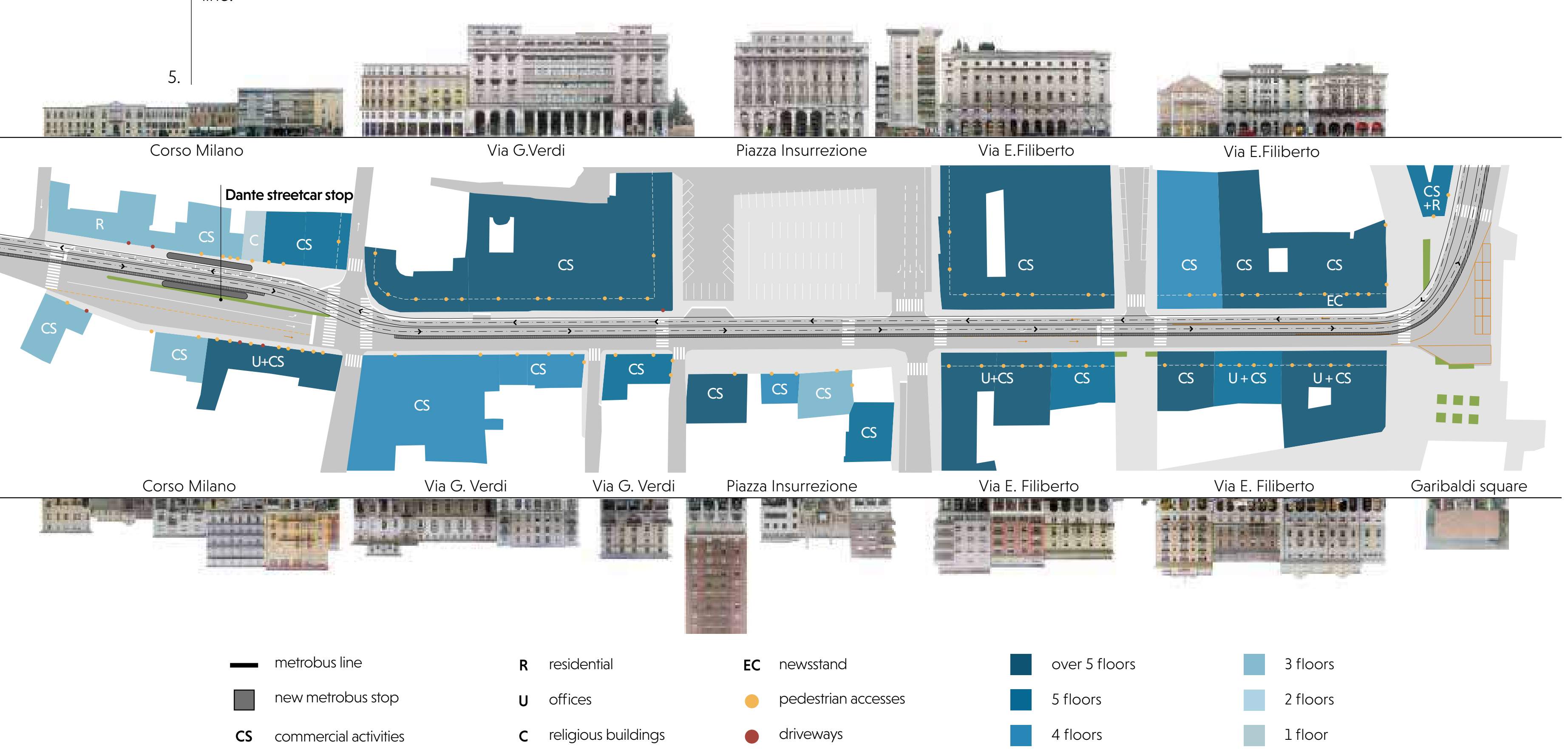
It uses TRANSLOHR STE3 electrically-driven vehicles with **4 carriages, powered by a single wire with a return through the rail, able to communicate with the signaling systems on the ground thus giving further optimization for the travel times.** The definition of the route also into took account the results of the transport studies and was finalised to maximise the use of dedicated lanes (available for almost 90% of the way) so that passengers were guaranteed certain travel times. Various alternatives for the route were analysed in the preliminary project which, considering the route of the SIR2, set out in the **Urban Mobility Plan for Padua**, as unchanged, focused on finding the best configuration of the different roads, assessing the result from the point of view of the effectiveness of the route, the impact on the other traffic components, the environmental impact and the construction costs. In particular, the placement of the route was assessed with the guideway on the side, central and with both guideways on one side.

The Environmental Impact Study analyzed three levels of specificity:

- **level of contest**: The urban space of the tramway, marked by the building fronts at the sides of the road, also defines both the horizontal dimension the route can 'move' in (the current road) and the vertical dimension (the building fronts to the left and right);
- **level of content**: According to the law (Prime Ministerial Decree 27/12/88), the environment components of a space should be divided into description and characterisation but the elements in the confined space didn't always coincide with this;;
- **level of effect**: The impact on the urban landscape was limited to the route while, from the urban planning point of view, it can be felt in a wider area of about 250-300 m on both sides of the tram route, corresponding to the area of influence of the users.

The facade of the buildings along the SIR2 line.

5.



SIR3: 3D model of the stop Iris Park

6.

The Mestre Tram

Rubber-tyred guided tram system (STG)

The project concerned the creation of the rubber-tyred guided tram system for Mestre and Venice, divided into two lines. Line 1 starts in Favaro, transits the interchange with Line 2 in Piazzale Cialdini, Mestre, and terminates in Piazzale Roma, Venice, covering a route of about 14 km. Line 2, about 6 km long overall, starts at the interchange, crosses the centre of Mestre, passes under the railway lines at the

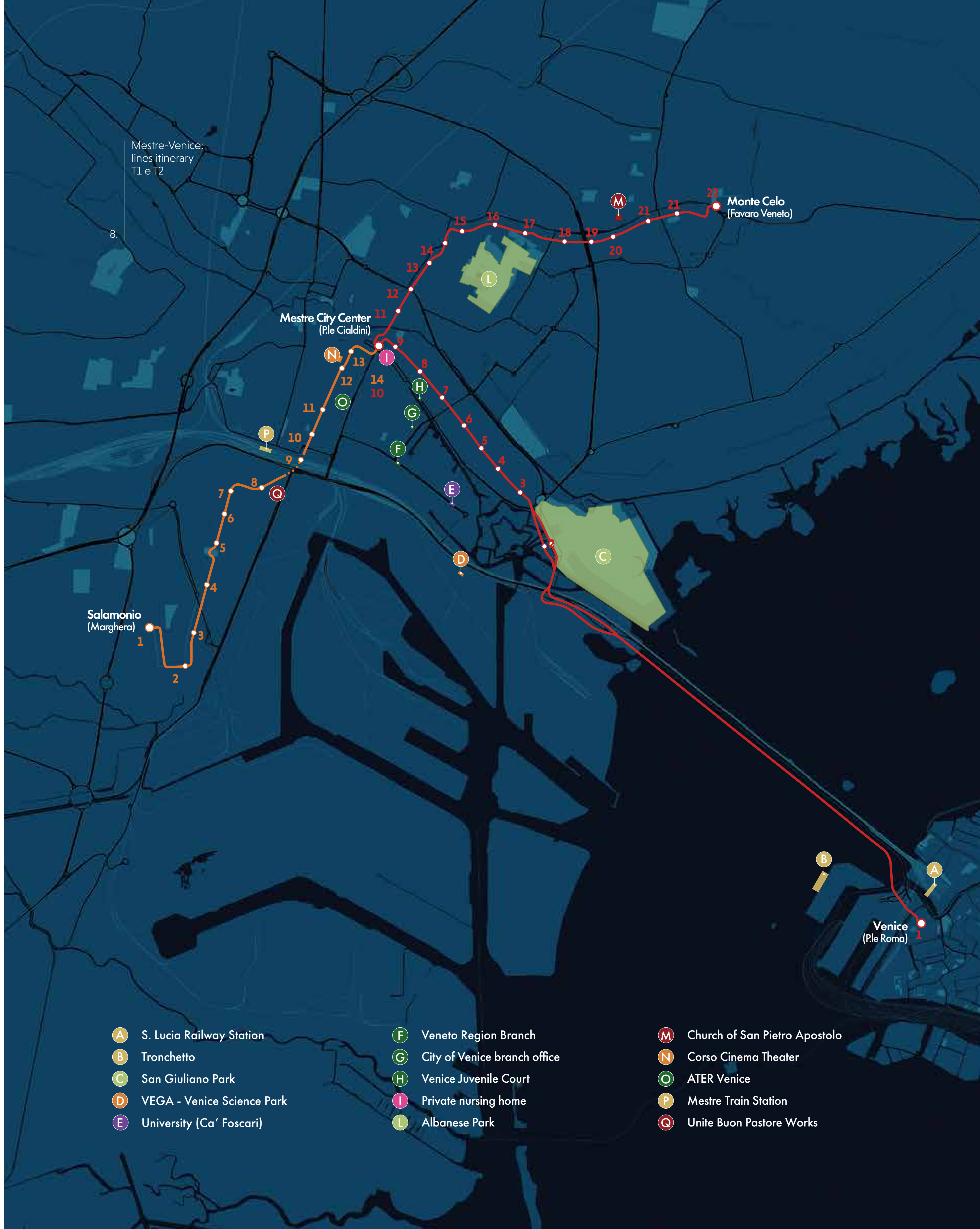
T1

1. VENICE terminus
2. San Giuliano
3. Forte Marghera
4. Boerio
5. Molmenti
6. Sansovino
7. San Marco
8. Cattaneo
9. Manuzio
10. Mestre Centre (T2)
11. Bissuola
12. Oberdan
13. Serravalle
14. San Donà
15. Pasquaglio
16. Pineta
17. Rielta
18. Cervino
19. Marmolada
20. Pastrello
21. La Piazza
22. MONTE CELO terminus

T2

1. SALAMONIO terminus
2. Bottenigo
3. Emmer
4. Beccaria
5. Mercato
6. S. Antonio
7. Lavelli
8. Giovannacci
9. FS Stazione
10. Sernaglia
11. Cappuccina
12. Villa Erizzo
13. Olivi
14. MESTRE CENTRE terminus

7. Metrobus operating in Mestre



8. Mestre-Venice: lines itinerary T1 e T2

station and reaches Marghera at the Panorama Terminus. There are 34 stops overall and the system travels a densely urbanised area, requiring the inclusion of the route in the complex network of urban streets.

These are some of the reasons why a silent and innovative transport system was chosen. Its silence is due to the use of a rubber-tyred guided tram system (TRANSLOHR) with a central monorail, fixed to a reinforced concrete platform suitably roughened on the surface, wide enough for the tyres to drive on.

In this context, NET Engineering took care of the final and construction design of the platform and interchange in Piazzale Cialdini, Mestre, the construction site set-up and the study of the road signs and roads. It also aided the sub-contracting Temporary Association of Businesses during the infrastructure construction stages.

The design of the platform – segments with an average length of 28 metres – was based on the study of the terrains crossed. The lagoon area, mainly clay, had low bearing capacity and a more salty air which led NET Engineering to be oriented to a rigid type of paving 28 cm thick, made of high durability concrete. The cable ducts, to power the drive, were housed underneath, in a protected position.

The reduced thickness of the tramway platform has allowed to keep the position unchanged for most important subservices, mainly the sewer system and electric lines to remain unchanged, ensuring their extraordinary maintenance without interrupting operation through the possibility of making the platform free-standing at certain points of the route.
Other services were moved to facilitate maintenance. The route had to be in a reserved lane to ensure the efficiency of the operation of the new infrastructure, and this could be guaranteed for more than 60% of the route.

The main challenge for the NET Engineering designers related to the section of the route on the Ponte della Libertà in Venice. Different technology was suggested for this with the creation of a hard-wearing, highly resistant kerbstone of modified bitumen requiring low maintenance able to deal with the subsidence due to the continuous passing of the tram.

This solution, much closer to traditional flexible paving, allowed the work to be started and fulfilled, reducing the time required and so limiting the impact on the existing traffic on the bridge.

Sustainable mobility to reconnect the urban fabric

The Bolzano tram Technical and economic feasibility

In 2019, in the Notice to present applications to access resources for mass rapid transport, the Ministry of Infrastructure and Transport (MIT) advised administrations of the opportunity to benefit from a grant for the design and construction of mass rapid transport systems, assisting their efforts towards more and more sustainable development of areas. Bolzano seized the opportunity offered by the MIT and planned the creation of a new tramway. The Technical and economic feasibility Project curated by NET Engineering is intended to define the aims and features of the operation through the indication and analysis of all the possible alternative design solutions.

The project, consistent with the basic criteria and choices indicated in the Sustainable Urban Mobility Plan, is configured with two lines that overlap for most of its length and which fork at the Bivio Merano stop, Line 1 going north branch off the hospital and Line 2 going south towards Ponte Adige, thus ensuring the best service in view of modal movements towards public transport. The design plan consists of an integrated infrastructural corridor able to valorise the identifying elements of the city, reconnect the urban fabric and promote the redevelopment of the existing context in the suburban areas of the city, connecting them more effectively with the historic centre and its services. The tram crosses key points of the city (station, historic centre, the Court, Viale Druso and hospital), serves many types of users and, from time to time, adapts to the contexts so that it, too, becomes a promoter of spatial transformation and redevelopment.

The study imagines the new line as an infrastructural, technological and services platform for the whole of the Bolzano urban area which can ensure:

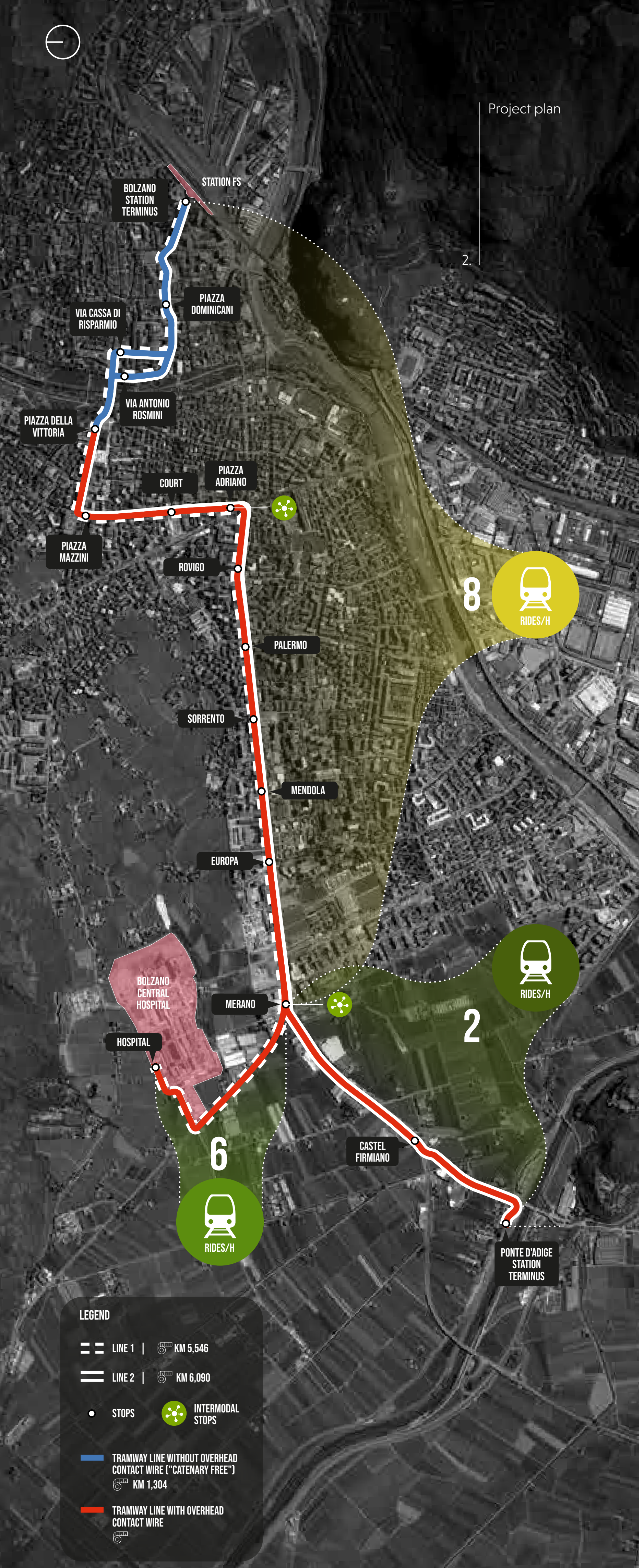
- **A highly accessible intermodal transport system referring to:**

  An operational model that minimises change times with a view to improving the user experience;

  Integration with the railway system in correspondence with the Ponte Adige terminal through the reorganisation of the spaces and connection with the future interchange car park planned beyond the river, guaranteed by a new pedestrian walkway over the River Adige;

  Implementation of interchange nodes for last mile travel using micromobility services and sharing mobility;
- **A traffic monitoring system connected to the traffic light regulation system**,(Urban Traffic Control) and that of public transport stops;

1. Stop at the train station: 3D simulation



Project plan

2.

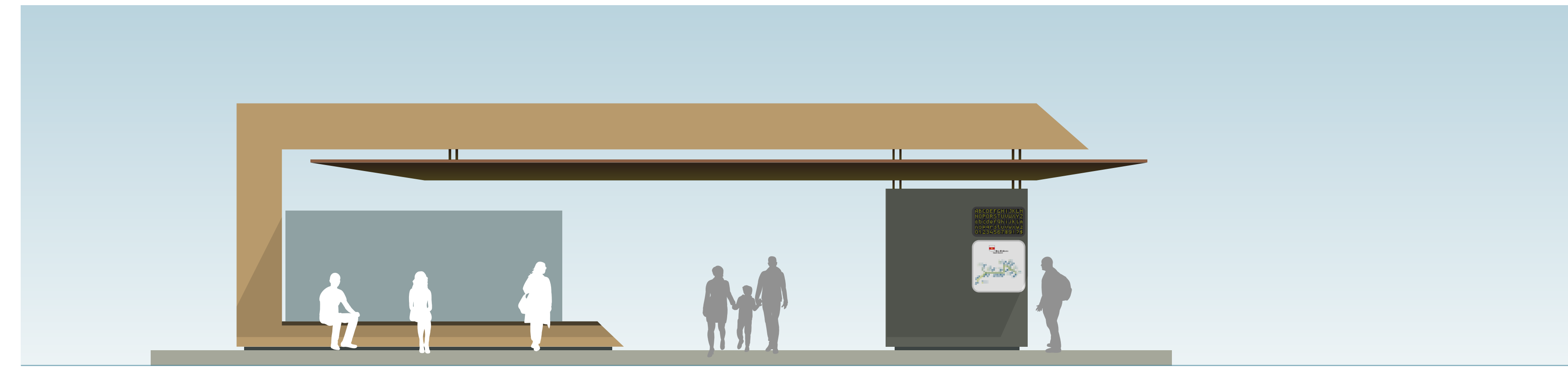
- **A traffic control system based on the traffic lights infrastructure**, which allows the implementation of private traffic and public transport regulation policies. The tram will be supported by a signalling system which will always ensure priority at traffic lights, i.e. manage the traffic light system along the project corridor so that the tram will always have priority for road safety.

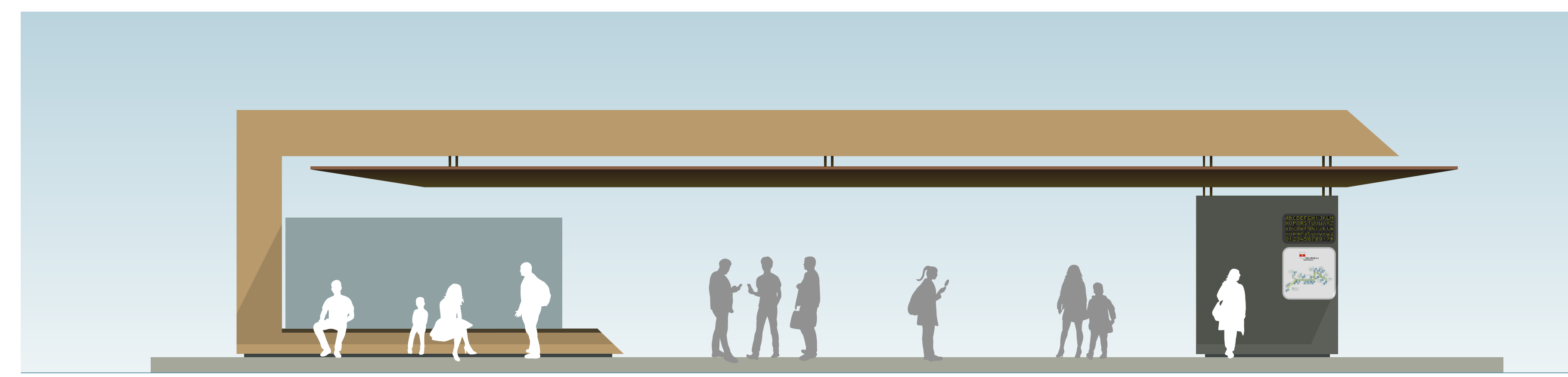
Sustainability and area

The tram does not run with the catenary system in the section from the station at Ponte Talvera, over a distance of about 1.3 km, but is battery powered (catenary-free technology) to preserve the historic centre area as much as possible and minimise the impact of the line in areas of great architectural and landscape value.

The architectural concept of the stops and depot for the rolling stock is **oriented to modern sustainability criteria and inclusion in the area context.** As a result, the creation of a green roof and the use of local materials, easy to maintain and very durable, were planned for the depot. **The environmental impact of such an important work as the tram was carefully assessed, also in terms of the acoustic-vibrational impact and electro-magnetic compatibility.**

The Bolzano tram project was a unique opportunity to also think of a **functional architectural redesign of some spaces in the city** to make them really usable by citizens and ensure better operation of the road system for both public and private transport.





Types of stop solutions: SMALL, MEDIUM and LARGE solution

3.

Simulation of entry in the context of the historical center

4.

Redefining public transport networks

Drafting the operating programme of the new Sondrio and Valchiavenna public transport network

Drafting the new Sondrio Urban Traffic Plan is part of a wider process that aims at new mobility planning, especially provincial public transport, in accordance with a configuration respecting the latest criteria on transport service organisation and protection of environmental and social sustainability.

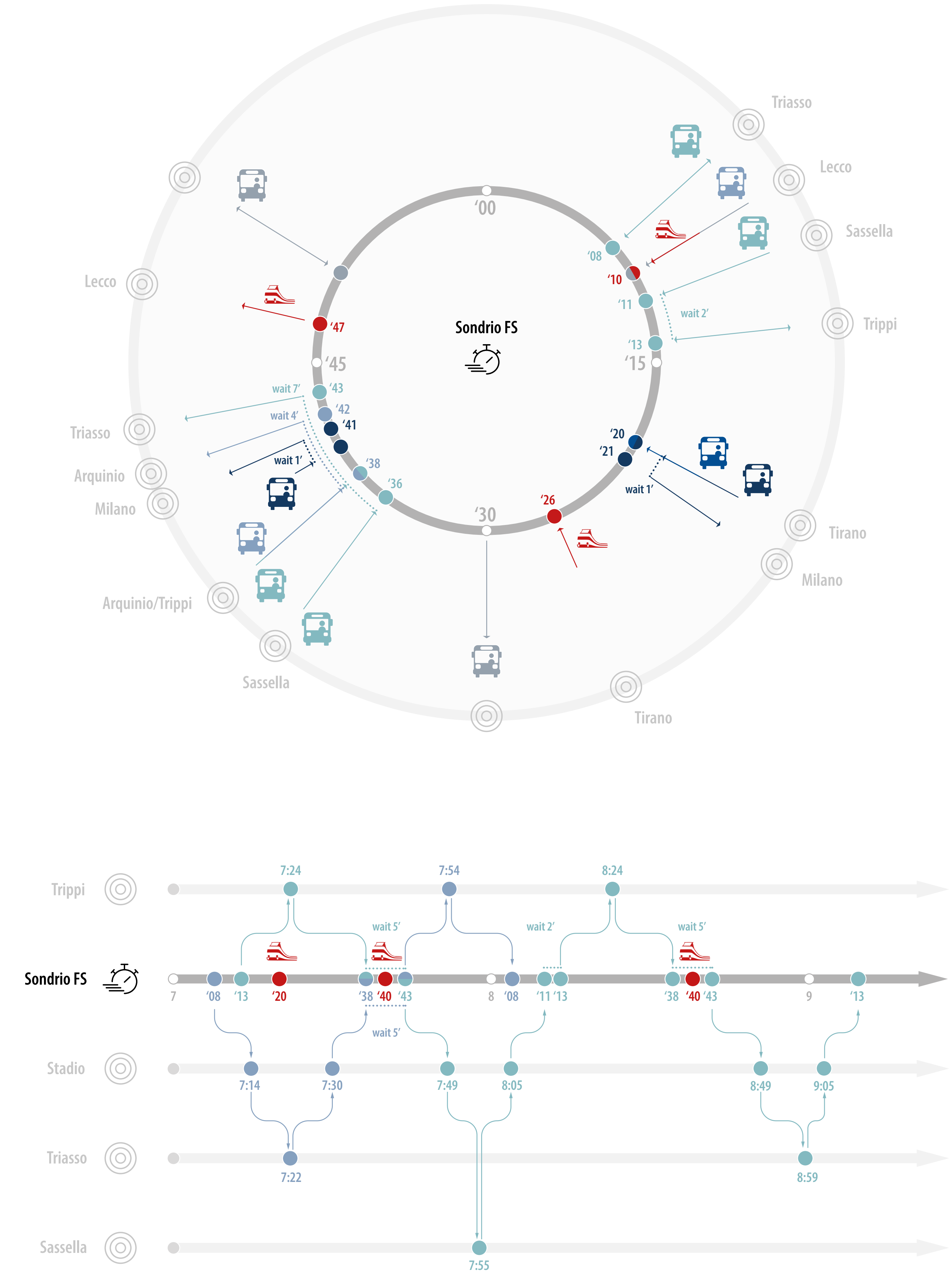
In this context, NET Engineering worked with the Sondrio Basin Local Public Transport Agency in devising and **creating two plans that completely redrew local public transport (LPT) in Sondrio on one hand and Valchiavenna on the other.**

The main challenge was linked to where the project had to operate – the administrative centre of a mountain province of 21,200 inhabitants and an extensive Alpine geographic region, Valchiavenna, consisting of three valleys, 12 municipalities and inhabited by about 30,000 people.

The primary role of public transport in mountainous areas is to ensure minimum services (for going to health, scholastic and work centres) for residents, especially in the most fragile sectors of the population, and to support tourism in both summer and winter months. However, over the years, the LPT services in Sondrio (urban) and Valchiavenna (suburban) had tried to satisfy the needs of the local user responding to the demands of specific users and the yearly scholastic variations, at the same time losing attraction for both tourists and other potential users.

Therefore, intervention was required to start **modernisation of local public transport while taking account of the features of the area, the people living in it and the people visiting it.** A proposal defining a new LPT operating programme was drafted starting from the analysis of the context and **respecting environmental, social and economic sustainability** principles and some specific criteria – clock-face timetable, reinforcement during rush hour, 'pendulum' routes and consistency with the Sondrio General Urban Traffic Plan. In addition, rendezvous with trains to and from Milan were also programmed to favour intermodality and offer a **transport service perceived by the user as unique** even though provided by different vehicles, connecting local journeys to the regional administrative centre.

NET Engineering also worked with the Sondrio Basin Local Public Transport Agency in **discussions with stakeholders**, and especially the companies providing the service, curating ad hoc communications that could both increase the effectiveness of communication and clearly show the interchanges set out by the new operational programme and, therefore, the potential of the new service for users.



Clock and graphic timetable for arrivals/departures of new urban lines and trains at the Sondrio station node

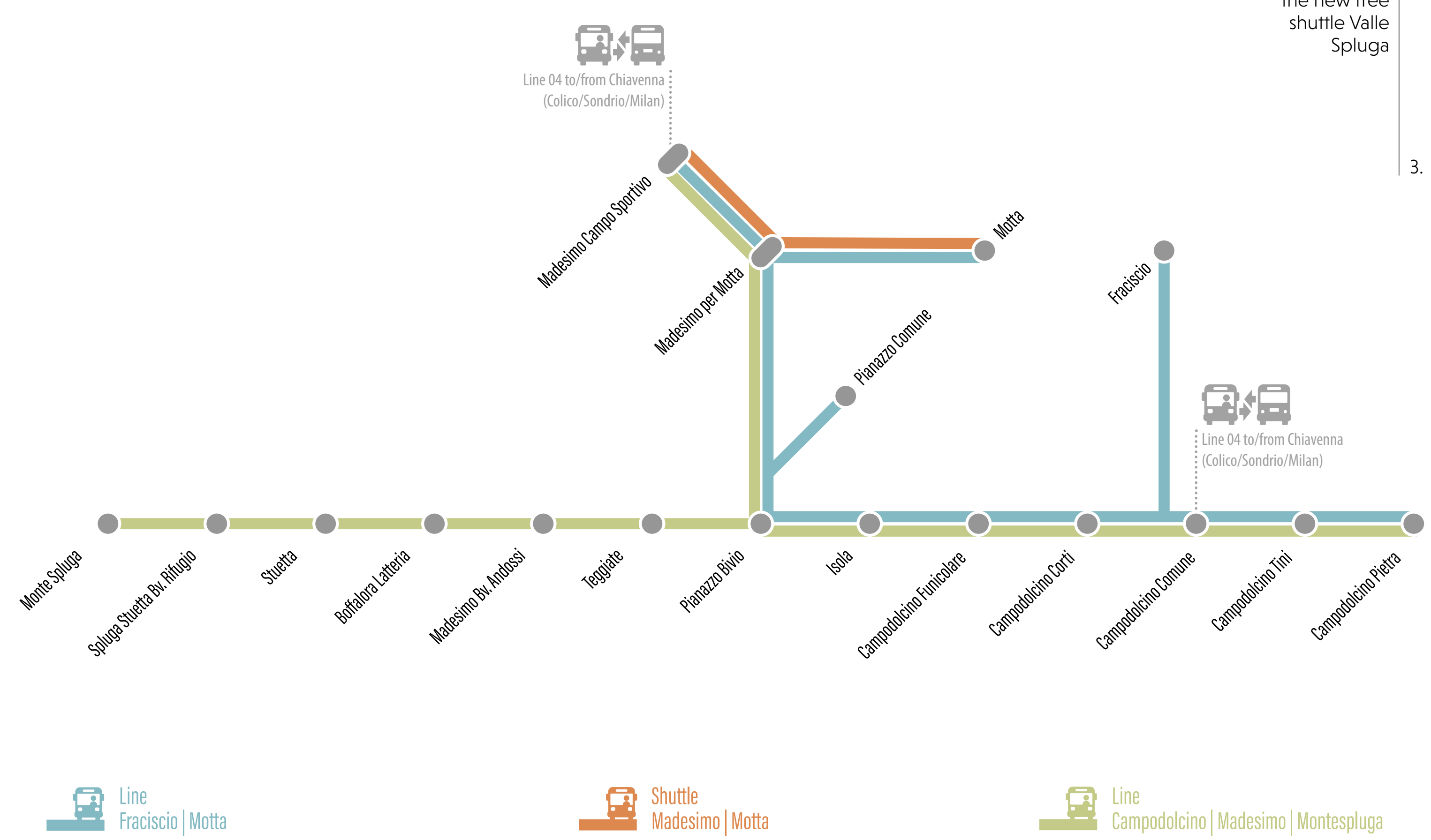
1.

This was an essential process for **supporting local mobility companies in changing their perspective, raising their point of observation** often focused on solving operational type problems and therefore not always able to seize the opportunities offered by a context which has recently become more and more attractive for traditional, young and green tourism.

The new operating programme devised by NET Engineering for the new shuttle in Valle Spluga (between Madesimo, Campodolcino and Motta) was tested during the high summer season of 2021. Various questionnaires were used to assess user satisfaction and the positive results motivated the client not only to confirm the service but also extend it to the winter season, further reinforcing it.

Scheme of the new free shuttle Valle Spluga

3.

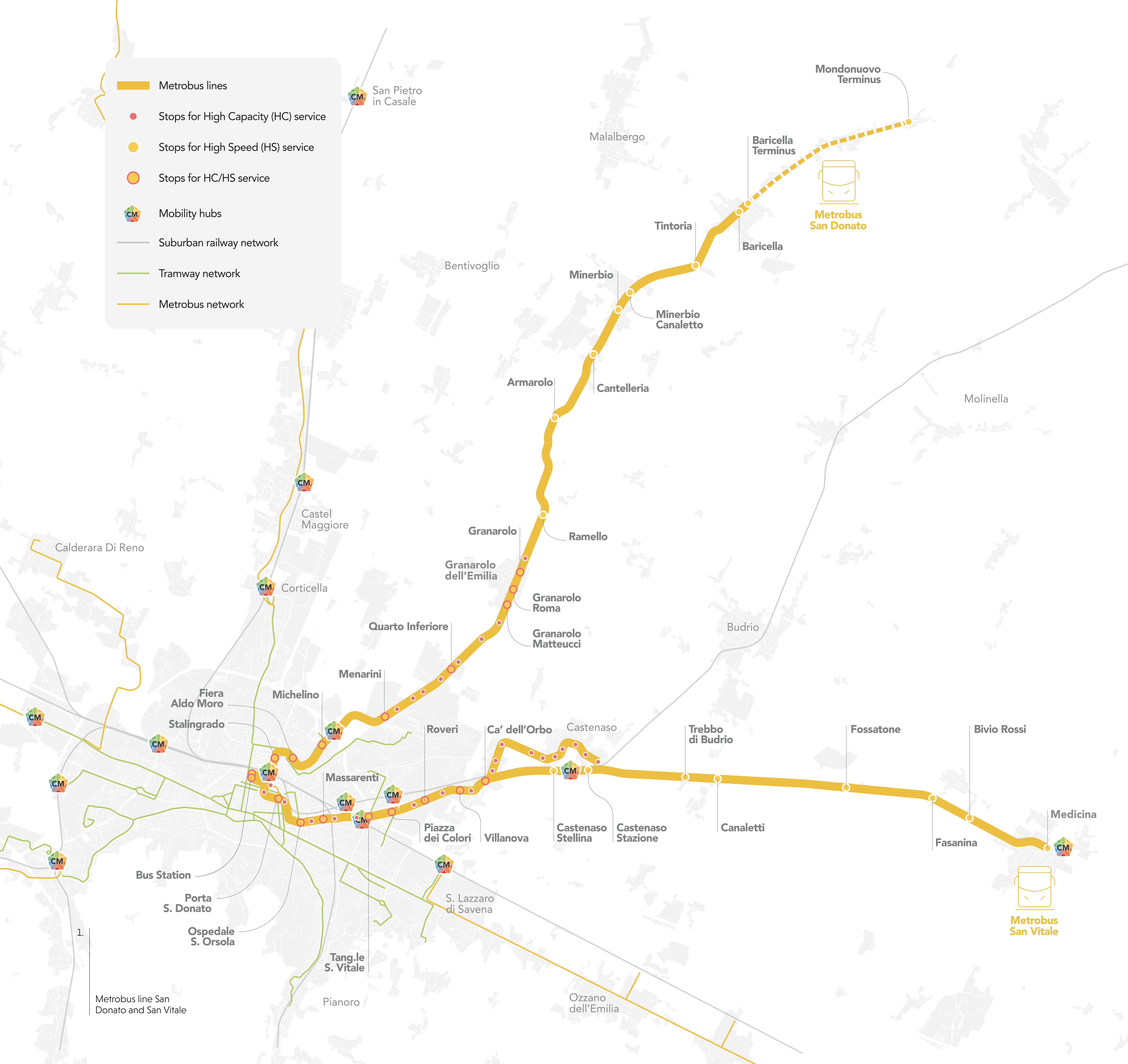


Informative map of the new free Valle Spluga shuttle

2.

Sustainable mobility in metropolitan areas

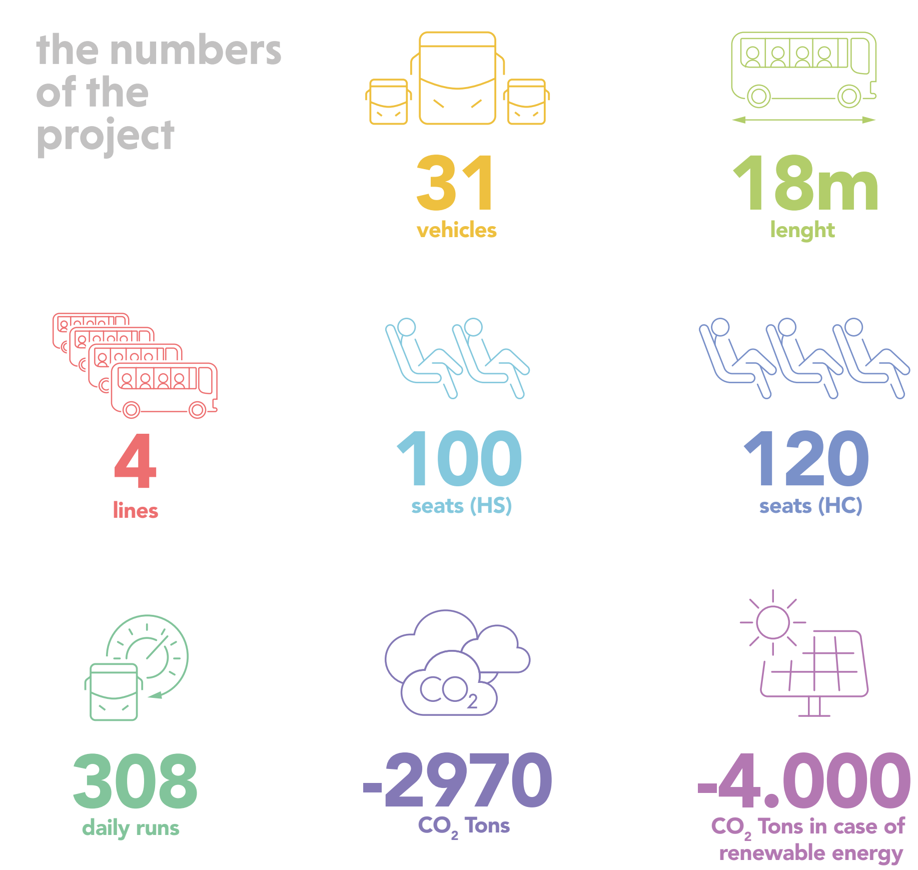
The Bologna and Florence Bus Rapid Transit



The Bus Rapid Transit (BRT) is the most cost-efficient answer for high capacity public transport. It includes a great variety of solutions brought together by a road corridor with infrastructure where buses able to provide a higher frequency, quicker service than traditional road transport systems circulate. The aim of the BRT is to bring service performance closer to assisted transport systems while maintaining the costs of road vehicle-based systems.

BRT Bologna

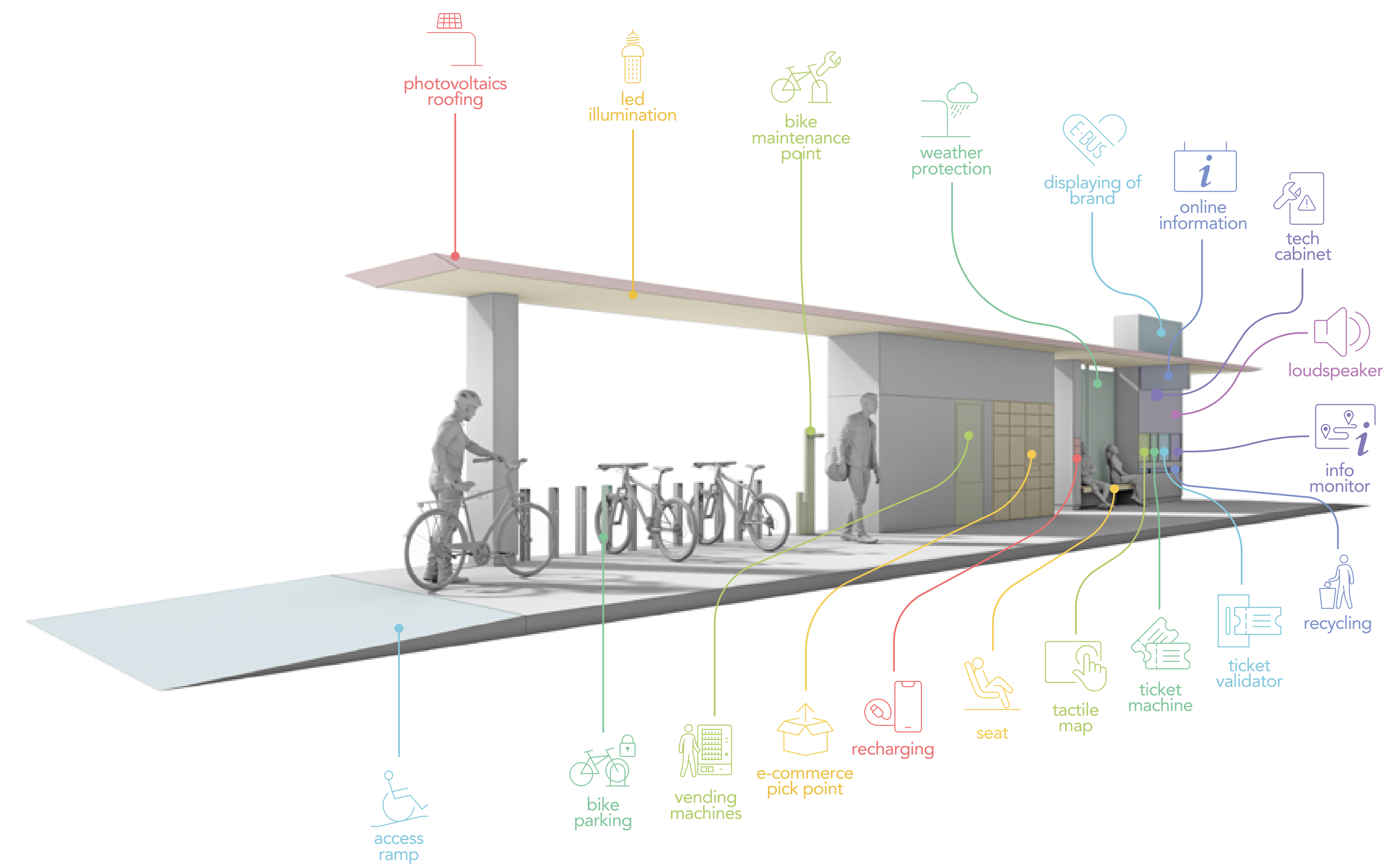
In mid-2020, the Metropolitan City of Bologna entrusted NET Engineering with drafting **Technical-Economic Feasibility projects for two suburban BRT lines** – the 'San Donato' (Bologna-Baricella) and 'San Vitale' (Bologna-Medicina) routes. The aim of the projects was to create public transport services that could increase the accessibility of two regional areas along the routes not currently served by mass rapid transport systems, ensuring connection with the main metropolitan town, increasing the attraction and competitivity and opposing the inequality linked to the under-provision of services.



The projects form part of the operations established by the Bologna Metropolitan Sustainable Urban Mobility Plan.

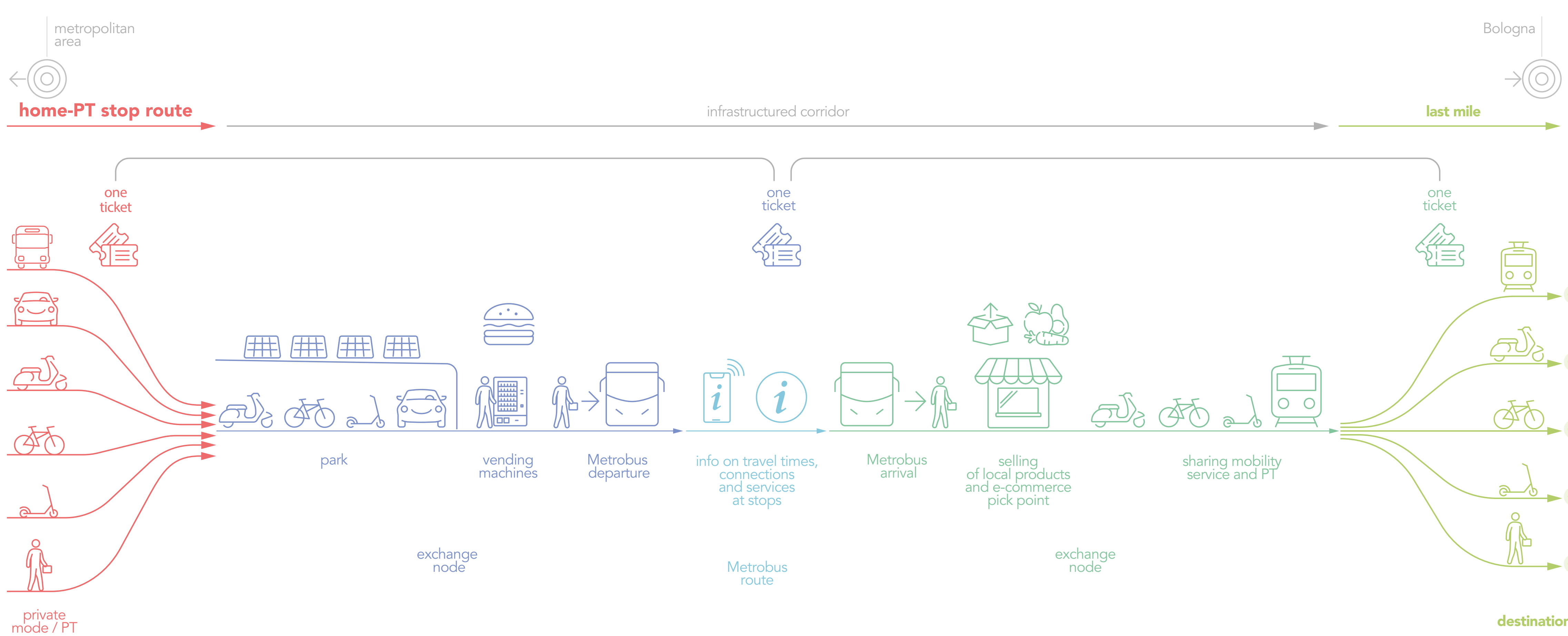
Currently, **the sustainability of a project is not just assessed on environmental topics** but also on economic and financial ones, the ability to share with stakeholders, integrate with the network of existing services and infrastructure, information for users (Mobility as a Service – MaaS), technology (smartness), and the maintenance and management experience. To that effect, a system design process was adopted for the Technical-Economic Feasibility Project for public works (PFTE) of the Bus Rapid Transit lines which took account of all these elements and mutual interrelations influencing the strategic and operational design choices. Methodologically speaking, this design process set out:

- **A study of the current area and transport setting and city planning,** essential for the integration of the project into the context and the indication of any restrictions;
- **The indication of the need for transport services** the so-called 'unmet demand', assessed based on a qualitative-quantitative analysis of the urban planning, social-economic and transport context, and a quantitative analysis of the spatial, temporal and modal features of the demand for movement;
- **Analysis of the modality**, technology, level of infrastructure, integration opportunities, and simplification of maintenance and management of possible alternative designs;
- **Definition of the operating model**, the transport service that responds best to the needs indicated for capacity, availability, route and speed.



3. Stop concept for the Metrobus (type LARGE)

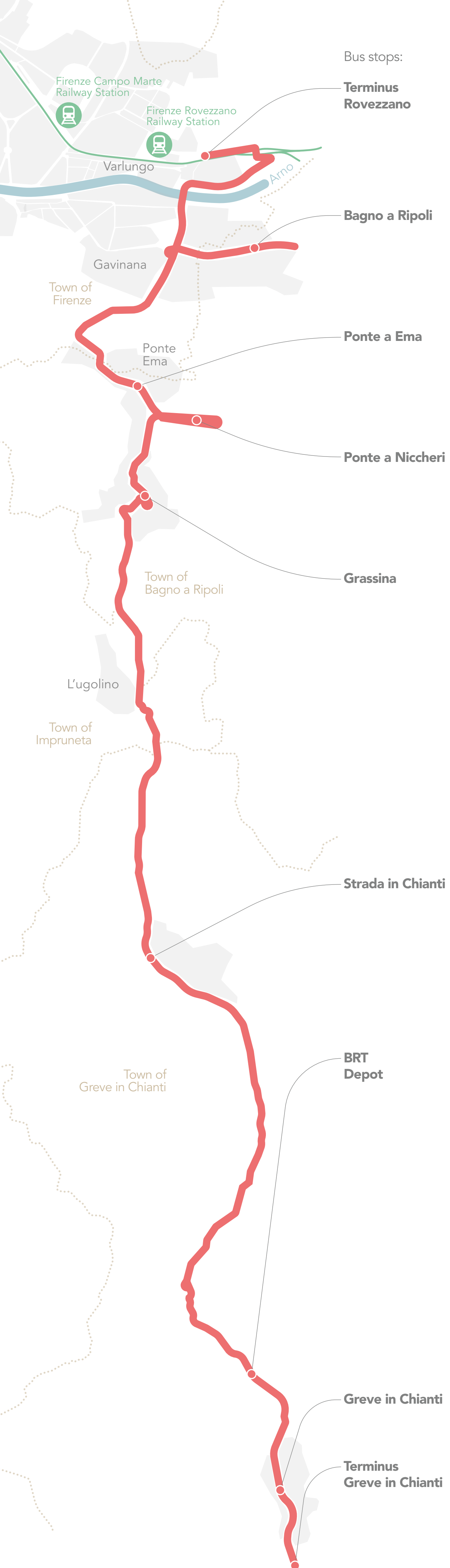
2. Offer of mobility and supplementary services on Metrobus routes



Therefore, the design choices made led to the BRT services design, specially innovative not only because they are the **first examples of Bus Rapid Transit systems in Italy designed to connect a metropolitan centre to suburban and out-of-town areas but also because they respect various features making them sustainable from many points of view including exclusively electric power supply.**

Assessment of the effectiveness of the various design alternatives technologically supported the creation of an out-of-town public transport service using only electric buses, driving the designers in the **search for the optimal solution to ensure the autonomy of an electric vehicle along an especially long section outside an urban environment.**

The answer was given by an analysis that takes into account not only technical feasibility but also, as said, economic sustainability, ability to respond to the demand for transport, etc. Detailed simulation tools corroborated the technical choices made with the aim of refining the analyses in terms of travelling time and robustness of the operating model and impact on vehicle mobility.



4.

Line Greve in Chianti
Florence Rovezzano

BRT Firenze

NET Engineering's Bus Rapid Transit proposal for the Metropolitan City of Florence was developed with the idea of **converting the methodological, strategic and analytic structure in the PUMS into an out-of-town transport service consistent with the needs of the area, effective** in terms of offer, **resilient** as able to respond to changes, including sudden ones, in the reference context, and cost-**efficient**, also considering the many restrictions of the area involved in the project.

The project, which sets out the creation of two lines – Poggibonsi-Osmannoro, then extended to the terminus at Guidoni, and the Greve in Chianti-Florence Rovezzano line, is an element of great innovation in the rapidly transforming public transport panorama, and is **one of the first international experiences of using electric buses over large distances in morphologically complex out-of-town contexts** (hills).

Therefore, the project aims to play an essential part in the process used by the Metropolitan City of Florence in **planning sustainable mobility as a tool to manage the transformation processes of the urban and metropolitan areas**, investigating the response to economic and financial sustainability of mobility demand needs, supporting the sharing of initiatives through public engagement processes, intensifying integration of services, infrastructure, business models, information to users (MaaS), technology (Smartness), rolling stock, and maintenance and management experience with the existing network.

As the project intends to be a **best practice in the national transport panorama**, it was developed attaining a significant and refined level of detail including the configuration of the operational routes, connection with the feeder network, position, the diagram and set-up of the stops and exchange car parks, and the increase in effectiveness of mobility centres with the aim of responding more and more specifically to mobility demand needs, estimated on the various time lines following a **multi-modal transport model** that assessed the effectiveness of the project alternatives and supported the definition of the final structure, in accordance with appropriate indicators.

