CITTA' DI VENEZIA

Insula

braccio operativo del Comune di Venezia per la manutenzione urbana, le infrastrutture e l'edilizia

Ramses. Surveying a city

Cà Farsetti, Sala del Consiglio
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Since its very foundation, Insula has worked for the preservation and maintenance of Venice, firmly believing that such a unique city, unlike any other in the world, needs constant attention and equally unique sophisticated instruments. *Ramses* is a tool coherent with the original mandate of the company and it was conceived and funded as such. In an overall framework of financial hardship, in recent years Insula has paid particular attention to projects that could contribute to reducing costs and simplifying procedures – without compromising the high level of quality – and we believe *Ramses* to be an instrument of excellence with great potential. Its development however requires further investments that – despite the commitment of the city administration – are not available today, because the city no longer has the resources necessary for its survival. On this occasion, we would again like to recall that because the Special Law was not re-financed by the Government, in recent years there has been a drastic cutback in the works that have led to a halt in the *Integrated Canal Project*, a programme that jointly involved the National, Regional and City governments. At this rate, there is a very real danger of not having the funds sufficient to continue the necessary process of scheduled maintenance in the historic city centre, and to return the city to the irreversible deterioration that in the past has endangered its embankments, its foundations, its extraordinary architecture, as well as its daily and social life.

Paolo Sprocati
president Insula spa

Only in Venice, probably, would it have been possible to develop such an ambitious and innovative project for the preservation and protection of the urban fabric.
Ramses, in fact, is on the cutting edge in the implementation of systems for altimetric surveys, the modeling of space and three-dimensional laser scanning because it was conceived, developed and tested on the city of Venice, which once again proves to be a perfect "laboratory" for creativity and innovation.
In Venice, project requirements are never the usual, and are almost always more challenging.
In Venice, the methods with which projects are developed and prepared for construction are more complex than in other places and often confront researchers and designers with situations that require them to sharpen their ingenuity.
In Venice, finally, the possibility of testing systems and products on the field carries with it the incredible distinction and renown of this Place.
The results that were achieved bear witness to the quality of the project and its importance for a more complete understanding of the working context for those involved in urban maintenance and in the preservation and protection of Venice.
They are there, finally, to demonstrate that the delicacy and "fragility" of our city requires tools like these in order to be governed and guided in its modern vest.
They also go to show that the resources dedicated to the development of these systems, are crucial investments for a deeper understanding of the territory, which alone can make it possible to intervene wisely for its preservation and protection. In Venice and elsewhere.
Yet Venice can be a credible candidate for world leadership in the implementation of innovative technological systems, that it can export to places where similar needs can find solutions that are often easier.

Antonio Paruzzolo
Councilor for productive activities and partnerships

The use of *Ramses*, an important "aggregate of knowledge, commitment and technology", will give us a unique, fundamental tool to rely on, that can be placed at the service of the City for a variety of applications, the most important of which is the defense against *acqua alta*, the high tides that are such a difficult problem for Venice to solve.
In fact, the possibility of optimizing the management and utilization of the city, thanks to our understanding of the geography of the pavement in both plan and elevation, will be of primary importance in the case of high tides to predict the potential damage caused by flooding.
Thanks to the elaboration of surveys conducted with *Ramses*, we will have an accurate new three-dimensional system that will increase our understanding of pedestrian circulation in relation to tide levels, the length of the routes that will require the installation of the "passerelle", the raised walkways.
The acquisition of a representation in real terms of all the information relative to elevations will unquestionably create important scenarios that can bring significant benefits for the protection of the City of Venice.

Alessandro Maggioni
Councilor of public works

Ramses. Surveying a city

The Ramses project

The first three-dimensional survey to the centimetre of the paving of a city in the world. This is RAMSES (an acronym for *Rilievo Altimetrico, Modellazione Spaziale E Scansione 3D,* Altimetric Survey, Spatial Modeling and 3D Laser Scan), precise to the centimetre in surveying the paving in the historic city centre of Venice. Promoted by the City of Venice and implemented by Insula spa, the project was developed by the temporary association of businesses Tecap studio srl and Innova Technology Solutions spa.
This survey is the only one of its kind in the world, in terms of both the quantity of data collected, and the precision to the millimetre, but above all the integration of traditional and cutting-edge technology, which has drawn the point zero of the city: an immense three-dimensional photograph of existing conditions, with capillary detail on the entire urban scale. The entire pedestrian circulation system, basically, for a linear development of streets and squares approximately 140 kilometres long and a total of approximately one million square metres.