Arrangement of some areas of intervention

5.

6.

Type of stop

Coordinated image and public engagement

Starting from the extensive knowledge of the context and the design details, NET Engineering took care of **Project Communication** to satisfy the requirement of the two clients to have a document setting out the project to stakeholders.

After analysing the communication style adopted by the clients on mobility topics, a co-ordinated image was devised, clarified in the design of the logotype, the choice of the dominant colours, font and visual-narrative style marking all the information material.

A product able to perceive the end user and their needs was created by **interpreting the designers' work and valorising the clients' choices** for the Bologna Metropolitan City Bus Rapid Transit – the redesign of the technical documentation, use of infographics, selection of renders and images, and careful rewriting of the "more technical" texts enabled information to be transmitted via infographics able to explain effectively the routes, services adopted at stops, number of routes, project data, work fulfilment times and the positive effects on the area.

7. BRT of Florence: the logo and the color choices that led to its creation

8. Florence BRT: logo overlay

9. BRT of Bologna: The coordinated image and key points from the summary

Vicenza cycle path schedule

A support tool for planning sustainable mobility

The spread of sustainable mobility services in cities, plus discouraging use of private vehicles, is a central topic treated with increasing participation and commitment by public administrations.

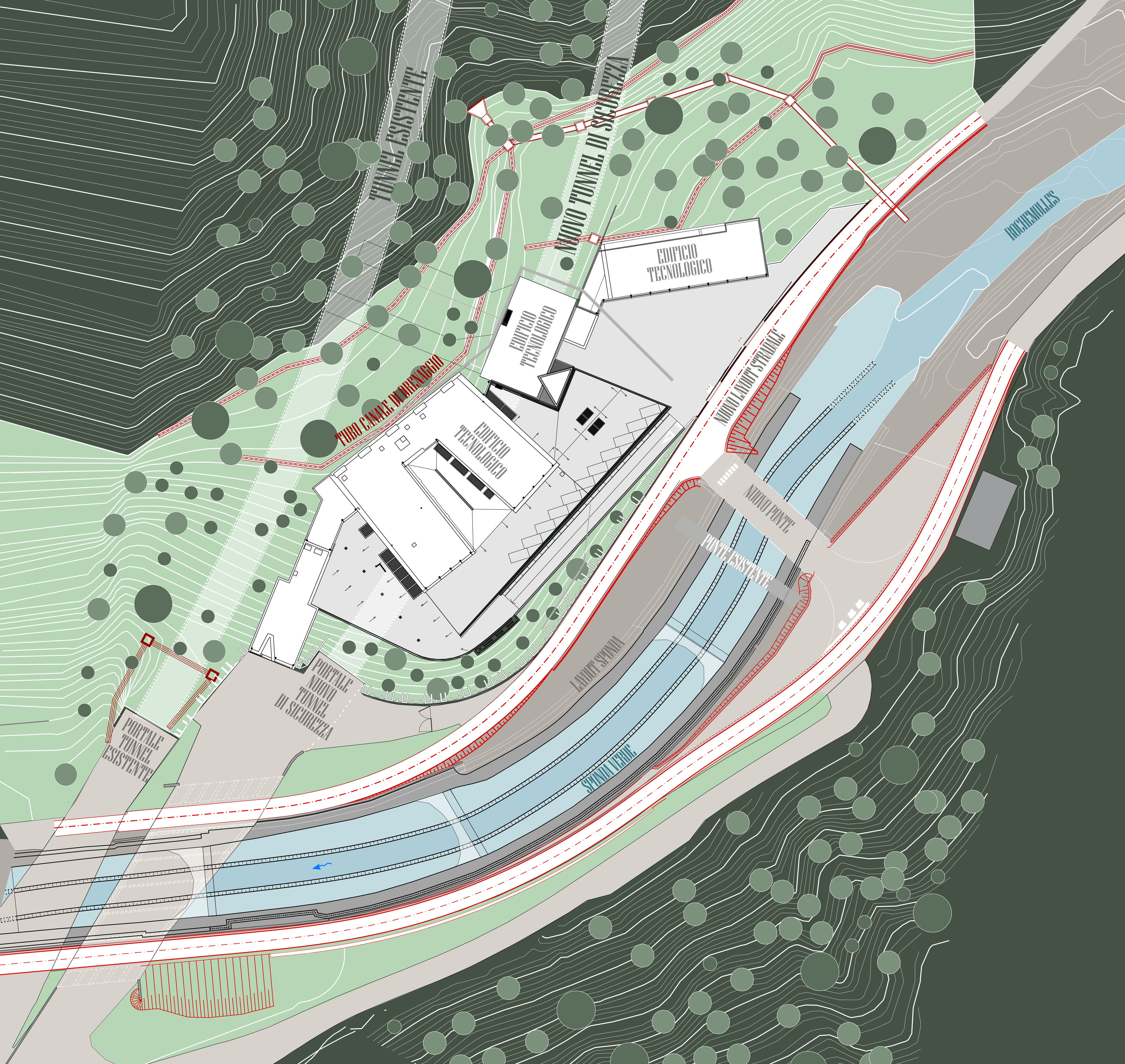
The Municipality of Vicenza took a cue from the best practices of European countries, more evolved in terms of cycling, and started planning sustainable mobility, aiming at encouraging use of bicycles as the alternative to the private car. Currently, cycle paths in the city have varying levels of comfort and danger. On one hand, the city has many cycle-pedestrian paths and two-way cycle paths physically separated from vehicle traffic but there can be problems at junctions and roundabouts. Therefore, to encourage cycle mobility, spaces must be specialised and, where this cannot be done, safe use of roads must be ensured for vehicles, cyclists and pedestrians.

With this background, the city of Vicenza called on NET Engineering to draft a schedule of cycle paths as part of the European 'ITAT3022– PRO-BYKE' project co-financed by the Fondo Europeo di sviluppo regionale e Interreg V-A Italia-Austria (European Fund for Regional and Inter-regional Development V-A Italy-Austria) as a support tool in planning type solutions for cycling. The aim of the schedule is to give type examples and guidelines for the future planning of cycle paths, directing the designer towards finding the best technical solution based on the operating situation, traffic conditions and the environmental context, respecting current Italian law and paying attention to design criteria and the innovative operations adopted by other countries.

When drafting the schedule, NET Engineering used Street Type, an innovative tool developed by Transport for London which defines a new support framework for political, operational and investment decisions for road transport infrastructure. The tool uses a classification matrix of nine categories to map city streets according to the type of movement people and good (not vehicles) make and the features of the places, i.e. businesses on the roads and their relationship with the urban fabric. Mapping city streets using the movement-place diagram provides public administrations with support in establishing a priority of the various streets, maximising use of the available space in the existing road network and establishing the need for strategic infrastructure interventions.

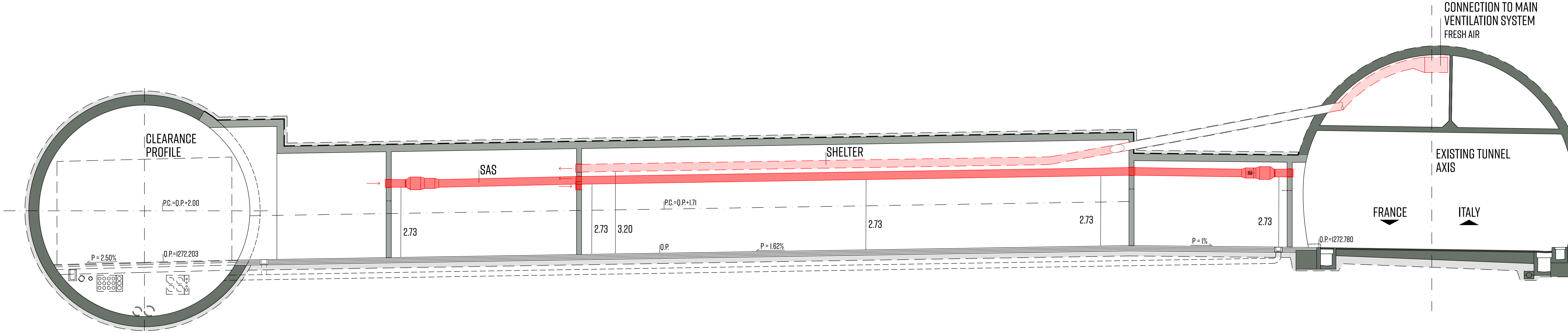
NET Engineering involved Cyface, a German start-up which devised a monitoring system for bike use and the state of the road surface, in the project with the aim of offering an extremely precise contribution to the client. Therefore. citizens were asked to download the Cyface app and use it on their bike journeys. This enabled bike use to be mapped, tracing the departure and arrival points, indicating aggregation points, i.e. points of interest for cycling, and also slow points – places where the administration should give priority to intervention.

1. Examples of types of solutions: Bus stop in line with cycle lane; Roundabout intersection with segregated cycle path; Traffic light signalized intersection



The Italian section of the Frejus tunnel

The strategic role of the safety tunnel in the Italian-French connection



1.

Communication bypass between the existing tunnel and the new one. Cross ventilation integration

The construction of the safety tunnel alongside the existing Fréjus road tunnel is one of the most significant construction sites in the national scene of public works. The tunnel is almost 13 km long (6.4 km of which in Italy) and has an excavation face 8 m in diameter. The strategic importance of the project lies in the updating of one of the busiest Alpine crossings to the latest tunnel safety standards, thus allowing an important development of the road network with France. On the Italian side, the current entrance to the Fréjus Road Tunnel is a little north of Bardonecchia, about 200 metres east of the railway line. The safety tunnel project set out the excavation of a tunnel east of the current one with a layout more or less parallel to that of the existing road tunnel.

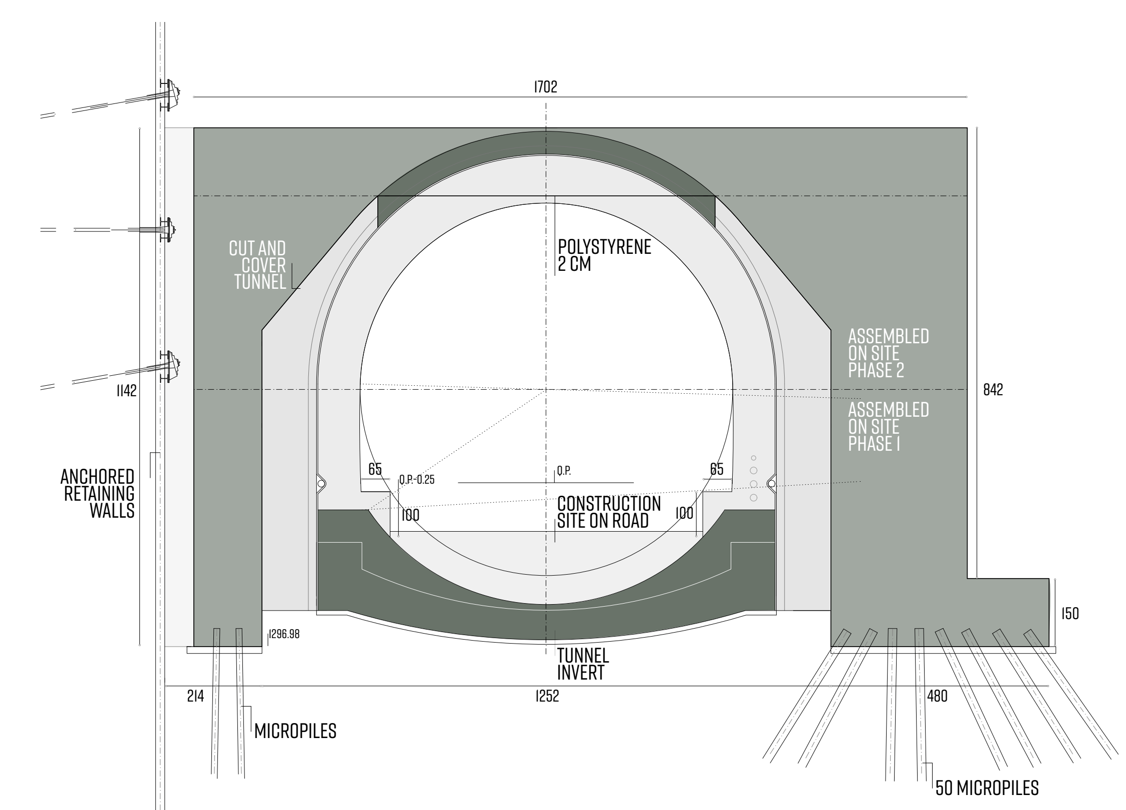
Change of direction

At first, the project planned a safety tunnel 5 metres in diameter connected to the existing tunnel with by-passes for vehicles and pedestrians, with the aim of equipping the current tunnel with escape routes if there was a fire. After the fire of 2005, the Fréjus Safety Committee decided to amend the project creating a second tunnel with a diameter of 8 metres.

At the end of the work, **there will be two one-way road tunnels connecting Italy and France, fitted with the latest safety installations and thus making the Fréjus tunnel the longest European double-barrel tunnel. The project for the new tunnel was completed by a series of external improvements like the access roads, works crossing watercourses, new buildings serving the safety installations** (ventilation, electrical circuits, fire-prevention, etc.).

A multi-disciplinary challenge

The complexity of the work, which uses various excavation techniques – TBM and traditional technologies – to adapt to the different geological situations met, required a significant design commitment, which was handled through the integration of specialist technical and organisational skills. The multi-disciplinary design work led to the drafting of papers on various areas – geology and geotechnics, structures (bridges, tunnels and retaining walls), hydraulics, roads, environment, construction site set up, and safety. The design experience, but the construction site even more so, undoubtedly presented an invaluable opportunity



Transition section: first segment

2.

for technical and methodological growth. The design and construction of such a long road tunnel poses a series of multi-disciplinary and human problems of enormous complexity. A large group of designers from three different Italian companies interacted, continuously co-operating, with the Works Management team, Fréjus Safety Committee and the French designers. The tunnel was excavated using the same Single Shield TBM used in the French Lot I, purchased by the temporary consortium and subsequently adapted to the excavation of the Italian section. **The excavation work continued for 491 days** in which a total of 6.285 km of tunnel were dug. A traditionally dug section of 68 m with the shape and size to allow the subsequent passage of a TBM was created during the excavation with the TBM. The machine used for the excavation was then dismantled and removed from the construction site in April 2015. The particular nature of the excavation was due to crossing sections where the roof was very thick, more than 1,800 metres, which required continuous monitoring of the excavation parameters with the aim of preventing and keeping watch over any convergence. The creation of technical station 13/8 is currently in progress and the completion of the excavation of Shelter No. 34, used as storage for the explosives, is planned.

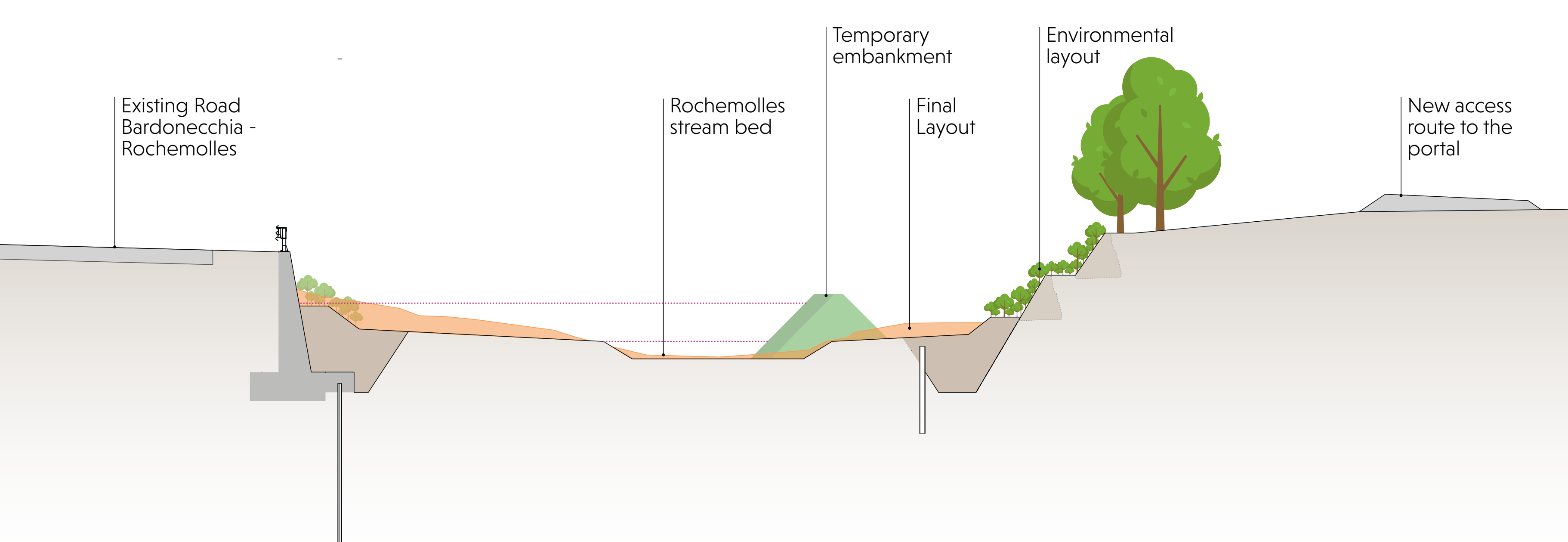
At the same time, the work for the new systems, especially the installation of the lighting and the ventilation and fire prevention systems, is being carried out.

The new tunnel has generated positive economic and social effects, enabling the passage of a new power line with very low environmental and landscape impact. The creation of a pilot project is also planned that would allow the extraction of the natural heat of Mount Fréjus and its enhancement for civil and domestic use. A singular aspect of the creation of works in the tunnel is that the final **design stage has to be followed by a technical assistance service during construction which is able to adapt the original plans to the 'in progress' results of the site**, and resolve any critical points met.

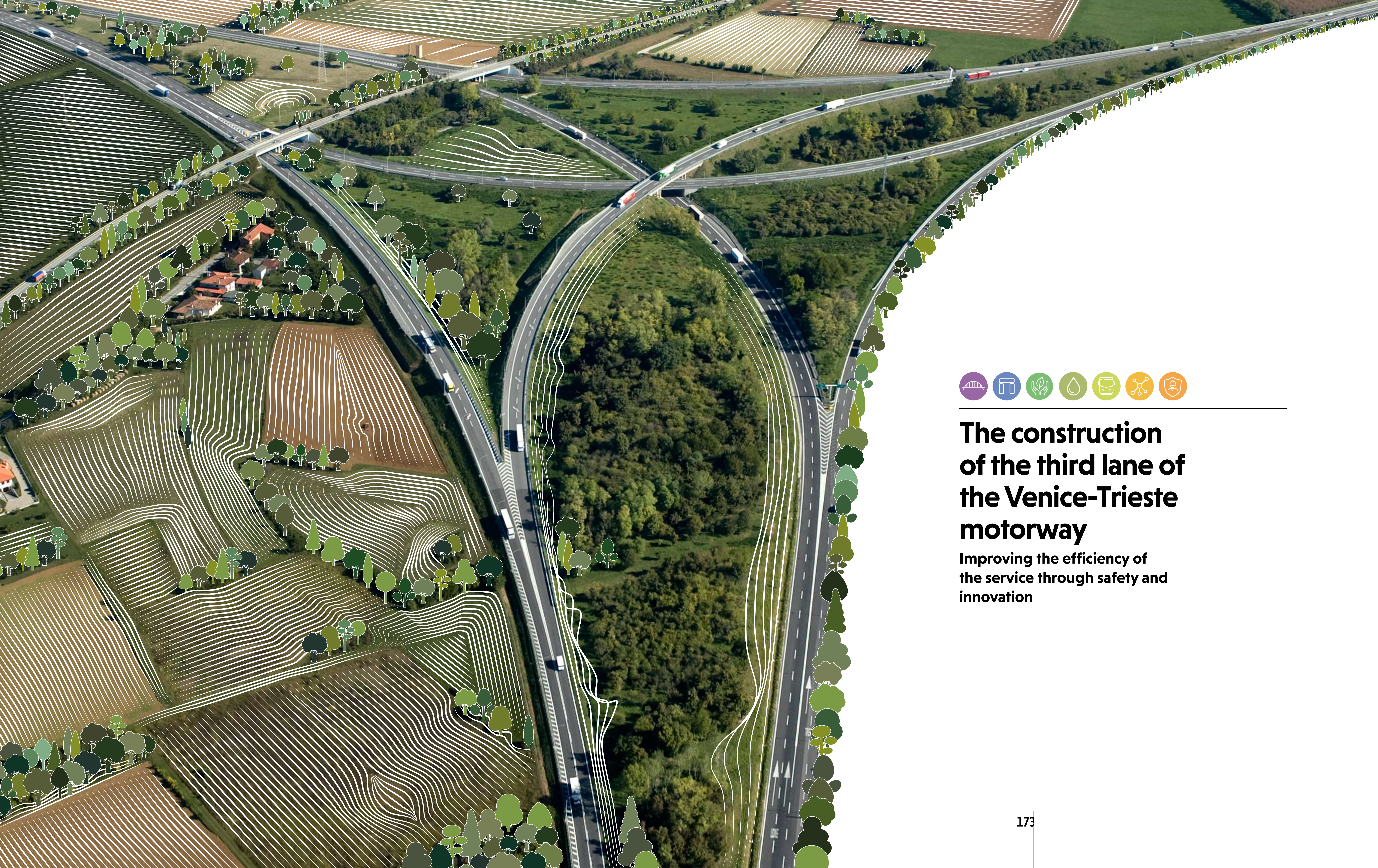
Progressive integration

Another specific point of the project was the need to ensure the progressive integration of the new safety tunnel with the existing, operational tunnel by making the new safety areas available keeping pace with the progress of the excavation face. **The tunnel was fitted with the latest smoke and fire signalling equipment and temperature** detection sensors along the route a short distance from each other monitored by a control room, called the Centralised Control Post. A hydrant system supplied by water tanks has been installed every 130 metres. Two thermographic portals have also been created and put at the entrances; they can detect whether there is abnormal heat-generation in the vehicles in transit. These specific items have led to a high level of attention both in the detailed planning of the operations and the management of the integration stage between the two tunnels. Currently, the excavation stage has ended and the tunnel will soon be commissioned.

TYPICAL SECTION - OPERATIONS IN RIVERBED

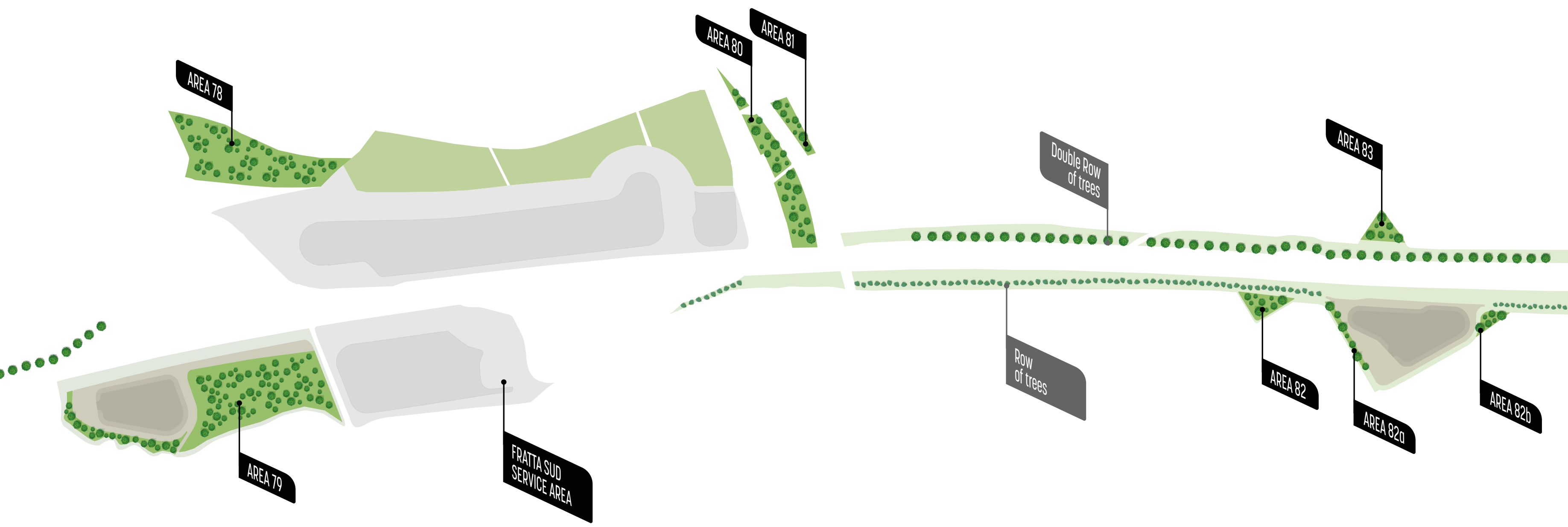


3. Entrance to the new tunnel, Italian side: excavation with TBM



The construction of the third lane of the Venice-Trieste motorway

Improving the efficiency of the service through safety and innovation



1.

Environmental works around the Fratta Sud service area

The final design to widen the A4 Turin-Trieste motorway from two to three lanes was developed in two different projects. The first concerned the section in Veneto, between San Donà di Piave and the Alvisopoli junction for an overall distance of 33 km+500 m. The second project concerned the part in Friuli Venezia Giulia, in the Quarto d'Altino-Sistiana section, and between Gonars and Villesse, for a distance of 15 km+862 m.

The aim of the project is to increase the level of service safety and accessibility of the territory to the infrastructure and enhance the environmental characterisation elements of the territory.

In Veneto, the project included the upgrade of the Cessalto, Santo Stino di Livenza and Portogruaro by-pass, the variants of the interfering ordinary road network and some new roads. The planned works included significant structural works, particularly those concerning the crossing of the River Livenza, which represented a unique opportunity to improve the flow conditions of the disturbed waterways.

In Friuli, the Palmanova intersection, a motorway junction close to the built-up area of Palmanova which allows the interconnection between the A4 and A23 motorways, was significant. The three routes, Udine, Venice and Trieste, are symmetrically connected with a three-pointed star configuration. This is a singular point where **ramps and structures, which have been adequately sized and checked from the transport and safety points of view, are concentrated.**

Special attention was paid to the study of the environmental and landscape integration of the work, with the intention of creating infrastructure that becomes an integral part of the landscape, also transforming it, as far as possible, into a planted corridor where part of the structures can reinforce the environmental characterisation of the area. For this purpose, the project suggested large longitudinal vegetated structures, in both the traffic island and along the lateral structures (the tree rows along the path).

The importance assumed in the motorway greenery system, from the rolling tanks / water treatment and this both for their extensions and potential as an ecological role which they can take from established plants (halophytes, hedges for disguise and any insertion of arboreal at core shrubs). In addition is scheduled soundproofing the reuse of excavated material, and specific treatment for platform water.

The effects socially and on the project area can be summarised as follows: **resolution of extensive flooding problems** in the areas near to the A4; improvement of **accessibility of the infrastructure**; improvement of the **'permeability of the work'** from the hydraulic and secondary connections points of view; improvement of the safety conditions in the operation of the infrastructures; improvement of the safety conditions during construction; green works and environmental mitigation respecting the Kyoto protocol.

Likewise, the project also set out the **updating of significant structures such as 12 bridges and viaducts, 18 flyovers, 20 underpasses**, with the prospect of a future widening of the motorway section to four lanes.

However, the following were built from scratch: **2 highway overpasses, 16 overpasses for secondary roads, 15 underpasses, 2 railway underpasses, 3 flyovers, 4 bridges over main waterways and 4 over secondary waterways.**

The project has a system of water disposal from the roadway with a depuration process through a first treatment plant (oil spill tank) **which intercepts the pollutants if there is an accident** – an automated procedure is planned for this purpose managed by the concessionaire's control centre; a lamination or lagooning area, to ensure the hydraulic constancy of the system through the modulation of flow, limiting the flow rates to low values compatible with the territory (10l/s per ha) - and a final treatment plant, with the aim of reducing any residues and improving the quality of the water to be introduced into the identified receptors.

The other arrangements include: a technological communication network (fibre optics), electric grid and a phone network, which runs both on the north side and up the southern one of the A4; the remote monitoring of the gutter and a system of diversified plants for video surveillance and the automatic traffic control system (DAI). The combination of these **technological networks has made it possible to reduce maintenance and operating costs, improve user safety by detecting dangerous conditions** and promotes optimized management of emergency situations.

The venetian section San Donà of Piave-Alvisopoli

The overall length of this section of the project is about 33.5 km and set out the updating of the junctions of Cessalto and Portogruaro and the transfer of the toll booth of San Stino of Livenza. An **Environmental Impact Study and an Environmental Effects Study** were drafted for this section. The design used a **multi-disciplinary approach** typical of system engineering to indicate the best technical solutions, using multi-criteria analysis.

Layout of the San Donà di Piave - Alvisopoli project

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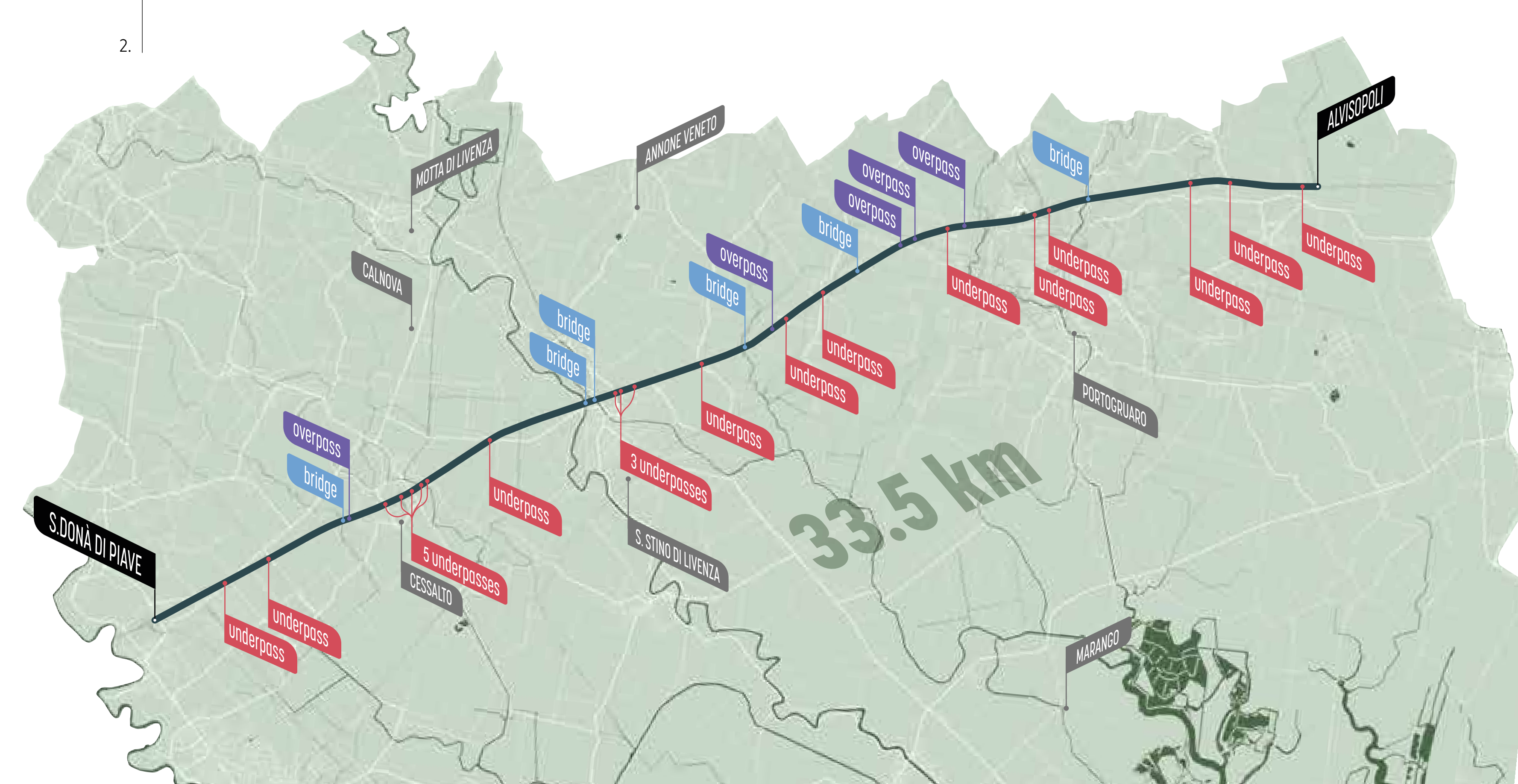
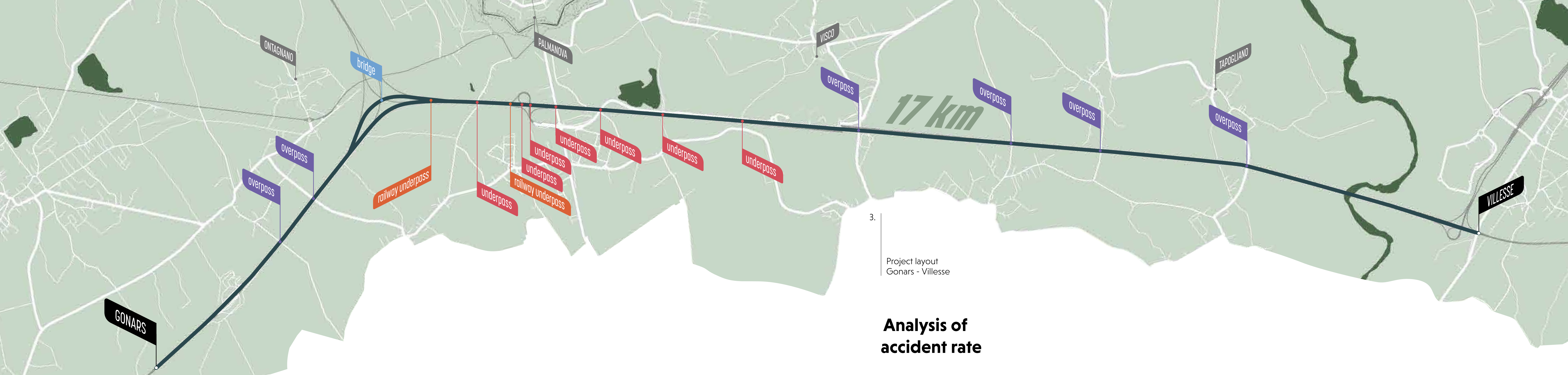




3.

Project layout
Gonars - Villesse

The Gonars-Villesse section in Friuli

The infrastructure concerns the area of seven municipalities in Veneto and three provinces; their involvement was necessary so that solutions where several bodies had given their opinion could be shared. During the design, a **technical comparison was initiated to benefit the territory affected by this work**, which enabled the rationalisation of crossings of the River Livenza, the many existing canals and the optimisation of the reclamation network drainage systems. The hydraulic work also acts as a body of water to protect the area and, in relation to the morphology of the area, flood prevention after heavy rain.

The project concerned the construction of the third lane of the A4 motorway between the junctions of Gonars (province of Udine) and Villesse (province of Gorizia) for an overall distance of about 16 km. The section involved in the work included the Palmanova junction, where there is the intersection between the A4 and the A23 'Alpe-Adria' motorway, **considered one of the critical points of the whole Veneto/Friuli motorway network in terms of congestion and accident rate.**

The extension of the road section enabled the optimisation of the geometric conformation of the intersection and vehicle traffic flow conditions through a careful transport study.

From the environmental point of view, the construction of **new green areas along the motorway route was planned to compensate for the estimated increase in the CO2 emissions**, in accordance with the indications of the Kyoto Protocol. In addition, the plant for the collection and treatment of first flush waters, based on **phyto-treatment technologies**, was designed.

The project also set out the updating of all the structural works, a viaduct, 7 flyovers and 7 underpasses, which were sized with the prospect of a future widening of the motorway section to four lanes.

Analysis of accident rate

NET Engineering developed **an analysis of the accident rate in both sections that set out the statistical analysis road collisions** in the previous three years and the kinematic reconstruction of the various types of incident so that the risk factors linked to the infrastructure could be indicated and adequate minimisation measures chosen.

The application of an **innovative traffic simulation model,** based on a statistical description of the behaviour of vehicles incorporated in a set of similar features (MESOSIMULATION), enabled the impact of the construction sites on circulation to be assessed and their space-time positioning to be organised better to ensure the highest possible safety levels and optimisation of vehicle traffic flow conditions.

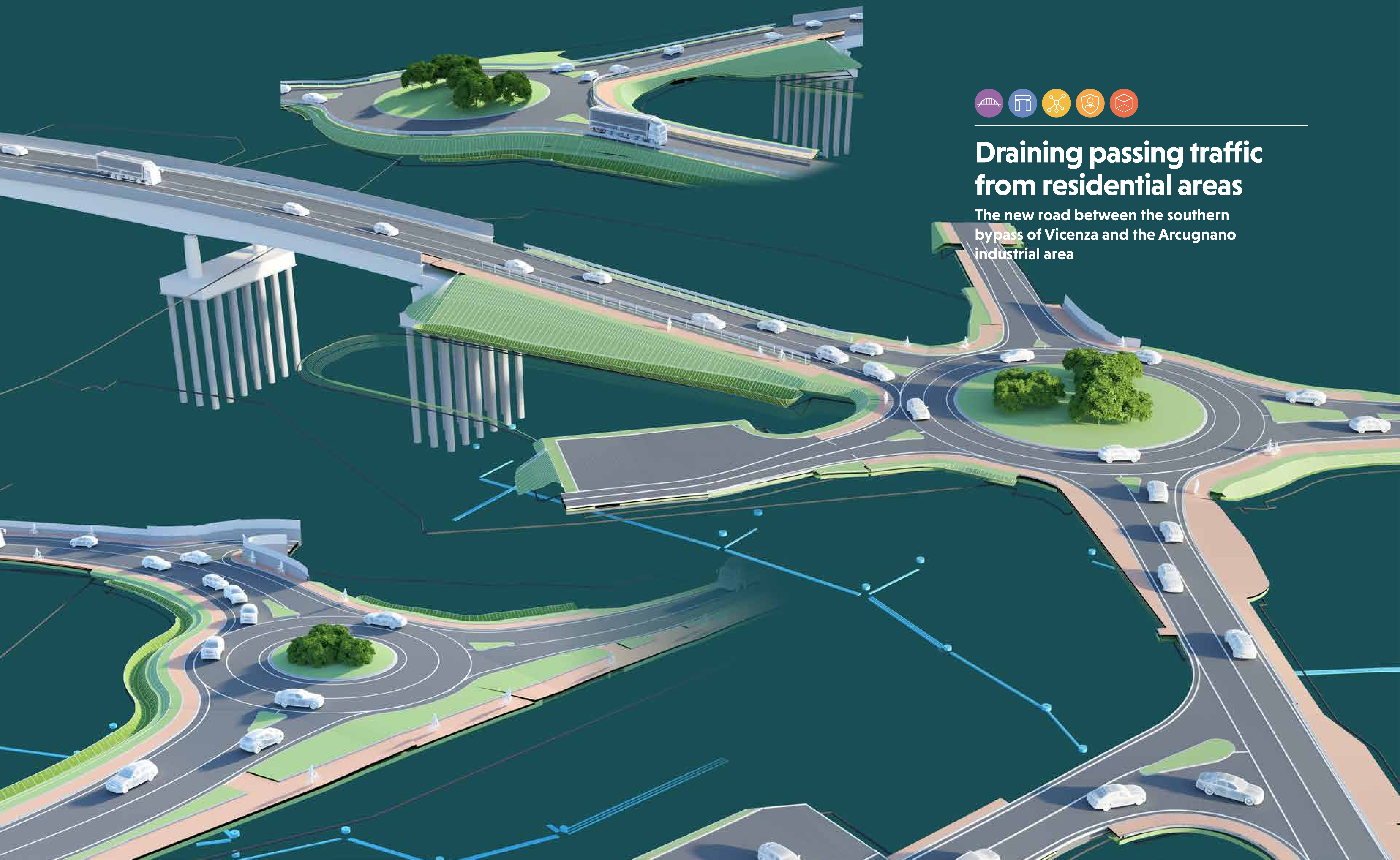
Dialogue with stakeholders

As already mentioned, during the planning stage a technical discussion was initiated with local authorities and services. In particular, the relationship and dialogue with the Consorzi di Bonifica has greatly influenced the planning phase. In fact, these are entities that have been waiting for the construction of the work for some time to start a common process aimed at solving the numerous critical issues of the water network close to the road infrastructure, which in turn led to situations of flooding, creating inconvenience to the territory.

The solution studied and implemented envisages a gutter channel approximately 14 km long, capable of filling, north of the A4, the excess volumes of water during meteoric events, and redistributing them correctly in the channels south of the A4, through a system of sluice gates and overflows capable of suitably regulating excess flow rates.

This optimal solution was identified only thanks to a constant and fruitful dialogue with the institution concerned.

The direct involvement of stakeholders right from the design phase is a procedure that NET Engineering constantly applies, certain of the benefits that the sharing of choices in the design phase generates in the subsequent steps of approval and implementation of the projects.



Draining passing traffic from residential areas

The new road between the southern bypass of Vicenza and the Arcugnano industrial area

NET Engineering curated the Technical Economic Feasibility Project and **Final Design, developed using BIM**, for the creation of the new road connection between the Tangenziale Sud (southern bypass) of Vicenza and the ordinary road network of the municipalities of Arcugnano and Altavilla in the province of Vicenza. In detail, the work is localised south of the A4 motorway, in the area between the Casello of Vicenza Ovest (West Vicenza Toll Booth) and the northern extremities of the Berici Mountains. The aim of the project is the rationalisation and improvement of the provincial and municipal road networks around the A4 motorway-Tangenziale Sud, Vicenza urban roads and the Strada Provinciale 106 della Pilla (Pilla Provincial Road 106) to the south.

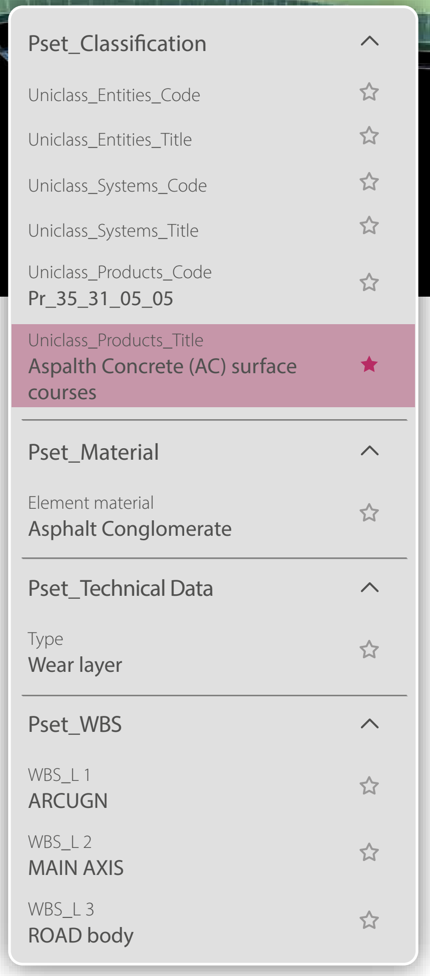
The new infrastructure is intended to 'drain' consistent traffic flows that currently cross densely urbanised areas, channelling them outside the built-up residential areas with a route that extends partly in the West Vicenza service station and partly through the Arcugnano manufacturing area, where redevelopment and completion of the existing road network is planned.

Overall, **the operation was designed to ensure adequate safety standards for the role assigned to the new road connection while containing the land take as far as possible and minimising the environmental impact** associated with the construction of the planned new works. The new road layout and the technical features of the planned infrastructure will thus bring **significant benefits both for safety and the reduction of pollution (acoustic and atmospheric) for the resident population with the resulting appreciable advantages for the area crossed and road users.**

The planned system originates from the roads in the West Vicenza Motorway Toll Booth car park and ends on the Pilla Provincial Road, setting out the implementation of safety measures for the existing local road network, for an overall length of about 2.6 km.

The main operation concerns the construction of the connection between the West Vicenza Motorway Toll Booth and the Sant'Agostino industrial area (about 970 m), ensuring continuity in the traffic flow from the motorway to the manufacturing area. In addition, redevelopment aimed at improving the safety of vehicle, cycle and pedestrian circulation and stopping along the main road in the industrial area, with special attention to the circulation and manoeuvre needs of heavy vehicles, is planned.

Both drafting the Technical Economic Feasibility Project and the subsequent Final Design stage **involved the local administrations and bodies managing the area**, which contributed to the assessment of the different proposals and finding the one considered preferable in terms of urban planning and environmental function.



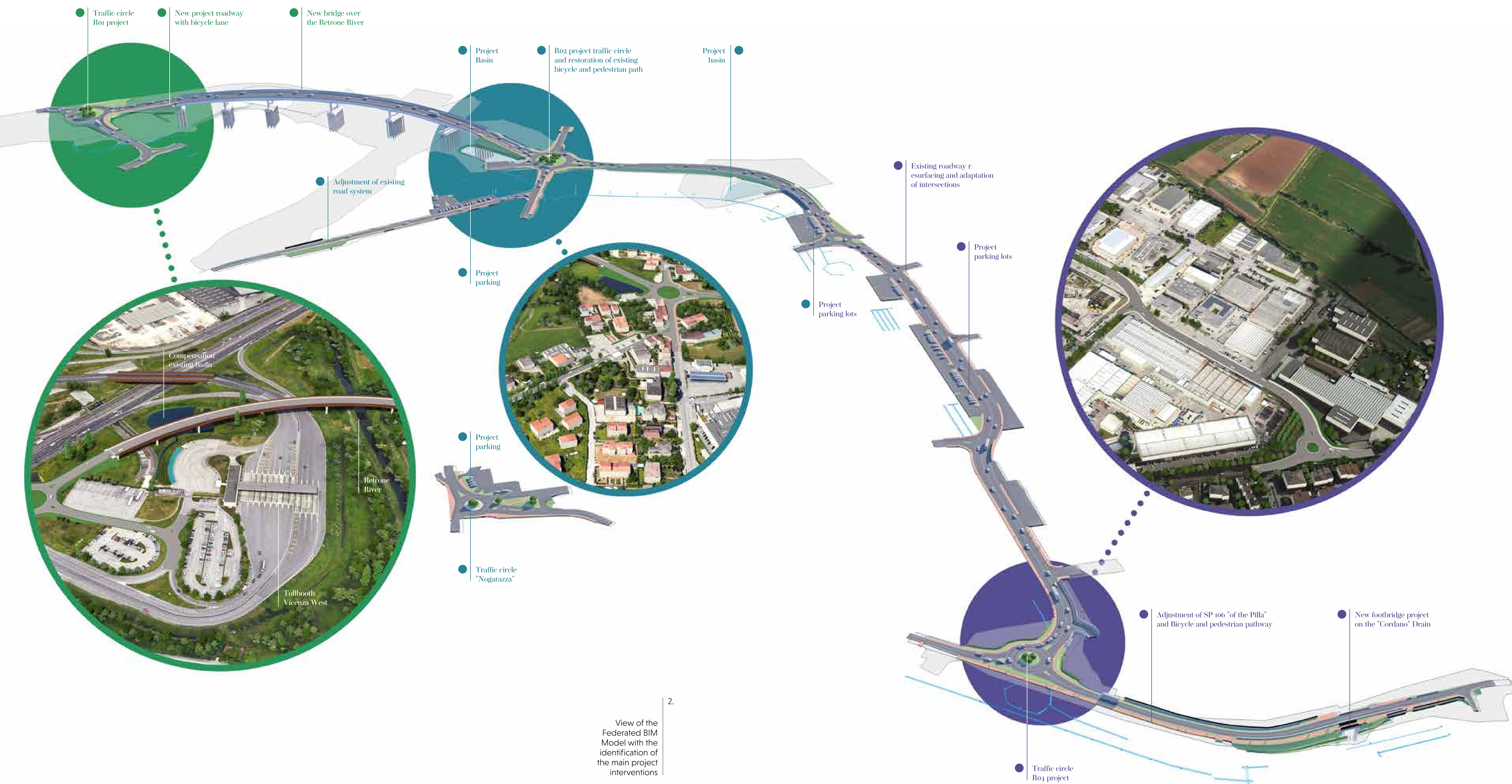
1. View of the infrastructure model and reading of the Pset_Parameters attributed to each modeled element

BIM 5D

The project was created using BIM methodology which significantly facilitated the interaction between the disciplines involved – road infrastructure, structure and hydraulics.

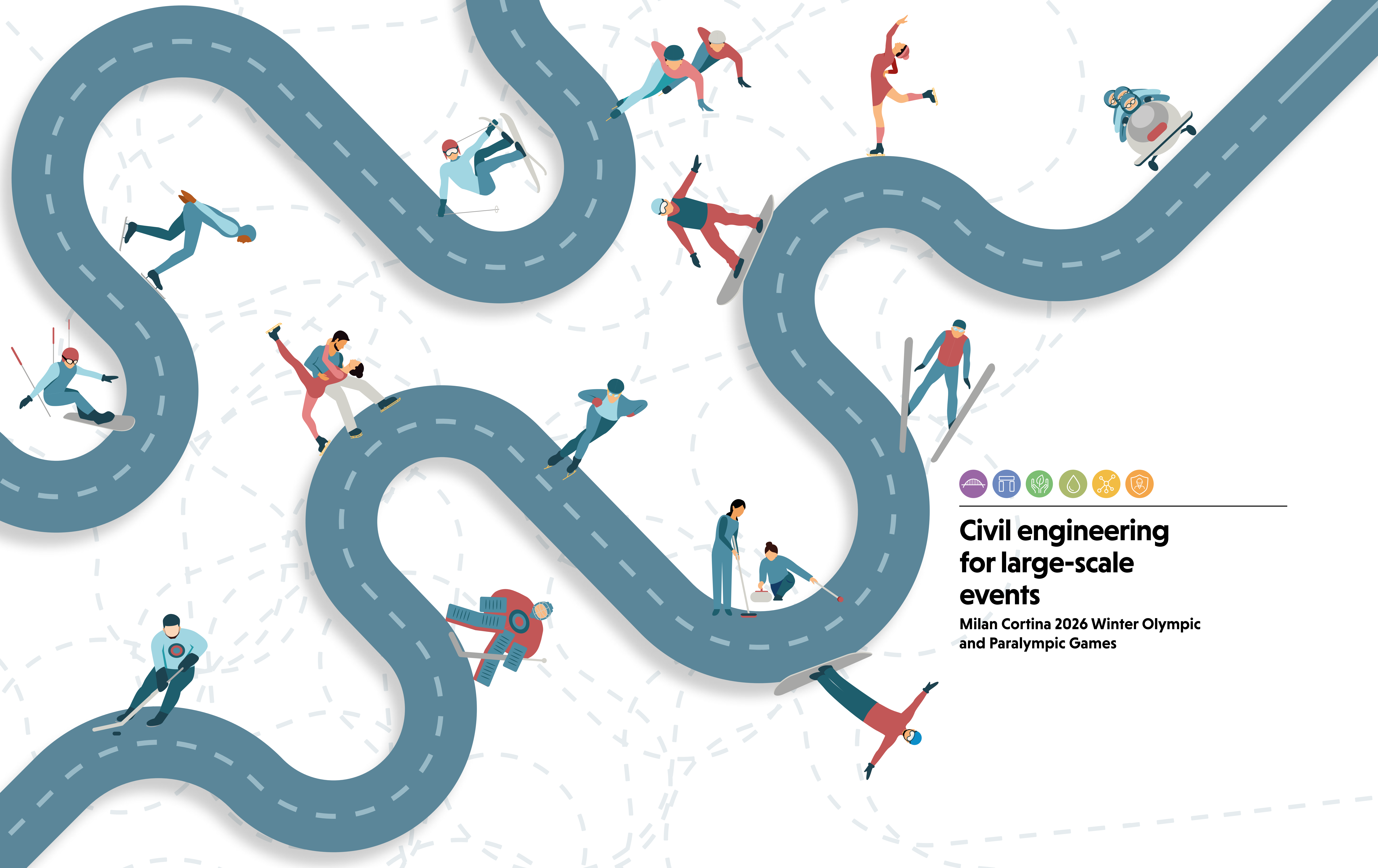
A federate model was created starting from the BIM models devised for each discipline, respectively with Sierrasoft Roads, Autodesk Revit and Autodesk Civil 3D, which enabled analysis of the interferences and BIM (LC1, LC2 and LC3) co-ordination checks to be made.