The starting point

To guarantee the management and utilization of the city and its infrastructure, especially in the context of Venice and its islands, it is important to have a better understanding of its territory.
In fact, understanding the geography of the paving in plan and elevation is crucial for the City of Venice especially when the tides are high, to guarantee pedestrian circulation and to predict the damage that might be caused by flooding. The model of the paving used in Venice up to the year 2010 was based on a data bank that was constantly updated thanks to the surveys made to plan integrated maintenance projects for the city. The information was however composite and heterogeneous in terms of density, precision and reliability, making it impossible to provide an altimetric model of the city discretized at better than an average of 10 cm. Twenty years after the last complete campaign to survey the city of Venice, the model often proved to be imprecise thanks to the scarce density of the original data; it had little significance because of the ample interval of discretization. On the basis of this data bank, however, it would have meant little to discretize the model at intervals of less than 10cm.
The use of this reference to predict the consequences of high tides in Venice led to an erroneous assessment of pedestrian transit in relation to the level of the sea, the length of the routes that required raised walkways and the level at which private thresholds would flood.
The realization that we needed the support of a more detailed tool led to the development of Ramses, a topographic survey and laser scanner that is homogeneous in its precision (1 cm altimetric and 2 cm planimetric) and in the way it works, with a much denser grid (2500 points per square meter) from which it is possible to generate a three-dimensional model with more precise contour lines, discretized at 1 cm. Thus Ramses can considerably reduce errors in the assessment of viable paving for pedestrian circulation, in the estimation of the raised walkway routes and the elevation at which building thresholds flood, in relation to the tide level.

The phases of development

The campaigns were divided into several different phases both for the topographic part, and for the laser scanning.
For the topographic campaign, several different networks were monumented to guarantee precision to the centimetre for the overall reference system. The new topographic network is therefore constituted by a GPS network (65 benchmarks in the historic city centre) that serves as the overall framework. Following is the

densification of the plan network that connects every street in the city to the main network. The high-precision levelling (that defines the differences in elevation of the physical surface of the terrain) also connects over 4,400 benchmarks in the system.
For the laser scanning campaign – a methodology that was preferred over others because of its rapid and comprehensive acquisition of information – two different laser-scanning tools were used with the help of four teams each composed of three operators. This choice of organization guaranteed continuity during the surveying phase, and throughout the development of the entire project.
The instrumentation that was used made it possible to acquire almost 8,500 points per square meter during each single scanning phase. Using a mobile station made specifically for Venice, over 20,000 scans were completed. Every single scan surveyed a small part of the paving and, aggregated with the adjacent scans and linked back to the reference system, contributed to identifying the exact position of a large number of points in space (up to 7,000 points per square metre). Successive elaboration with specific software provided the three-dimensional representations.
In this case, the laser scanner made it possible to create an extremely detailed and precise archive of elements that will be useful for managing maintenance work; this information can be updated periodically in later campaigns finalized towards the observation of specific phenomena.

Ramses

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ATI Tecap studio srl e Innova Technology Solutions spa

survey topographic network
Tecap studio srl

laser scanner survey
Innova Technology Solutions spa

The results

The numbers developed by the Ramses project are truly considerable. Over 140,000 photographs were made, 20,000 cylindrical panoramas and 20,000 laser scans. Nine bridges in the historic city centre were surveyed in 3D: Scalzi, Rialto, Cereria, Sbiaca, Foscari, Guglie, Tre Archi, Santa Margherita and the recent Ponte della Costituzione designed by Santiago Calatrava. In addition, over 60,000 terabytes of data were elaborated using *ad hoc* procedures and sophisticated reverse engineering operations.
The definite data of the 3D scans in clouds of points thus made possible a faithful reconstruction, to the centimetre, of the plan of the paving throughout the historic city centre of Venice, with the creation of equidistant contour lines one centimetre apart.
In the post-process phase, the footprint of all the buildings was extrapolated and all the openings in the walls up to a height of 120 cm from the ground line were identified.
Each level of information was represented three-dimensionally and geo-referenced. The discontinuities in the paving (ramps, steps, access to bridges and the urban furniture in the city) were all identified and mapped.
From the cloud of points, the real position of all the manhole covers in the public paving was mapped. The individual elements were surveyed and connected in a database that describes, for each one, the characteristics, the network it belongs to and the most important information on the single object: almost 80,000 elements were catalogued, including all existing sewers, drains, outlets and manhole covers in the city.
Ramses is also the first full-scale map ever to be realized and surveyed from the land three-dimensionally.
The results achieved were the product of an intense research and development effort that involved the finest of young Italian talent. The use of these methodologies, the post-production phase, the monitoring and management of the entire production process was entrusted to a special team that was responsible for implementing specific protocols and procedures to verify the data.

Benefits for the city

Technological innovation for the development of tools that improve the quality of everyday life and services.

Ramses has created a 3D photograph at the urban scale of the entire pedestrian circulation system that can provide the quantitative and qualitative data required for a correct evaluation of the necessary routine maintenance processes, that indirectly help to improve the life of the population.

The completion of this survey will improve certain activities that have a profound impact on everyday life: a precise understanding of the paving elevation will make it possible to predict how much of the surface will be flooded, pinpoint the elevation of the thresholds and optimize the installation of the raised walkways to ensure the circulation of people and things.