In detail, the models were not only implemented through 3D modelling but also with all the design and planning information. Subsequently, the quantities for computation (BIM 5D) and project tables were extrapolated.



2.

View of the Federated BIM Model with the identification of the main project interventions



Civil engineering for large-scale events

Milan Cortina 2026 Winter Olympic and Paralympic Games

The Ministries of the Economy and Finance, and Infrastructure and Transport, with Lombardy Region, Veneto Region and the autonomous provinces of Trento and Bolzano were appointed to carry out the **works essential for making the existing infrastructure indicated in the candidacy dossier efficient and appropriate** for the **Milan Cortina 2026 Winter Olympic and Paralympic Games** in Decree Law 16 dated 11 March 2020.

Cancellation of level crossings

Among the works set out by the Decree Law there is the **cancellation of level crossings on Stelvio Strada Statale 38** (Stelvio State Road 38) along the Milan-Tirano railway line. The **Alternative Projects Feasibility Document** curated by NET Engineering set out the **elimination of 14 level crossings** in the Sondrio-Tirano section. NET Engineering developed the design solutions, **assessing each alternative from the quality, environmental, technical and economic points of view.** When necessary, the hydrologic and hydraulic context of the area where the work would be carried out was also analysed and the results influenced specific design choices.

After the selection of the alternative designs, the **Technical Economic Feasibility Project** of the chosen solutions was developed. The **Final Designs** are currently being implemented.

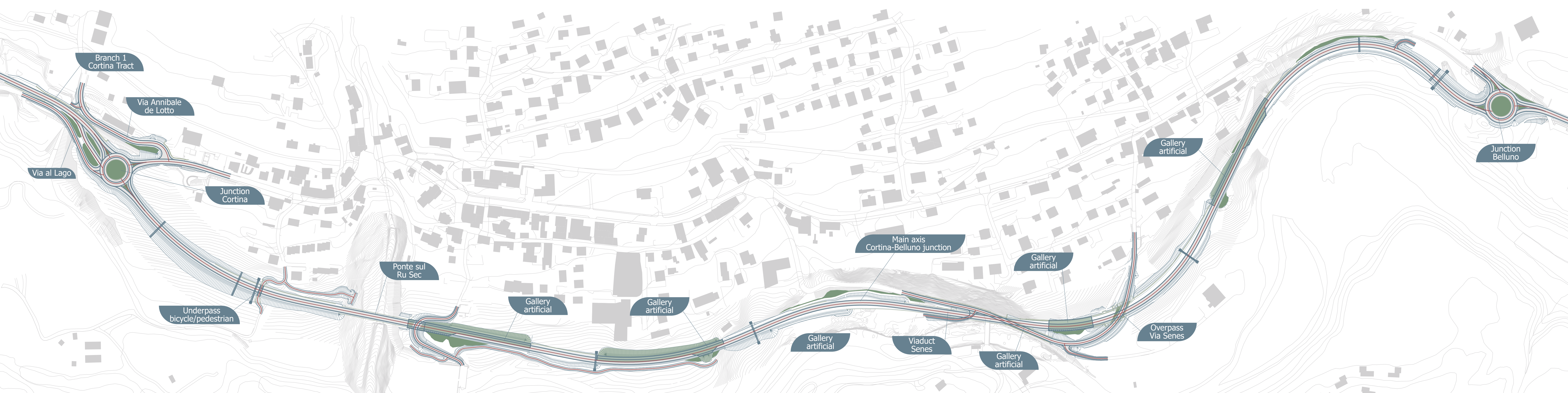
San Vito di Cadore

In the same context, Net Engineering was responsible for **planning the operations on Alemagna Strada Statale 51 for the elimination of various critical points affecting safety and the efficiency of the road network.** In detail, NET Engineering **produced the executive design of the SS 51 variants for crossing the municipalities of San Vito di Cadore and Tai di Cadore** (Belluno).

The project devised for crossing San Vito di Cadore sets out the creation of a C2 category road (secondary suburban road) to **by-pass the residential centre** by separating from the current Strada Statale 500 metres to the south and north of the town. Two roundabouts will be created near the two junctions of the new road on both the Cortina and Belluno sides which will connect the variant with the SS 51 and other secondary roads. The new route also plans the creation of four artificial anti-noise tunnels, a viaduct, bridge over the river Ru Sec with a span of 80 metres, a flyover, a cycle-pedestrian underpass and various other supporting works including some of considerable height.

Framework plan of the works of San Vito di Cadore

1.



Tai di Cadore

The project devised for crossing the centre of Tai di Cadore, created in collaboration with the partners Systra SWS and VAMS Ingegneria, plans the creation of a **new natural tunnel** creating a paved by-pass as a main work. Two main roundabouts at the mouths and a new reworking of the north link for Pieve di Cadore have also been designed. The creation of new intersections with existing junctions, the remodulation of the cycle path, the hydrological organisation of three canals, technological systems and minor support works for the roadworks are also planned to ensure the correct usability of the operation.

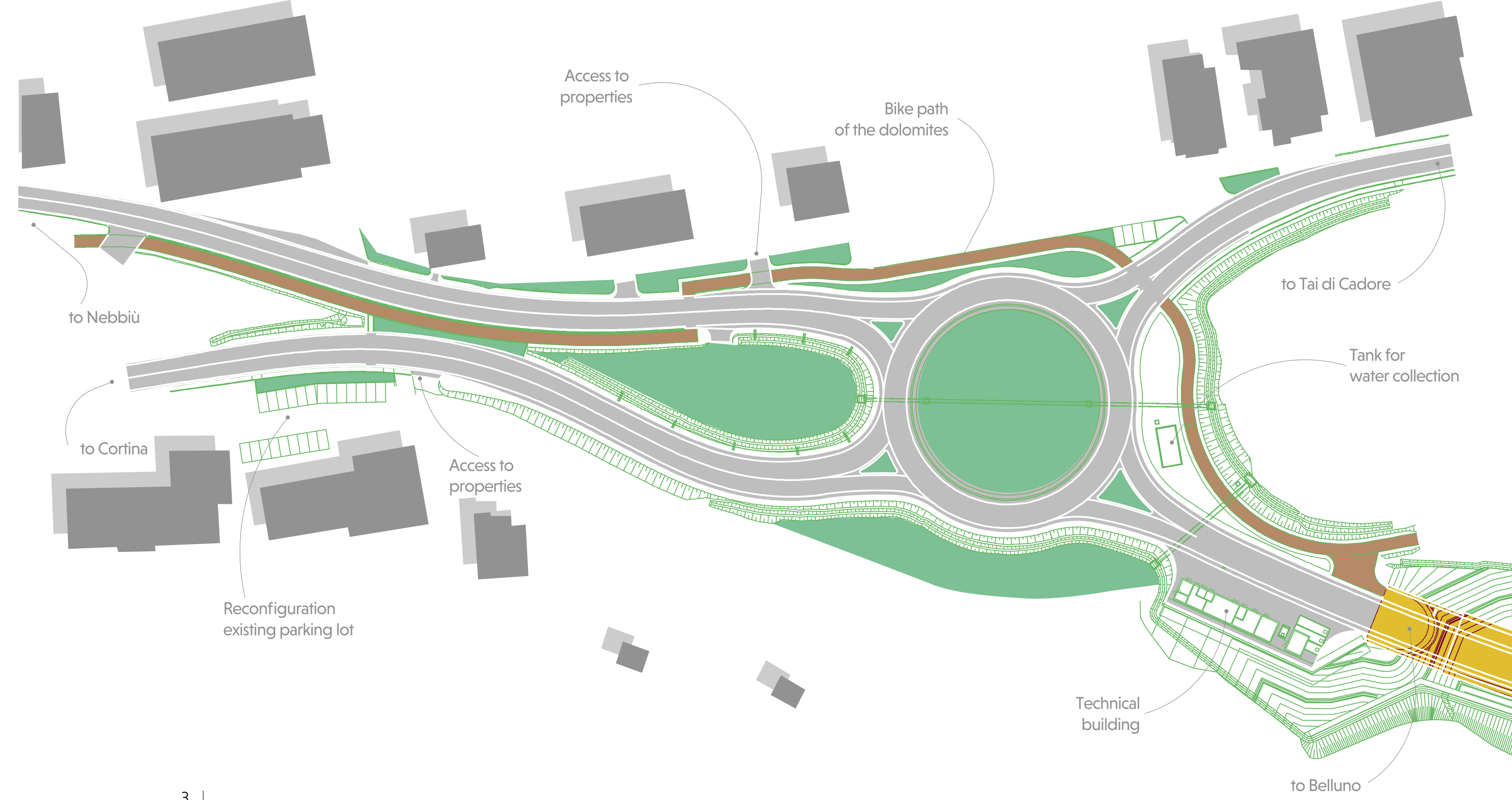
Attention to the region

All the projects curated by NET Engineering under the creation of works for accessibility to Cortina were developed starting from special **attention to the region and its inhabitants.**

The impact on the region of both construction work and operation were assessed for each alternative design. The choice was made to safeguard certain habitats from noise, to avoid specific works in some periods of the year so that the habits and behaviour of the local fauna were not affected, and to reduce noise pollution during the construction phase, towards sensitive receptors, etc. while the construction site was active.

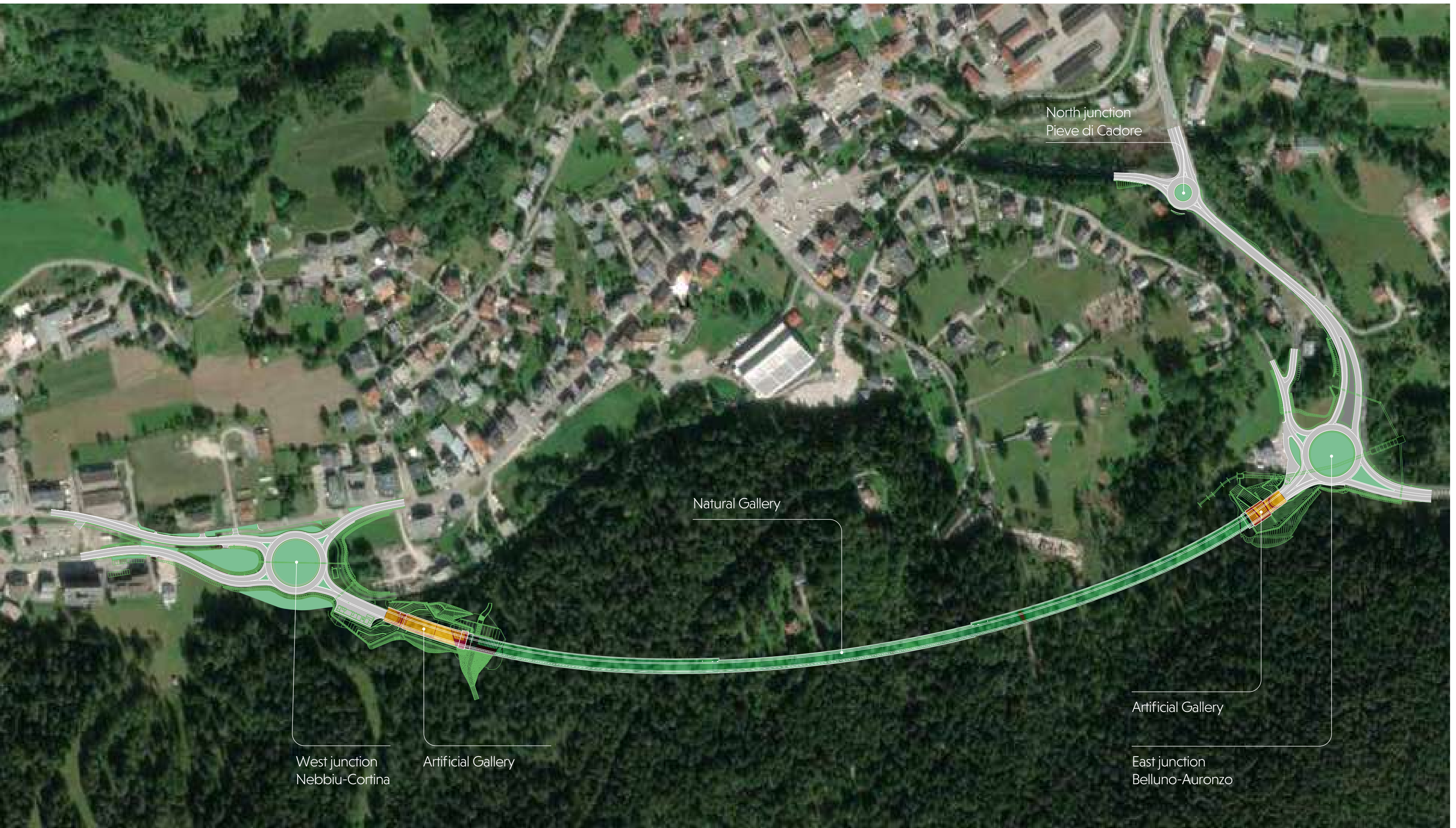
Great attention was also given to the details of the choice of **finishing materials**, such as corten steel, with the aim of **increasing the environmental mitigation works and acceptance by the population. Discussions with stakeholders**, conducted by the clients for both the projects eliminating level crossings and those adapting the SS 51, were essential in choosing the alternatives and the definition of the design details.

The Senes viaduct, developed to bypass the municipality of San Vito di Cadore is an example. The initial suggestion developed in the Final Design was to build a bridge with four spans to improve the visual aspect. This was discarded after public engagement in favour of an alternative design with the construction of a viaduct with just two spans and the replacement of part of the work with stone and vegetation-clad walls. It's therefore clear how **assessment of the regional impact – most importantly the landscape and visual impact of the works, must involve the people with daily lives in the areas involved in the projects.**



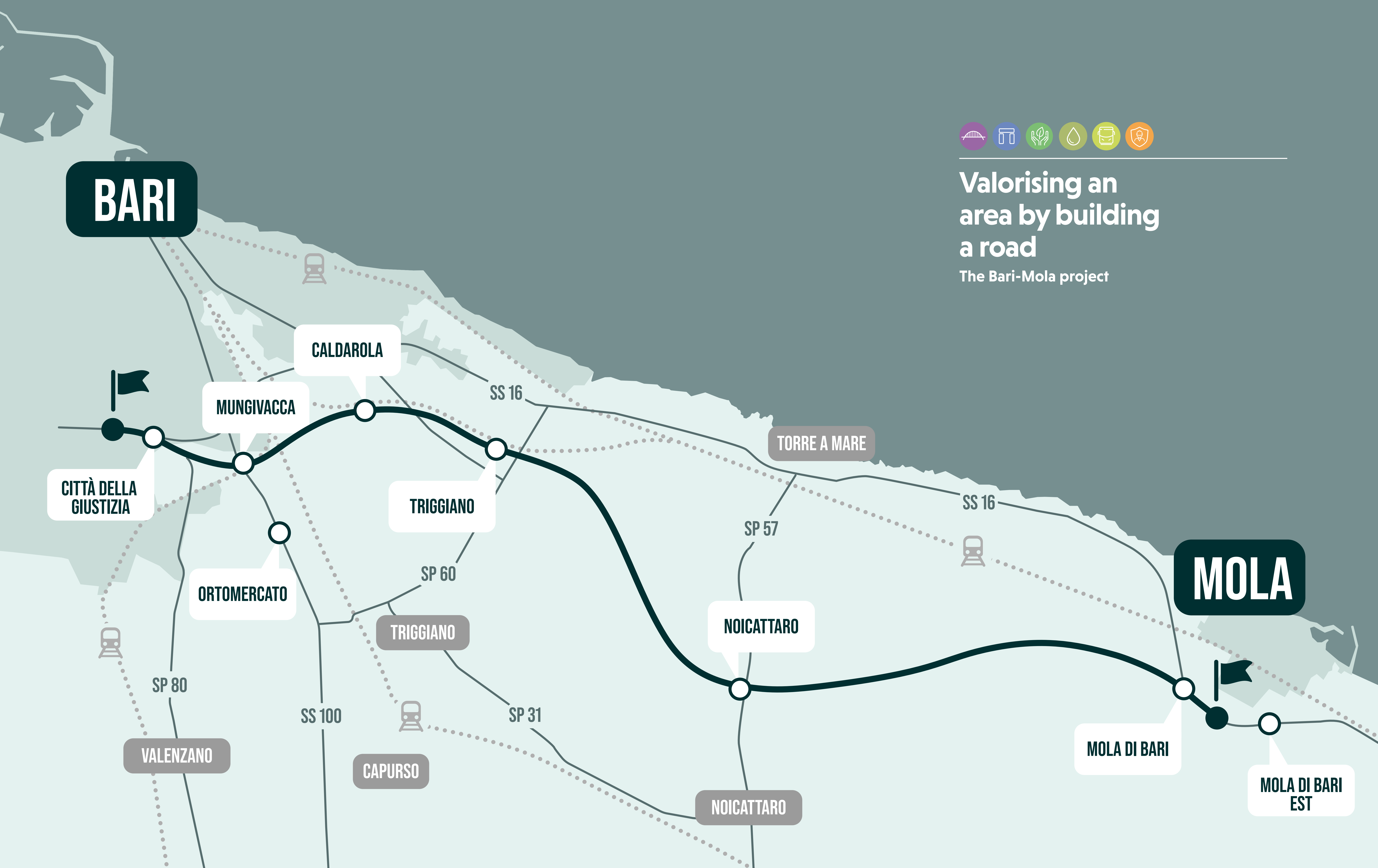
3. New roundabout on Cortina side in Tai di Cadore

2. Variant to the town of Tai di Cadore



Valorising an area by building a road

The Bari-Mola project



The Adriatica SS 16 is the longest State road in Italy and is more than 1000 km long. It connects Padua to Otranto (Puglia) passing along the Adriatic coast and running through many Italian tourist places. It is very congested, especially near to large residential centres where the original route sometimes acts as a bypass.

This is the case in Bari where the SS 16 reaches the limits of its capacity every day during rush hour.

In addition, since there are currently many critical points from the technical, functional and road safety points of view (no hard shoulder, traffic island in the middle does not comply with the law, unprotected direct accesses and off-road obstacles, and human settlements on the edge of the platform), ANAS decided that action had to be taken, **planning a variant to the SS 16 with an overall length of 19.6 km in the section between the municipalities of Bari and Mola di Bari.**

NET Engineering supported ANAS in drafting the **Technical Economic Feasibility Project** and was responsible for drafting the **Final Design.**

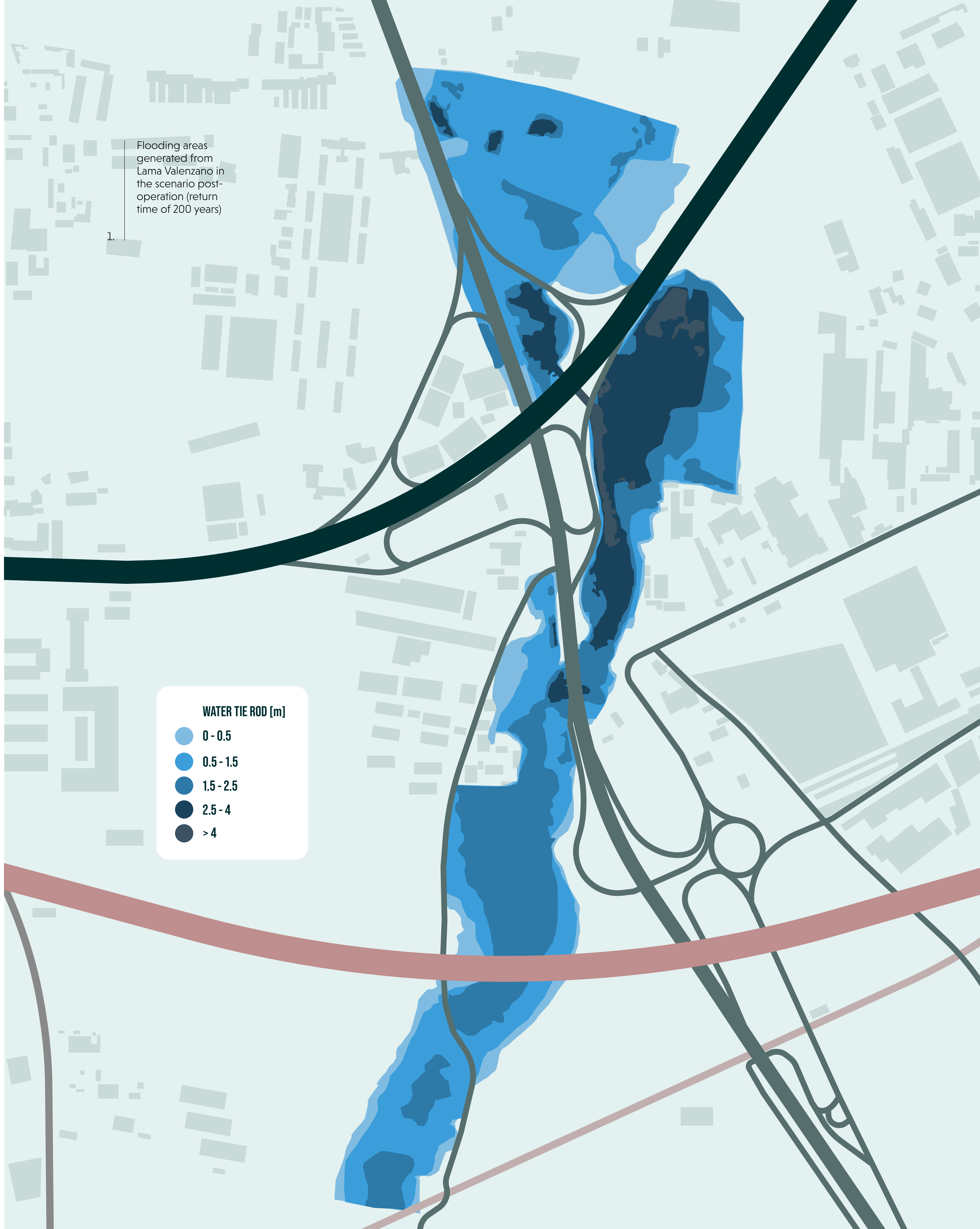
A multi-disciplinary project

Three alternative designs were analysed within the Technical Economic Feasibility Project. The main difference for the same road section was the plano-altimetric route because of the extension and features of the works and the interconnections and junctions with the existing road network. NET Engineering curated the draft of the transport study, the costs-benefit analysis and co-ordinated drafting of the environmental impact study so that the different design proposals could be carefully and effectively assessed and compared.

The **transport study**, created to estimate the effects of the new work on the mobility system, was divided into the following activities:

- Reconstruction of road mobility in the current scenario;
- Definition of the reference scenario for the timeline for activation of the work but without project intervention, to be used as a comparison scenario to assess the effects of the new infrastructure on mobility situations;
- Construction of the project scenario in the various configurations corresponding to the three alternatives analysed to prefigure the effects induced on road mobility by the new work;
- Extraction of summary transport indicators.

The costs-benefit analysis assesses the improvement that the fulfilment of a specific project generates on social well-being, allowing an assessment of the economic sustainability. It is therefore a tool which gives objectivity to the decision-making process, reducing the scope of controversy and subjective discretion and adopting criteria that allow respect for rules of general interest. If the benefits of a project exceed its costs, then it can be considered economically sustainable. The costs-benefit analysis for the SS 16 variant was carried out at the same time and in a completely comparable manner for



all the alternatives so that not only the effective advantages the work could generate for the community could be assessed but also to find the best answer and so the one able to ensure the greatest benefits.

A structured analysis of the alternatives, from the strictly environmental point of view, was made in the scope of the **environmental impact study**. The methodology used for comparison is based on the assessment of sustainability of the different initiatives through a logical sequence. This starts from definition of the environmental objectives to be achieved and leads to determination of the balance of resources connected to the work through the schematisation of the work environment reports.

All the studies carried out by NET Engineering indicated the same design alternative as the best as it came closest to the preset objectives and **reflected the environmental, social and economic sustainability criteria.**

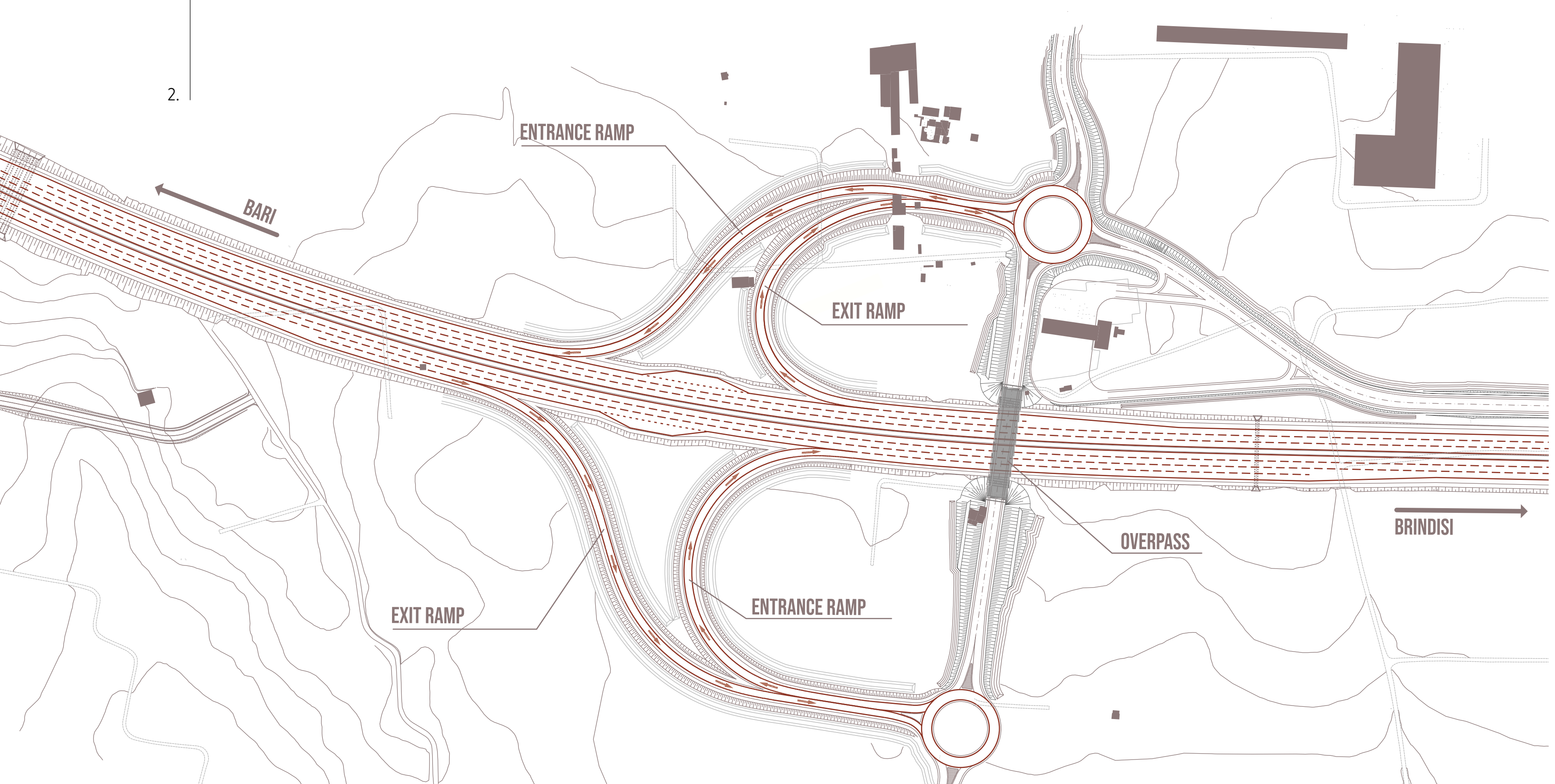
The alternative chosen, for which the Final Design was developed, sets out road infrastructure fully in the variant compared to the existing road with three lanes in each direction. The work planned along the variant includes seven junctions, some of which are especially complex, new entrance ramps, and updating and redevelopment of the existing sections with the aim of rationalising neighbouring local roads and increasing the usability of the new route. Further, in terms of the traffic system, the restoration of continuity of all the local roads involved through underpasses and overpasses of the new road infrastructure is planned.

The route is more or less parallel to the coastline, meeting many main and secondary watercourses in the form of ditches. These are typical of the Bari area and have low surface circulation as most is underground. In addition, the ditches only have water when it rains otherwise they are mostly dry.

As the watercourses in the first part of the route near Bari are both hydraulically dangerous and risky, NET Engineering **drafted careful hydrologic and hydraulic studies**, developing single and two-dimensional modelling so that the hydraulic compatibility of the work could be assessed and the type and size of the hydraulic crossing works could be determined, ensuring compatibility of the work with the local context.

Planimetric view of the Noicattaro junction

2.



Attention to the area and stakeholder engagement

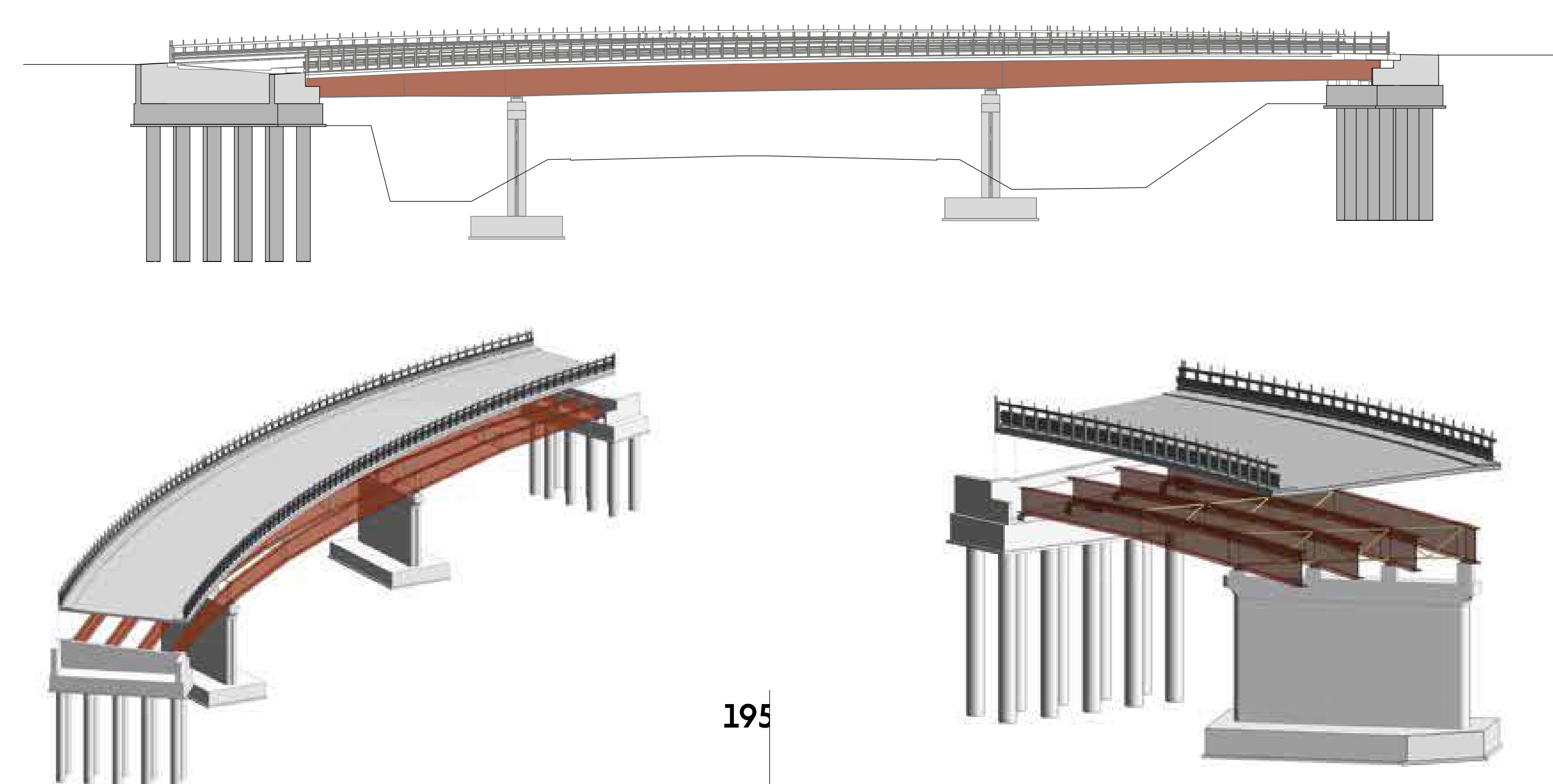
NET Engineering is supporting ANAS in the current public engagement process. This is a **well-structured path aimed at the in-depth understanding of the specific requirements of the area, finding possible feasible solutions with stakeholders and significantly increasing acceptance of the new infrastructure by the population.**

Discussions with the institutions and bodies involved started in the stages prior to development of the Final Design. **All the area's requests were accepted through work on ad hoc design solutions.** To give some examples, the following were planned: sections of the road in cuttings not initially budgeted for, an in-depth study of the landscape impact and important environmental mitigation works, and analysis of the stages of the construction site so that the environmental impact could be reduced in terms of energy savings and attention to the natural resources in the context.

Therefore, the SS 16 variant will be a work careful to respect the vocation and morphology of the places it crosses, contributing to the reduction of urban pollution, improving accessibility of the area and increasing competitivity.

Axonometric view of the digital model of one of the crossing works

3.



The new urban gate in Venice

Designing access roads to Porto Marghera

Since the 1990s, there have been several operations in the Prima Zona Industriale (First Industrial Area) of Porto Marghera (Venice) aimed at transforming and re-converting the industrial hub following the slump of the original manufacturing businesses. The key player in this process was the Parco Scientifico e Tecnologico Vega (Vega Scientific and Technological Park) created in the areas previously used by fertiliser production plants. Today, it houses companies involved in research, innovation and advanced services. The Vega Centre and all the other businesses situated in about 100 hectares of the First Industrial Area generate significant traffic flows on the road structure which has various incongruences.

The NET Engineering project (Final Design, Working Drawings and Works Management) intends to solve these difficulties with a significant engineering work, **a true urban gate suitable for the transformation and development prospects of the area. The work, designed entirely using BIM, plans the creation of a new multi-level intersection** along the current SR 11, Via della Libertà, the only access road to Venice, improving accessibility to the industrial area and increasing safety along the highway but with a clear separation between through traffic (traffic crossing the area) and local flows.

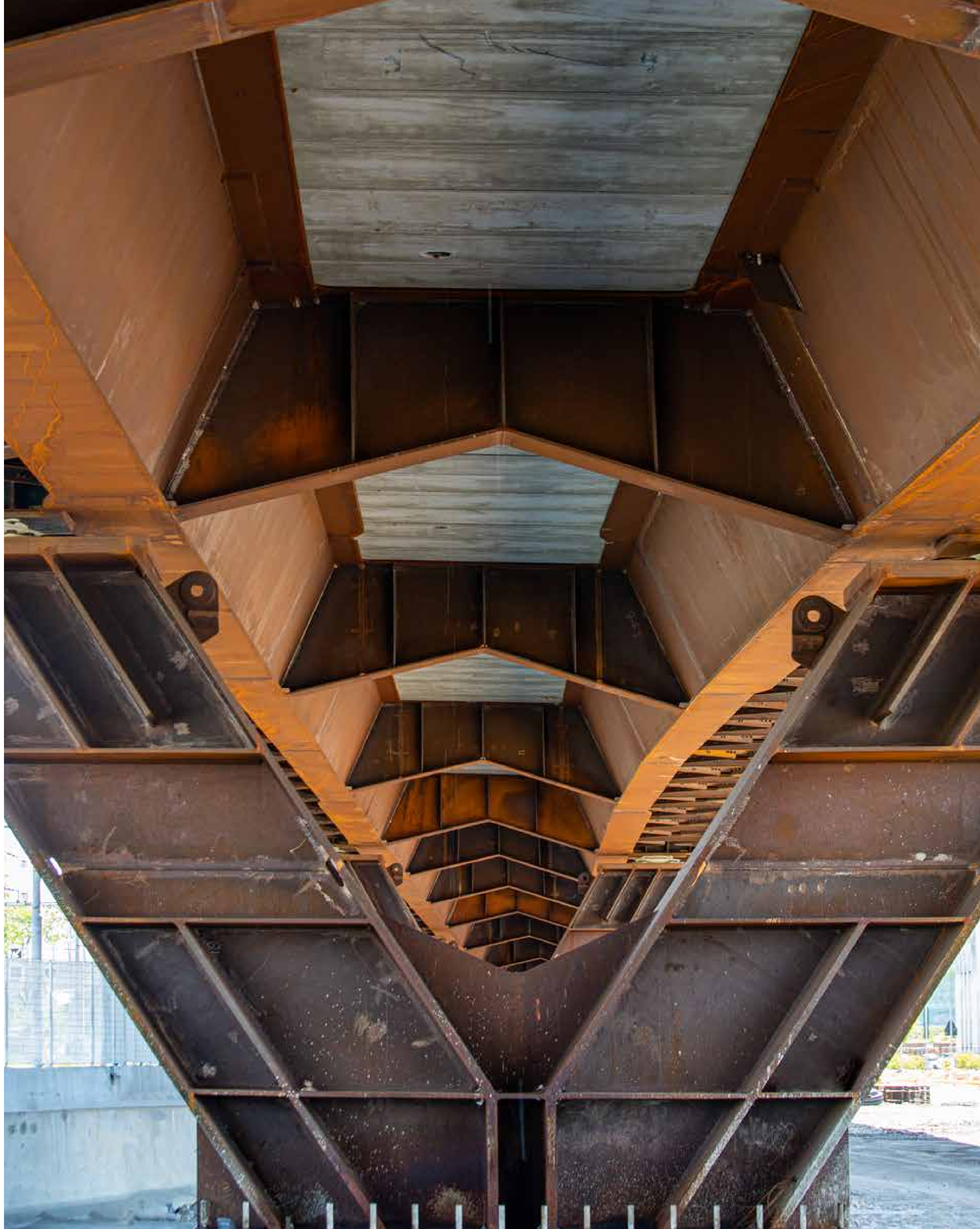
Accessibility will be through a new large roundabout connecting both the SR 11 and the Mestre urban network. Through traffic will pass over the roundabout on a viaduct and then enter an above-ground artificial tunnel. Creation of a further raised roundabout connected with a ramp giving direct access to Mestre-Venice is planned above the deck of the tunnel. This manoeuvre, currently not possible from the existing viaducts which will be partially demolished and structurally upgraded, will improve the Mestre-Venezia connection and have a positive influence on the currently congested local traffic.

The viaduct was designed as a double closed caisson in exposed self-protecting integral scheme steel (i.e. a deck in-built to upright supports and so without specific constraint devices), extended over four spans. The piles, also in self-protecting steel, consist of double shafts separated at the summit to sustain two neighbouring pairing stem and joined at the feet forming a 'V' in the section going into the foundation.

The design solution arises from various factors. First of all, work had to be **done in narrow spaces** – the new road lies between the Vega Centre, whose name it takes, and the vast sidings of Mestre station. Secondly, **the operation consists of works shaped in a particular way so that ground level obstructions are reduced, to allow construction in an area where traffic cannot be interrupted and to limit maintenance.** This required study of the special deck structures starting from a non-standard approach and **non-conventional methodologies.** This led for example to modelling the whole viaduct as a 'shell', omitting the classic truss modelling, resulting in clear economies in materials and greater understanding of an operation

Metal pile with a paired stem

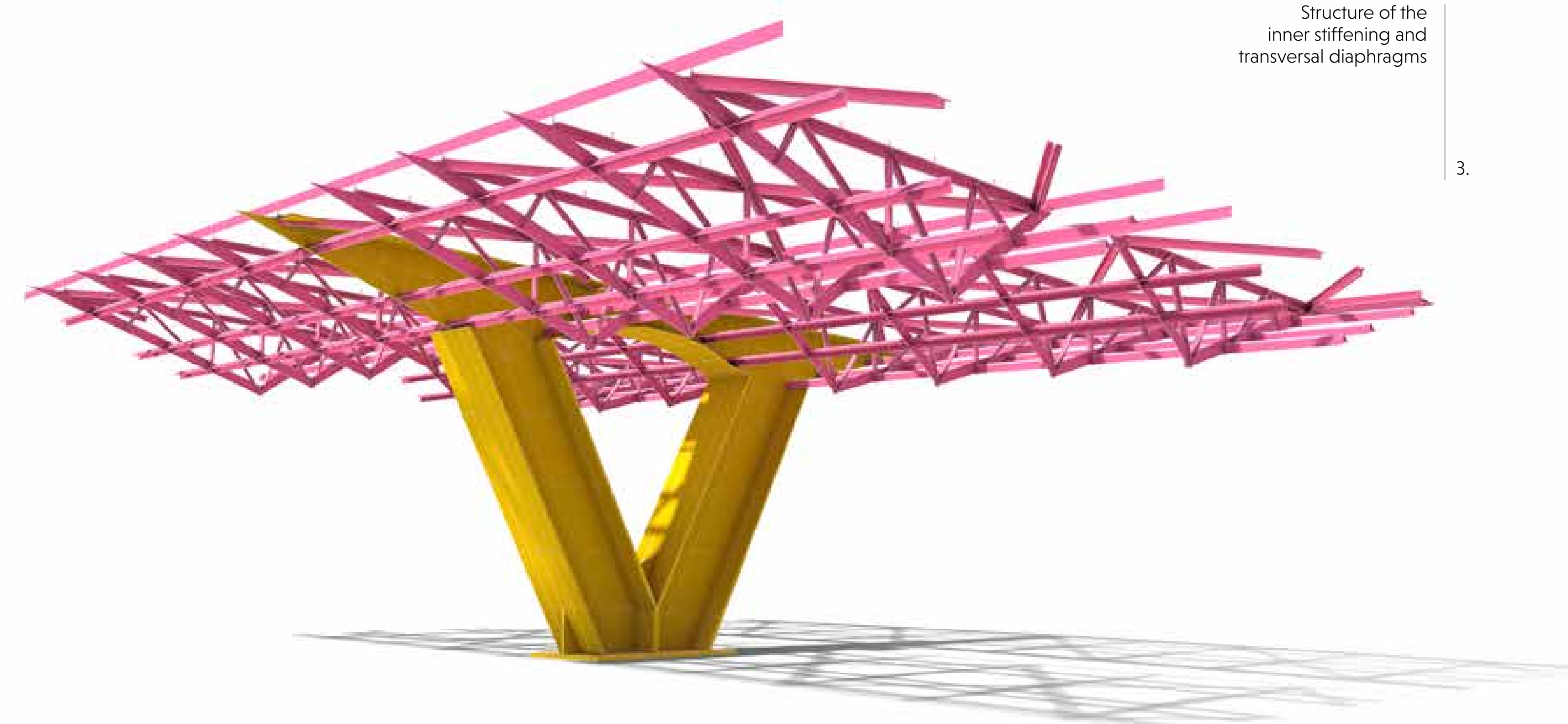
1.



in itself complex which perceives the deck as a winged structure.

NET Engineering paid special attention to the formal aspect of the work with the aim of bringing it into line with the value of the Vega Centre, at the same time recalling some elements already used for the Darwin Bridge in Padua as a characteristic feature of the designer's vision.

Careful study of how the new infrastructure slots into the urban context (a feature of bridges visible from below where the underlying spaces are used ordinarily), the search for a design alternative that makes the best use of the space, reorganising it and responding to the client's needs through a harmonic solution, enabled the post-industrial area to be **valorised and an important identity to be returned to the whole area.**

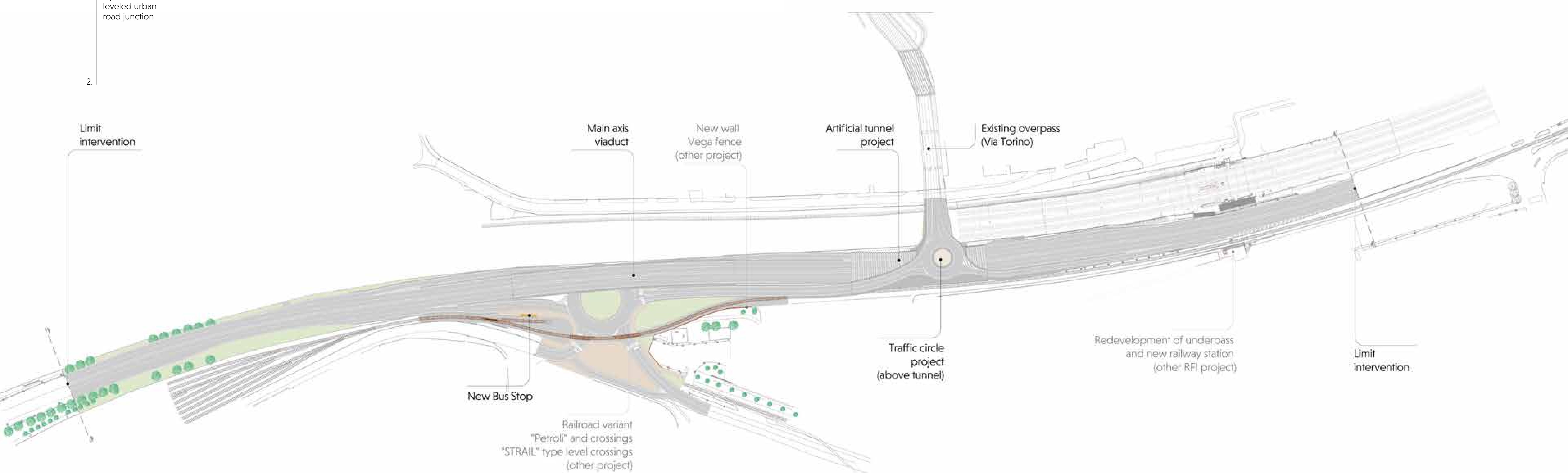


Structure of the inner stiffening and transversal diaphragms

3.

Planimetric layout of the de-leveled urban road junction

2.



Azerbaijan - 34 Km of future along the silk road

The Baku-Shamakhi road connection in the Shamakhi-Agsu section

In the 'Third Highway Azerbaijan Project', 'Azeravtoyol' (the body for the management of State Roads in Azerbaijan) assigned **NET Engineering with the feasibility study of the Shamakhi-Agsu road section in the strategic corridor that links the Caspian Sea to Georgia in the pre-Caucasian area of Azerbaijan.**

The study was financed by the World Bank (IBRD) and the International Development Association and falls within the wider context of investment along the so-called 'Silk Road'. Over the centuries, this road has brought culture, goods, spices and wealth to the Mediterranean basin and is now a 'sensitive' element in the Asian geopolitical chessboard.

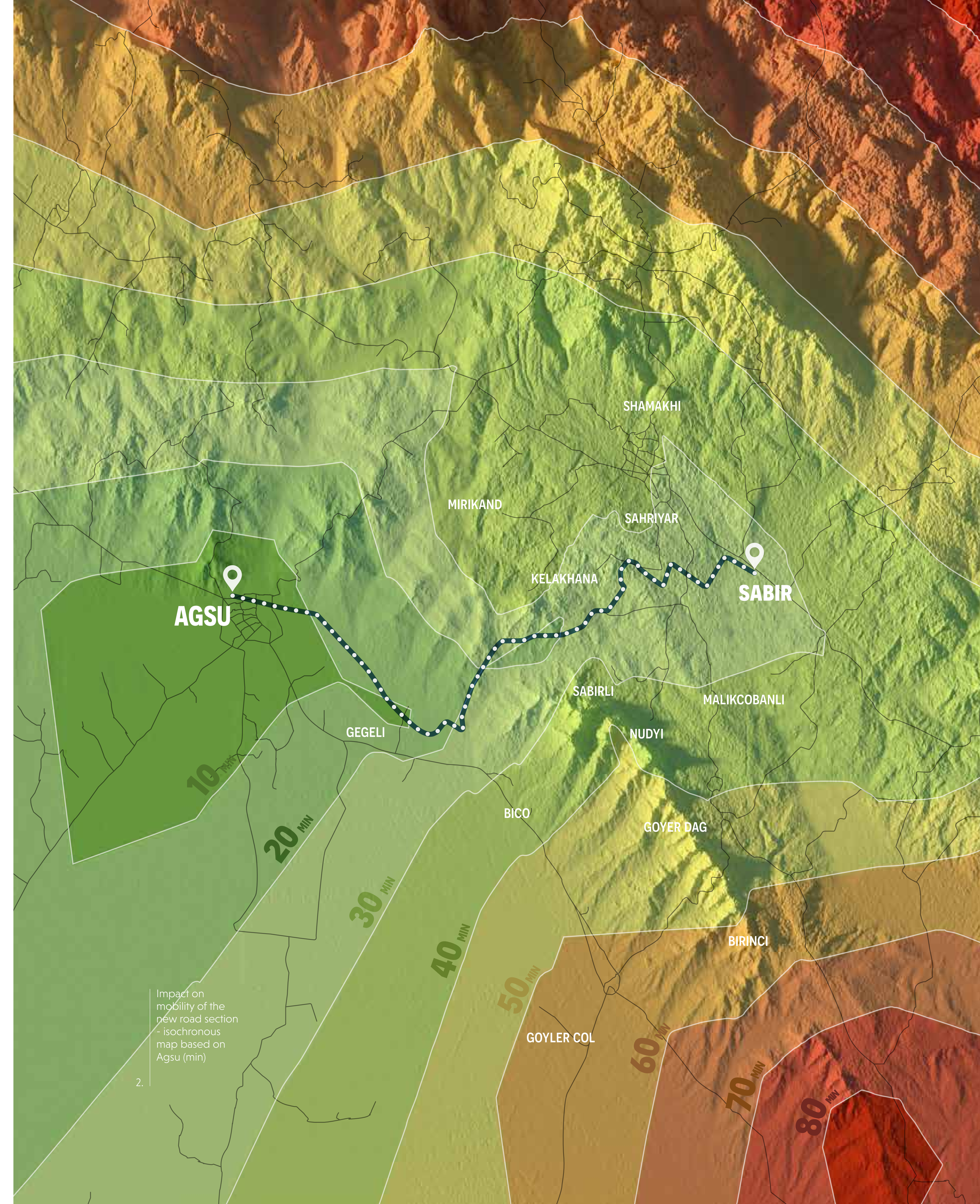
The work is part of an especially delicate regional geomorphological context. It's also a central element for local economic development and is significant for regional development as a potential driver of growth for a rural area and a tourist-minded vocation which is currently underdeveloped compared to the urbanised areas of the country.

"In 2016, the preparations for the first Formula 1 Grand Prix were in full swing, the roads of the city circuit were being asphalted and the brass in luxury hotels was polished yet, less than 200 kms away in the countryside of Shamakhi, children were tending goats and their parents were taking apples to market, travelling along muddy roads up in the mountains."

The new road connection was designed to eliminate the last bottleneck of the M4 road corridor M4, the most complex and challenging – 34 km of narrow road that winds up the clayey slopes of the pre-Caucasians, unstable, subject to frequent earthquakes with narrow hairpin bends where erosion and landslides are almost the norm. **A 34 km-section inaccessible to heavy traffic which crosses an area with significant tourist, naturalist and cultural value.**

Local features - gullies near Goyler Dag

1.



Impact on mobility of the new road section - isochronous map based on Agsu (min)

2.

3. Local features - existing dirt road between Goyler Dag and Goyle Col

Shamakhi is on a vast upland with hilly terrain dotted with pastures and vineyards. Agsu is situated at an altitude about 700 metres lower, in the large alluvial plain of the River Kura where Iran lies on the other side. There is a long, clayey escarpment in the middle, furrowed by gullies of narrow valleys with steep, 'ribbed' slopes.

"Shamakhi was the old capital of the governorship of Azerbaijan in Imperial Russia until the terrible earthquake of 1859 which destroyed the city. After this, the capital was transferred to Baku."

The project had two distinct stages.

The first stage aimed to sound out all the possible alternative routes that could arguably connect Shamakhi to Agsu, including the so-called 'Option 0', the rehabilitation of the existing route. Ten different alternatives were considered, ten routes with different geometric-functional features, different structures necessary (viaducts, bridges and tunnels), different constraints imposed by the area, different costs and opportunities. The extensive, complex analysis led to three 'feasible' alternatives, worth further detailed study.

The second stage made an in-depth analysis of the three alternatives based on additional geological and geotechnical surveys, environmental assessments, and estimates relating to the demand for movement and the impact on mobility.

In addition, discussions with the technical experts of the World Bank also revealed the local community's need to assess 'sharing' the project and further investigation of the impact on cultural, religious and artistic artefacts.

"The support of an expert on the behaviour of tortoises living in the area was required as the construction of a road would have a significant impact for them."

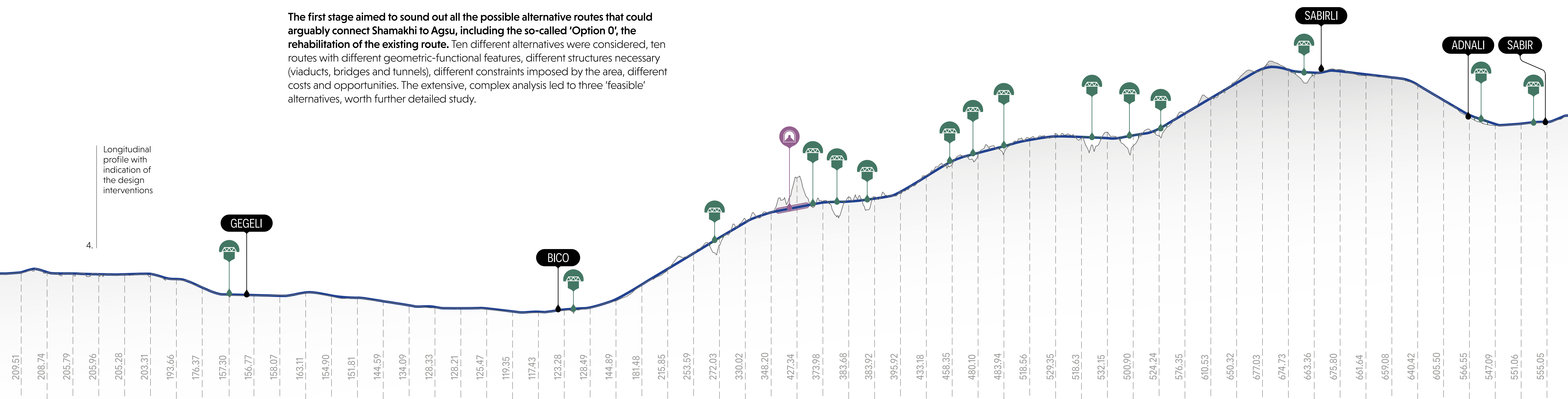
"Discussions with local representatives to understand their needs and the social dynamics that such a project can trigger were stimulating. We made a detailed study of the position of the junctions along the route as these were, in effect, 'entrances' for the villages to areas that, up to that time, had been considered distant."

The work posed difficult challenges, overcome with targeted solutions – the introduction of 'innovative' project and instrument operating systems integrated with traditional methods, the adaptation of the proposed solutions to the real technical ability of local businesses, the establishment of a harmonious relationship of mutual trust with the client and the World Bank through constant visits to the area and continuous communication, which enabled the development of a shared path despite sometimes very different views, methods and backgrounds. The system engineering approach typical of NET Engineering enabled Azeravtoyol to analyse the current and future mobility requirements, give a consistent response and check the environmental, economic, financial and social sustainability.

The development of the project helped the understanding of **how much a road connection can contribute to change in depressed areas**, requiring the NET Engineering project managers to evaluate alternative routes not only based on technical and orographic constraints but also on the connection opportunities between currently abandoned, poorly connected villages. Thus, the road becomes an element which guarantees access to education, support for families, who can reach local markets more easily, and the development of tourism, with greater links from and to Baku, the capital.

Although impoverished, the areas of operation were 'seen first-hand' (and long sections 'made on foot' several times) so that there were the solid elements forming the base of the study of the macro alternatives and the choice of the route. This direct experience in the field, both professional and human, put the NET Engineering designers before unexpected scenarios and emotional times, creating an invisible connection of respect, harmony and complicity.

4. Longitudinal profile with indication of the design interventions



Bridges – more than just a physical connection

A journey through history, technology and the future

The construction of a bridge isn't just the project for the deck but all the different works that are part of it – supports, foundations, the mass of soil involved and, last but not least, the surrounding environmental context of where the bridge is or will be. The bridge itself is an architectural and engineering product that responds to precise technical, infrastructural and aesthetic requirements. **Building a bridge is a creative act similar to the conception of a work of art, where scientific and artistic skills contribute with capacity, foresight, perspective and ability in the management of the available resources.**

Currently, the need to put the specific capabilities of stakeholders, regional managers, architects and designers in the different stages of design, particularly the infrastructure work, into an integrated whole is becoming more and more obvious. On this, the 'best practice' pursued in NET Engineering for many years, independent of the specific place and client with whom we work, has led to the **consolidation of the system engineering method and a cultural and professional growth that has changed the shared view of the world at Group level, multiplying the number of possible points of view.**

This approach, consolidated over time and able to orient the project to **operations that redefine the relation between nature and man's intervention**, has also been applied in the most recent constructions of bridges, the key players in this section.

1. Aerial view of the Adriatic bridge in Bari

The Darwin Viaduct

East Padua road junction, Padua (Italy) – 2005

The Darwin Viaduct marks the road junction at the East Padua motorway exit and the connecting infrastructure between Corso Argentina and S.S. (Strada Statale – Trunk Road) 307 which is a very important crossroads in the urban and regional road network. **The bridge is all steel and has an overall span of 550 m with 11 bays, and consists of three steel arches** (150 m wide and 25 m high at the road level), above the deck.

This bridge encapsulates many concepts, some innovative, which were brought together in an **iconic work** characterising the eastern access to Padua at the beginning of the millennium. The 'urban bridge', whose distinguishing feature is that it can be observed not only in perspective and by those crossing it but also by those who pass under it.

From the composition point of view, a shell section was adopted, which goes beyond the normal criteria of the sections of girder bridges (which traditionally indicate central layers and flat arches), and is more similar in conception to that with a 'wing' profile adopted in aeronautical constructions.

It was decided to adopt complete structural continuity between the deck and the metal piles – the concept of structural 'continuity' became the guiding element for the whole work, which was only disconnected at the ends (on the transition abutments to the approach embankments) while the deck, piles and foundations, including the lateral access ramps, were totally connected, i.e. without links, supports or joints of any kind.

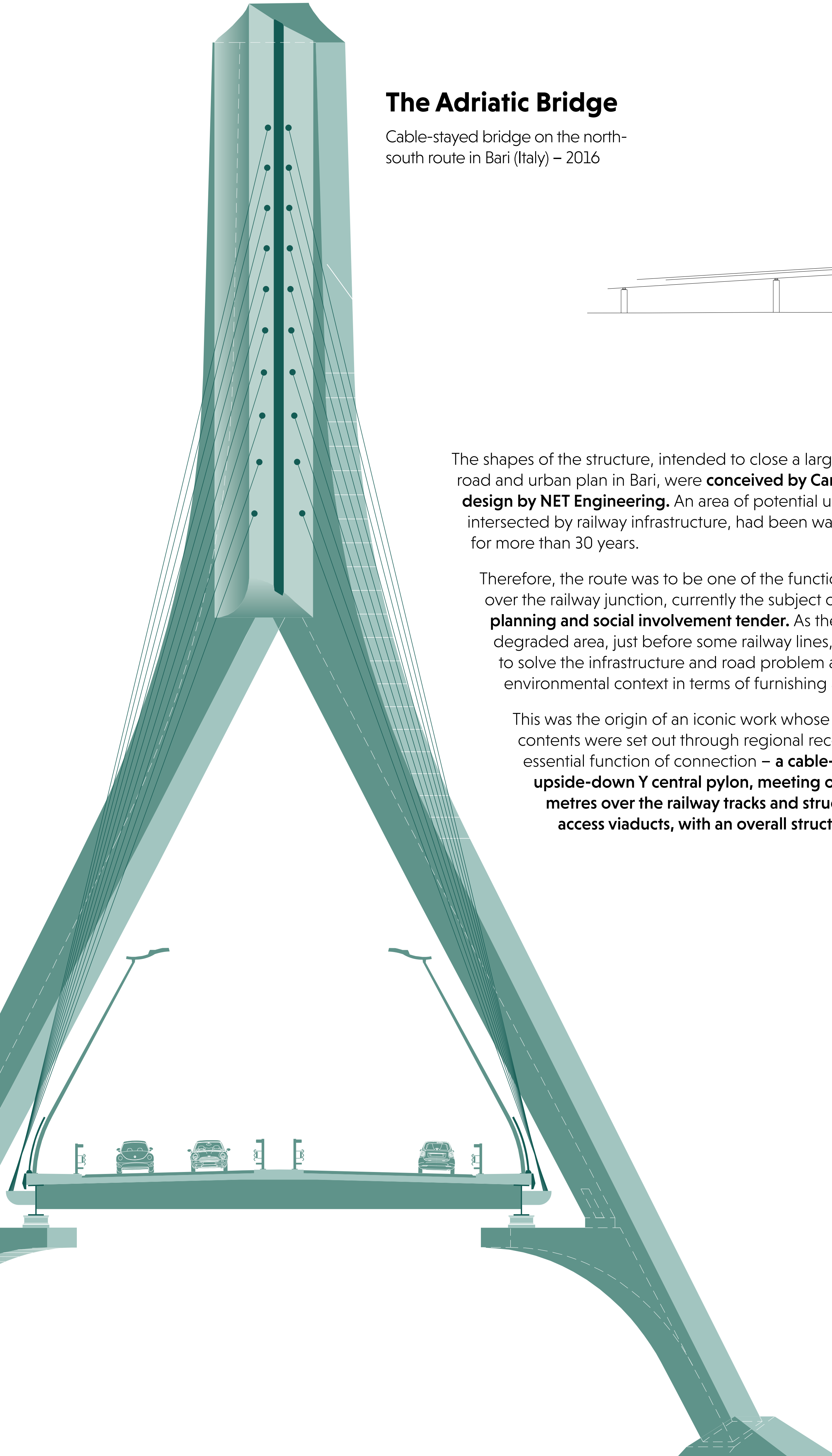
The result gives the effect of seeing the structure as a unit, a co-ordinated whole. It should also be remembered that the bridge serves a very important road junction on the city ring road.

Arched profile

Although formally important, the viaduct initially appeared as a 'low' work in a plain area. To remedy this, large, high illuminated arches were planned to make the work visible from a distance and make it a **symbolic 'gate'**. The arches themselves have no static function and are only marginal for illumination but, however, they are notable structurally for their size and interaction with the wind. The arches take up a characteristic shape of Paduan architecture, where the arch is one of the most recurring elements in a typical porticoed city.

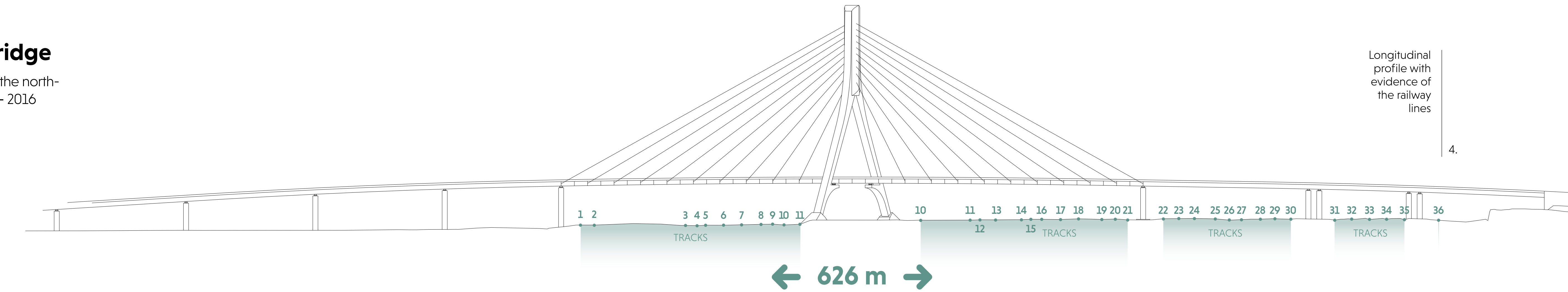
The Darwin Viaduct is the archetype of the formal concept of 'monumental bridge', i.e. a work that introduces important elements not directly connected to the function to carry out but to a more representative one – access to a certain place.

The innovative elements introduced in the work at the time of its conception were the concept of **'end-to-end bridge'**, i.e. having continuity between the deck and supports on large bridges – and the **shell section**.



The Adriatic Bridge

Cable-stayed bridge on the north-south route in Bari (Italy) – 2016



Longitudinal profile with evidence of the railway lines

4.

The shapes of the structure, intended to close a large gap in the continuity of the road and urban plan in Bari, were **conceived by Carlos Fernandez Casado, with design by NET Engineering.** An area of potential urban expansion, but critically intersected by railway infrastructure, had been waiting for the gap to be filled for more than 30 years.

Therefore, the route was to be one of the functional connections in passing over the railway junction, currently the subject of a very wide-reaching **urban planning and social involvement tender.** As the route lies in a somewhat degraded area, just before some railway lines, the aim was twofold – to solve the infrastructure and road problem and also regenerate the environmental context in terms of furnishing and organisation.

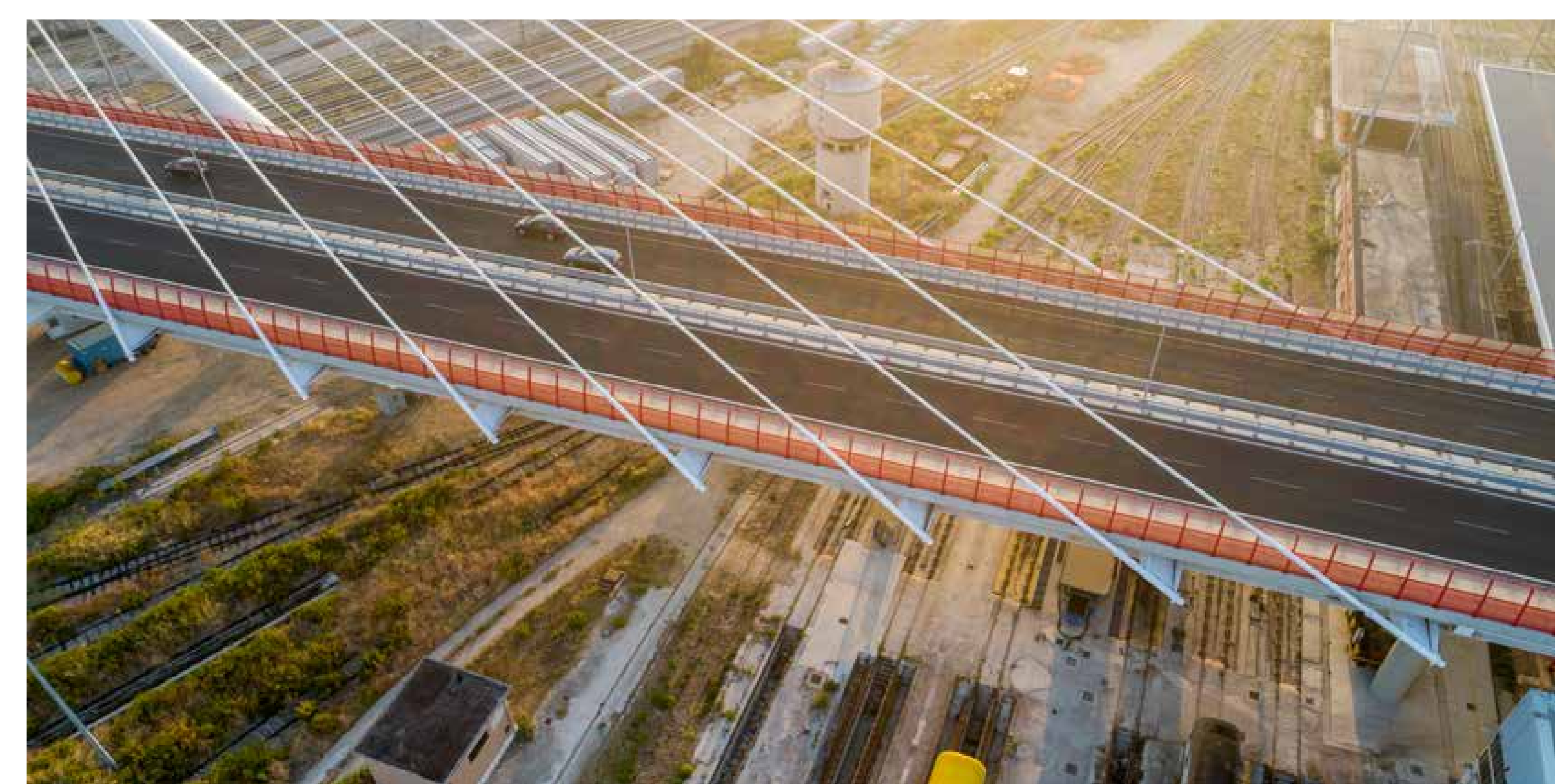
This was the origin of an iconic work whose important engineering contents were set out through regional recovery combined with the essential function of connection – **a cable-stayed bridge with a single upside-down Y central pylon, meeting on a double span of 112 metres over the railway tracks and structurally continuous with the access viaducts, with an overall structural length of 626 metres.**

The position of the bridge in the town and its size required a design that was very aware of the aesthetics and with which the administration wanted to distinguish and mark out the area positively. The need to overcome a large number of tracks with lightness and minimum impact pushed towards the choice of an unconventional structure just like the stages of construction, which set out the start of the cantilever deck, from the abutments to the centre, without involving the underlying railway circulation. **As it is an urban bridge, care was taken with the appearance and formal order, including the lower part of the viaduct**, e.g. choosing supports with a rounded section, linear elements for the deck and the choice of particular 'patterns' for the visible surfaces of the containing walls of the access embankments.

The main challenge in drawing up the project concerned the time available to pass from the concept of the work to the executive project. The result was attained by thinking of an extremely detailed ad hoc process **– a real 'project of the project'**. From the technical organisational point of view, the design service given led to the definition of the work through all stages enabling the client to start the tender in the limited times dictated by the expiry of the Community financing

Detail of the strand attachments

5.

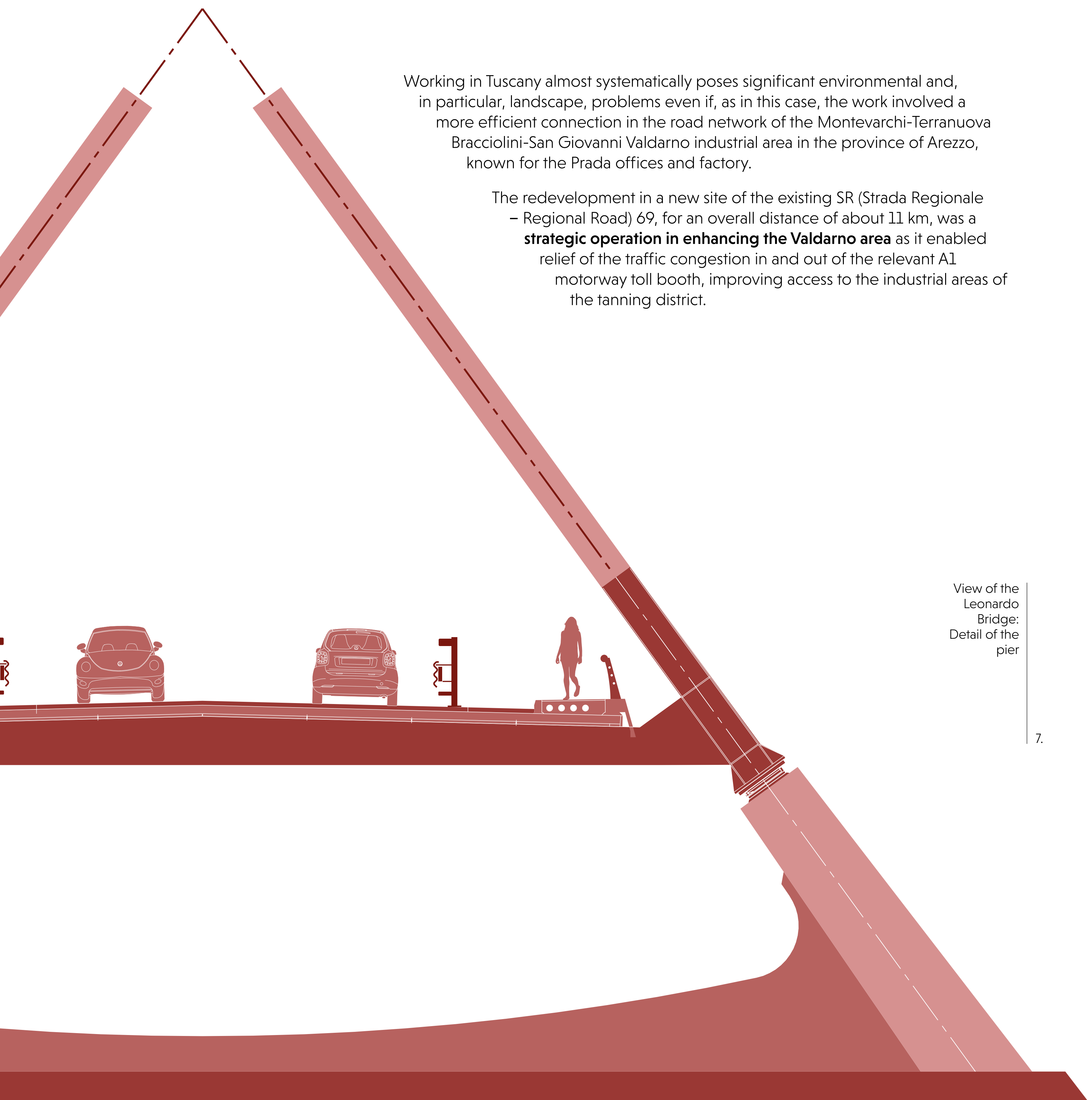


Aerial view of the Adriatic Bridge

6.

The Leonardo Bridge

Variant to the SR69 with the new bridge over the River Arno, Arezzo (Italy) – 2016



Working in Tuscany almost systematically poses significant environmental and, in particular, landscape, problems even if, as in this case, the work involved a more efficient connection in the road network of the Montevarchi-Terranuova Bracciolini-San Giovanni Valdarno industrial area in the province of Arezzo, known for the Prada offices and factory.

The redevelopment in a new site of the existing SR (Strada Regionale – Regional Road) 69, for an overall distance of about 11 km, was a **strategic operation in enhancing the Valdarno area** as it enabled relief of the traffic congestion in and out of the relevant A1 motorway toll booth, improving access to the industrial areas of the tanning district.

View of the Leonardo Bridge: Detail of the pier

7.

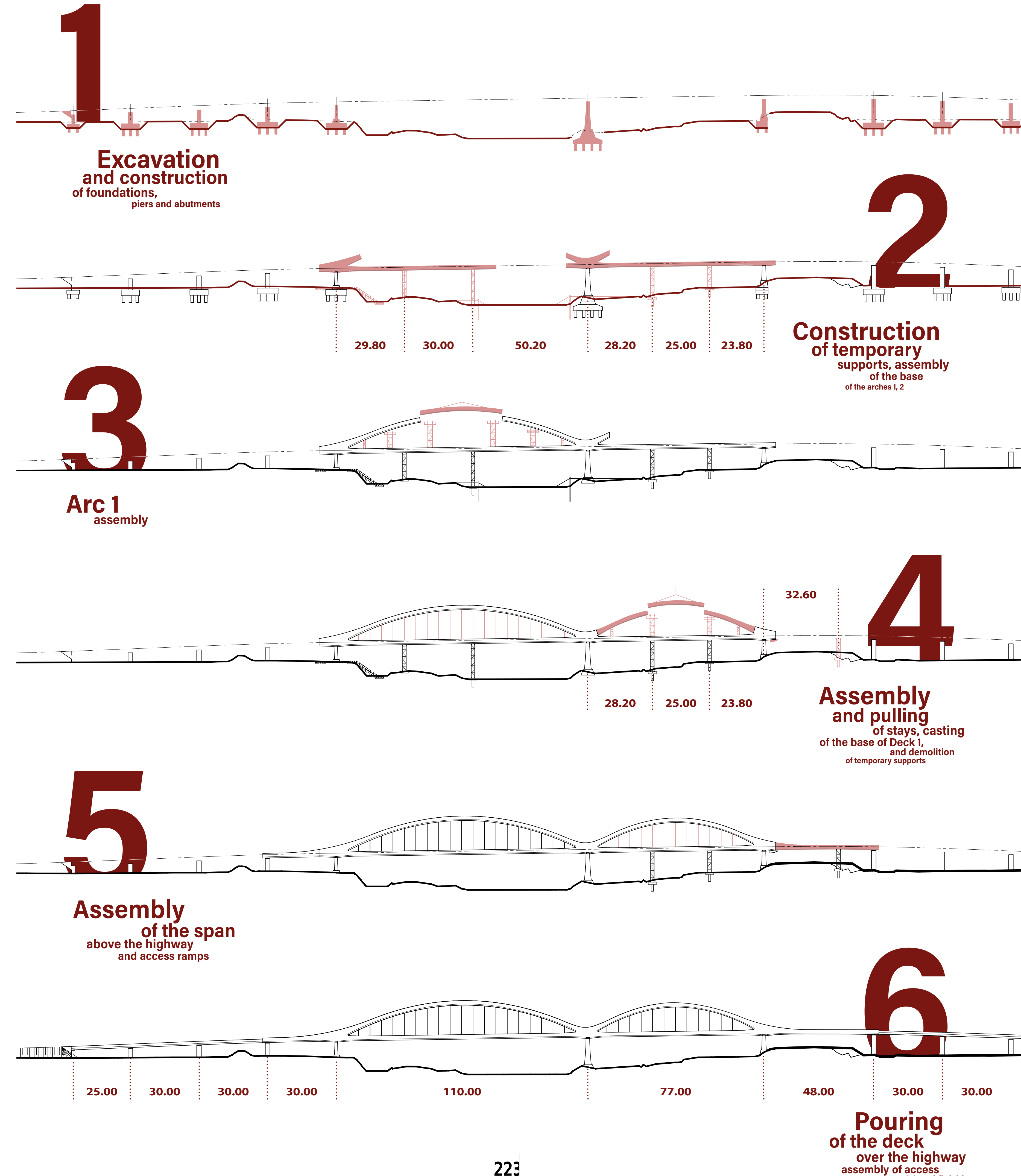
The New Bridge, which crosses the River Arno Nature Reserve, has special symbolic value and was **designed in co-operation with the Oficina de Proyectos Carlos Fernandez Casado**, one of the most prestigious international names in the sector.

The New Bridge is **495 metres long and crosses the Arno and A1 motorway with two main spans over the river sustained by two steel inclined arches and three smaller side spans**, one of which was constructed by cantilever above the motorway. The metal arches were steeply inclined to enhance the idea of junction at the top and thus reinforce the 'access gateway' effect to the industrial area. A construction work is the union of the nature of the places hosting it and the function attributed to it.

The originality was preserved by giving the columns in the Arno a sculptural form, shaped by the need to house the lower inclined surface of the main arch-beam (following the criterion that the function inspires the form).

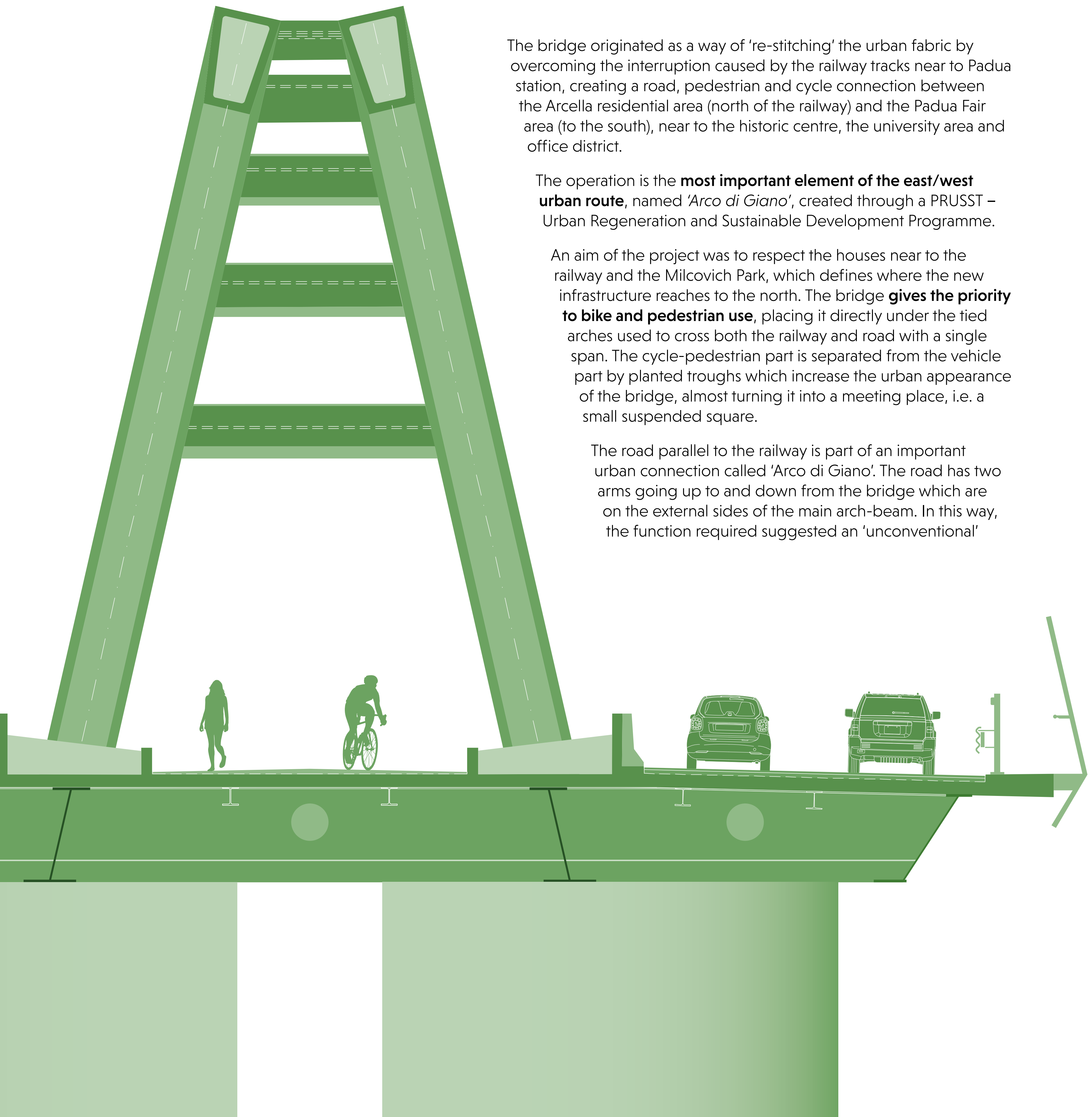
The inclusion of the bridge also considered the problem of a landslide of the overlooking Poggilupi hill which menaced the existing road and would have conditioned the new one. **Carefully designed, almost invisible work, of containment and stabilisation gave the technical solution to the hydrogeological instability** and allowed the landscape recovery of the whole hillside, now lined by the new road.

8. Panoramic view of the Leonardo Bridge



The Bridge Unità d'Italia

Trade Fair Overpass, Padua (Italy) – 2011

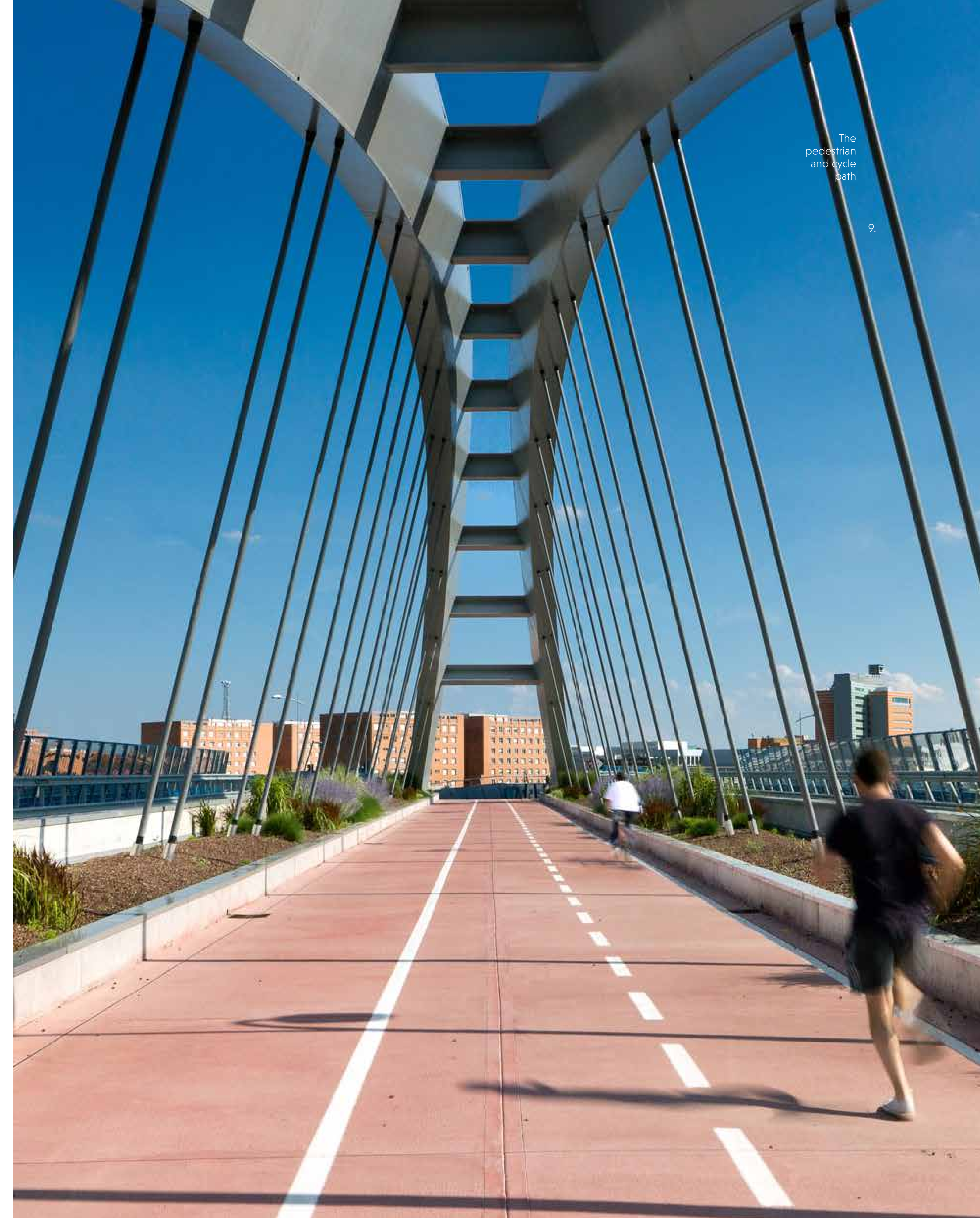


The bridge originated as a way of 're-stitching' the urban fabric by overcoming the interruption caused by the railway tracks near to Padua station, creating a road, pedestrian and cycle connection between the Arcella residential area (north of the railway) and the Padua Fair area (to the south), near to the historic centre, the university area and office district.

The operation is the **most important element of the east/west urban route**, named *'Arco di Giano'*, created through a PRUSST – Urban Regeneration and Sustainable Development Programme.

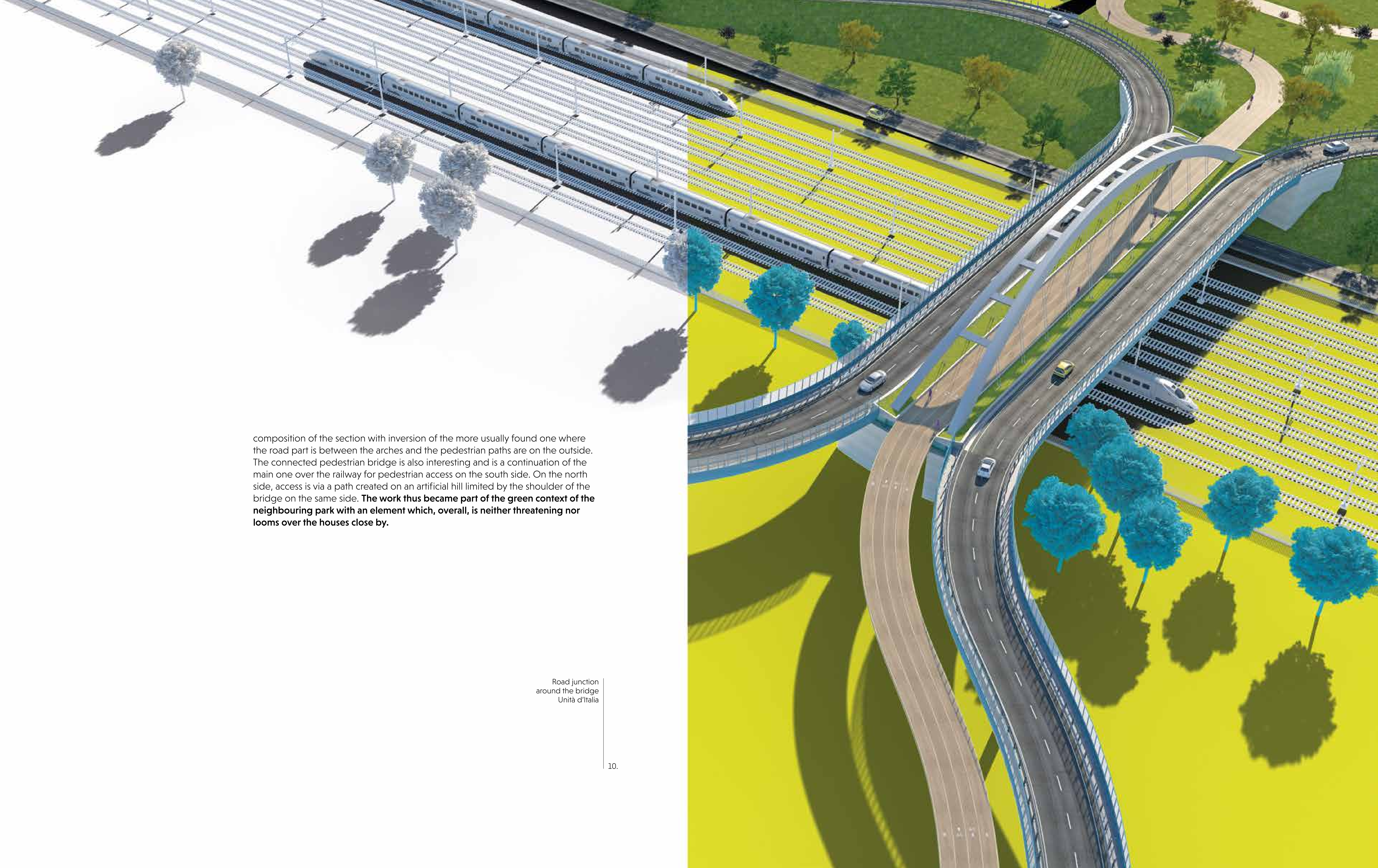
An aim of the project was to respect the houses near to the railway and the Milcovich Park, which defines where the new infrastructure reaches to the north. The bridge **gives the priority to bike and pedestrian use**, placing it directly under the tied arches used to cross both the railway and road with a single span. The cycle-pedestrian part is separated from the vehicle part by planted troughs which increase the urban appearance of the bridge, almost turning it into a meeting place, i.e. a small suspended square.

The road parallel to the railway is part of an important urban connection called 'Arco di Giano'. The road has two arms going up to and down from the bridge which are on the external sides of the main arch-beam. In this way, the function required suggested an 'unconventional'



The pedestrian and cycle path

9.



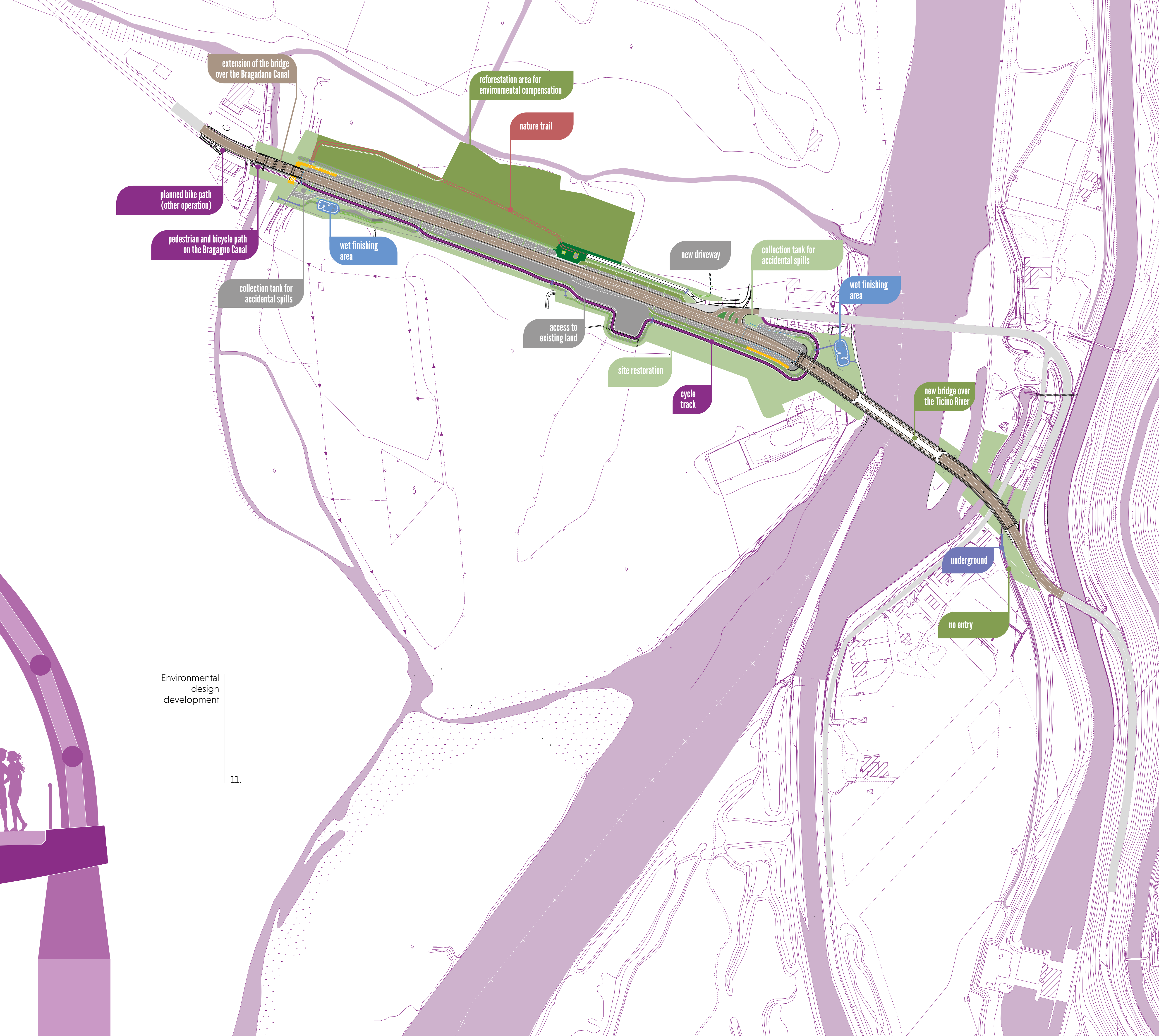
composition of the section with inversion of the more usually found one where the road part is between the arches and the pedestrian paths are on the outside. The connected pedestrian bridge is also interesting and is a continuation of the main one over the railway for pedestrian access on the south side. On the north side, access is via a path created on an artificial hill limited by the shoulder of the bridge on the same side. **The work thus became part of the green context of the neighbouring park with an element which, overall, is neither threatening nor looms over the houses close by.**

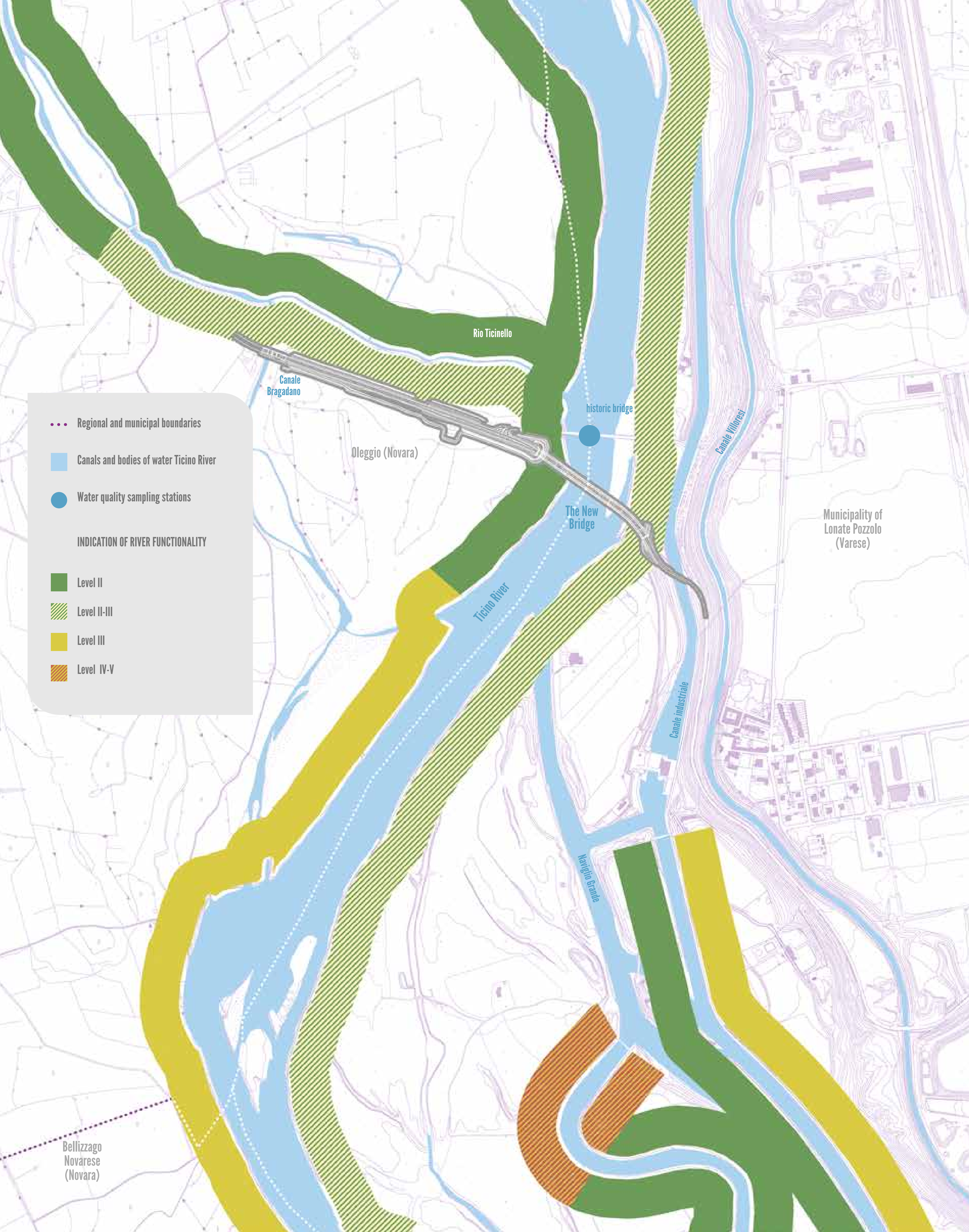
Road junction
around the bridge
Unità d'Italia

10.

The Bridge over the Ticino

Project for the new bridge at Oleggio, Novara (Italy) – 2011





12.

Environmental impact study - water environment

13.

Rendering of the Oleggio bridge project

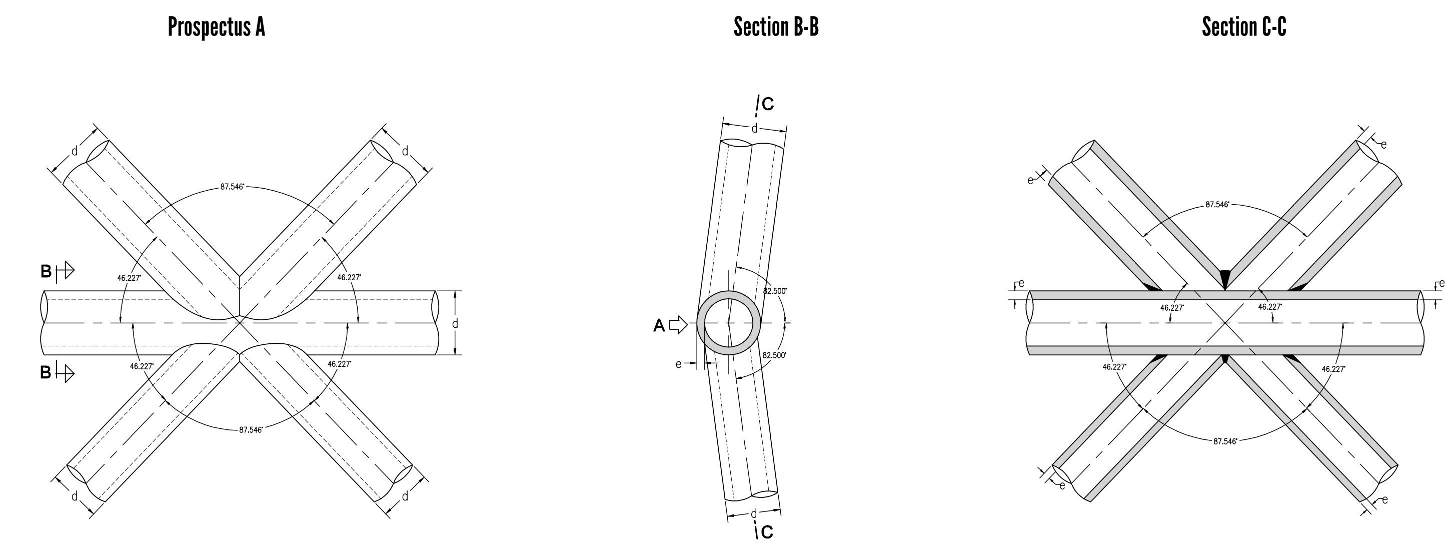
This bridge hasn't yet been constructed and, more than others, **tries to blend the work with the natural environment.** It originated with the need for a better road connection for people wanting to reach Malpensa airport from Piedmont using the old inter-regional road.

The existing bridge, a physical element forming the border between Piedmont and Lombardy regions, was built in 1889. It is an iron truss structure with a single lane used alternatively and so completely inadequate for the changed transport requirements. Nevertheless, the structure is fine evidence of industrial archaeology and is an example of the radical technical innovation made possible by the use of iron from the second half of the 19th century.

The area involved in the works is subject to extensive environmental restrictions as it lies within the Parco fluviale del Ticino (the River Ticino Park) which extends on both banks in Piedmont and Lombardy regions. The restriction of the natural river environment led to the choice of working, e.g. for the foundations, with the least possible impact at the construction stage.