In particular, every Venetian can find the elevation of the threshold of his own home and take the necessary measures should the predicted tide level be above this elevation. Online, from his own home, the citizen, as well as the tourist, will be able to check viable circulation routes in advance.

The benefits are therefore to the citizen as well as to technical personnel.

Technical personnel will in fact be able to count on a useful model for the simulation of the damage that could be caused by high tides and to identify the areas where protection measures should be concentrated. This project – which identifies the actual elevation of Venetian public paving – is one of the essential elements in the plans for measures to be adopted locally by responsible public bodies to protect the city from the high tides, which includes waterproofing the embankment walls of most of the islands in the historic city centre, and in some cases raising the paving itself.

Having surveyed all the manhole covers and drains, this plan and photographic survey – which will be available to the agencies that operate on underground utilities – will facilitate maintenance work on the water, sewer, power and telephone systems.

New possibilities are offered to administrators for development.

Most historic Italian cities, which are now pervaded by the desire for regeneration, restoration and revitalization, setting aside the great utopian projects, must come to grips every day with the problem of their deterioration and urban maintenance.

Venice is the symbol of these special complex issues – the continuous erosion of the building foundations, the wave motion, the capillary rise of humidity, added to the presence of millions of tourists and commuters who stomp through the city every day – and a three-dimensional survey, if extended to the buildings in their entirety, could provide a new and innovative instrument to facilitate both the monitoring and maintenance of existing conditions.

Ramses can therefore open the door to complex situations: from the problem of sinkholes to operations for monitoring kinematic phenomena, from the need for concrete data and actual drawings to serve as an operative basis in the field of diagnostics to the consolidation and restoration of the architectural heritage. Bringing together all this data makes it possible to enrich the basic cartography, to create new thematic maps and new models for innovative monitoring systems based on a common tool. For example, from the cloud of points acquired in Venice, with appropriate elaboration and the help of adequate software, it becomes possible, by measuring the reflection of materials, to verify the presence of vegetation, the degree of humidity and luminosity on the basis of which the deterioration of a building can be mapped.

In addition to the development of tools for city planning and architecture (which are indispensable for scheduling the maintenance of a complex historic city centre), this three-dimensional model can be used to represent realistic virtual itineraries, creating a broader information system in which the historical, cultural and tourist information may be accessed simply and immediately.

What is Insula and what does it do?

Insula is an entirely public company, the operative arm of the City of Venice in the execution of urban maintenance works and services in the city, combining the expertise of a design firm and a tendering authority within a single organization.

The complexity of the city's structure demands a superior degree of specialisation by the parties involved both in the design and coordination of work and in its material execution. To solve the problems created by time, neglect and the slow corrosion of the water, Insula operates on the territory with a system of works to protect the urban and architectural heritage: from the restoration of the retaining walls to guarantee the stability of embankments and buildings, to the maintenance of working conditions in the sewer system to ensure optimal sanitary conditions; from restoring bridges and raising pavement levels to allow pedestrian circulation even during high tides, to upgrading the underground utilities (water, power, gas and telephone) and installing new networks; from minor maintenance work to complete restoration, conservation and renovation projects to protect the building heritage.

Over the years, the company has restored 67% of the embankment walls and 63% of the bridges. It is continuing its work to radically renovate and upgrade the system of waste collection and removal; 24 km renovated out of a total of 120. With this project, Insula demonstrates the level of understanding it has achieved in managing the maintenance of a European, and international-level city.

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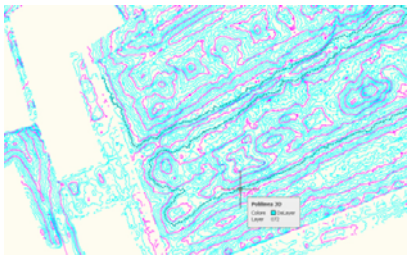
The benchmarks

More than 4,400 benchmarks have been monumented in the historic city centre of Venice. They are the benchmarks for the GPS network, the densification network and the reference grid.

The datum

The survey has produced a datum with a density of 2500 points per square metre. All these points are linked to the reference grid and are hence geo-referenced with a precision of 2cm in plan and 1 cm in elevation. These points were used to establish contour lines and the edges of the paving and elements of discontinuity (steps, thresholds, manholes, wellheads, bases of porticoes)



Contour lines

The datum generated the contour lines with a discretization of 1 cm.

Paving and lines of discontinuity

The datum generated the boundaries of the paving, the edges on the ground of the buildings that border the surveyed paving, the lines of discontinuity (steps, handrails, urban furniture, street lighting, etc.)

Sewers and drains

A survey was made of all the manhole covers and sewer drains in the historic city center. The typologies were gathered in a schedule to which all the elements of the cartography refer.

Bridges

Laser scanning techniques were used to survey the bridges Della Costituzione, degli Scalzi, dei Tre archi, de la Sbiacca, delle Guglie, de la Cereria, Foscari and Santa Margherita (Innova Technology Solutions spa) and Rialto (University of Padua).