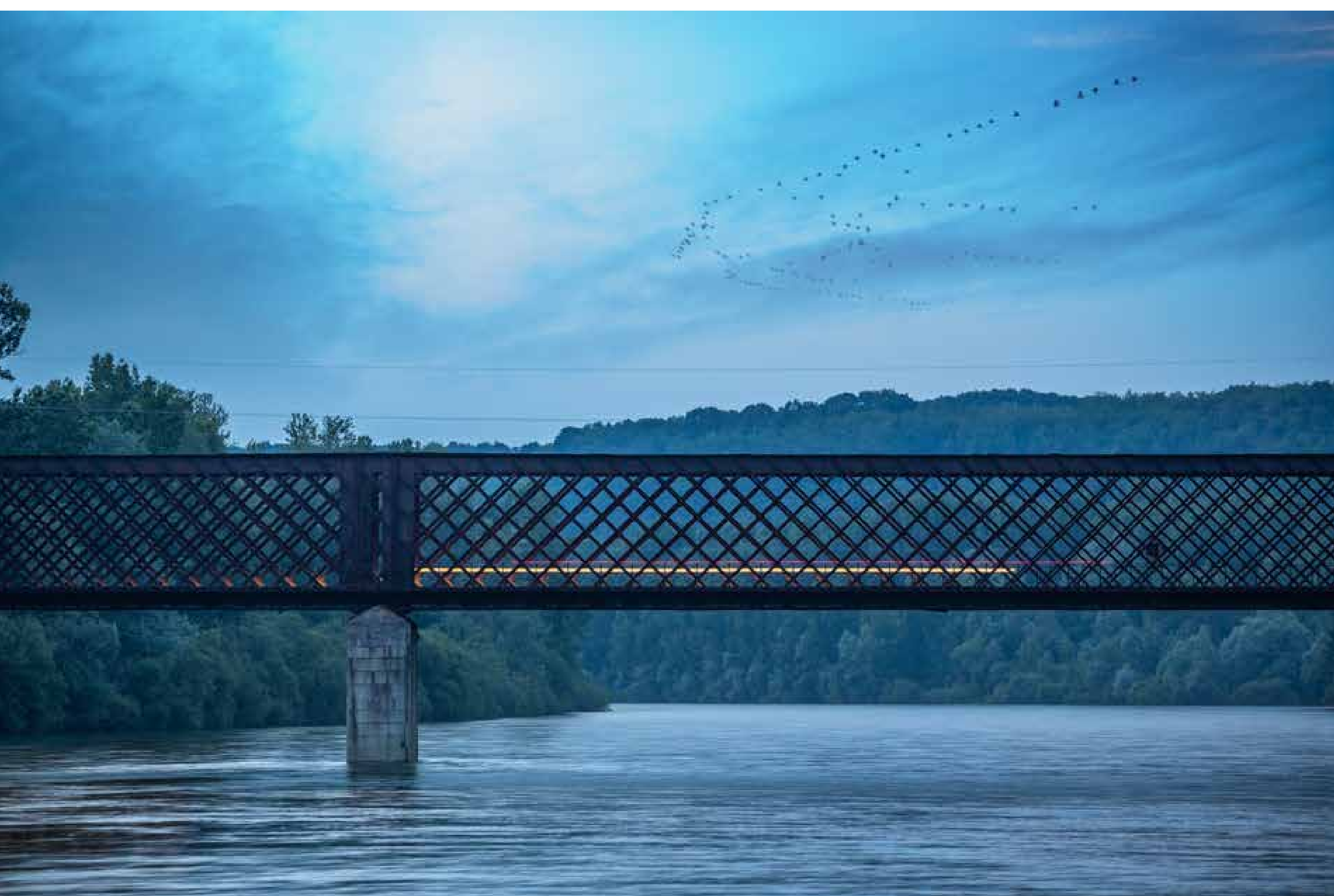
However, the presence of the historic 'lattice bridge' couldn't be ignored, as it is a consolidated element in the environmental context. Its downgrading to a bridge for cycle paths in the area, after adequate preservation and restoration, has been theorised. Therefore, a form has been adopted which, in modern terms, recalls that of the 'screen' (i.e. the lattice which was a feature of the elevation of the historic bridge) – a framework of a lattice bridge with a mixed system of prestressed concrete for the deck, an upper closing 'cord' and walls of linear metal elements forming the lattice.

Obviously, it's an unusual shape that has led to the use of specific models and the conception of singular construction methods.

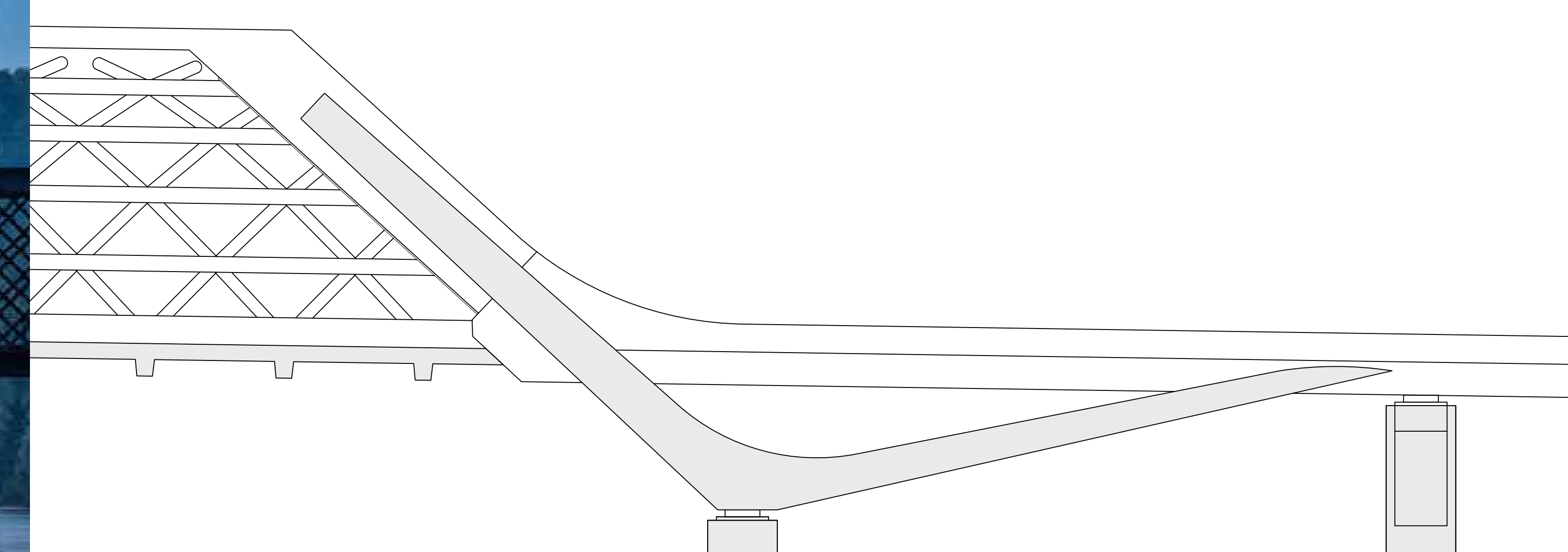


15.
Details of the new reticular solution

Existing Oleggio Bridge
14.



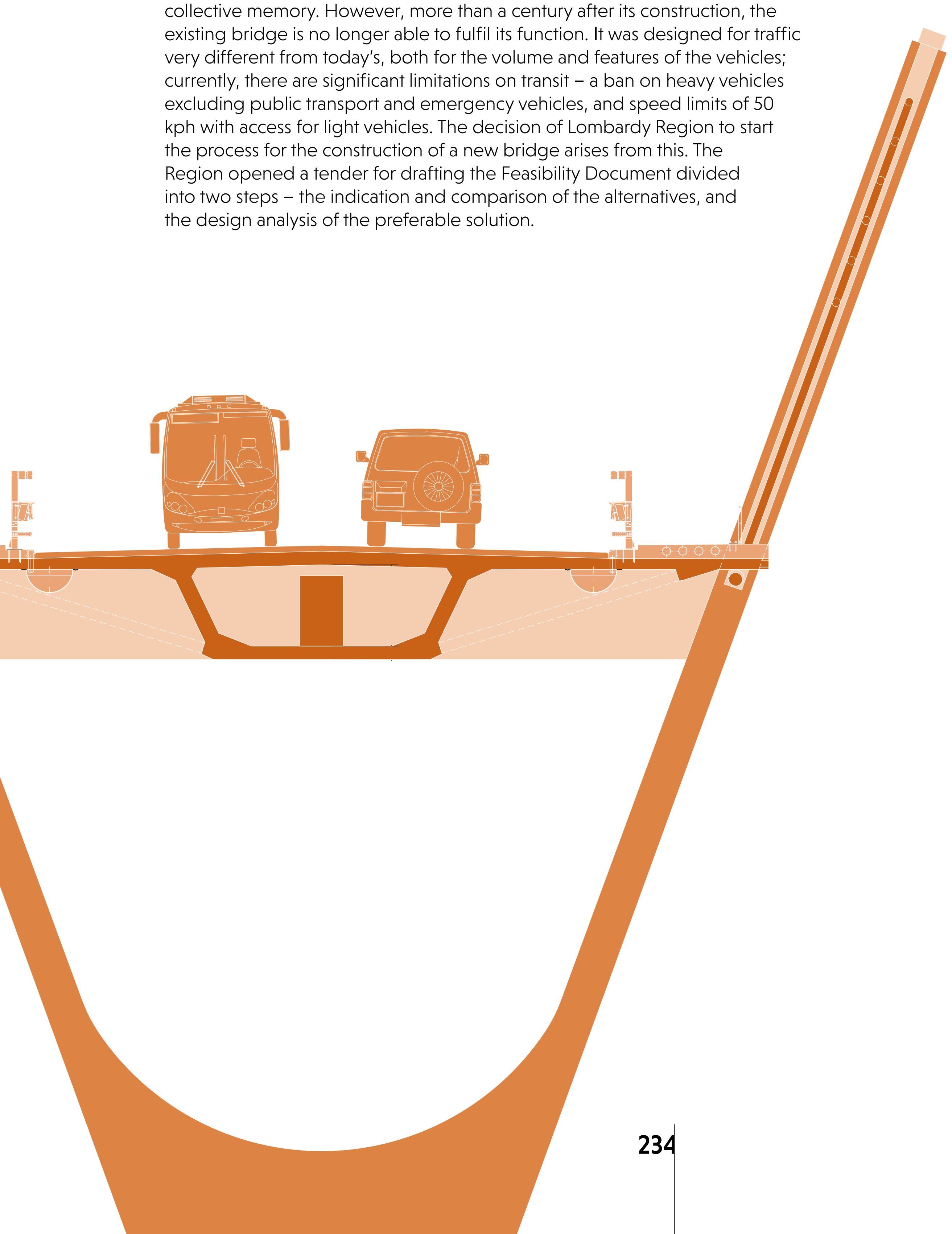
Detail of the first pylon on the river bank
16.



The Becca Bridge

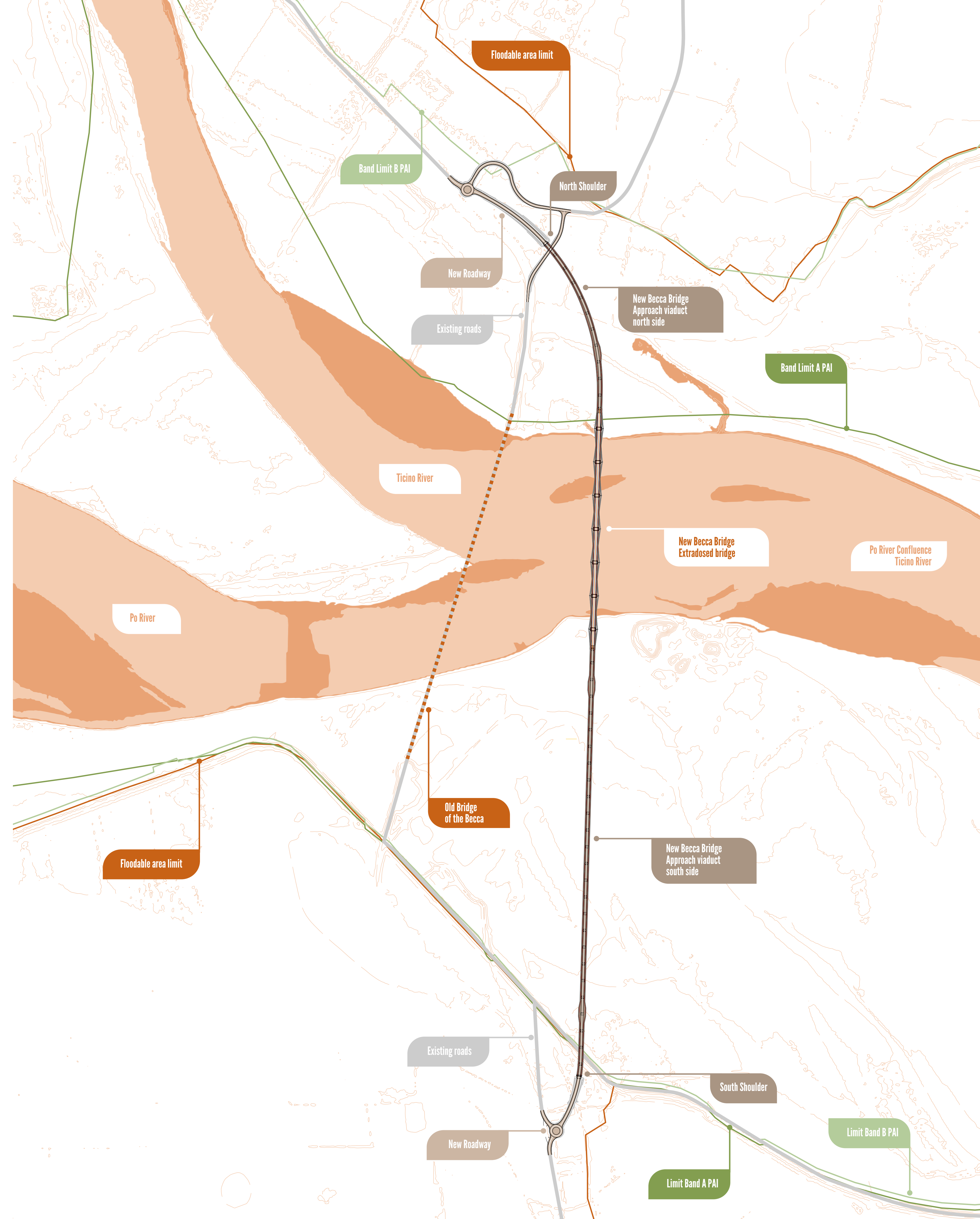
Becca Bridge was built in 1912 where the Rivers Po and Ticino join in the province of Pavia – 2021

The aim was to stabilise the connection between the Oltrepò area and the rest of Lombardy and, therefore, no longer subject to the conditions of the rivers. Today, Becca Bridge is an essential element in the landscape, of the local identity and collective memory. However, more than a century after its construction, the existing bridge is no longer able to fulfil its function. It was designed for traffic very different from today's, both for the volume and features of the vehicles; currently, there are significant limitations on transit – a ban on heavy vehicles excluding public transport and emergency vehicles, and speed limits of 50 kph with access for light vehicles. The decision of Lombardy Region to start the process for the construction of a new bridge arises from this. The Region opened a tender for drafting the Feasibility Document divided into two steps – the indication and comparison of the alternatives, and the design analysis of the preferable solution.



Project plan

17.



Realistic photo insertion for the assessment of the landscape impact of the new work

18.

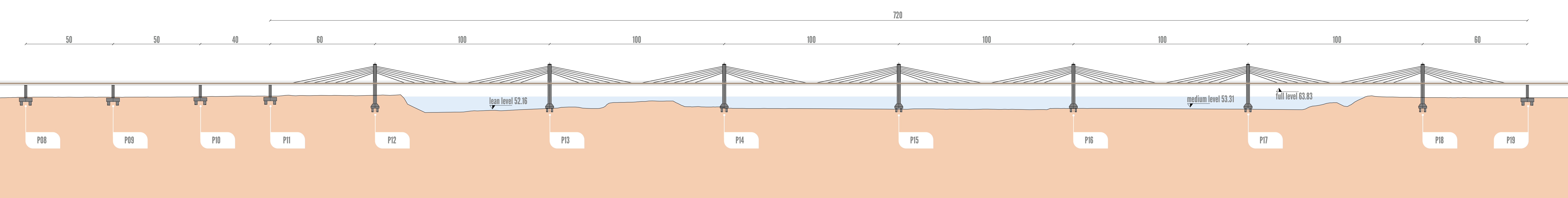
The project was developed to allow all-round vision of both the operation and context of the bridge, perceived not only as interdependent systems but also a single complex system. Therefore, the aims of technical and economic efficiency, hydraulic safety, protection of the environment and collective assets (including the landscape and memory) were examined with the opportunities and restrictions seen through analysis of the subsystems involved (mobility, hydraulic context, natural and human environments, construction techniques etc.). A series of different alternative projects, differing in positioning and architectural-structural solution, arose from this process.

The requirements were reconstructed through a transport study which enabled estimation of traffic demand that the future infrastructure will have to satisfy, taking into account the evolution of the demand and also possible closure to traffic, for obsolescence, of other bridges over the Po in the same area. The estimate of vehicle flows over the bridge was also used to check the design solutions proposed through micro-simulation of the junctions of the new road network with existing ones and simulation of the sound impact of the new infrastructure. The design proposals indicated were submitted to the main institutional stakeholders, with the proposal for conversion of the existing bridge to a different use. Their comments contributed to further extending the overall view of the project.

The subsequent comparison of the alternatives was conducted using an approach based on Cost-Benefit Analysis and Multi-Criteria Analysis starting from the Envision™ rating system and Life-Cycle Assessment.

This enabled assessment of the environmental, social and economic sustainability aspects of each design, with reference to the whole life-cycle of the work. The result was a clear and comparable indication of the economic efficiency features and the overall performance of the individual alternatives thus allowing a rapid assessment of the preferable solution for design analysis.

Architecturally and structurally speaking, the new Becca Bridge features a sequence of anchoring aerials which make the shape recognisable. The whole structure consists of an extrados bridge 720 metres long with 6 central spans of 100 metres and 2 side spans of 60 metres, and two approach viaducts of 530 metres (the north viaduct) and 1275 metres (the south viaduct) with central spans of 50 metres and side ones of 40 metres.

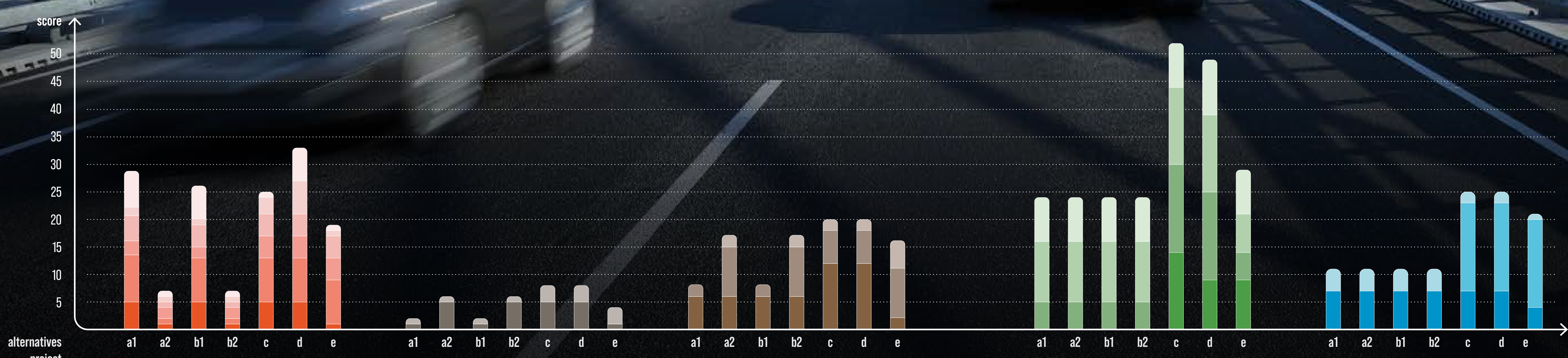


Longitudinal section New Becca Bridge

19.

Three-dimensional simulation with a man-height point of view

Envision



Quality of life

- Stimulating growth and sustainable development
- Minimize noise and vibration
- Minimizing light pollution
- Improving mobility and accessibility in the community
- Preserving the landscape and local identity
- Improving public space

ENVISION

Leadership

- Provide for stakeholder involvement
- Extend the useful life of the infrastructure

Resourse Allocation

- Net embedded energy reduction
- Support sustainable sourcing practices
- Use of recycled materials

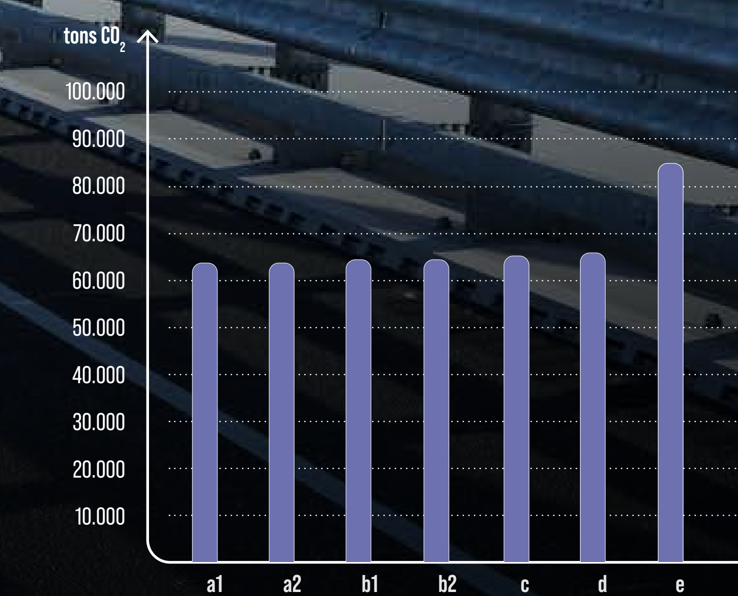
Natural World

- To safeguard the original habitat
- Protect marshes and water surfaces
- Safeguard the functions of floodplains
- Restoring disturbed soils

Climate Change and Risk

- Reducing greenhouse gas emissions
- Adaptability to climate change
- Reduction of the heat island phenomenon

Life-Cycle Assessment



CO_2 emissions

Global Warming Potential

- Tons of CO2 produced

Results of the comparison of the project alternatives through Multi Criteria Analysis based on the Envision protocol and through Life Cycle Assessment

The Bridge over the Brenta

Bridge railway, Padua (Italy) – 2021

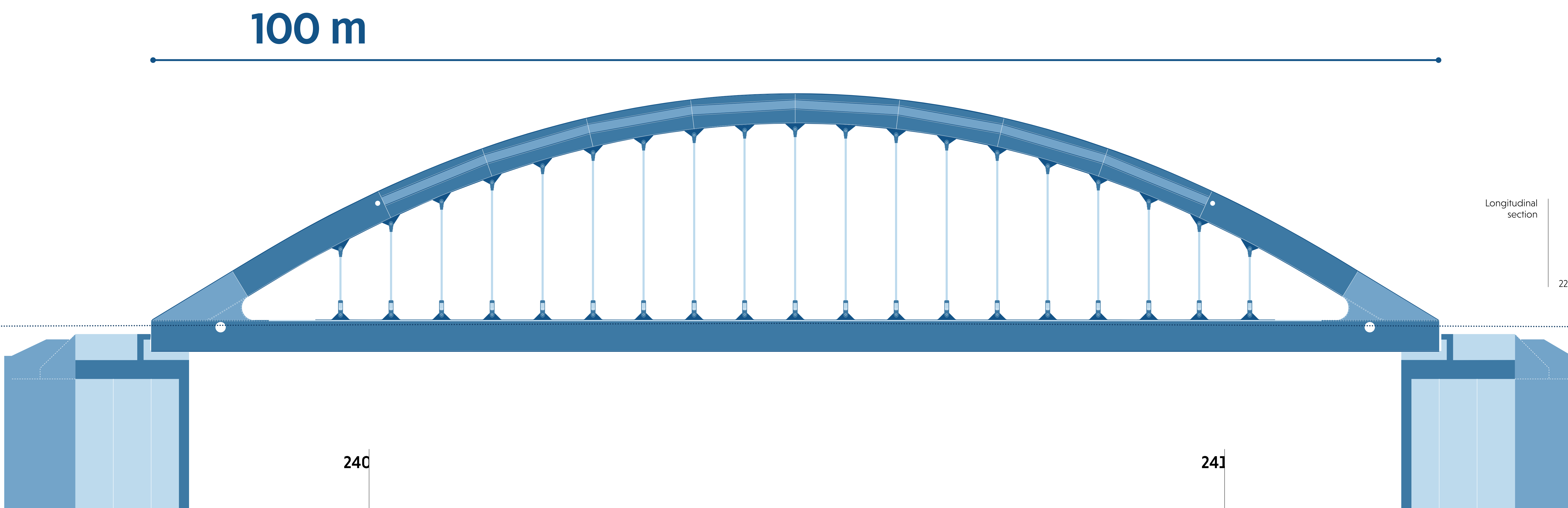
The final project to double the railway crossing of the River Brenta was one of the most important operations in the implementation of the Veneto Sistema Ferroviario Metropolitano Regionale (SFMR – Regional Metropolitan Railway System) as it completes the double track configuration of the whole Padua-Castelfranco Veneto line, which is in the Adriatic-Baltic corridor, a leading international freight route.

The aim of the project was to **cross the River Brenta near Padua with a single span of 100 metres,** so that any interaction with the underlying river flow could be avoided. **The already large span would become even bigger considering that the bridge has double track railway in a section of the line that is about 1,900 metres long overall and was intended to redouble the line.** Therefore, the structure to cross the River Brenta, with a free opening of 100 metres, is effectively **the longest single-span railway bridge in the whole of Italy.**

In addition, the infrastructure designed by NET Engineering aimed at eliminating the severe critical factors hydraulically of the existing bridge. To do this, not only did the new, larger, deck have to be built but the existing route also had to be connected to the new one with a low incline so that the performance of the line could be maintained.

In the field of railway bridges in Italy, this bridge is at the upper size limit. The work is a Langer-type tied-arch bridge and was intended to overcome the limitations imposed in the field in Italy to date. The work will clearly be useful in **increasing use and offers greater efficiency of the railway infrastructure with obvious environmental advantages but, most of all, greater safety.**

There is an interesting river landscape close to the bridge, featuring well-used 'life paths', which forms a 'green belt' in an urban context. Attention to the shape, and not only the function, was central to **harmonising the technological railway sector with the value of the context.** The arch was designed to be as low as possible, including sound insulation barriers inside the main structure, following an innovative idea with respect to the standards of Italian Railway Network.



Longitudinal section

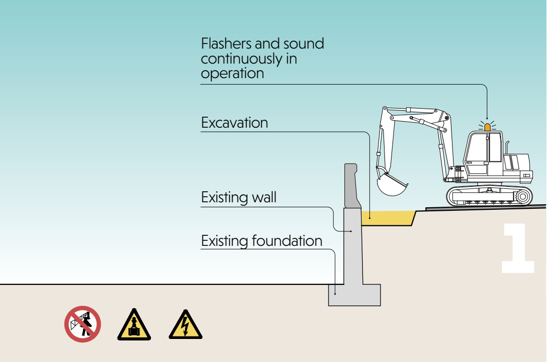
22.


23.

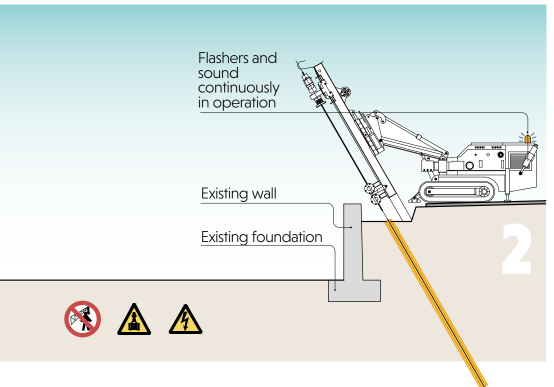
3D model of the bridge over the Brenta river

Technical innovation for motorway safety

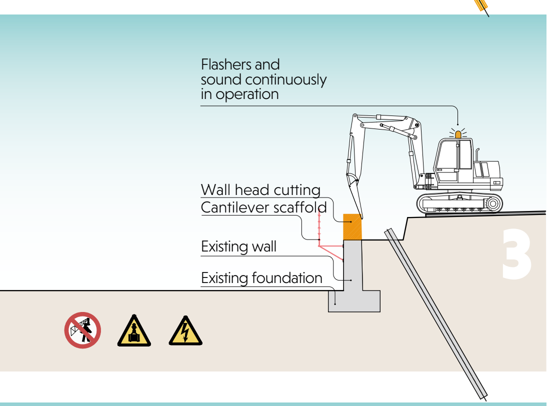
Final Design of the works for the replacement of the integrated barriers



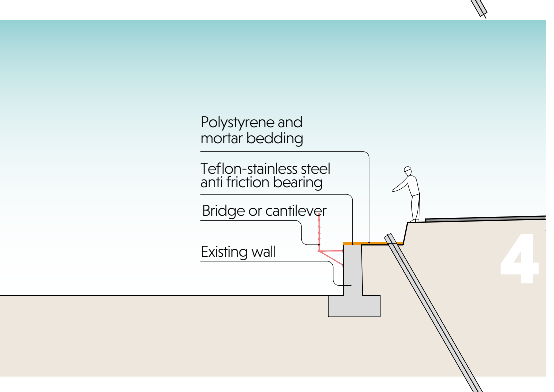
EXCAVATION UP TO THE BORING LEVEL OF MICRO PILES



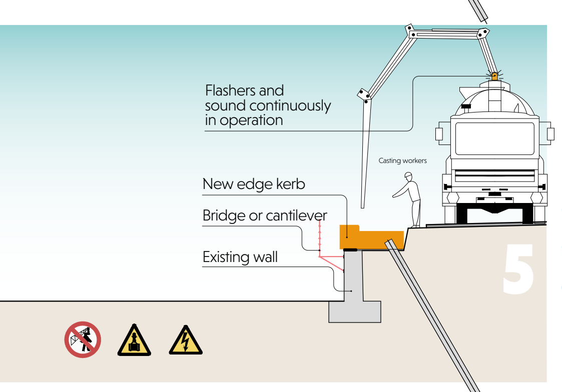
EXECUTIONS OF INCLINED MICRO PILES



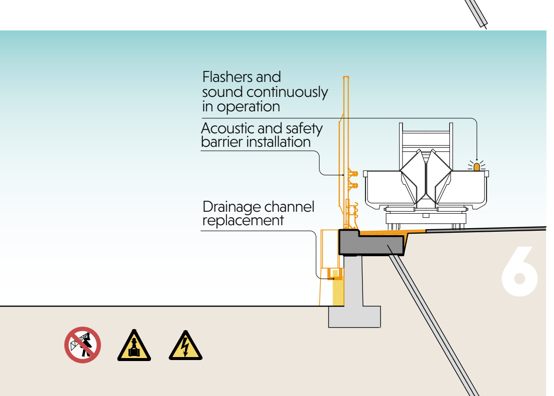
CUTTING OF THE EXISTING WALL HEAD BY DIAMOND WIRE



SETTING OF ANTI FRICTION BEARING AND CONCRETE CASTING PLAN



SETTING OF FORMWORK AND STEEL REINFORCEMENT, CONCRETE CAST KERB



CONCRETE BACKFILL, ROAD RESURFACING, ACOUSTIC AND SAFETY BARRIER INSTALLATION, WATER DRAINAGE SYSTEM RESTORATION

Autostrade per l'Italia has recently started a vast programme to replace the integrated barriers currently found on the motorway network. A new model of safety and noise protection barrier has been patented; named Integautos 2.0, it performs better than the existing barriers.

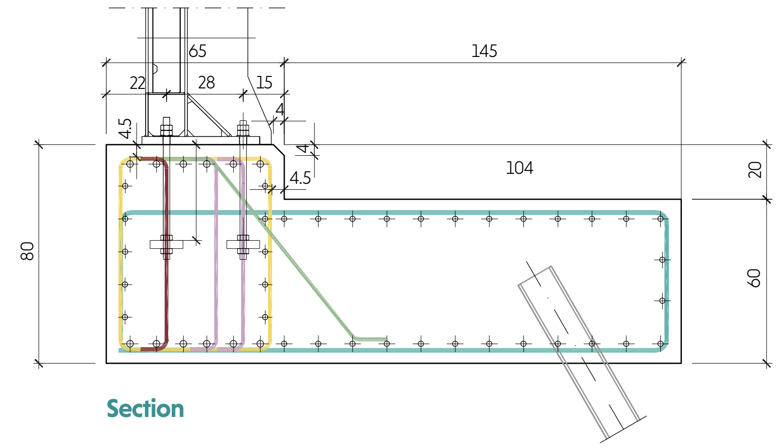
NET Engineering was responsible for the **Final Design of the extraordinary maintenance replacing the old integrated barriers** and the installation of the "Class H4 integrated bridge side or roadside safety and noise protection barriers – Integautos 2.0" along various sections of the motorway network.

Structural and geotechnical surveys and vulnerability assessments were carried out to ensure respect for current legislation on the construction and anchorage of the barriers to the support element and **determine the compatibility of the current walls and kerbs with the new installations.** This highlighted that the existing works offer limited, uncertain or even no guarantee of ability to act as structural and support elements for the new barriers. As a result, a **new reinforced concrete kerb was designed clearly overlaying the existing works and which, although keeping the volume of this road section unchanged, can lighten its structural effort,** especially knocks from turning/swerving vehicles and the wind.

This is a **specially reliable, ad hoc kerb, able to respond to the expected structural behaviour with stability and safety features established by legislation for travellers and noise protection** for receptors near to the motorway.

The work designed by NET Engineering is innovative for various reasons. The new reinforced concrete kerb has been designed for motorway sections on an embankment with support walls, and small yet frequent bridge structures. The standard solution sets out a structure above the existing wall, previously cut down at the top, supported on one side with a foundation with a single line of slanting micro-stakes, not interacting with the wall and, on the other side, an **anti-friction support system** applied to the top of the wall. This technological detail has been specially designed to reduce resistance to horizontal movement between the existing wall and the new kerb laid on it to the minimum. The operation obtained enables the existing wall to be relieved of the destabilising horizontal action from knocks and partly the existing soil filler, transferring to the wall only a component of stabilising vertical load. The remaining action is transferred to the ground by the new deep foundation.

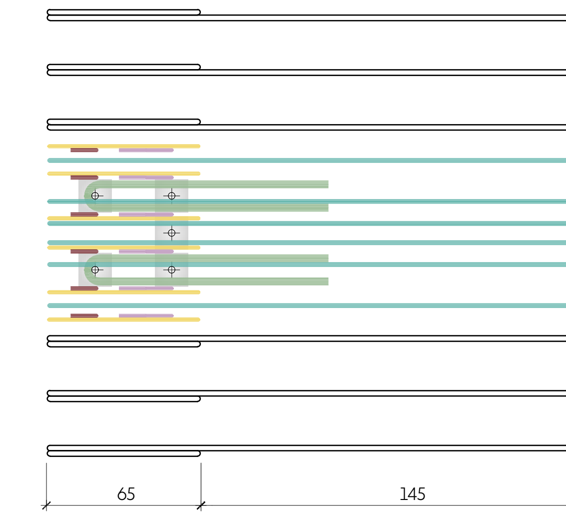
The particularly high stress transmitted to the anchoring node is absorbed by the new kerb in which the detail of the armature is designed with mechanical precision. At the same time, that detail is organised so that prefabrication can be made and so rapid and exact execution ensured. Lastly, the weight and geometry of the structure ensure its wind stability.



Section

1.

New edge curb: supplementary reinforcement detail

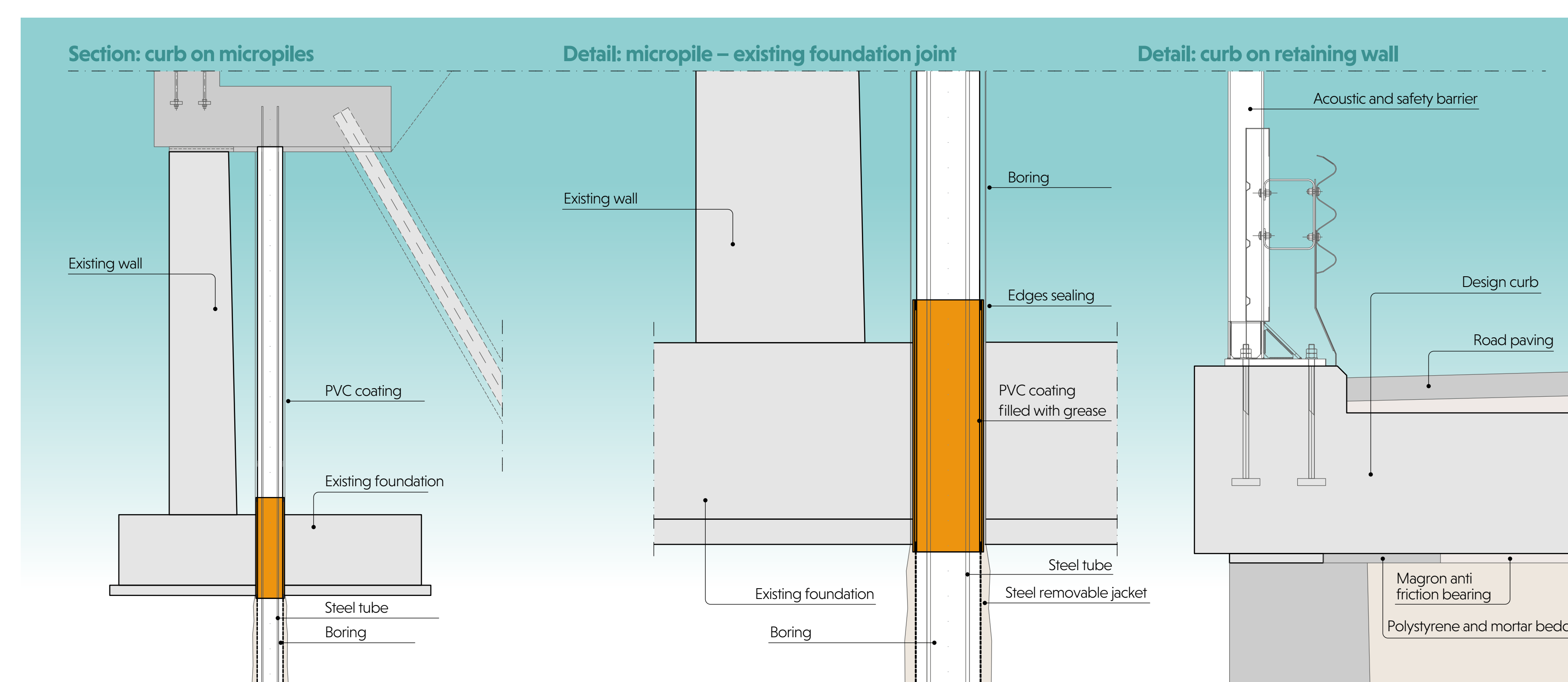


Plan

An important condition to the sizing of the work is dictated by the limitations on volume set out by the client to reduce the area of the roadworks during the work on the roadside as much as possible and ensure respect of the border with the private properties adjoining the motorway, especially in the highly built-up sections.

Alongside this type of standard solution, the NET Engineering project indicates some variants which allow the new kerb to be included along the walls at a lower height or when there are non-removable side obstacles and in correspondence with structures with reduced light that can be climbed over.

NET Engineering's answer enables the integrated barriers on motorway sections to be modernised quickly and easily, contributing to an increase in the safety level of users and attention to the area. At the same time, it responds to the rapidity with which the operators intend to intervene.



Ensuring the safety of infrastructure heritage

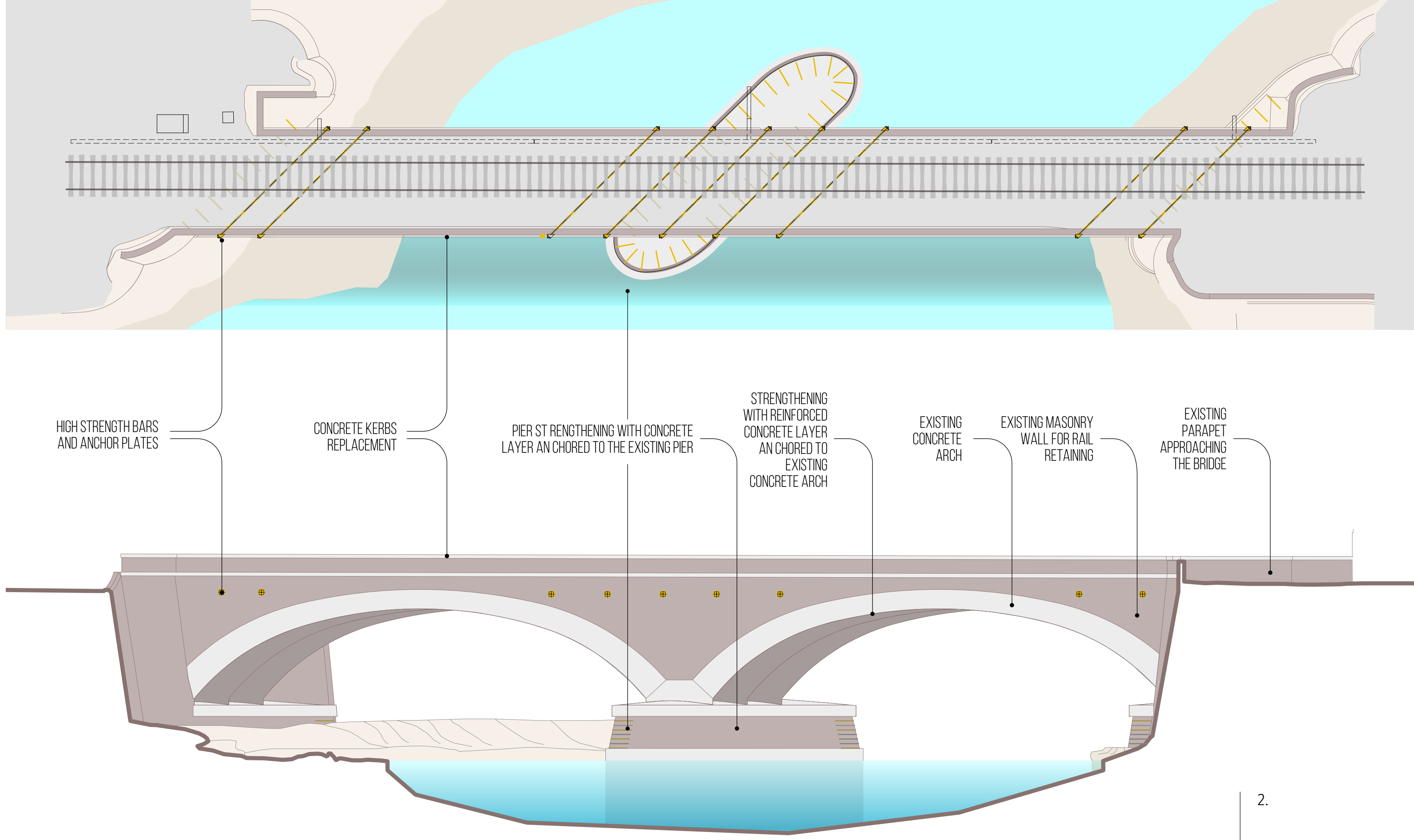
Checks on the seismic vulnerability and structural resistance of bridges

In Italy, experts and legislators only began to pay attention to seismic surveys and checks on buildings and infrastructure at the end of 2002, after the earthquake in Molise had caused the catastrophic collapse of a school. Almost 16 years later, in the summer of 2018, the case of the Viadotto Polcevera, also known as the Morandi bridge, forced the rapid approval of new legislation including on the structural resistance of existing works.

Dealing with **checks on the seismic vulnerability and structural resistance of bridges** means not only carrying out a diagnosis of existing works but also encountering a variety of construction methods, materials and fulfilment times. It means trying to reconstruct the past of each infrastructure that no-one knows. It means manoeuvring amongst original projects, designs and reports, sometimes completely outdated, and ascertaining the correspondence between what has been declared and what is found in the field. In Italy, bridges built in the early 20th century or after the Second World War are inspected much more often than more recently built ones.

After the collapse of the Morandi bridge, the census and monitoring of the existing infrastructure began. This work quantified that about 50% of the entire national heritage of structures did not sufficiently comply in terms of either maintenance or structural resistance to satisfy the Italian legislation in force.

The situation is, at least partly, **different for railway bridges and viaducts which have been subject to checks on structural resistance for some time.**



Example of a steel truss railway bridge for which 'VAL4' type structural analyzes are carried out

1.

2.

A 'three staggered slices' existing bridge with 2 spans
Figure above: Schematic view of structural strengthening to achieve design seismic requirements
Figure below: state of art before strengthening

Among the first in Italy

NET Engineering has acquired experience in this sphere; before 2018, the company had started to conduct static structural analyses, and often seismic ones too, on railway infrastructures, developing a very specific – and pioneering – skill on operations on existing works in Italy. To date, NET Engineering has provided assessments of the seismic vulnerability and structural resistance to operating loads in accordance with the new legislative framework to various Italian road and rail infrastructure operators for a total of more than 200 works analysed.

The experience gained by NET Engineering in this sphere and the constant discussions with Consorzio FABRE, which has promoted and co-ordinated research on the assessment and monitoring of bridges, viaducts and other structures since 2020, have enabled the development of specific expertise in the analysis of the works.

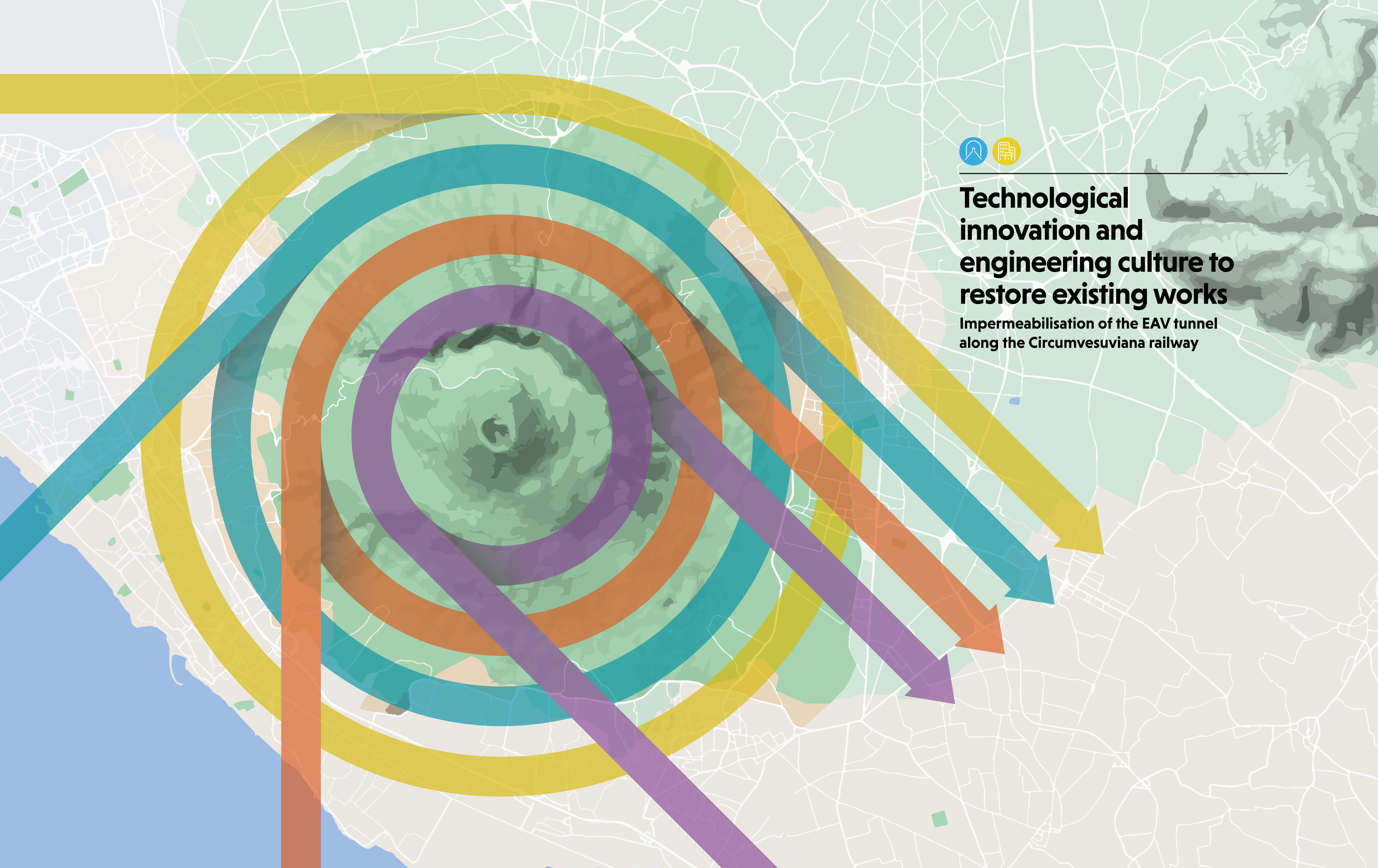
Based on the structural type and the conservation state of the infrastructure or buildings, **the plan of geotechnical-structural surveys and appropriate inspections in situ** can be arranged for the conscious definition of the knowledge levels and confidence factors on which to base the analyses and calibrate the check criteria.

3. Load tests for the dynamic characterization of the work

4. Examples of reinforced concrete viaducts for which 'VAL4' type structural analyzes and related reinforcement projects are carried out to make the works adequate and operational

First of all, the **deteriorations are studied** and, from these, indications on the specific areas of each infrastructure which should be surveyed can be provided. Today, there are sophisticated instruments giving a true X-ray of a work. In addition, **the use of drones** allows critical points to be perceived even in areas difficult to access, making ad hoc operations possible. After the interpretation of the data supplied and all the analyses set out by the new legislative framework (static or dynamic, linear or non-linear), the state of health is established and the structural resistance of the work established.

Then, in agreement with the client, the **most adequate methods of operation** are assessed to ensure the improvement or upgrading for seismic and static action. The conservation of existing works is certainly more sustainable than their demolition and reconstruction from scratch. Yet it is essential to have understood and accepted that signing a project declaring the fitness of an infrastructure to carry out its function for a further period means assuming an enormous civil and criminal responsibility as, in effect, the onus of partial knowledge of the work referring to the period spent on it and the maintenance and monitoring not implemented in the past is accepted. This **responsibility requires consciousness and awareness as it concerns the safety and efficiency of the Italian infrastructure** heritage so that it can continue to be used respecting the law.

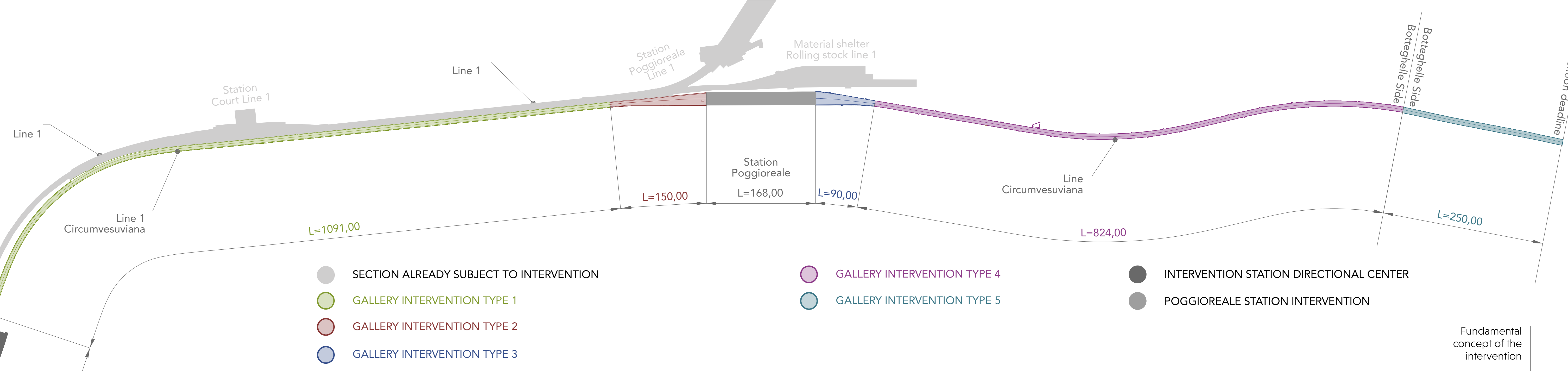


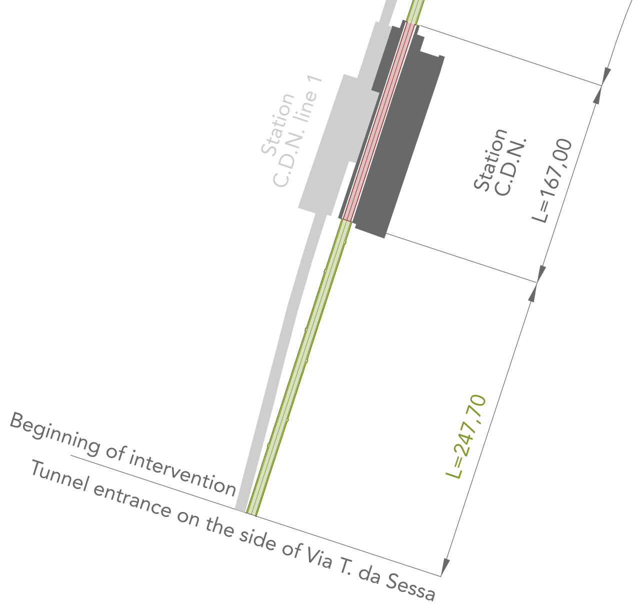
Technological innovation and engineering culture to restore existing works

Impermeabilisation of the EAV tunnel along the Circumvesuviana railway

Planimetric aspect of the section involved and its subdivision based on the peculiarities of the intervention

1.





Restoring a metropolitan tunnel

The EAV tunnel on the Naples-Nola-Baiano section of the Circumvesuviana railway was constructed in the 1970s and 1980s and is affected by water infiltration caused by a rise in the water table, ongoing for a number of years.

There have been various attempts to stop the infiltrations over the years but the problem has never been completely solved because the railway is at a lower level than the current water table. NET Engineering was assigned to the **definitive planning of the waterproofing operations and the restoration of the tunnel** for an overall length of about 3 km. The aim of the work is to **dry out the railway track**, thus rationalising use of the dewatering system currently operating.

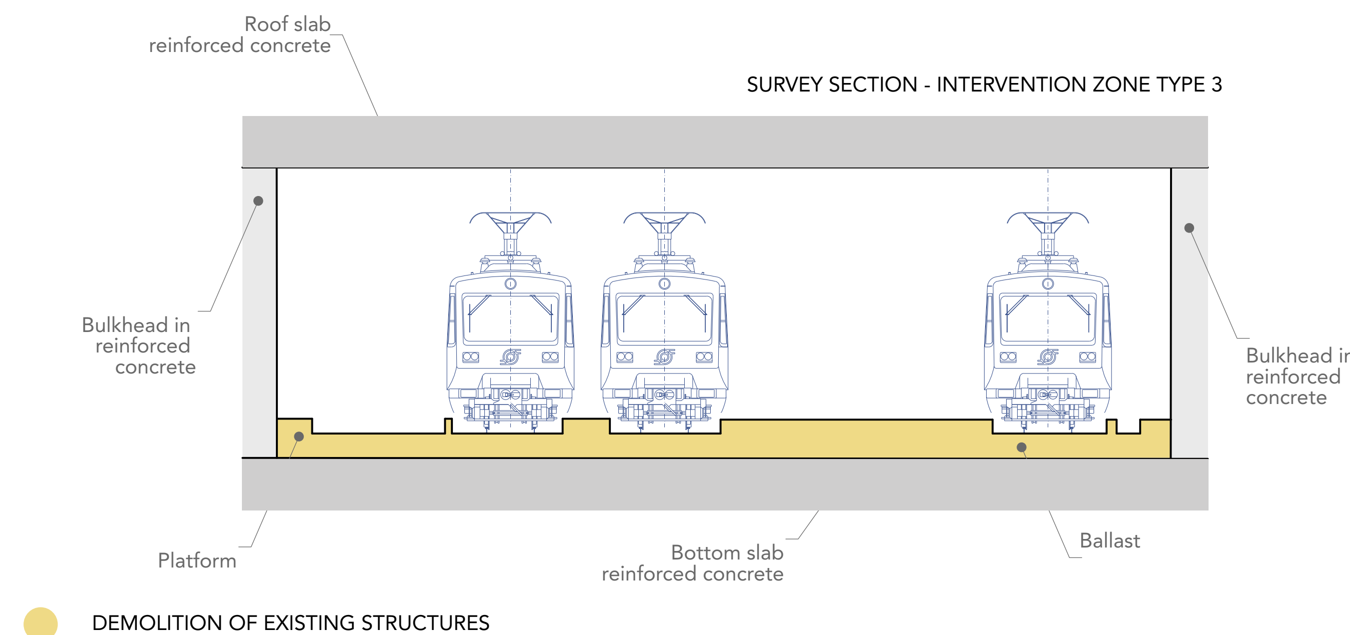
Starting from the information collected using the **laser scanner on the internal surfaces**, which gave precise, measurable detection of the widespread damage/deterioration of all the exposed surfaces, a detailed operation plan was drafted.

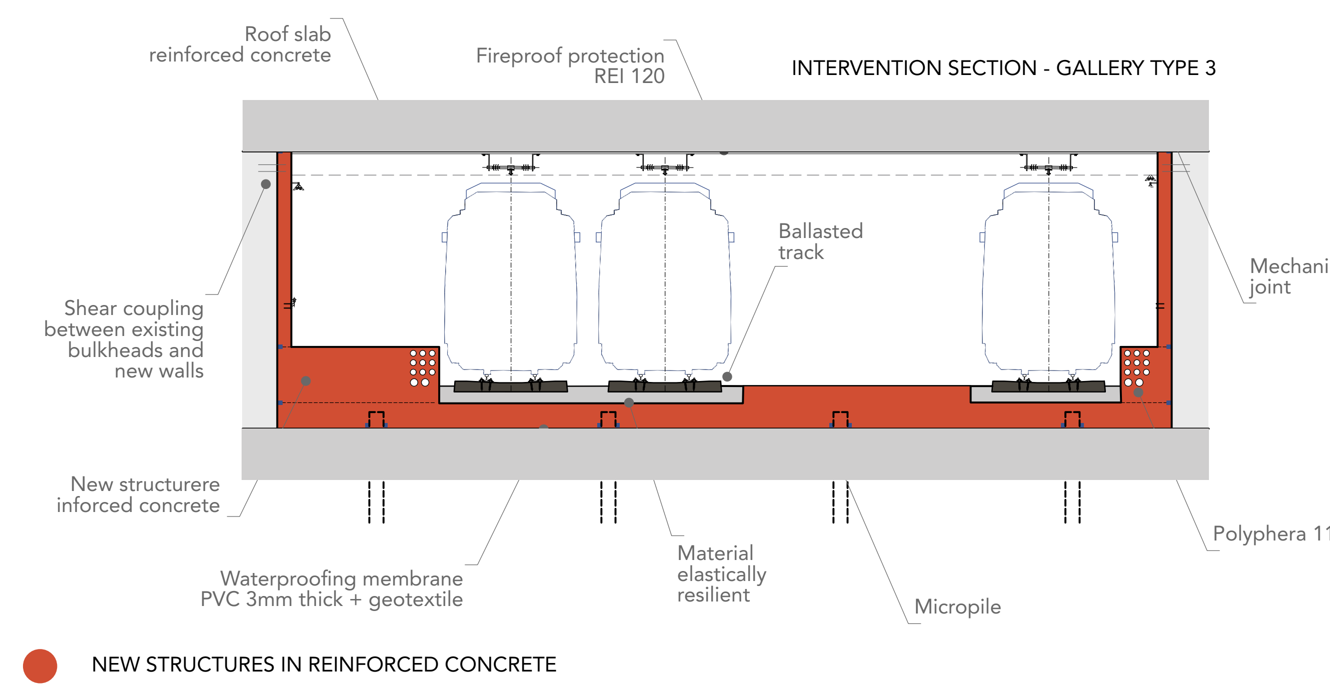
Firstly, the project sets out the **restoration of the existing structures**. In detail, the localised and widespread deterioration in correspondence to the bulkheads and upper slab will be renovated to preserve the static function of the ceiling and reduce the degree of permeability with specific treatments. After this, **a U-section, reinforced concrete structure will be created** consisting of the base floor and two side walls prior to demolition of the existing side platforms, until the extrados height of the base slab is reached. The new structure will be waterproofed adopting two different solutions:

- by inserting a **PVC membrane between the existing structures, and new casts,** taken to near the outer slab;
- by creating casts using a **cementitious waterproofing** system with appropriate additives to the cement and the creation of joints and, if necessary, injections at predefined points.

Fundamental concept of the intervention

2.





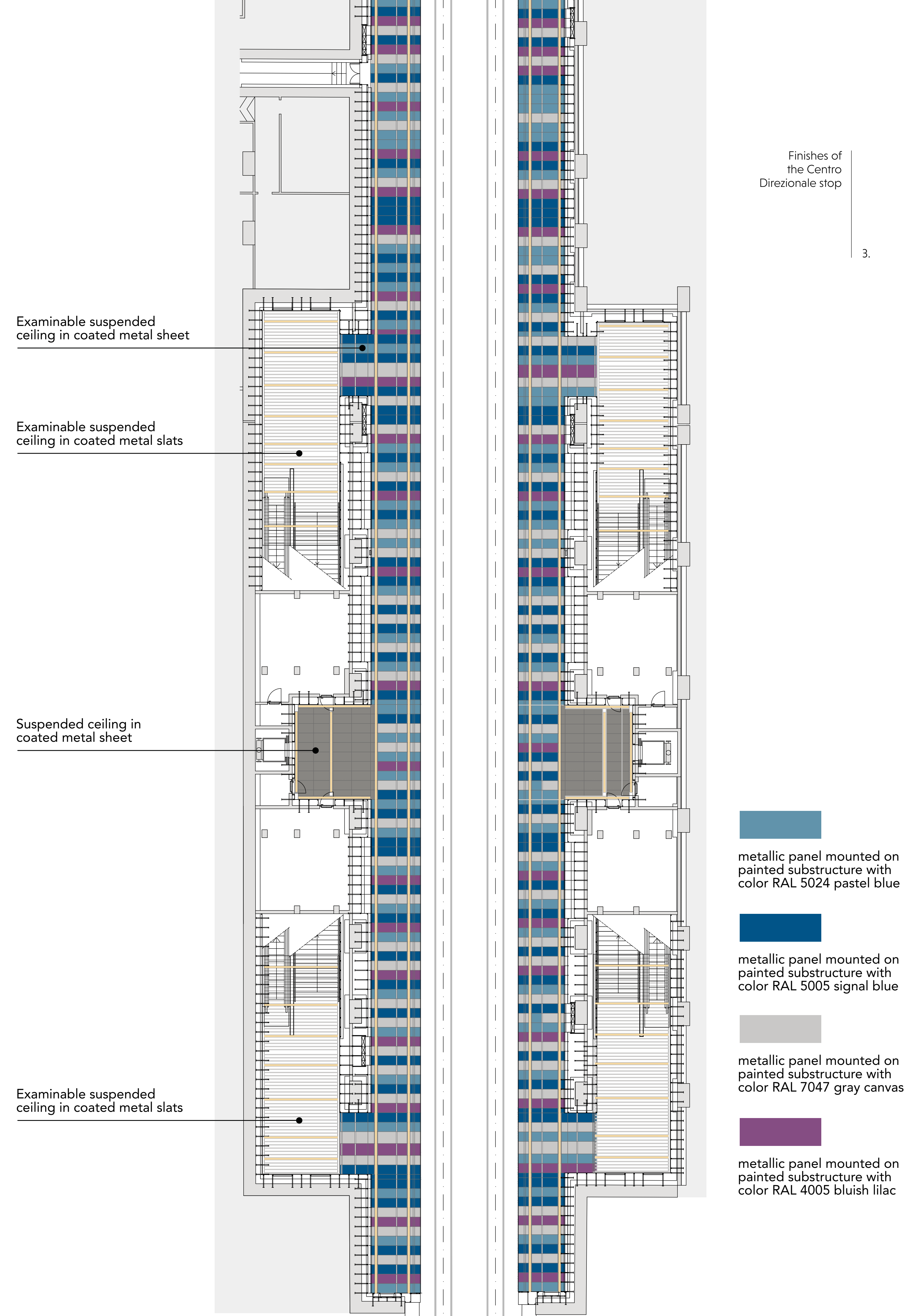
Five types of intervention have been indicated along the line tunnel which differentiate according to the geometry of the new structures. There are also 2 further types for the Centro Direzionale and Poggioreale stations which are found in the section under examination.

Updating station works: an architectural project

Following the waterproofing of the EAV tunnel, NET Engineering curated the **Final Design of the updating of the station works and the new finish for the Centro Direzionale stop.** As this is a railway redevelopment, the main design theme was to indicate and analyse all the essential elements for station operation so that their size and position could be optimised, keeping the current positions of lifts, moving staircases and escalators to the mezzanine floor. The construction of the new bottom slab will mean the track level will be raised along the whole line. As a result, the Centro Direzionale stop will require an **increase of 55 cm in the track level for both existing platforms** to allow the introduction of the waterproofing structure. As a consequence, all the lifting mechanisms to the mezzanine floor and the relative parapets will be updated. The flooring, ceilings and platform furniture will all be new, including latest generation paths for the visually impaired. Special attention was paid to the design of the walls. **The choices on architecture and the finish came from the desire to give the stop an identity common to that of the station.** The stop on the Circumvesuviana line is part of the same context as the Line 1 station, designed by Miralles Tagliabue EMBT studio, and under construction. As a result, NET Engineering chose to use the same architectural language and the same materials, planning a shaped curved coating for all the walls to characterise the station, with seats housed in the niches.

Approaching an existing work means understanding its peculiarities, catching structural features without being able to read the project, interpreting its deep problems starting from the often incomplete and practically incompletable data.

So what should be done? How can an infrastructure be made safe? How can a tunnel be recuperated and restored? In this context, it's essential, **especially for tunnelling**, that there's a significant design effort but, above all, great **professional maturity**, knowledge of construction methods and thorough **engineering culture** that can understand the 'symptoms' that show.



Finishes of the Centro Direzionale stop

3.

Urban renewal

The Termini and Piazza dei Cinquecento Hub, Rome

A mobility project for urban regeneration

NET Engineering's role in urban regeneration projects is to **offer design solutions with a wide interpretation of sustainability, starting first and foremost from the understanding and interpretation of mobility needs, translating them into new transport infrastructure projects that aren't just about accessibility and usability of the area concerned but also reconnect the whole area.**

There will be an important urban and functional redevelopment project, promoted by Gruppo Ferrovie dello Stato Italiane (Italian State Railways Group), involving the Termini and Piazza dei Cinquecento hub, one of the largest intermodal hubs in Italy, and certainly one of the most critical contexts for transport in Rome.

Designing sustainable mobility

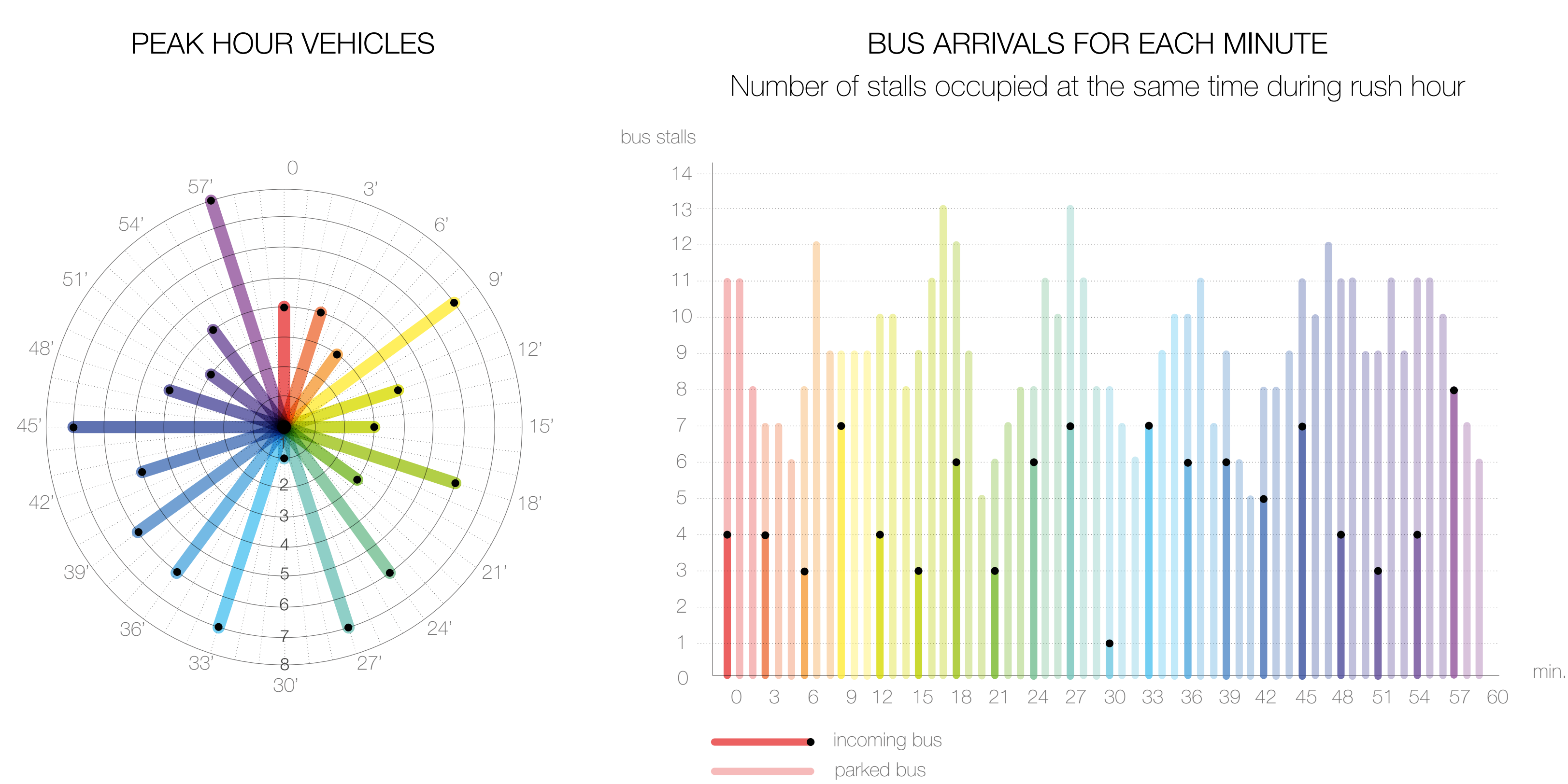
The challenge that NET Engineering faced in the development of the project, winner of the competition announced by Grandi Stazioni Rail and assessed by a jury of experts chaired by Patricia Viel, architect, was to keep the balance between the **functional aspect** while valorising a public space that, starting from the architectural project developed by TVK and IT'S Architettura, returned centrality to the concept of 'empty'.

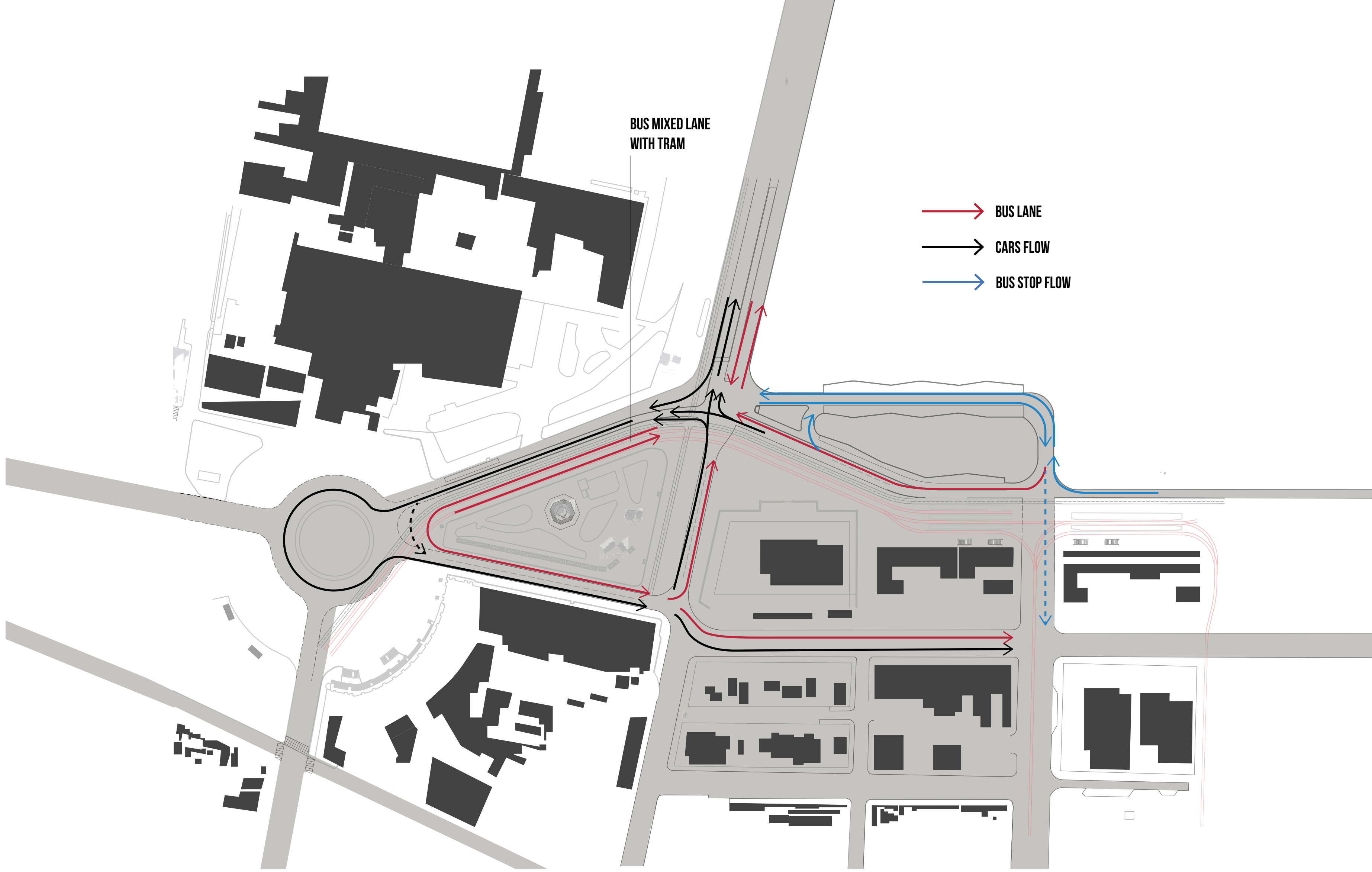
As transport designers, NET Engineering seized the opportunity to **make the pedestrian the key figure, implementing a process intended to progressively reduce vehicle traffic as it approaches the square**, making pedestrian and bike mobility the prevailing and priority methods of the scope of the project.

This vision was translated into persuasive aims for mobility planning which led to the **redesign of the bus terminal** (16 bus lines, with an average of four movements per minute, i.e. a bus arrives or departs about every 15 seconds, converge on Piazza dei Cinquecento, and 13 stalls occupied at the same time during rush hours), a consistent rethinking of the **circulation diagrams, geometry of road sections, integration of the new tram terminals** and a **new cycle path system planned** by the Sustainable Urban Mobility Plan (SUMP) that was being designed.

The bus terminal, the functional centre of the square, should be accessible, welcoming, 'legible', functional and favour modal interchange. As a result, a new geometry, at least in Rome, was developed which goes beyond the traditional layout, organised with individual platforms, and uses a concept oriented to the creation of large macro-islands, appropriately profiled to facilitate the entrance and diversion of buses along the perimeter. A concept which turns the vehicle space 'consumed' by the traditional layout into a usable pedestrian area taking

1\. Analysis of bus arrivals (grouping for 3 minutes) and stall occupancy during rush hour minute by minute





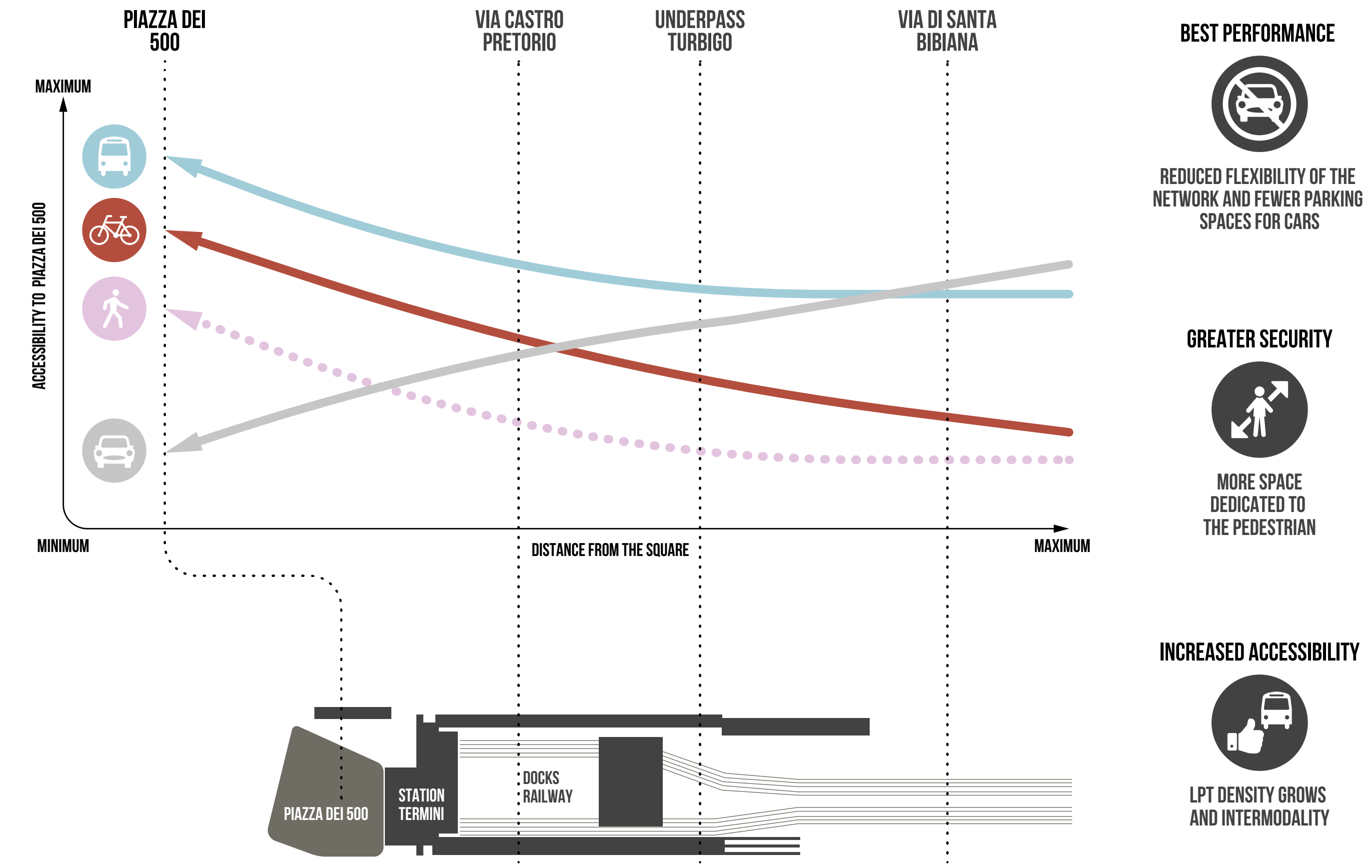
2\. The new layout of the bus terminal and the circulation patterns inside and outside the new bus station in Piazza Cinquecento

BUS LANE
TOUR BUS/PULLMAN
HOTEL
BIKE
BIKE HUB 400MQ
METRO
ROME TERMINI STATION ENTRANCE
ISLAND
B
A
PREFERENTIAL BUS
TAXI
CAR FREE ZONE
PEDESTRIAN PATHS
CAB WAITING
CHARGING STATIONS
CAR SHARING
BUS ROUTES
TRAM ROUTES
CYCLE PATHS
BIKE SHARING
SECTION A
VIA GIOLITTI
3,5
bus lane
6
driveway
2,15
flower-bed
2,5
bike lane
7,5
tramway
SECTION B
VIA DE NICOLA
2,5
4
pedestrian
7
driveway
4
traffic island
7
bus lane

the pedestrian to the services and making access to the buses simpler and more immediately legible.
As the result of an overall redesign of the circulation layouts, with the approach to the square from East to West, the side roads Via Giolitti and Via Marsala will become more and more public transport, shared mobility service, taxi, pedestrian and bike oriented. For this, the overall architectural and urbanistic vision is interpreted, for mobility, through the opportune allocation of space for moving and stopping, integrating the planned new tram lines (Termini-Giardinetti and Termini-Vatican-Aurelio) and the bike corridors set out by the SUMP, defining the new areas for the taxi rank, kiss&ride and airport shuttle services along Via Giolitti, the car sharing services along Via Marsala with the terminus of the urban bus lines for the districts north of the station.

Square will become a place for pedestrian and bike mobility. It will promote the exchange between buses, tram lines and underground lines via safe paths and clarity on the positioning of the services; it will also offer a cycle hub for safe bike storage.

The mobility study developed by NET Engineering for the Termini and Piazza dei Cinquecento hub substantially succeeded in the aim of availability to the city, interpreting the needs, **integrating the already planned development projects and enhance their expected benefits.**



4. The traffic calming around Piazza 500

3. From left: view from Via De Nicola, view from Dinosauro (main entrance on Piazza dei Cinquecento), view from Palazzo Massimo

Atmospheric agents: An opportunity to promote urban sustainability

The Scalo Farini Milan Master Plan

Scalo Farini (Farini Railway Depot) is one of seven Milanese railway depots included in the Plan Agreement, approved by Lombardy Region in 2017, for the urban redevelopment of the railway areas already closed and about to be closed in correlation with the extension of the Milanese railway system.

NET Engineering, working with OMA, Laboratorio Permanente, Phillippe Rahm architects, Arcadis and Temporiuso, won the international competition, launched by FS Sistemi Urbani and COIMA SGR, for the drafting of the redevelopment Master Plan of Farini Scalo Railway Depot (Farini Scalo). The general aim of the project, known as Agenti Climatici (Climatic Agents), is to influence urban climate, setting out **specific operations that will encourage the establishment of favourable environmental and climatic conditions built on sustainability and ecology.**

The planning concept was the result of frenzied search for the sustainability of a wider system and an effort to indicate the added value that a (now) empty space can offer to the urban system with a view to assist and extend the process of a whole town towards the reduction of the impact of anthropization.

The Master Plan, which concerns more than 41 hectares, destined for an urban park and residential, commercial and office buildings, has a very long timeline.

So various scenarios were imagined for Milan in 2035-2050 and, as a consequence, **various answers from both the points of view of the intended use of the building and planning the mobility.** NET Engineering's contribution led to the **definition of the specific mobility objectives, supporting the project of a layout that could favour movement by sustainable** means both within the Master Plan and the neighbouring urban contexts.

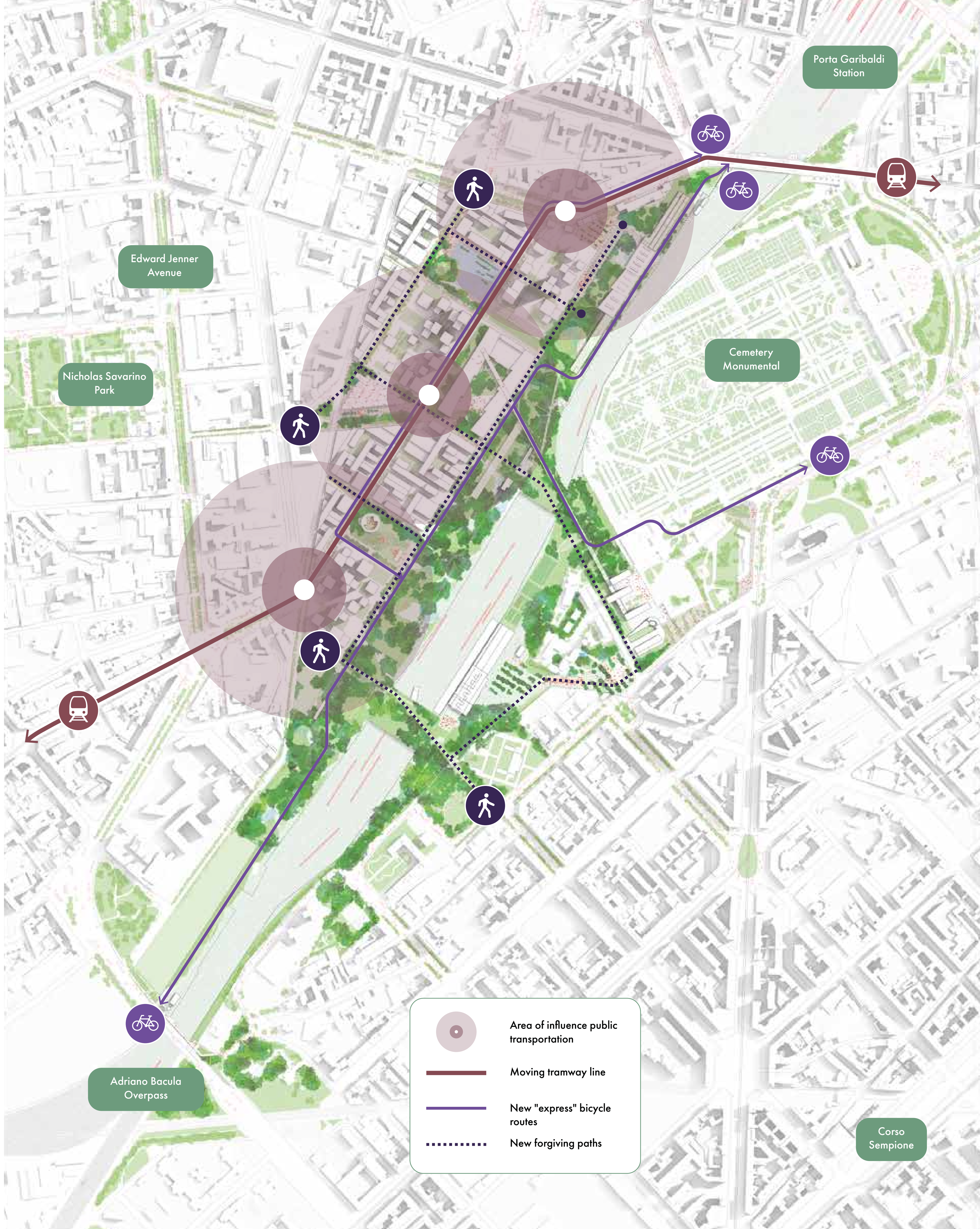
Mobility at Scalo Farini

Analysis of the reference context and the forecasts of the mobility policy tools, first and foremost the Milan Sustainable Urban Mobility Plan - SUMP, enabled indication of the new mobility needs in relation to the Farini Master Plan, a check on the network of transport services set out by the SUMP in this specific context and the construction of a new structure that goes beyond some elements, pursuing the aim of confirming the role of the new spaces in a system perspective. Contrary to what normally happens, **the Master Plan was made available to the city, trying to respond to still unanswered questions, offering solutions, imagining and assessing its impact on the urban context right from the beginning.**

Scalo Farini is reached by tram, in accordance with a route that supports new areas

Pedestrian, cycle and tram accessibility to Scalo Farini

1.

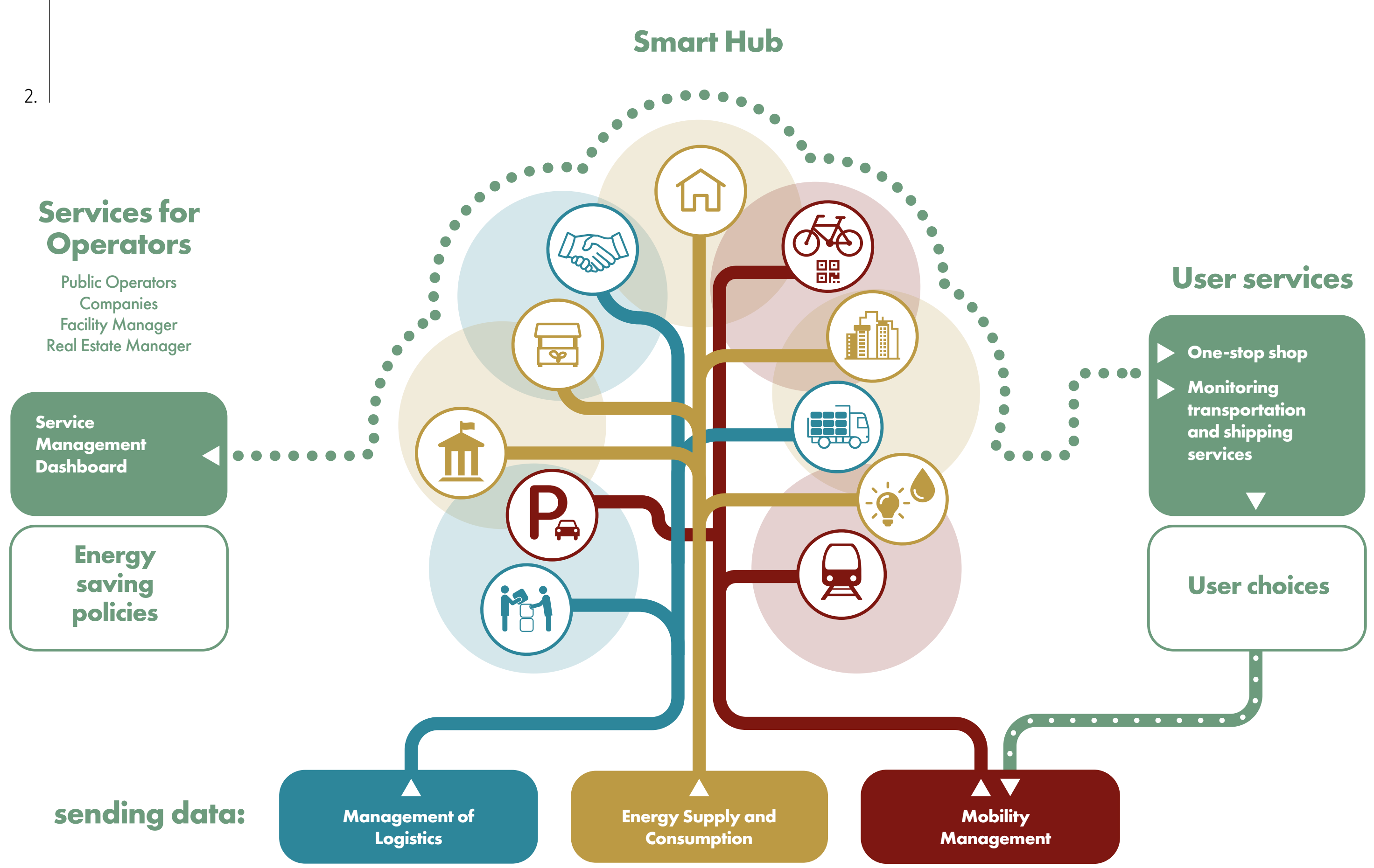


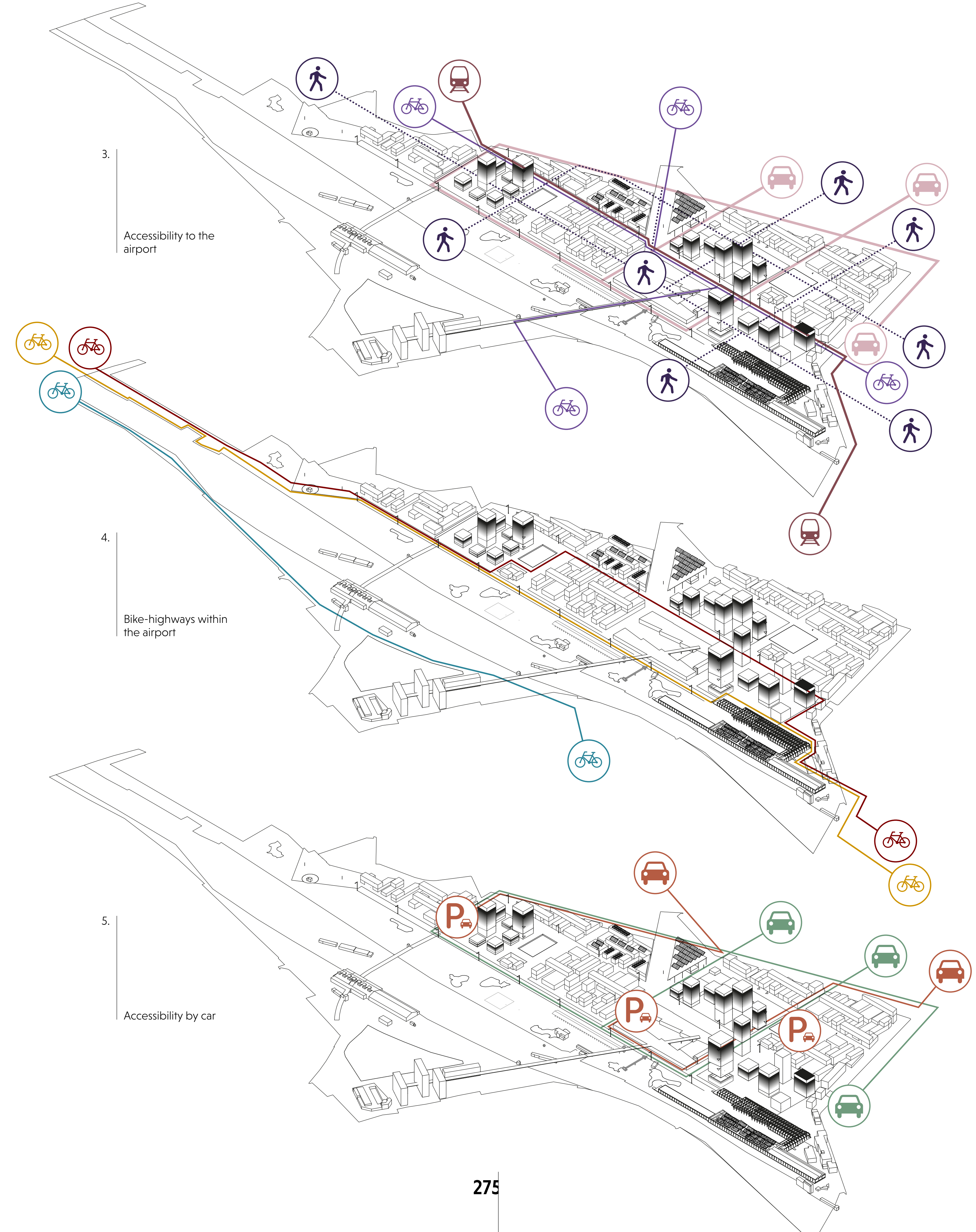
of settlement and is the backbone of the public transport system of the railway depot, offering a new corridor to Milanese public transport at the same time.
Scalo Farini is reached by train: the Lancetti stop has become an intermodal hub and laboratory of the new forms of mobility. Consolidation of bike-sharing is also planned to facilitate the destination centres within the area. The cycle-pedestrian network guarantees a direct connection to all areas of Scalo Farini via the new walkway on the sidings in 10 minutes on foot and 5 minutes by bike.
Scalo Farini is reached by bike, Using the bike-highways, part of and extending the wider programme of increasing the bicycle modal share that the Municipality of Milan is implementing.
A Scalo Farini is reached by car, Following an internal distribution of circulation and a digital wayfinding system that guides the user to the subterranean car park, minimising the route and discouraging mobility crossing the depot.

The Smart Hub

Scalo Farini is also a **digital platform managed following the Mobility as a Service** (MaaS) approach, able to integrate all the associated systems serving mobility, procurement, and management of energy resources. The platform is the Smart Hub of the Master Plan, **the key element for the overall management of the system**, which ensures a digital one-stop-shop to people and the managers of a monitoring panel and management for the check on the consumption of resources and minimisation of the impact.

2. Operation of the Smart Hub for overall system management





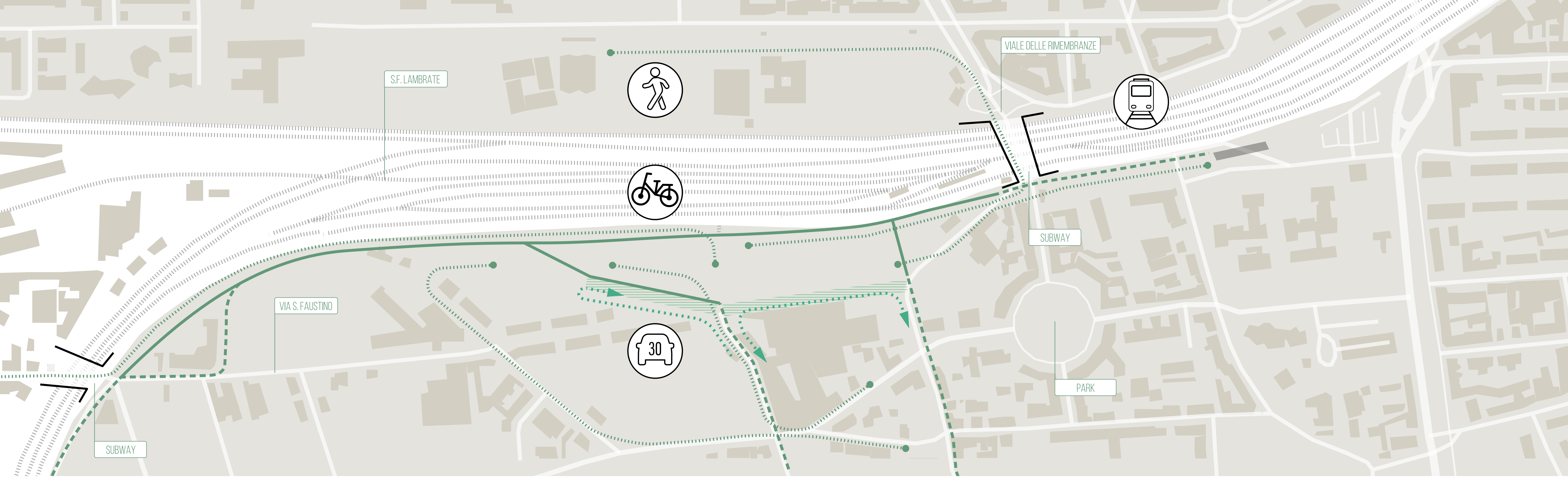
3. Accessibility to the airport

4. Bike-highways within the airport

5. Accessibility by car

Scintilla

Sustainable mobility for the former Lambrate railway depot in Milan



1.

Lot plan and pedestrian and cycle accessibility and traffic calming interventions (30 zones and shared streets)

It is well known that most greenhouse gas emissions in the world come from cities. It is also well known that urban population will further increase in the next decades – the UN estimates that the level of urbanisation will reach almost 70% of world population by 2050. So how can we reconcile sustainability with urban development? Urban regeneration initiatives are an example of how **sustainability should not only be seen as just a global motion but also as a design tool to indicate and make new services available to citizens, orienting communities to more sustainable behaviour, therefore better for everyone.**

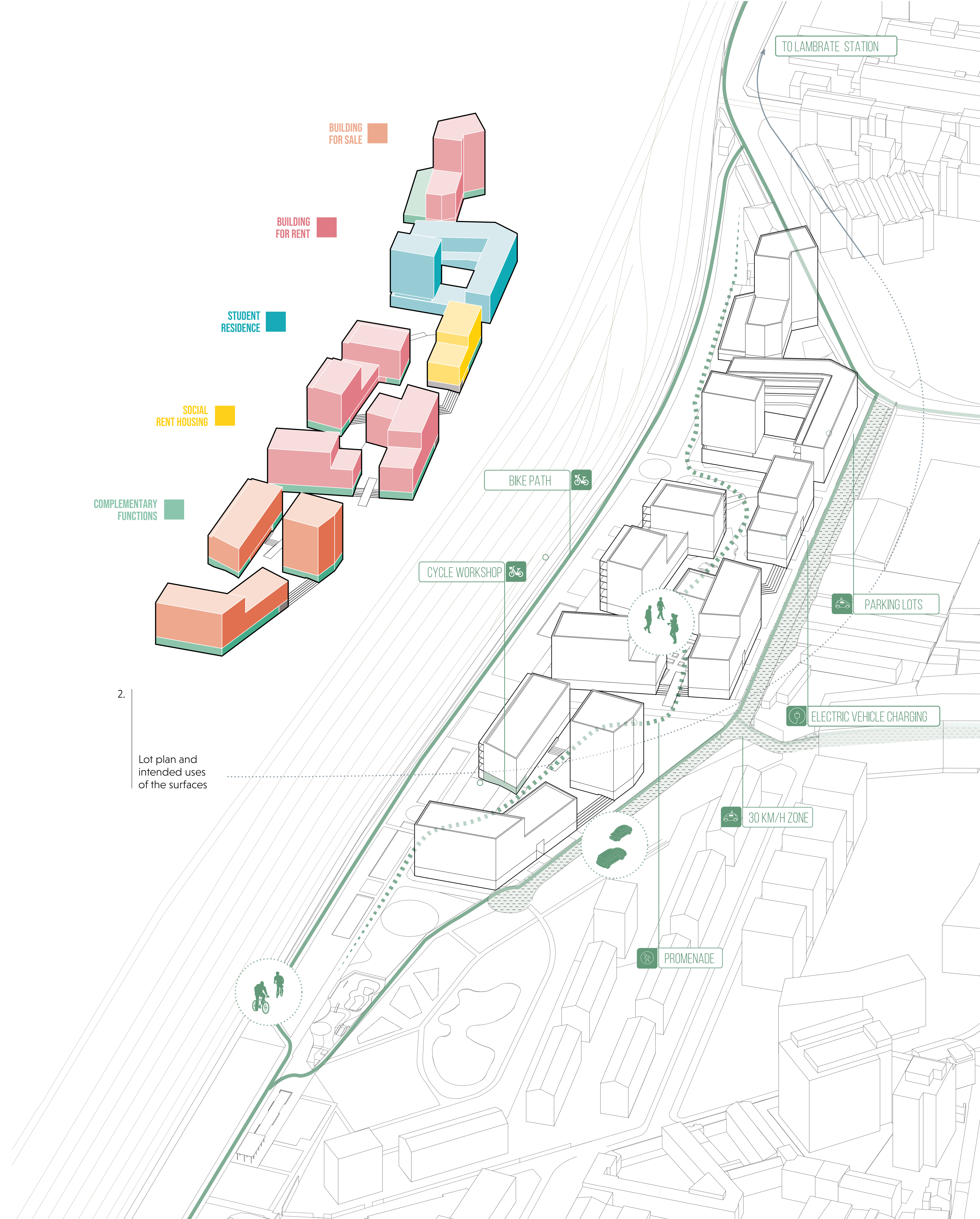
This was NET Engineering's approach to **Reinventing Cities**, the C40 initiative to stimulate sustainable development and the search for innovative solutions to the environmental and urban challenges. NET Engineering's project for the area of the former Lambrate railway depot in Milan was named 'Scintilla' (Spark) and developed in collaboration with Park Associati, Arcadis, Base, Fondazione CEUR, Siemens, Evoluthion and Revo. A spark is the primary element of an explosive action; in the design proposal, it meant the action that generates a change like an accelerator of regeneration.

Low-emission mobility

Reinventing the city means seizing every opportunity that the transformation areas give, enhancing their distinctive features. This also means creating new social, environmental and mobility connections for the Lambrate railway depot, an essential occasion for reconnecting the neighbourhood after the interruption of the railway. In this sense, the area was imagined as a hub of green mobility integrated with the services and transport systems provided by the Sustainable Urban Mobility Plan, whose design starts from following areas:

- **"Governance" of demand for original travel:** to get a sustainable mobility we can act on the quantity and quality of travel orienting the demand when it is generated, for example by placing in a targeted manner the various activities within the area of interest and encouraging, therefore, travel on foot or by bicycle. Another central element in this specific context is the vicinity of the Lambrate railway hub, one of the access points to the Milanese railway network of the area with the public transport system of the whole district. The deliberate choice was to position homes and functions (e.g. student housing) of the masterplan in the northern part of the affected area, closest to Lambrate station, to make it easy to reach on foot and by bike.

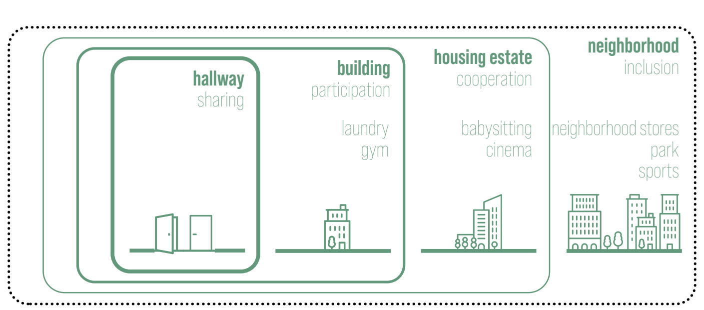
- **Mobility infrastructure**: The only way of overcoming the barrier of the railway is to use the subways at the north and south of the area in the public competition. The new constructions are, therefore, an opportunity to create a connection between the local area and the Lambrate hub, to strengthen all types of connection paying special interest to pedestrian and cycle connections.
The cycle and pedestrian connection between the railway hub and areas neighbouring the district will be accessible from north to south and vice versa, setting up a continuous network for sustainable mobility, currently intermittent. The lot will only be accessible by car in a northerly direction so that the circulation is closed, preventing traffic from crossing the area. The establishment of a 30 Zone will also increase safety near the new district and really turn the road into a shared space surrounded by welcoming green areas, converting what is normally seen as a expressway into a pleasant place.
- **Mobility services**: NET Engineering's proposal to promote modal diversification towards smart, green mobility is based on the creation of infrastructure and development opportunities for sustainable mobility and sharing services. This will give an effective, efficient answer to mobility needs by strengthening the 'last mile' connections - e-sharing services (bicycles, cars and electric scooters), widespread charging infrastructure near businesses and homes and local bike workshops for public use, just to give a few examples. The mobility services offered could be managed and monitored through a specific local app which would allow a check on free stands, vehicles available, how long a car park can be used, car-pooling requests, etc. giving integrated, real time information on availability and localisation of the services system.



2.
Lot plan and intended uses of the surfaces

An integrated nature-energy-mobility system

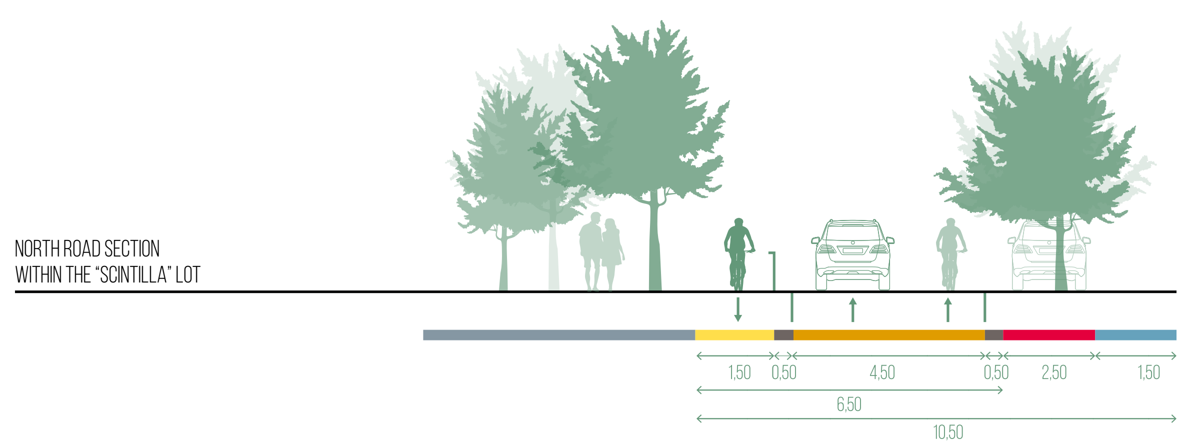
A new building

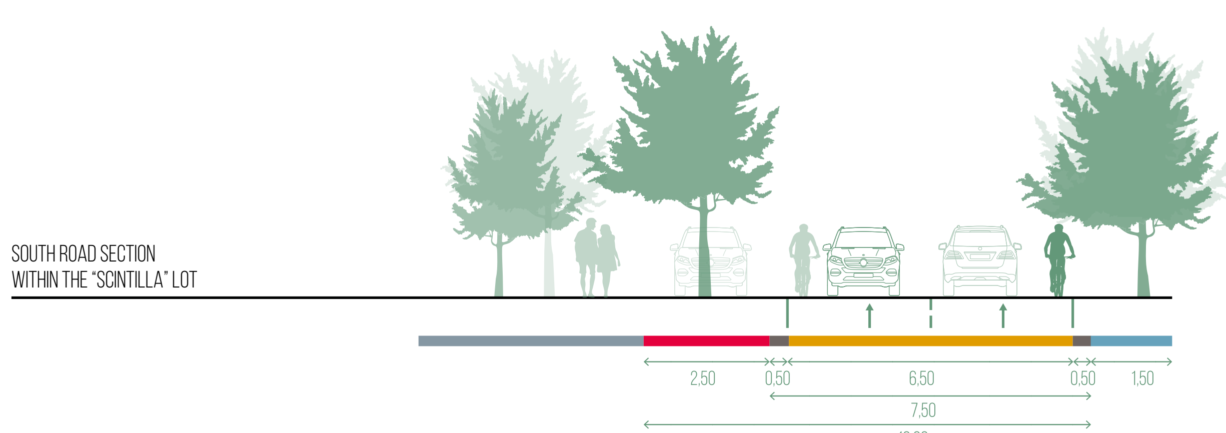


Community

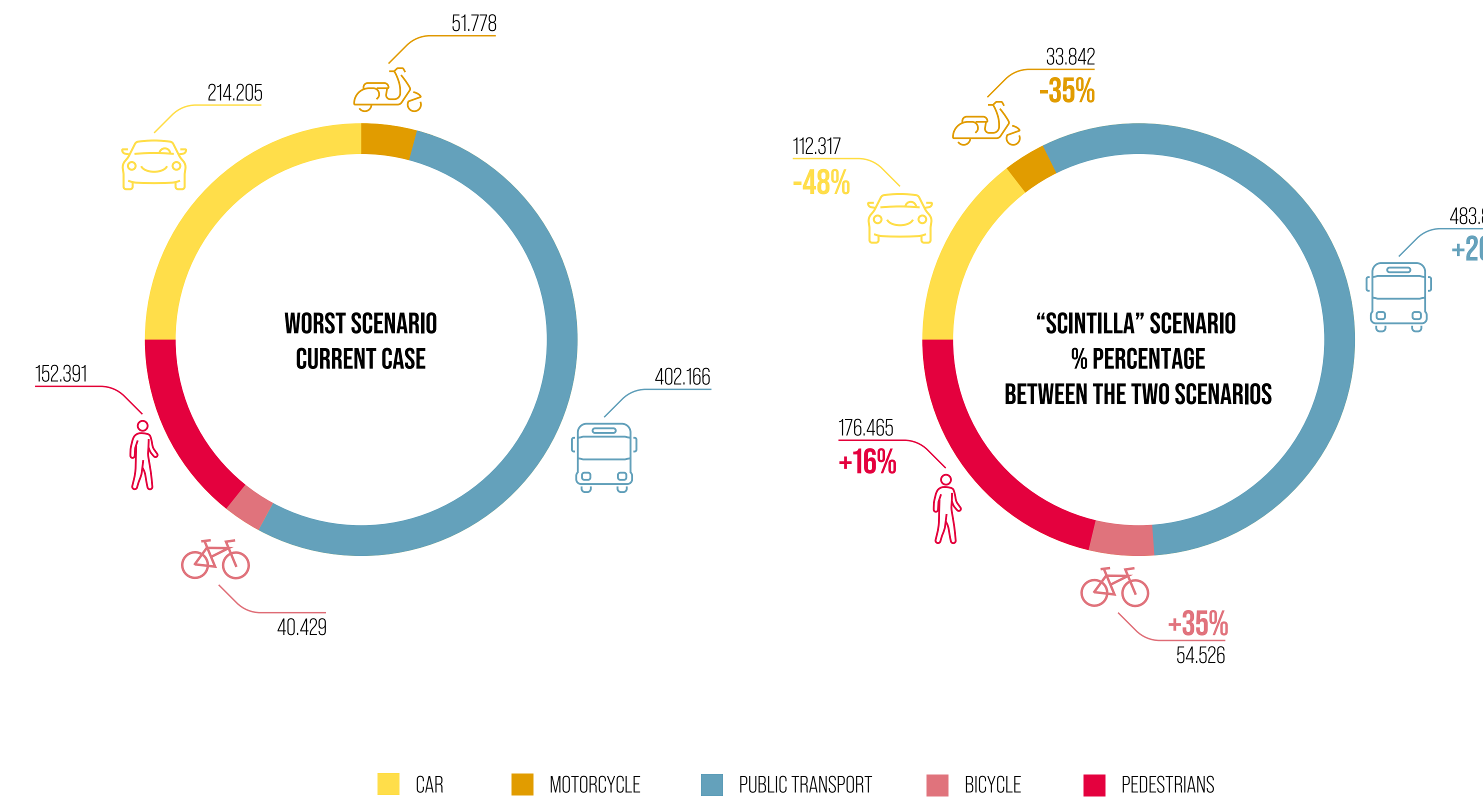
Estimating future mobility demand

Urban regeneration projects often have a rather long timeline. Therefore, the challenge for mobility designers is to **make design choices today that will be adapted to future movement habits.** NET Engineering was required to make a preliminary estimate of the potential demand of movements generated and attracted by the services and the residential settlements in the lot to develop the design proposal for the mobility of the former Lambrate railway depot. Reference was made to the manual "Trip Generation – An ITE Informational Report", drawn up by the Institute of Transportation Engineers, and an authoritative reference in the field to respond to this requirement.

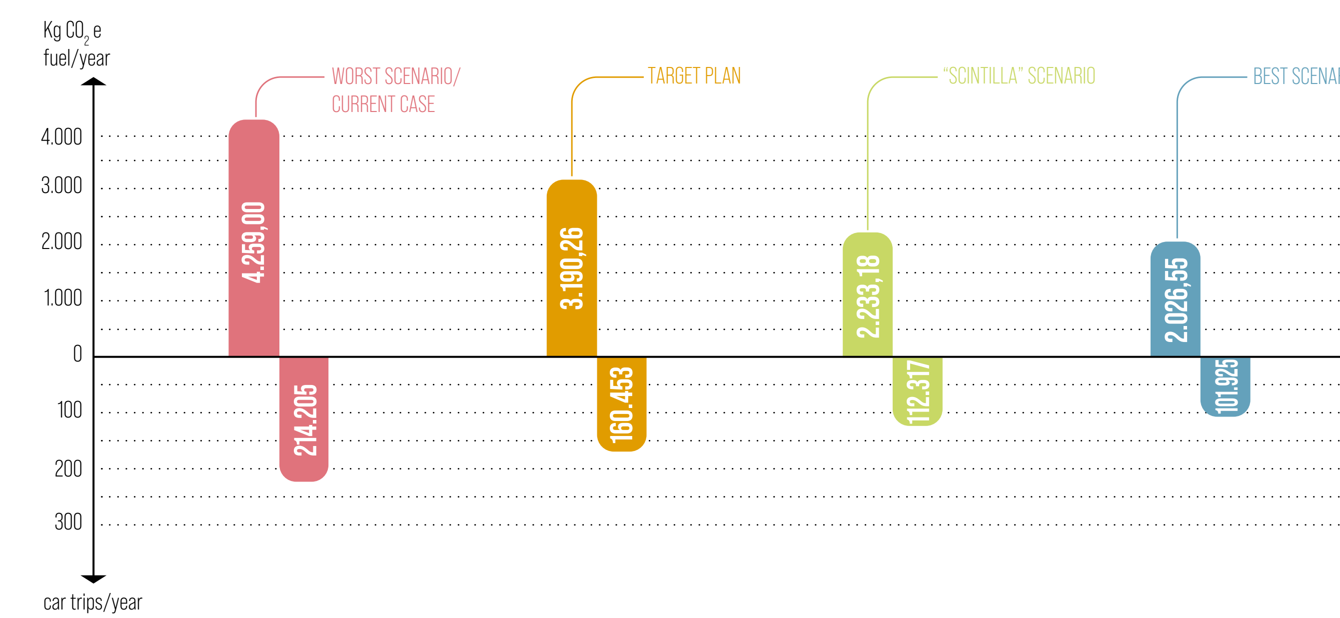


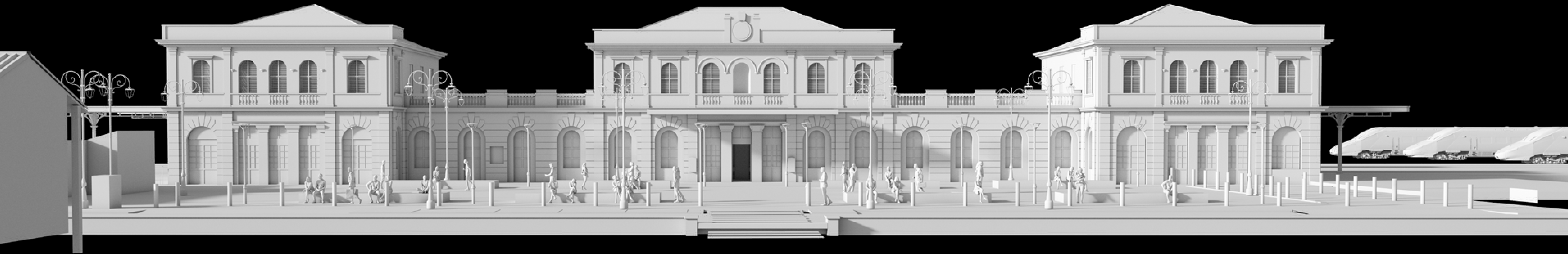


MODAL SPLIT OF YEARLY SHIFTS AND PERCENTAGE CHANGE BETWEEN SPARK SCENARIO AND WORST SCENARIO



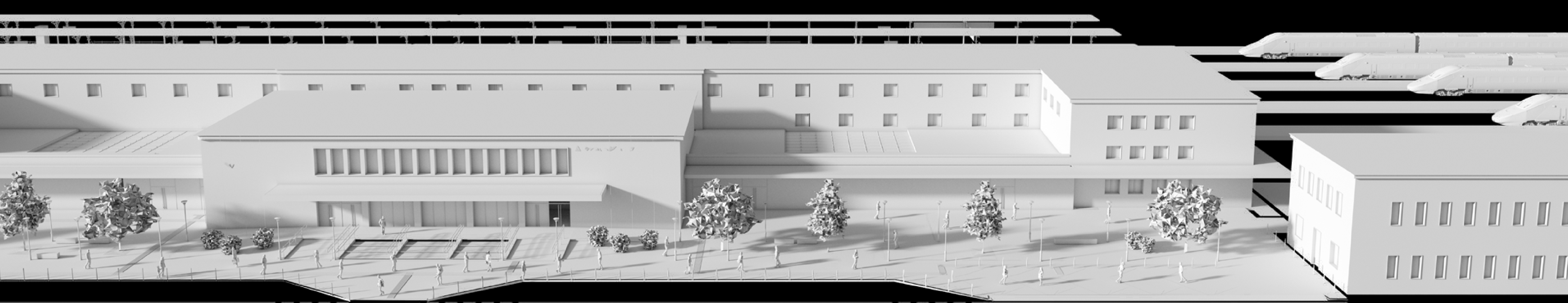
CO_2 EMISSIONS AND FUEL CONSUMPTION ON AN ANNUAL BASIS

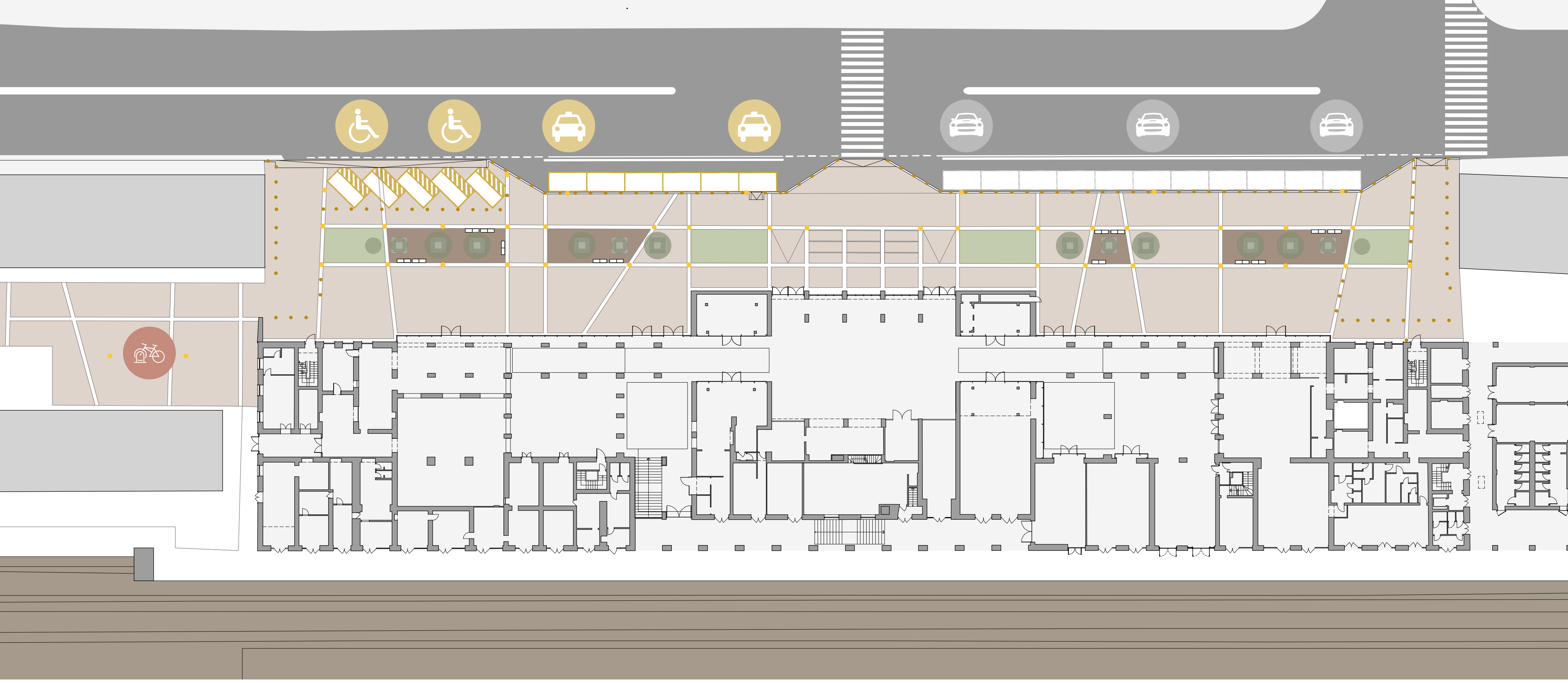




Revamping and restyling railway stations

A discussion-based, multi-disciplinary approach





1.

Alessandria floor plan and rendering of the bike station entrance

For many years, decades even, a lot of Italian railway stations were uncared for, often degraded, places where people didn't feel safe at quieter times. As a result, RFI – Italian Railway Networks, railway concessionaires and operators, and various local bodies started the transformation and reassessment of stations throughout Italy.

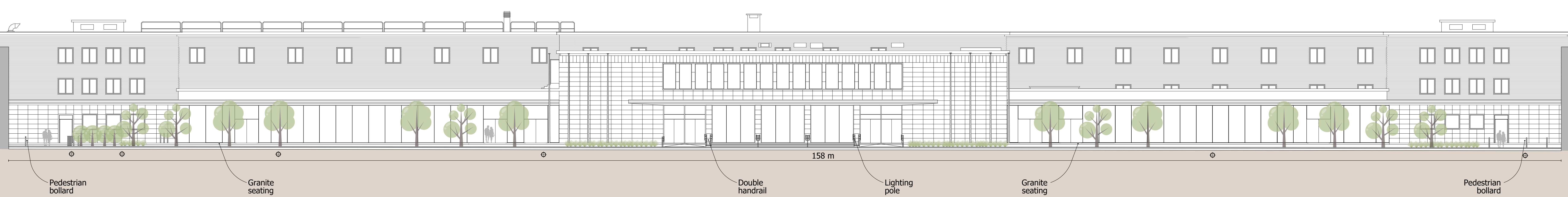
From the time they were created in the 19th century, Italian stations have partnered the evolution of the area in which they were built, supporting emerging changes and needs, becoming drivers of urban development. Therefore, stations should not be seen as just spaces designated for movement, travel and exchange but also places that can stimulate and partner the growth of the urban fabric, contributing to the generation of the quality of the geographical area they are part of. Each station, large or small, has the potential to generate positive effects in its area.

The role of architectural and engineering design in this context lies in being able to design a place that not only fulfils its primary function but is also attractive, captivating and welcoming for the end user while expressing the identity of the context it was built in.

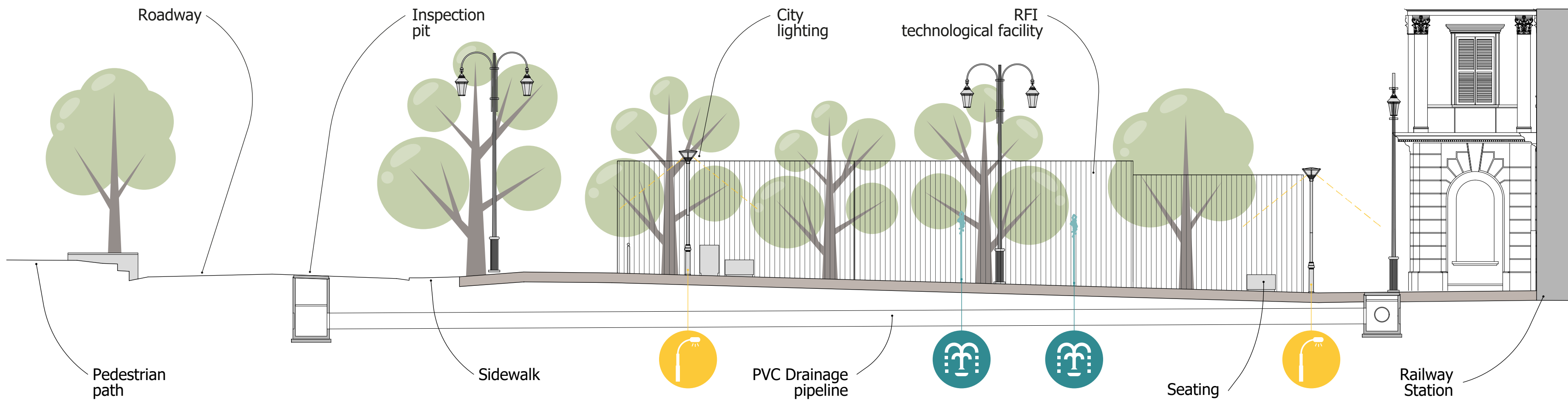
This was the direction that NET Engineering chose to follow during the development of the **Technical Economic Feasibility, Final Design and Specification Projects for the redevelopment of more than 50 Italian railway stations.** The projects developed by NET Engineering concerned **both internal areas and the areas outside the stations, often working in zones protected by the The**

Alessandria: station entrance elevation

2.



Cultural Heritage and Landscape Law Code, and concerned the redevelopment of passenger areas (redefinition of internal areas, reorganisation of spaces to expand their function, refurbishment of roofs and work on facades, and structural reinforcement for safety purposes); demolition and new designs for accessory buildings; restoration, redevelopment or design of subways, canopies and platforms; design of green areas; redevelopment or new design of external service areas and bike garages; connections with the existing road system; transport analyses and accessibility studies.



4.

Acqui Terme: cross section on the square entrance

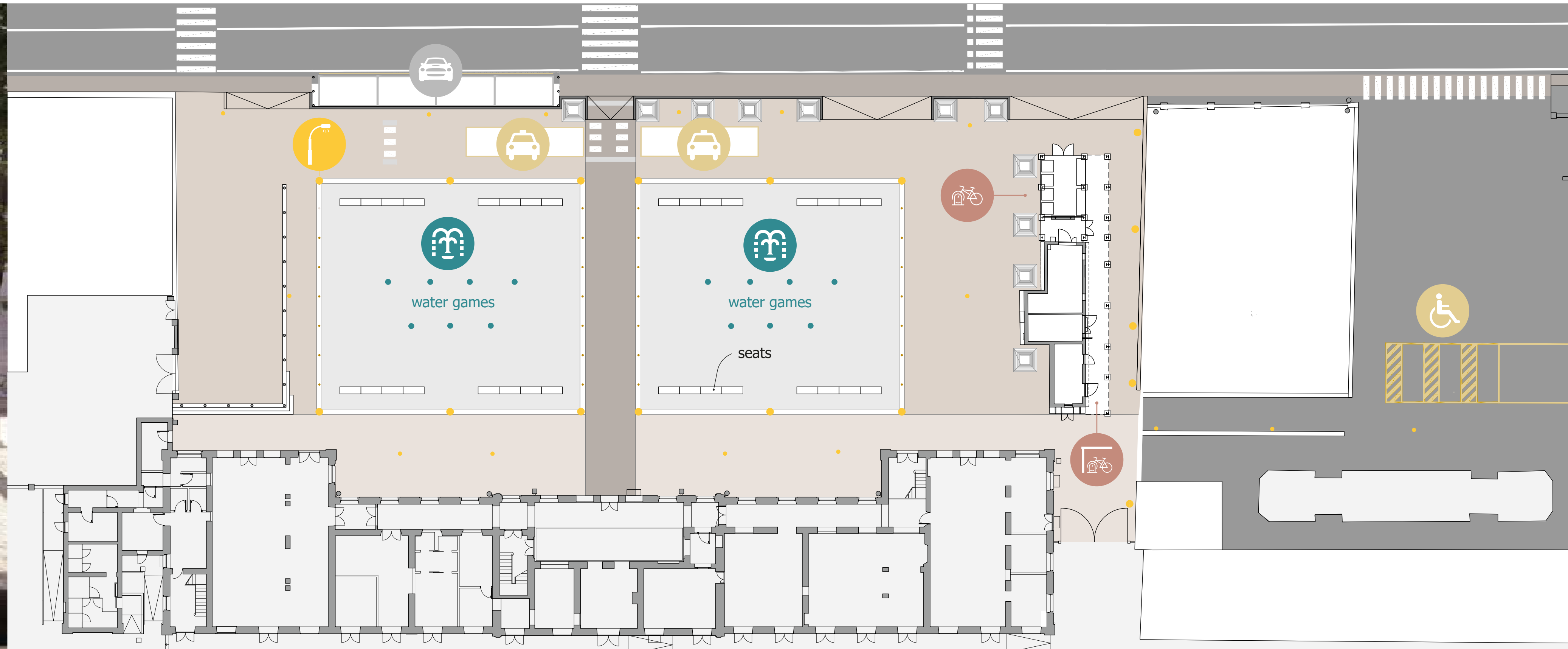
Discussion as an approach

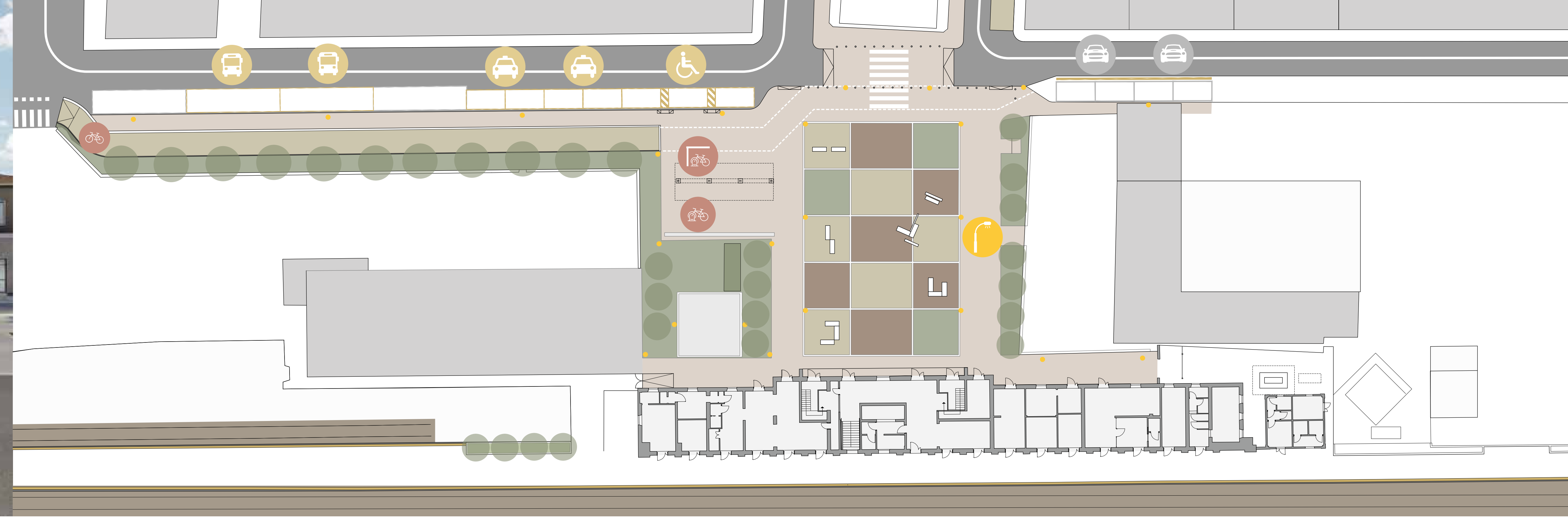
NET Engineering's approach in dealing with these complex projects was discussion, a constant, productive discussion, first and foremost with the client, who was involved in the design from the very beginning. This mutual discussion and debate process led to finding the best design choices, the cancellation of the re-work stages and a significant reduction in the project development time.

This approach generated growing trust from the client in NET Engineering which took on the role of qualified party on all the topics involved in this type of project. The use of BIM and software that allows three-dimensional representation of the design subject, giving an almost realistic image, facilitated the discussion, increasing its effectiveness.

Acqui Terme: Rendering on the station square; Planimetry of external areas

3.

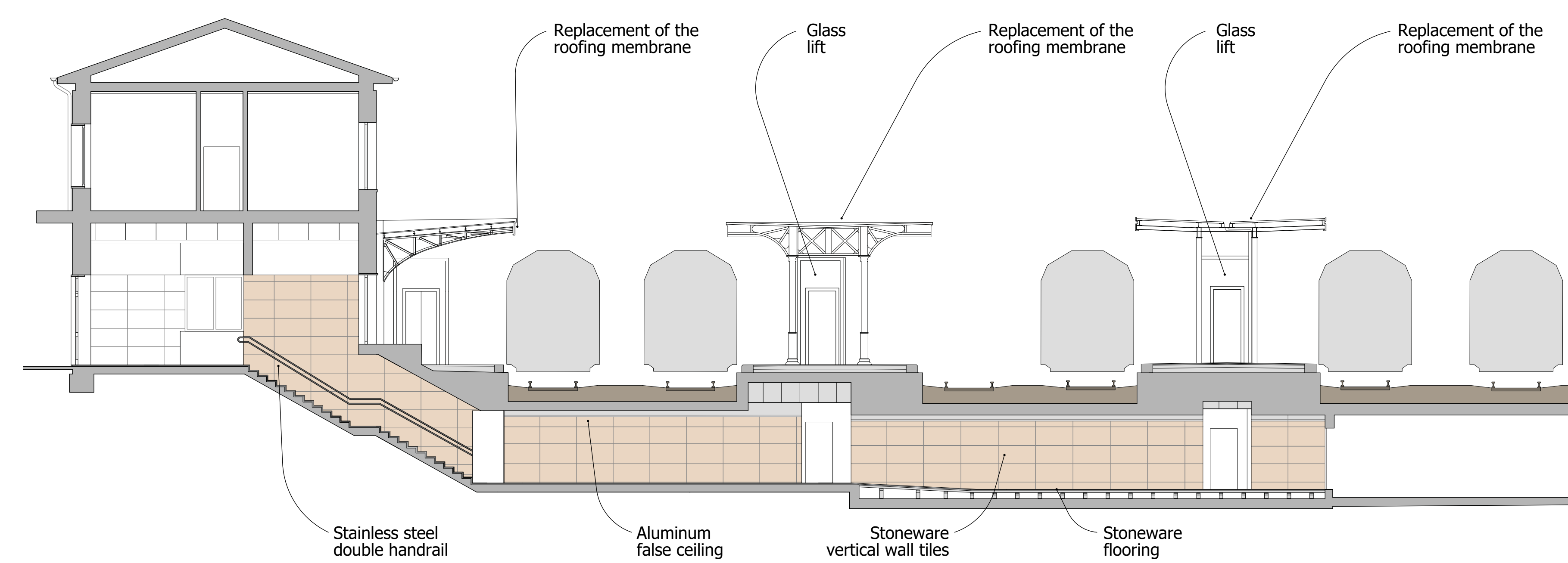




5.

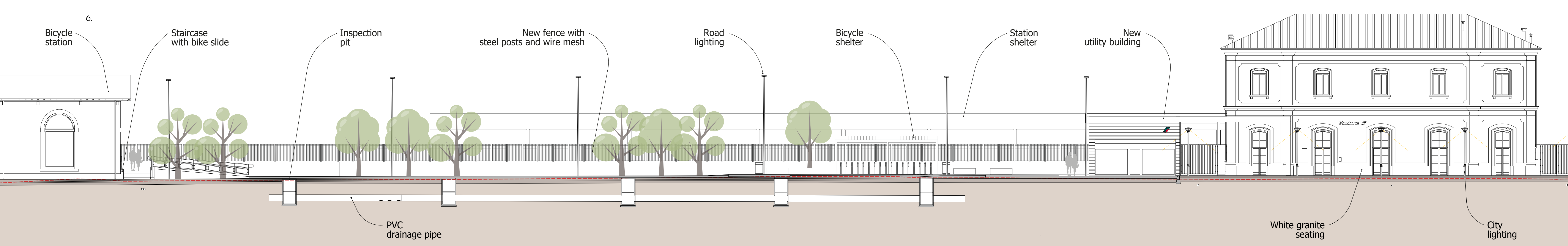
Cecina: rendering on the entrance square; general plan of interventions; cross section of the tracks

BIM and the software used are tools that allow how **each station actually sits in its urban or landscape context to be seen.** NET Engineering paid special attention to the railway route in relation to these topics – **historically perceived as a fracture in the urban fabric, the railway was valorised to make it homogenous with its environment.** Therefore, with skilful use of the design software,

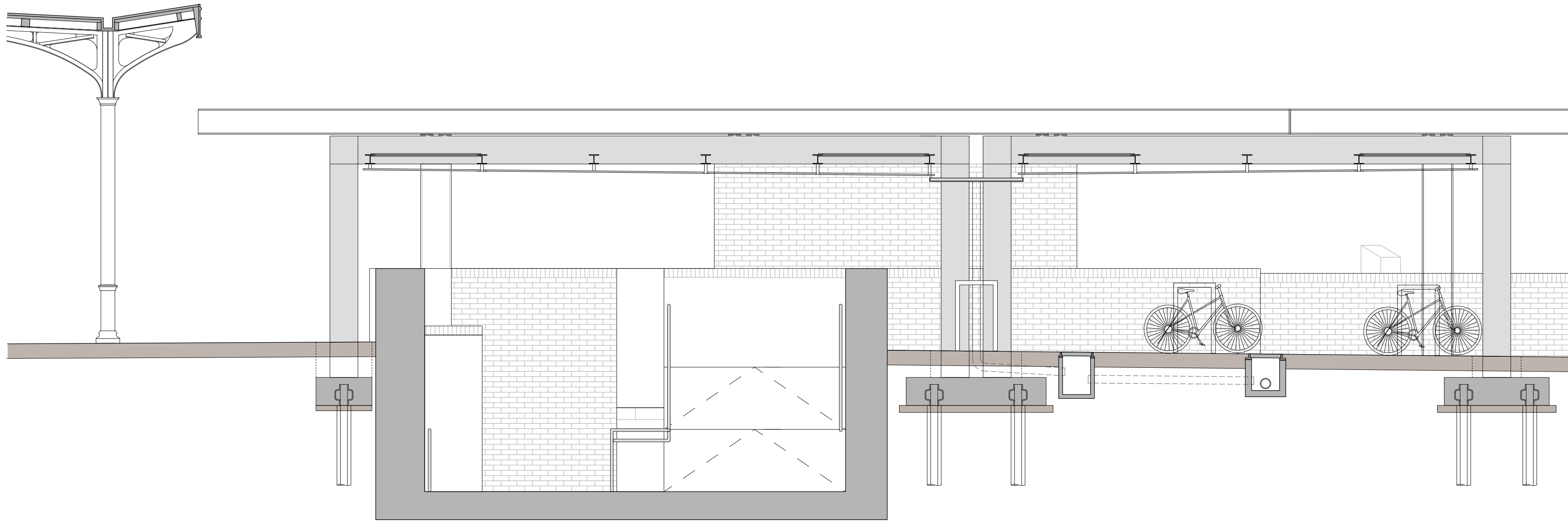


Collecchio: longitudinal section of the external square

6.



NET Engineering was able to **make the design object interact with its reference context** while dealing with the interferences that arose. Using a system approach, which allowed effective discussion between all the disciplines at play – architecture, structures, systems, calculations, safety and construction site, and transport, was essential for the successful solution of every problem found.



7.

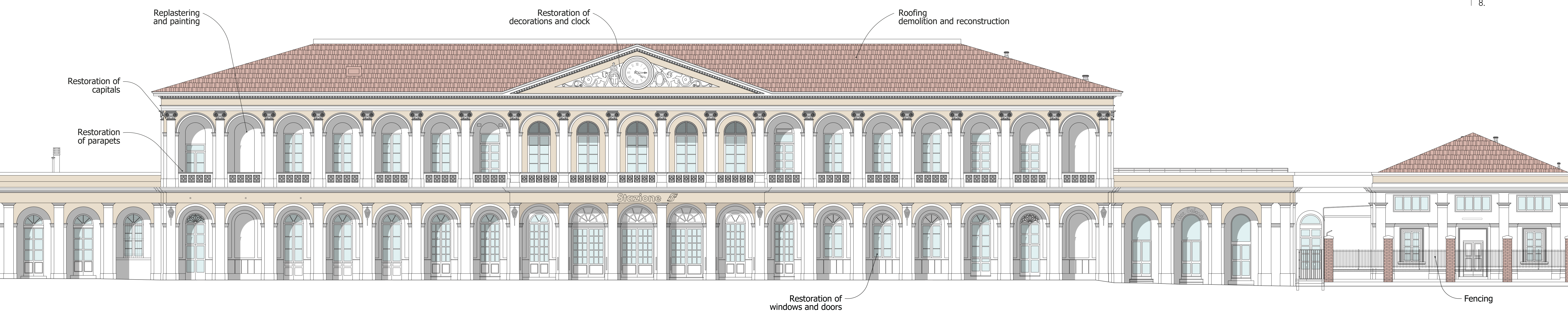
Lucca: cross section of new roofing shelter

Attention to sustainability

The latest amendments to the legislation and the introduction of the Do No Significant Harm principle, which sets out that operations provided for in the National Recovery Programme (PNRR) do not cause harm to the environment, motivated NET Engineering's designers **to look for answers that could further increase the value of the station redevelopment projects, introducing design elements sustainable from the energy, environment, hydraulic, systems, and materials choices points of view.**

Lucca: entrance facade of the travelers' building

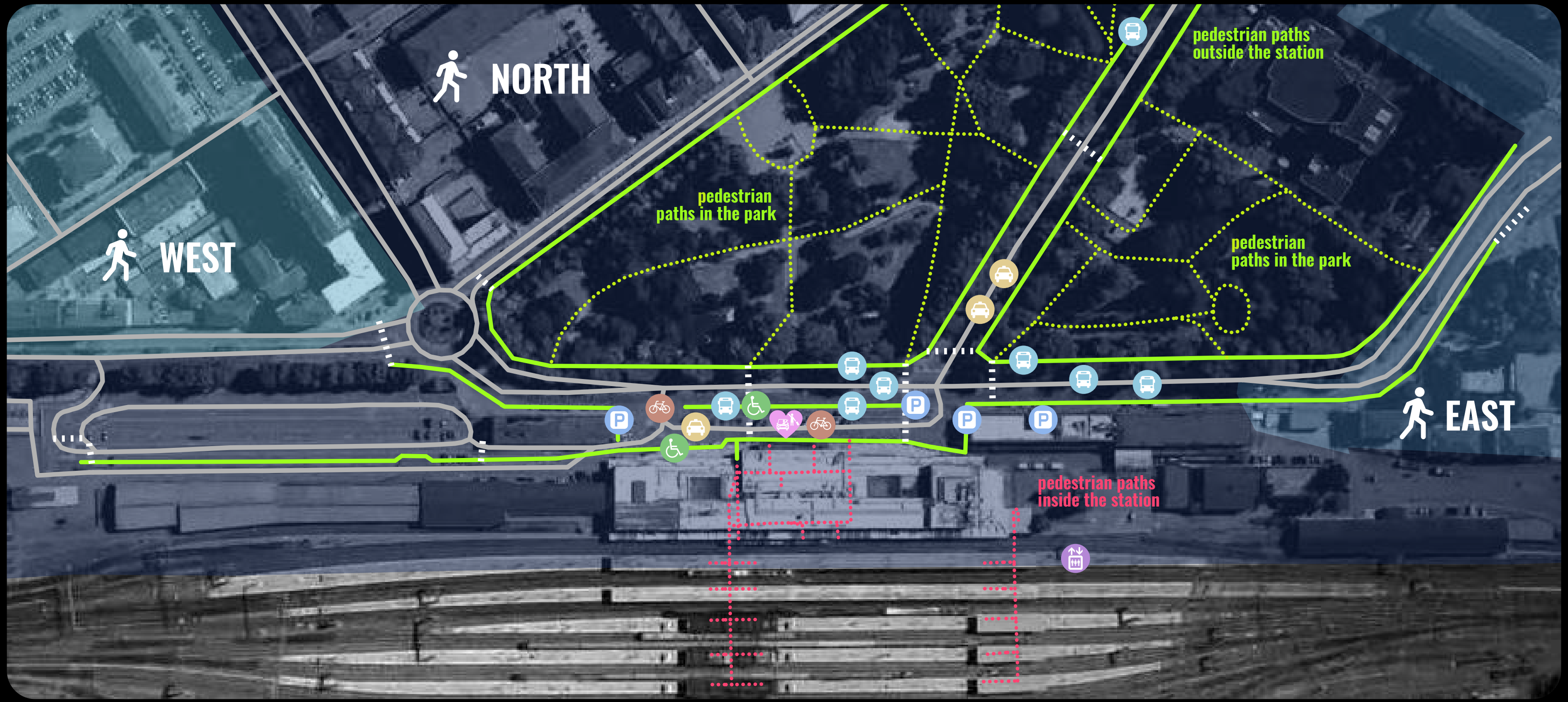
8.



Transport analysis

9. Alessandria: isochrone cycling and walking and population intercepted..

Below: station pedestrian graph and main mobility services



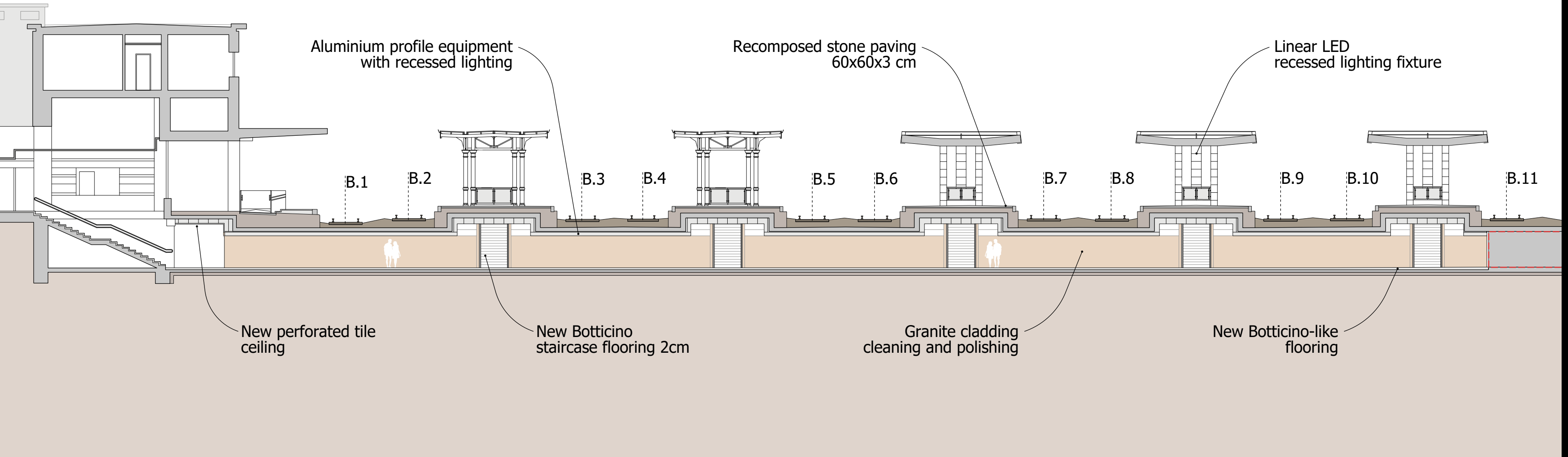
During the drafting of the Technical Economic Feasibility Projects, NET Engineering was responsible for the development of **mobility studies with the aim of finding out the transport needs in the areas of operation and to indicate the development plans.**

The project was considered as a 'mobility hub' and set out the complete reorganisation of the station following an integrated approach for the **allocation of the different mobility services and the internal spaces of the passenger building**, in accordance with a distribution logic that facilitates ease of recognition of platform access and valorises commercial areas, and **definition consistent with the distribution elements, routes, walkways, and subways** that simplify accessibility and are sized to the demand and train arrival and departure 'events' following the station operations model. A digital platform useful for geolocalisation and distinguishing all geometric, infrastructure and functional elements in the hub and intended to support the project choices and relative expected impact was implemented for the purpose.

The transport analyses developed by NET Engineering started from the principle that pedestrians guide the project – a station or interchange hub cannot ignore the fact that users move on foot inside it and/or to reach it. Internal and external pedestrian accessibility to the station was estimated using a station graph, an effective tool for quantifying the distances and travel times with respect to the expected flows.

At the same time, a **simultaneous analysis of the offer (the space and its services) and demand** (the users) was started which included study of the main origins/ destinations of travellers using the station, distances, travel times, directions, routes and modal-split so that the definition of a layout able to ensure full operation of the interchange hubs was guaranteed. The system of **railway stations as multi-modal hubs** was designed starting from this data, with the aim of bringing the station closer to the town and creating a reconnection between the urban environment and the railway hub.

10. Alessandria: cross section of the track bundle



CityLife Milan

Project management consultancy

The project

When most of the historic fair district transferred to the new Fieramilano centre at Rho-Pero, the area it left in the city, with a surface of about 255,000 m², was the target for an extraordinary urban redevelopment. In July 2004, the international tender was won by CityLife with a consortium of Generali Properties S.p.A, Gruppo Ras, Progestim S.p.A. (Gruppo Fondiaria-SAI), Lamaro Appalti S.p.A. and Grupo Lar.

The company CityLife, now controlled by Gruppo Generali, was formed after the assignment of the tender. The fulfilment of the project, launched in 2004, started in 2007. Most of the project had been completed by 2015, in time for Expo, but the work to conclude the whole compartment is still in progress.

The project was handled jointly by Zaha Hadid, Arata Isozaki and Daniel Libeskind, architects of different origins and culture, united by the privilege of having the most advanced experience of international architectural culture of recent decades.

Libeskind Apartments

1.

2.

Hadid Apartments

The CityLife project entailed important urban regeneration and requalification objectives thanks to its great visual impact because of the three famous skyscrapers: first of all, the creation of the largest pedestrian area in Milan, and also one of the biggest in Europe, with the circulation of cars and car parking only in the basement floors, secondly the halving of the existing volume, and the creation of the third central Milanese park.

In detail, the project concerned the creation of:

- **Three towers for management functions**: the Allianz Tower (by Isozaki), known as Il Dritto (the Straight One), the Generali Tower (by Hadid), known as Lo Storto (the Crooked One), and Libeskind Tower, known as Il Curvo (the Curved One), still in construction;
- **A park of 168,000 m²**, which will become the third park in the centre of Milan, after Parco Sempione (Sempione Park) and the Giardini Pubblici di Porta Venezia (the Indro Montanelli Public Gardens at Porta Venezia);

3. Generali Tower or Hadid Tower, nicknamed "Lo Storto"

The international tender for this was won by Gustafson Porter. The park will have integrated cycle and pedestrian paths and plenty of spaces for direct contact with the surrounding areas.

The new park will also complete the north-west Milan park group, thus making the activation of an effective ecological network possible;

- **Five areas of residential development;**
- **The new Museum of Contemporary Art**;
- **About 20,000 m² for business and services**;
- **Parking for about 7,000 cars, all underground**, for residents, workers and users of CityLife;
- **A cycle and pedestrian path** that connects CityLife to Sempione Park on one side and to the artificial hills of the Portello area and to Monte Stella, on the other;
- **Line 5 of the Underground with three stations**, Tre Torri in the centre of the area, and Domodossola FN and Portello neighbouring ones.

4. Urban gardens with Generali Tower in the background

The numbers of Citylife

3 management towers

168,000 m² park

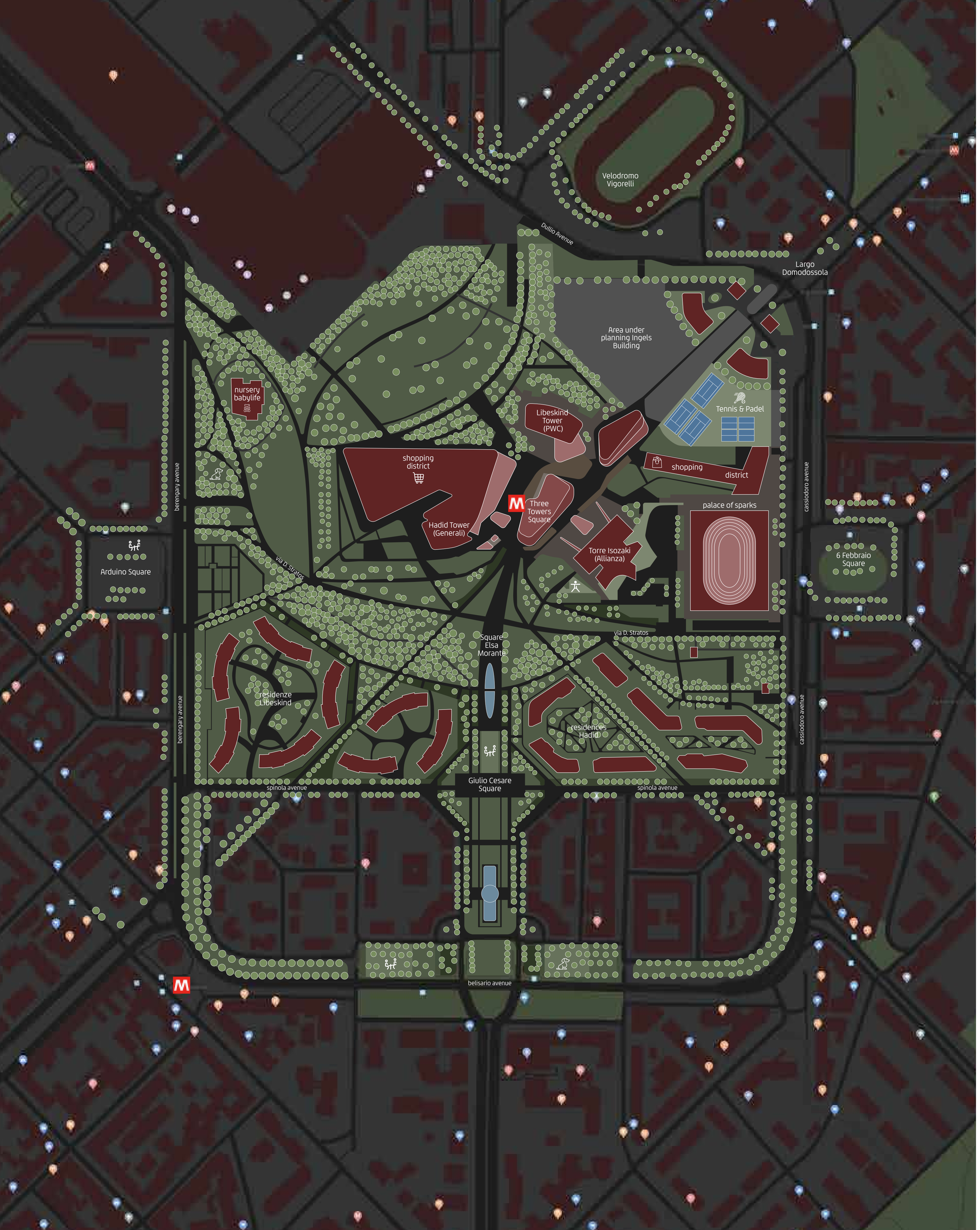
5 residential areas

7000 parking lots

20,000 m² trade & services

3 metro stations

bike & pedestrian path



Project management and the supervisory body

NET Engineering carried out the Project Management Consultancy on behalf of the investors. The company was the Supervisory Body on the final design developed by the General Contractor and the construction.

This was a strategic function considering the amount of investment and the construction complexity – ensuring the contractual times and the costs budget are observed is an essential condition for guaranteeing respect of any Economic and Financial Plan.

The aims of the work concerned, firstly, the **general co-ordination of the project** in step with CityLife. This consisted of a contribution to the definition of executive strategies of the project, the co-ordination of scheduling and the cost control and guarantee of quality. The work was finalised with the risk management relative to the different stages of the project and the resulting 'trend alerting' necessary so that CityLife could take corrective action. An integral part of the work concerned the progress report on the project.

In addition to co-ordination, Net Engineering also carried out: support to CityLife in the negotiation and signature of the contract with the General Contractor, with special reference to the definition of the price of the works assigned, the management of variants and reserves from the technical/contractual and economic point of view, in co-ordination with the legal asset, the technical contribution and co-ordination for the definition of contracts with various people other than the General Contractor, including co-ordination with the legal consultants during the negotiation with the different contractual counterparts, technical consultancy to CityLife during the different stages of development of the design, 'procurement' in support of CityLife for the definition and prequalification of contractors/suppliers and professionals, Quality Assurance of the construction and inspections, and lastly, the interface with the technical consultant of the bodies financing the initiative.

Thus, NET Engineering was able to ensure Project Management **organisation to the customer able to help them during negotiation of the contracts with the different contact people and, in particular, the General Contractor and control the development of the project by performing cost control, planning control and construction quality control.**

5.

Layout of the area

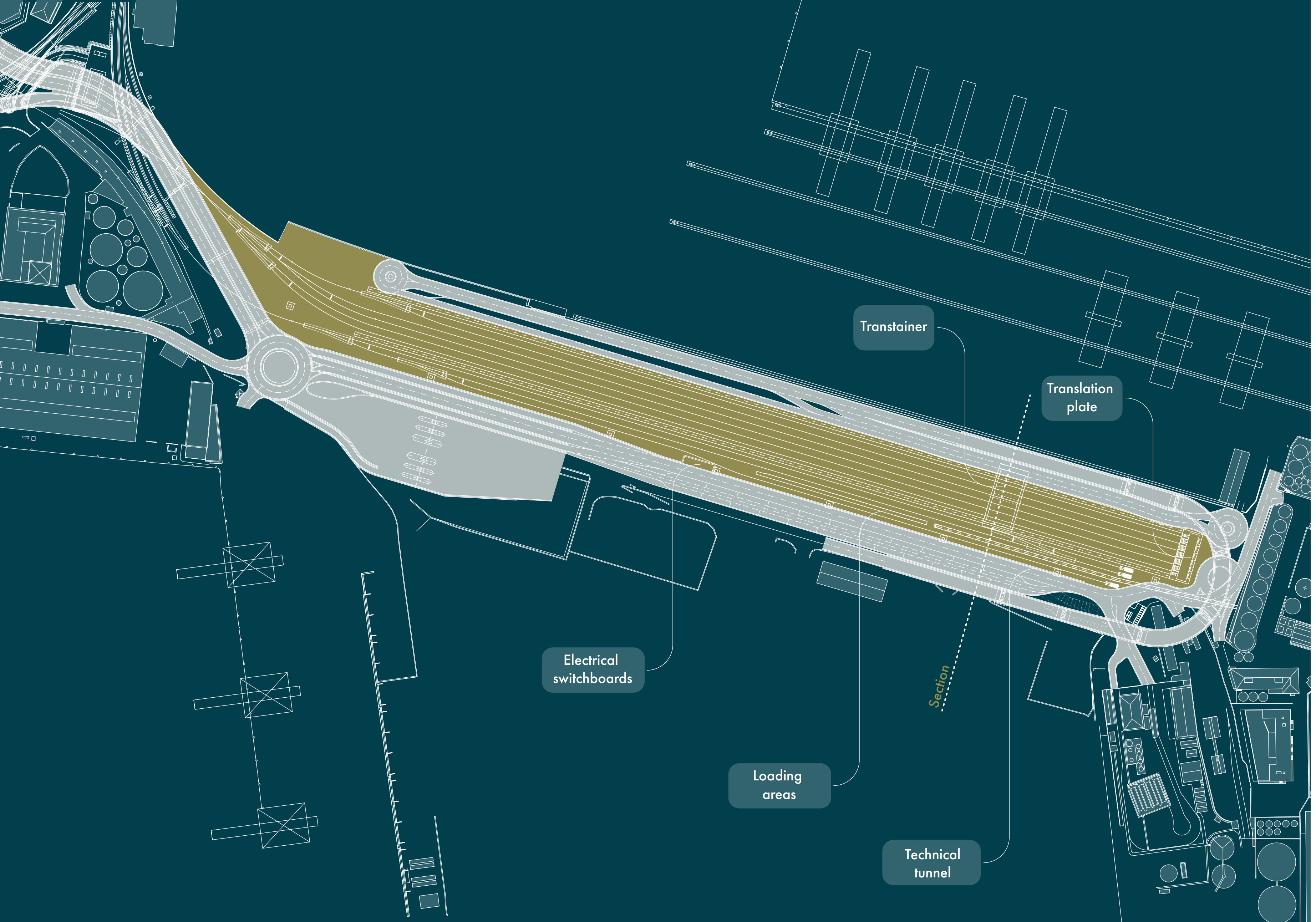
Aerial view of the CityLife area and the three Towers

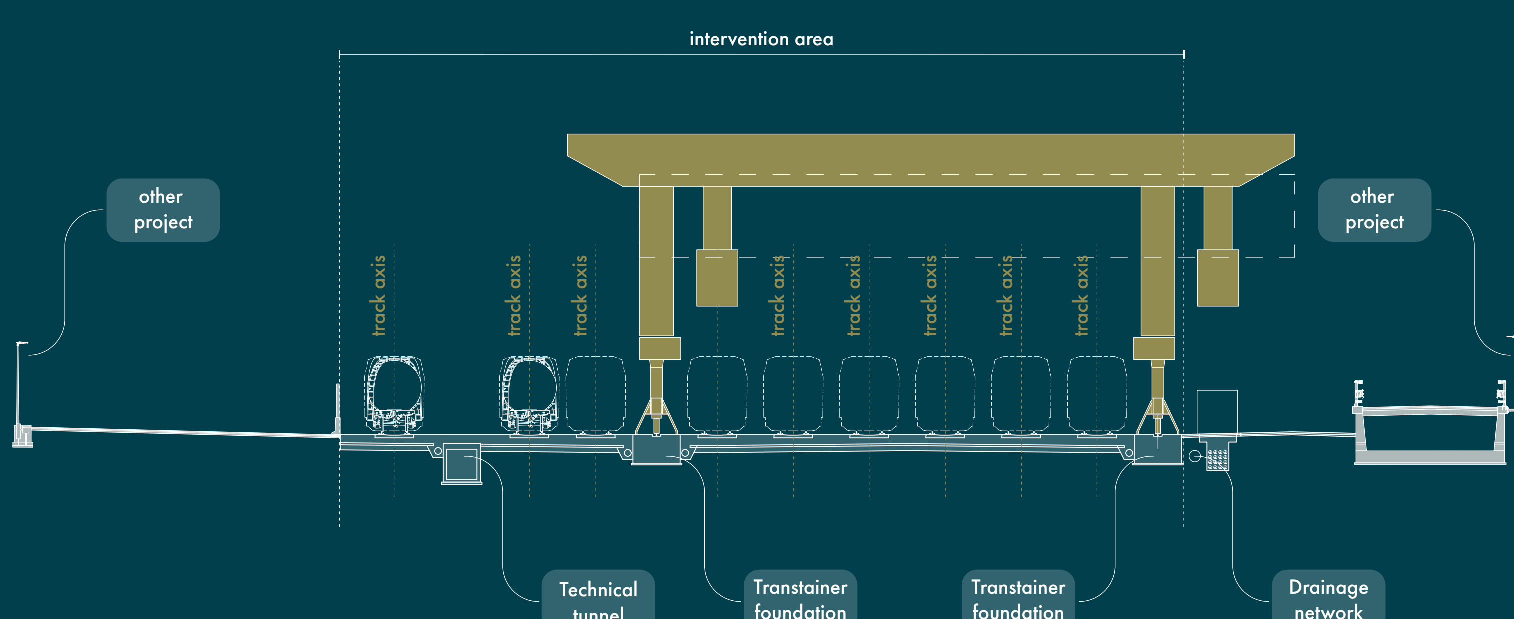
6.

indu
stry

Civil engineering serving the goods terminal

The reconfiguration of the Calata Bettolo terminal in the port of Genoa





1. Plan and typical section of the project area

Historically, the port of Genoa is one of the main seaports in the Mediterranean; today, it is still the largest port in Italy with terminals equipped to deal with all types of goods and passenger traffic, offering highly complementary specialised services. One of the port operators, PSA SECH, has managed the Calata Sanità terminal, near the Calata Bettolo terminal, since 1993. The terminal has a favourable position for access by both sea and land as it is connected to the main transport road and rail networks. This makes it a nodal access point for the industrial areas of Northern Italy and Southern Europe.

The need to reconfigure the Calata Bettolo goods terminal arose to allow the modernisation of the logistic management of containers and hydrocarbons, seizing the opportunity of a road system project in the port which will impact the current operational configuration of the railway tracks. NET Engineering drafted a Final Design responding to the client's needs for a consolidated contract setting out **the complete operational revision of the shunting sidings, including lengthening them, and the creation of the civil and installation works necessary for the works to be totally functional.**

The project **contributes to improving terminal operations** ensuring the handling of a higher number of trains/day for both containers and hydrocarbon transport, with enormous advantages for the port and, in general, the Genoa Hub transport system. Six new shunting sidings will be built in Calata Bettolo on the side towards the mountains to serve the container terminal. The sidings will have a strengthened RMG **transtainer crane** for which the foundations of the two runway rails and a duct for all the auxiliary services and to guarantee the medium voltage power supply of all systems have been prepared.

Downstream from the tracks, the project sets out the installation of a **locomotive turntable** allowing movement of the engines at right angles to the track so that the greatest length of railway can be used to form trains.On the side of the sea, however, three tracks dedicated to the management of hydrocarbons from railway tankers are planned. The tracks will have a loading position and the related duct for the piping and electrical systems.

Once the project has been completed, there are plans for the creation of public lighting systems, with the positioning of lighting towers and cable ducts for the technological networks, the reorganisation of the rainwater disposal network with a drainage channel and the resolution of all interference with the existing services underground.

Simulation of the project of the new Bettolo terminal integrated with the road project

2.

NET Engineering also took on the railway signalling project arising from the integration of the tracks involving the port with the common RFI line, especially with the Single Genoa-Tortona HS Railway Project, which will increase the connections of ports in Liguria with the main railway lines of Northern Italy and the rest of Europe.

Environmental sustainability

NET Engineering also carried out the **environmental feasibility study within the sphere of the project.** In detail, this was an analysis of consistency with the planning tools and the structure of restrictions, in addition to the study of the environmental components involved in the project – atmosphere, hydrography, geology, land use, landscape, vegetation habitat and flora, acoustic climate, vibrations, ionising radiation and public health. Given the nature of the operation and context, special analysis was made of the **impact on the atmosphere during the construction stage and the acoustic climate** (construction and operational stages).

Personalised solutions

The design of the main civil works – the foundations of the transtainer crane, the transfer table for locomotives and loading positions for rail tankers – implied a **lot of research work and technical analysis** aimed at understanding the features of technologies unusual yet essential in a goods terminal.

The main result obtained by NET Engineering in this specific context was getting the **different engineering disciplines** to talk together for the ideal integration of the technologies in the project, reaching the point where personalised solutions outside standard ones were suggested, solutions able to optimise the space available in the best way.

Designing infrastructure for logistics means knowing how to **design works with particular features that will be built in very restricted spaces** where functionality of manoeuvres and operator safety are key parameters at the base of all planning. It means being able to adapt civil engineering skills to a market which makes technical and technological updating one of the main levers of advantage over competitors. It means talking to a client with very **specific requirements to be fulfilled in times that must be respected**. It means knowing how to move in an environment (the goods terminal) that is always operative during both the design and construction site stages.

3. Acoustic impact simulations

Study of the odorous impact of the sewage treatment plants

Latest generation forecasting models to safeguard public health

It is well known that one of the most important impacts of waste water treatment plants is the emission and spread of smell. Various parameters are used to describe smell, including the hedonic tone, i.e. the feeling of pleasure or distaste accompanying a smell, and this decides whether an odorous source is actually a disturbance or not. In the specific case of purification plants, the sludge treatment areas generate the most relevant emissions and, on their own, these account for about 50% of odorous emissions.

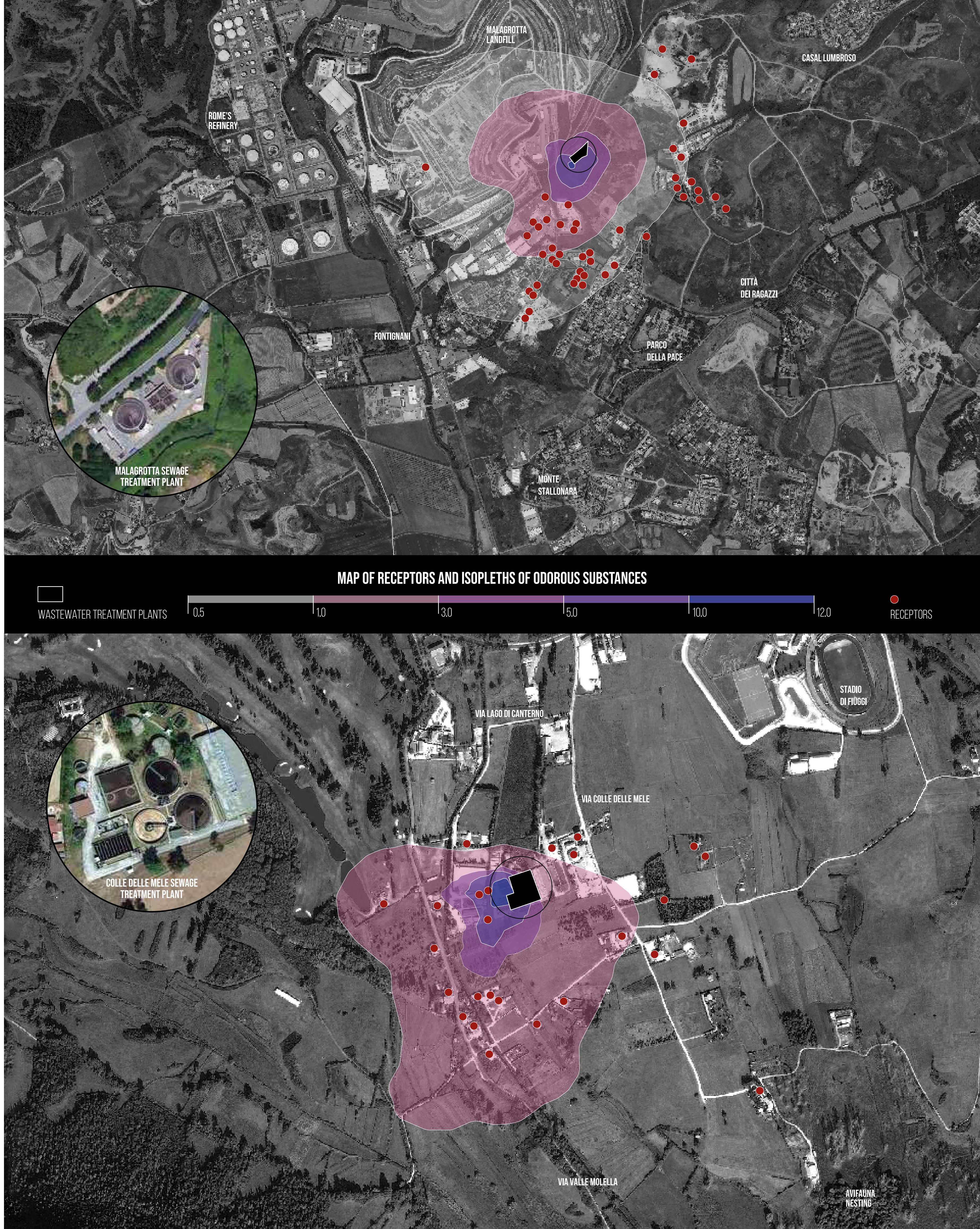
During plant modification or renewal authorisation procedures, management bodies are required to **produce studies forecasting the emissions of the purifier** paying special attention to the smell-producing type, a critical element for nearby residential areas.

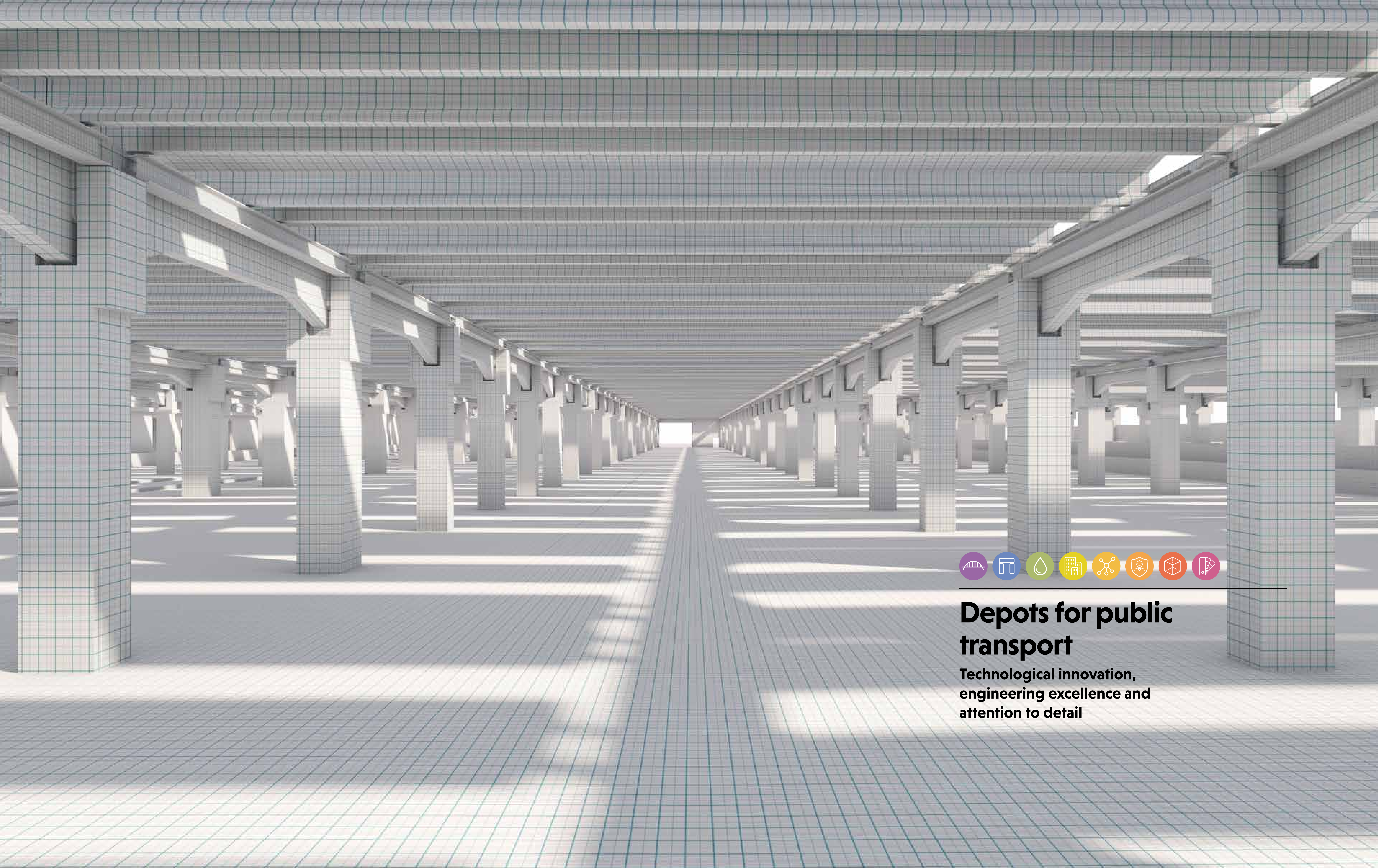
NET Engineering drafted **the study of the odorous impact generated** on the surrounding area for the Marco Simone (at Guidonia Montecelio, Rome), Massimina (at Malagrotta) and Colle delle Mele (at Fiuggi, Frosinone) purification plants. These are all biological, activated sludge plants; the first has a project potential of the equivalent of 35,000 inhabitants while the second has a project potential of the equivalent of 72,000 inhabitants although, at present, only one line equivalent to 36,000 inhabitants is operational.

The CALMET/CALPUFF/CALPOST suite, created to manage CALPUFF, the well-known multi-source, non-stationary gaussian model, developed on behalf of the California Air Resources Board and adopted as the reference model of the U.S. Environmental Protection Agency, was used for the calculations of diffusion of the odour-generating field in the environment. Application of the CALPUFF system requires the preparation of specific input data.

The calculation grids are set based on orographic data, land use (distribution of receptors) meteorological data (speed and direction of wind, air temperature, atmospheric pressure, humidity etc) and data on emissions (structural data of the source and emission factors). As a consequence, the area of influence of smell diffusion of the plant is established.

NET Engineering were aware of the impact that the plants in the study can have on public health and sociability and **carried out very detailed analyses**, developing numeric simulations in both the base scenario (most frequent plant operating situation and representative of the trend for the year) and the worst case, using reference forecasting models in the market so that the client was given the most accurate yet precautionary output.





Depots for public transport

Technological innovation, engineering excellence and attention to detail

Rebaudengo Underground Depot

Turin metro

Line 2 of the Turin metro will make crossing the city in a north-east/south-westerly direction easier and connect 32 stations in an overall route of more than 27 km. The infrastructure will contribute to strengthening connections between the main centres of the city - the FCA Mirafiori factory, the university centres of the Einaudi Campus and the Politecnico di Torino, the historic centre and Giovanni Bosco Hospital.

A depot with workshop in the underground area initially meant for the overnight parking of the Underground trains had to be planned so that the line could be immediately operational at the end of the works of the first lot, corresponding to the Rebaudengo terminus. NET Engineering aided Turin City in drafting the Technical Economic Feasibility Project of the depot. The project was totally developed with BIM methodology.

As the type of system (road or rail train) to be implemented had not yet been established at the design stage, the guidelines given by the client set out the development of a project that could be compatible and effectively covered the main systems in the market. The design of the underground depot started from this principle. The depot, at the northern end of the line, sets out a building with two basement levels and two storeys above ground.

Level -2, with an overall surface area of 8,500 m2, is intended for the housing and storage of rolling stock, cleaning and light maintenance with a bridge crane and inspection pit. The workshops for the works and building services, the air line and signalling system are on the same floor.

Level -1 is dedicated to the maintenance systems and rooms (welding, electro-mechanics, hydraulic and pneumatic systems, batteries, internal accessories and equipment).

NET Engineering planned and designed ad hoc a series of lowering trap doors for moving trains in and out of the underground line in addition to a special service lift so that the carriages can be transferred from one floor to the other.

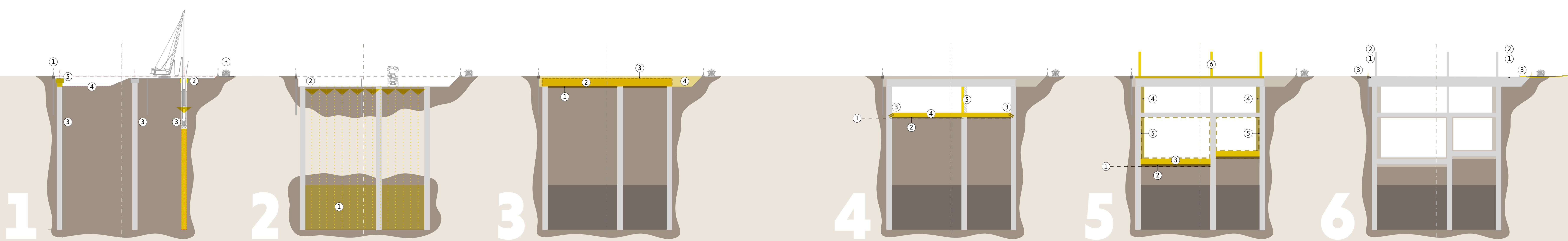
The floors above ground are mainly intended for offices and other technical rooms with a continuous glass façade for which a decorative coating and punched sheet shading have been prepared.

NET Engineering's main challenge concerned the design in an underground area and an extremely compact space. Extensive knowledge of the rolling stock made indication of the essential maintenance functions and discarding the superfluous ones easy for a situation which would host this type of working only temporarily.

The NET Engineering project is representative of an engineering approach based in system engineering and interaction between the various disciplines - structures, systems, architecture and routes have interfaced effectively as a result of the careful organisation of the BIM environment.

Executive phases of the construction of civil works

1.



CONSTRUCTION SITE AND GARRISON WORKS

1 Placement of construction site fencing and sound barriers

2 Execution of guide curbs for perimeter diaphragms

3 Execution of perimeter diaphragms and intermediate bars

4 Setback excavation up to impost height roof slab

5 Demolition of guide kerbs and scapitating top of diaphragms

* Traffic detour

CONSOLIDATION OF THE BOTTOM PAD

1 Carrying out the soil consolidation treatments for making the bottom pad

2 Carrying out any consolidation and support work on the excavation, where necessary, and excavation up to the impost level of the roof slab

CONSTRUCTION OF THE ROOF SLAB

1 Creation of lean layer (15 cm) with polyethylene sheet in between to facilitate detachment after subsequent excavation under slab

2 Formwork, laying of reinforcement and pouring of the roof slab

3 Laying of roof slab waterproofing system and related mechanical protection screed

4 Partial retiling of the roof slab

CONSTRUCTION OF THE INTERMEDIATE SLAB

1 Excavation to the impost height of the intermediate slab

2 Creation of lean layer (15 cm)

3 Installation of intermediate slab grouting bars on both perimeter diaphragms and intermediate bars

4 Laying the reinforcement and casting the intermediate slab

5 Partial demolition of the top of the central diaphragm and construction of the central pillars

REALIZATION BULKHEADS AND INTERNAL STRUCTURES

1 Excavation to the impost height of the bottom slab

2 Creation of a drainage layer and subsequent lean layer (20 cm)

3 Laying the reinforcement and pouring the bottom slab

4 Laying the waterproofing system on the perimeter walls

5 Laying of reinforcement, formwork and casting of liners and interior reinforced concrete structures in elevation

6 Construction of the elevation building for the two above-ground floors

SURFACE AREA RESTORATION AND SITE REMOVAL

1 Installation of surface water regulation systems

2 Implementation of final roofing retiling and final landscaping/exterior finishes

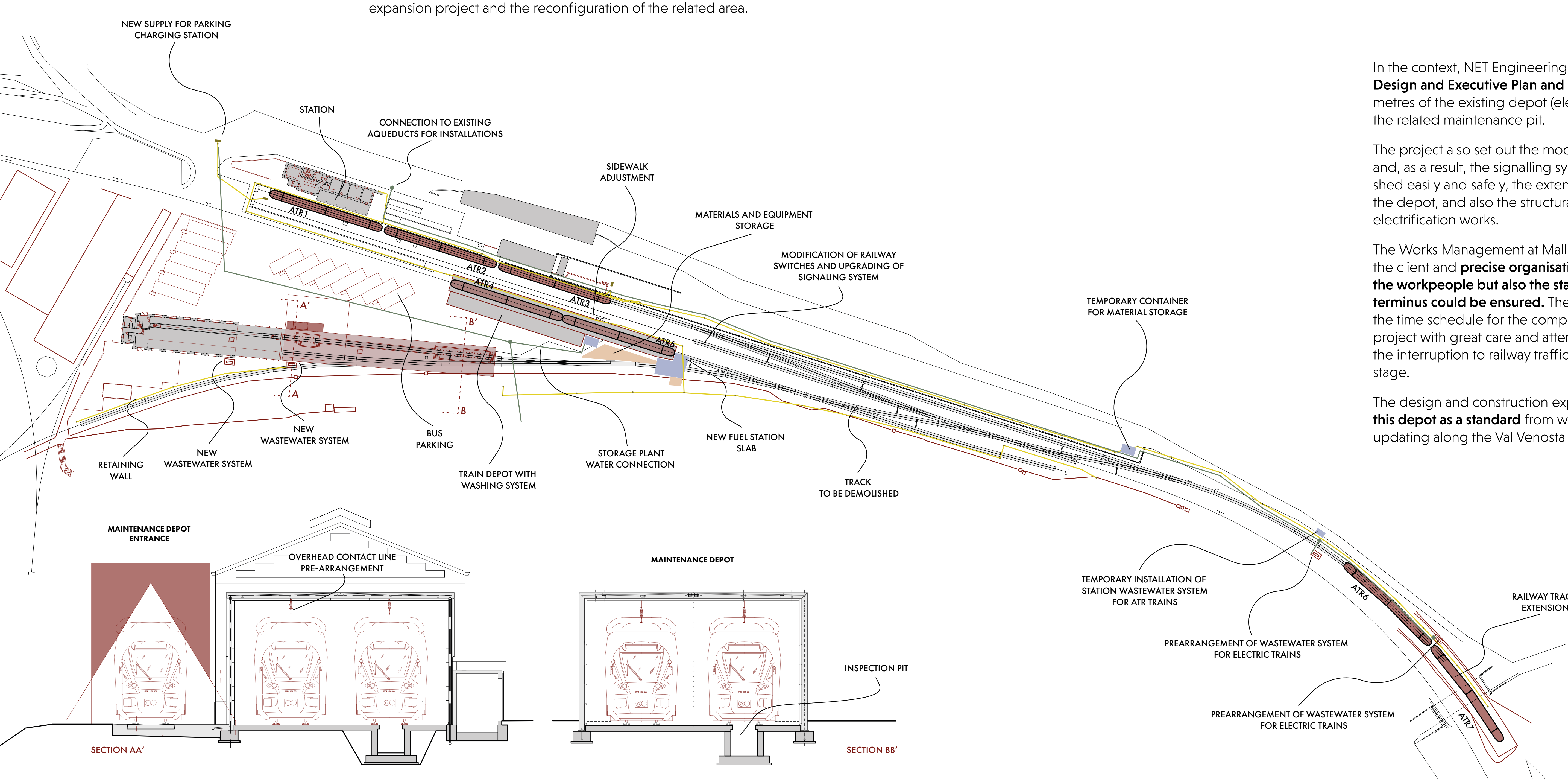
3 Road and sidewalk restoration and site removal

The Malles railway depot

The Val Venosta, Alto Adige, railway line

The Val Venosta railway line has been involved in an important renovation project by Strutture Trasporto Alto Adige S.p.A. (STA) since 2005. The project, preparatory to the more ambitious aim of regional redevelopment of the area, involves the electrification of the line as a priority so that the capacity, number of seats and comfort can be increased.

At the same time as the electrification of part of the route and the purchase of new trains, longer than the ones currently circulating, there is a station train shed expansion project and the reconfiguration of the related area.



In the context, NET Engineering was responsible for the **Preliminary Project, Final Design and Executive Plan and the Works Management** for the extension of 81 metres of the existing depot (electrical and mechanical installations included) and the related maintenance pit.

The project also set out the modification of the existing track structure using points and, as a result, the signalling system to allow trains to enter the new portion of train shed easily and safely, the extension of Platform 1 of the station in the direction of the depot, and also the structural adaptation of the complex with reference to the electrification works.

The Works Management at Malles station was marked by a constant interface with the client and **precise organisation of the site stages so that the safety of not only the workpeople but also the staff and users of the station and the nearby bus terminus could be ensured.** The NET Engineering Works Management curated the time schedule for the completion of the works within the time set out by the project with great care and attention with the aim of reducing to the minimum the interruption to railway traffic due to specific work during the construction site stage.

The design and construction experience at Malles motivated STA to **indicate this depot as a standard** from which the other train sheds and related planned updating along the Val Venosta railway line will start.

New Malles station area

2.

The Segrate-Pioltello railway workshop

The Mercitalia Maintenance, Gruppo FS, industrial building

Planning the renovation of a depot and railway workshop of 21,550 m² is certainly a challenge. It is a greater challenge if the project includes 68,000 m² of external areas, including the land with the railway and service area, and an even greater one if the project concerns a 1930s building and sidings bombed during the Second World War.

NET Engineering was responsible for the **Preliminary Project, Final Design and Executive Plan of the refitting of the architectural, infrastructural, structural and installations layouts of the Segrate-Pioltello (Milan) railway workshop, totally developed using BIM.** The industrial building, conceived and built as a freight depot, is undergoing an important modernisation project with the aim of **amending its intended use to a railway carriage maintenance workshop, planning the addition of new services and an upgrade of the production system.**

The renovation project drafted by NET Engineering mainly concerned the **architectural building elements and the reinforcement of the bearer structures of the building with seismic updating and creation of new structures functional to the work** (access ramps, external storage base of wheel sets, creation of internal maintenance pits, etc.).

In addition, the demolition and creation of new building services (mechanical, storm water runoff, fire prevention, electrical and special), the creation of the external car park and infiltration basin, organisation of the railway and the resolution of potential interferences with the existing sub-services were also planned. NET Engineering's work began with the reconstruction of the state of the work of the area using Laser Scanner, MMS and drones. The data was then imported and processed using BIM software, which enabled integrated co-ordination of the project, simplifying the management of a lot of information and facilitating interaction between the disciplines involved.

In detail, the architectural design brought many production lines implying handling of heavy materials together in the same space with the other functions set out in the building (administrative and operational offices, conference rooms, dressing rooms, canteen, the recreation room, etc.) fully respecting safety regulations.

Structurally speaking, **superficial defects and the specific geometry of the depot and its structure, consisting of hundreds of columns of a height that made visual inspection impossible, were reconstructed** through the Laser Scanner and the BIM model. Then there were investigations into the materials, which gave the NET Engineering designers detailed knowledge of the health of each structural element. Starting from the information gathered, the reinforcement rebars were designed – designated with BIM software, **the steel jackets respond precisely to the features of deterioration of each pillar**, providing the client with a specific, effective and efficient answer.

3. Point clouds from Laserscan survey of the depot

The Hamburg, Cologne and Essen depots

Designing some of the largest depots in Europe

The detailed design of the armature and structural steelwork for large public transport depots has benefitted from technological innovations and the spread of software dedicated to 3D modelling and oriented to BIM methodology. When

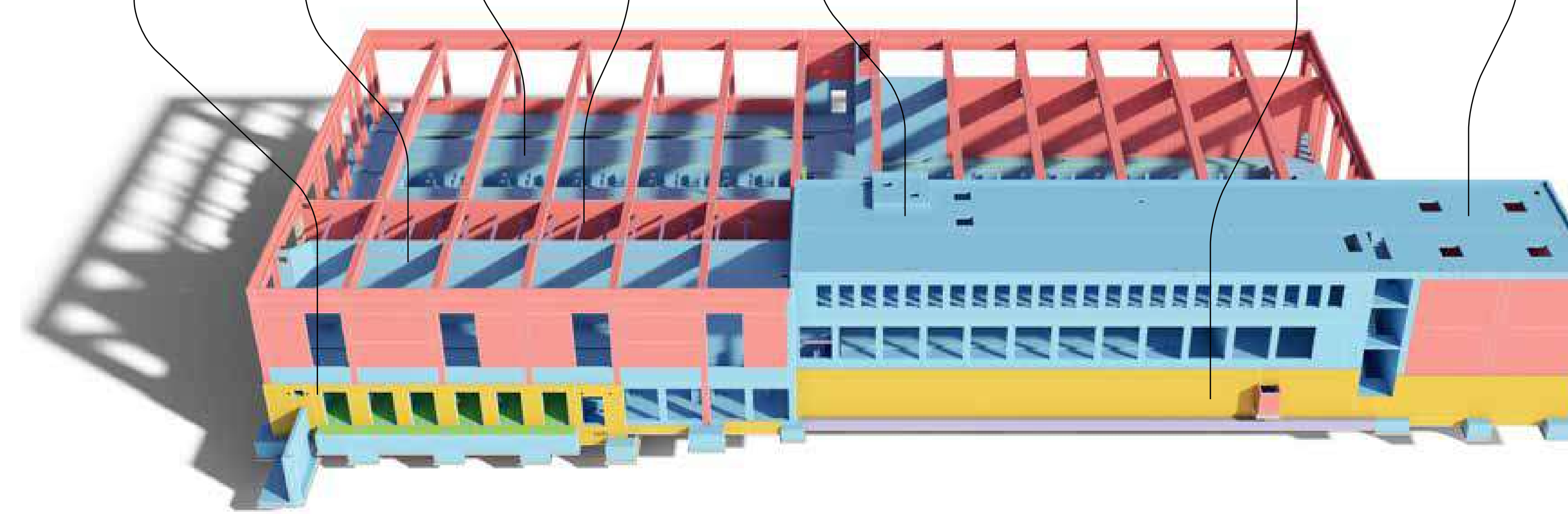
NET Engineering started the construction design of **the reinforced concrete of the Hamburg electric bus depot, for a fleet of 240 vehicles, one of the largest in Europe, not much of the software available was suitable for the work required.** The need for an IT tool able to make the armour converse easily with the carpentry ensuring, on one hand, the mutually unambiguous correspondence of three-dimensional objects and, on the other, allowing the automatic generation of tools lists, became clearer and clearer as designing with Autocad progressed. Therefore, NET Engineering chose to start experimenting with new software that not only made the design of reinforced concrete extremely precise but also simplified clash detection with the extension project for the **area of the storage facility and rolling stock maintenance of the regional railways and tram network in Cologne.**

Use of the new software was especially important in this project which set out the construction of two buildings, one for the storage facility (with a covered area of more than 16,000 m²) and one for the materials warehouse – an office building for management of operations, an electricity substation and a building for washing facilities. The industrial complex, **the largest depot for rolling stock in Europe**, also included the creation of 17 new tracks, 12 of which for the storage facility, 4 for sanding operations and one for the washing area. The 3D modelling software enabled the careful design of structural steelwork and armature within this vast and complex environment, respecting not only the considerable interferences with the systems component.

The use of software oriented to BIM methodology was fully utilised in the final design of the expansion and modernisation of the **Essen railway depot.** The project concerned the main depot – a secondary workshop authorised for both trams and trains, a carriage maintenance hall, a washing area, a spare parts warehouse and one for infrastructure maintenance materials. The working drawing of the armature and structural steelwork was especially complex as all the components of the maintenance pits would have had to be cast in place. The 3D modelling software thus facilitated the **discussion between the various disciplines** involved, ensuring a **prompt, accurate reply to the client's needs.**

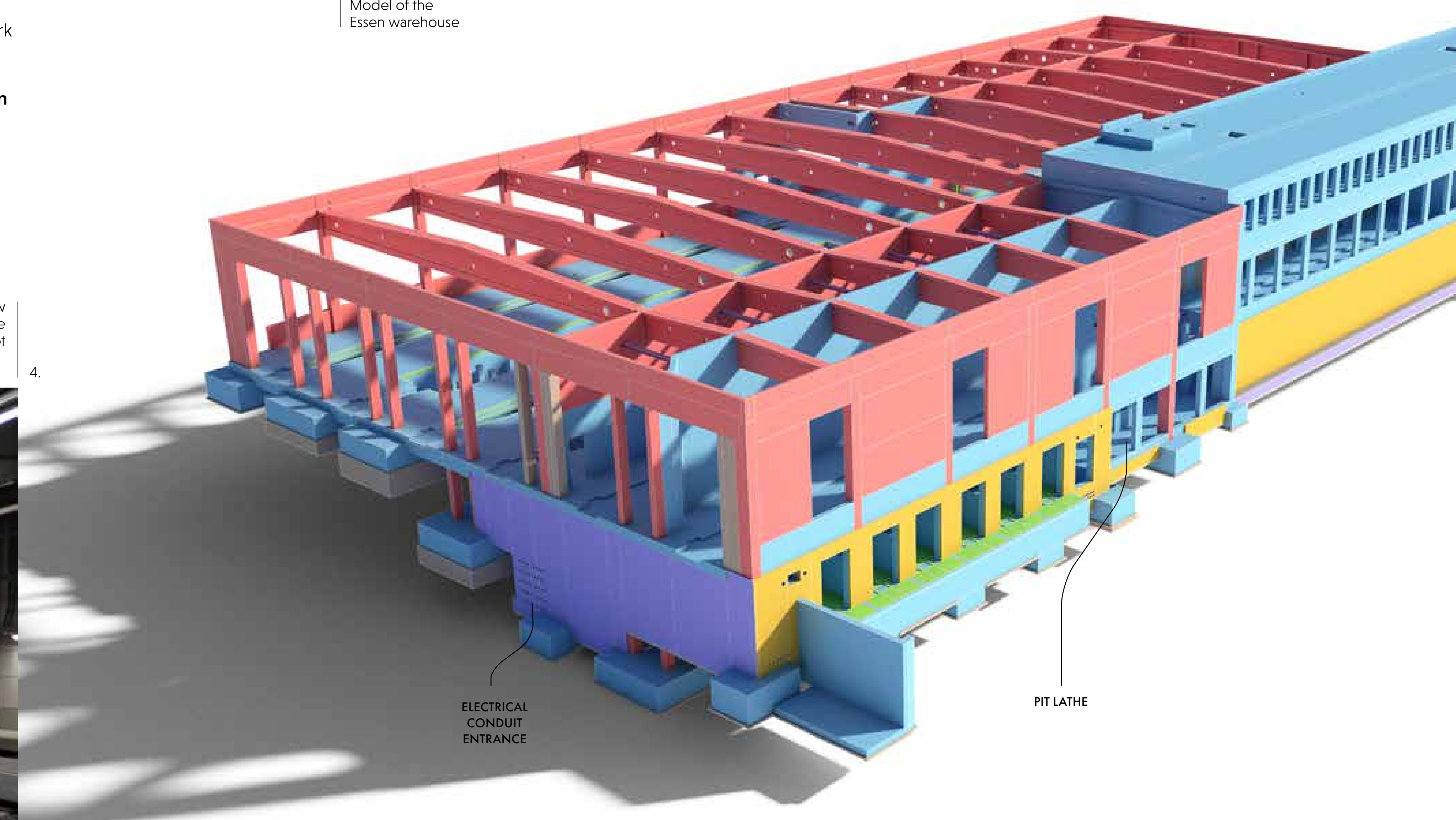
Internal view of the Cologne depot

4.



5.

View of the Revit Model of the Essen warehouse



NET for oil & gas and energy multinationals

The expansion of the refinery in Plock, Poland

PKN Orlen is a Polish company operating in the oil and fuels resale sector, capable of serving over 100 million European citizens. As part of the expansion of the Plock refinery, the largest complex of this type in Poland, and in particular for the construction of a new production unit called New Olefin Complex, NET Engineering **supplied a TechnipFMC provides geotechnical support for the FEED** (Front End Engineering Design) **phase**.

The work carried out was the following:

- **Interpretation of the available geotechnical survey and hydrogeological** monitoring data to define the reference framework for the design of the foundations.
- **Analysis of the hydrogeological and environmental data, with special reference to a possible pollution of the surface groundwater**, for the definition of groundwater management problems during site preparation and subsequent excavation for the creation of the foundations.
- **Analysis of the data of an area where considerable amounts of hydrocarbons have been found in the soil**, caused by leaks from a plant discharge treatment tank created some decades ago and which, over time, has polluted several hundred square metres to a depth of about 5/6 metres from ground level.
- The **sizing of the surface** and deep foundations.

In addition, **the earth movement project** was also developed for site preparation with the aim of minimising movement and avoiding treatment of groundwater as far as possible. If there were high concentrations of hydrocarbons, there would be the risk of problems in both safeguarding the workforce, especially during excavations, and logistical problems of disposal and treatment of the pumped water with a related increase in costs and times for the creation of the work.

Similarly, **the groundwater drainage system was sized** so that any effect on plant operations during heavy rainfall could be avoided/limited.

Reinforced concrete for industrial plants

The Berlin ozone reactor

The construction of the Schoenerlinde ozone reactor is the first step in an ambitious project of the Berliner Wasserbetriebe (BWB), the water management company in Berlin, so that a new purification process can be developed to ensure better quality water for the system in the German capital and, as far as possible, reduce the introduction of human traces to Lake Tegel, which supplies the drinking water for Berlin.

The Schoenerlinde plant is the **third largest water purification plant in Berlin and the largest ozone plant.** It can service 800,000 people and has been designed for a volume of about 2.1 m^3/sec in dry weather and 3.8 m^3/sec when it rains. This is the background to the development by NET Engineering of the working drawings for the reinforced concrete (structural steelwork and rebars) for the planned civil works.

The project for the new ozone reactor, the technological development of the existing plant in Berlin, provides for the mechanical and biological purification of black water which then flows to a second plant through an underground ducting system and the phosphate elimination process takes place there. The water is returned to the Tegel basin at the end of the operation.

The water from the Schoenerlinde flows area into the reactor where there are four tanks for the chemical-physical and mechanical purification processes. **As the tanks, which are on the two basement levels of the building, are subject to internal and external pressure and significant chemical aggression which compromises the durability of the concrete, a special design of both the structural steelwork and rebars and the on-site casting operation was set out.**

The ozone makes the project specially complex and implies **respect for very strict criteria for the sizing of the sections and the rebars with regard to fissuring**, as set out by German legislation on this type of hydraulic industrial construction.

Very short frequent casts were planned to deal with the problem. The continuous armatures were fitted with a special coating at each vertical and horizontal casting cycle to ensure a longer life for the work.

The project was developed entirely using BIM. NET Engineering developed a structural model essential for optimal design in a particularly complex context from the rebars prospective.

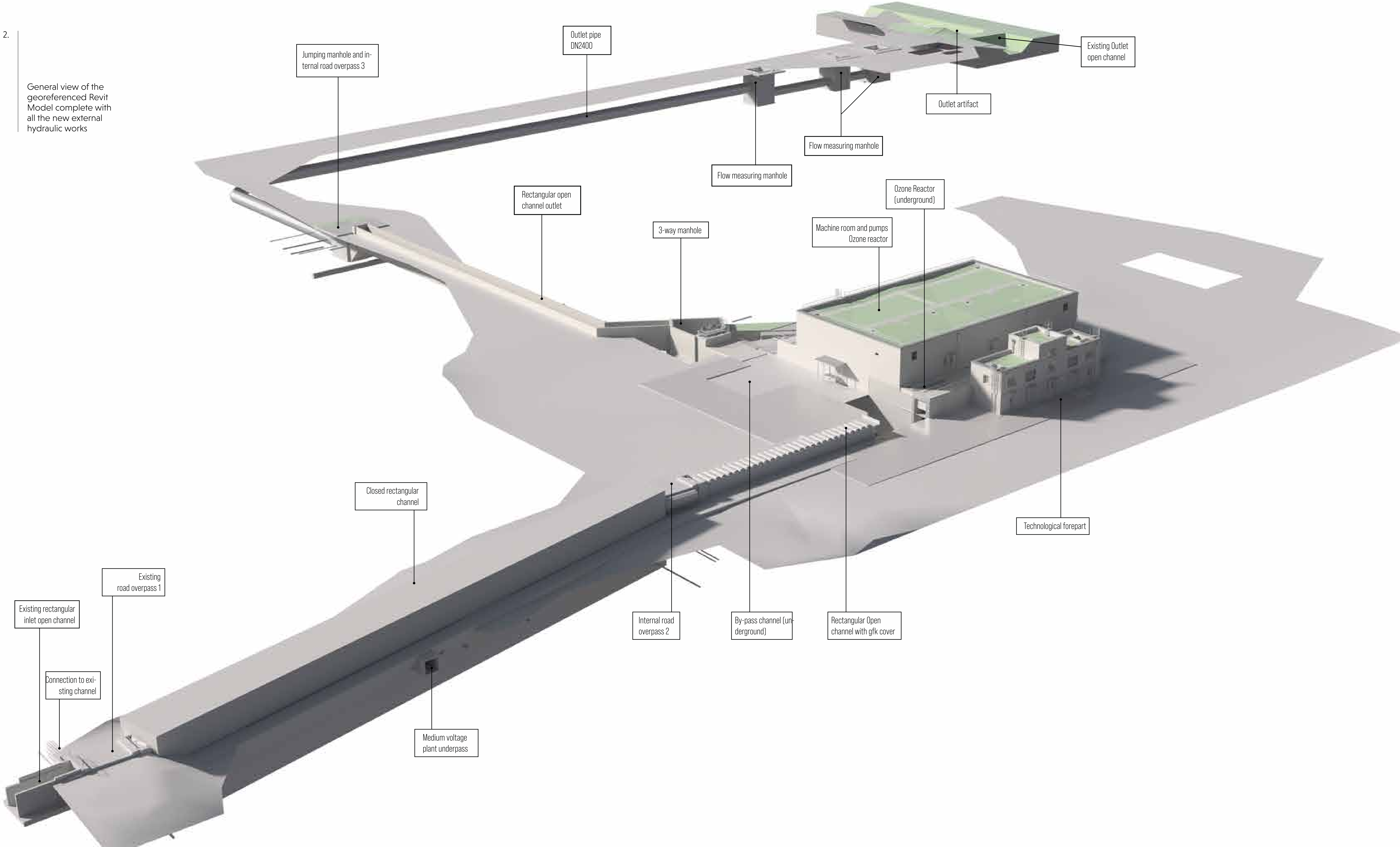
Longitudinal sections corresponding to the purification tanks (A) and corridors (B).

Cross section corresponding to the technical rooms (C).

1.

2.

General view of the georeferenced Revit Model complete with all the new external hydraulic works



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Pierpaolo Salvò
Margherita Sartori
Gabriele Sau
Cristiano Soave
Marco Sobbetti
Giulia Teodori
Raffaella Tessari
Tung Thai
Arianna Tonello
Paolo Toniolo
Andrea Totaro
Rachele Tracco
Angelo Triglia
Niccolò Valimberti
Cinzia Vanali
Margherita Villani
Nicoletta Zacchi
Roberto Zanon
Nicola Zanta
Carlo Zecchin
Orgerta Zeqo