# Between architecture and Digital Twin: the 3D survey of the Visconti Tower of the famous Monza Park

by Valentina Baratti, Giada Quercia, Gianluca Renghini

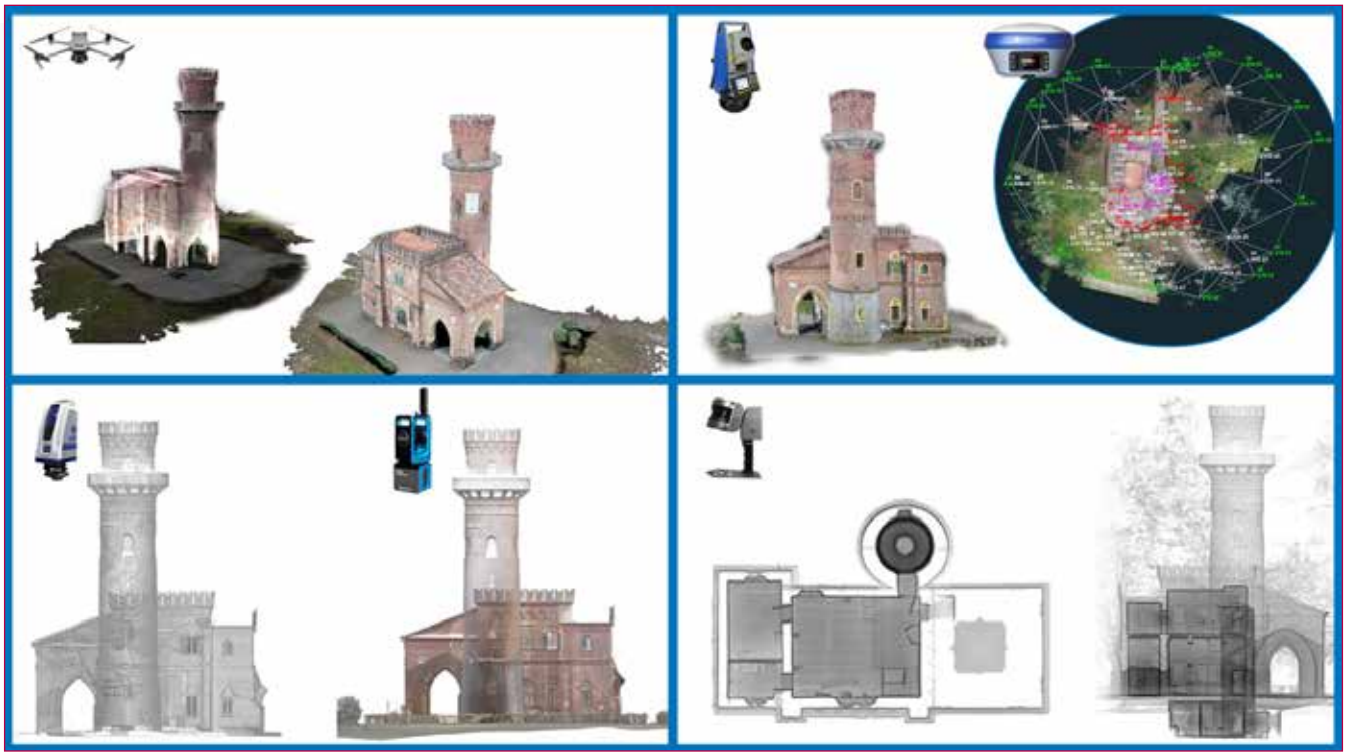

Fig. 1 - Instruments used and data exported.

In the month of March 2022, as part of a redevelopment project of the *Visconti* Tower, in collaboration with the Villa Reale Park Consortium, the topographic, 3D and aerial photogrammetric surveys of the Tower were carried out within the walls of the Monza Park, famous for the international racetrack and for its kilometers of city walls: one of the largest European historic parks. The surveys were carried out to obtain an extremely detailed, precise and georeferenced 3D model of the building in order to produce high-level internal and external elevations and floor plans. The result obtained is the digital model of the use of different survey tools and techniques integrated together.

## HISTORICAL NOTES OF THE VISCONTI TOWER OF THE ROYAL PALACE OF MONZA

The Visconti Tower, located inside the Royal Gardens of the Royal Palace of Monza, was conceived and designed in the first decade of the nineteenth century by Luigi Canonica, who was responsible for drawing up the entire perimeter of the current Monza Park, as can be seen from the cadastral map at that time. The idea of the tower with neo-Gothic shapes, howe-

ver, found its execution only in 1822, when Giacomo Tazzini, who succeeded Canonica in the role of architect of the Royal buildings, thought of exploiting the ancient rural building of the Tuscan vineyard casino to create a building “alla gotica” and enrich the royal gardens with another notable topical piece of the romantic garden repertoire: the gothic tower and the medieval ruin, so popular in the classic english gardens of those years. In a first draw the main elements of the structure are sketched, which will only be definitively completed in 1824, again by Tazzini. The new building, composed of a portico, a ground room and an upper room, is approached by a new circular tower about twenty meters high: inside a spiral staircase leads first to an upper gallery and finally to the crenelated terrace: a real lookout tower at the edge of the gardens from which was possible to enjoy an innovative and unusual point of view of the royal gardens and the park itself.

An engraving by Frederic Lose dated 1826 and entitled Le Tour dans le jarden, shows the tower finally completed and exactly how it is nowdays. Therefore it can be deduced that the date of the end of the works was between 1824 and 1826.

## INTEGRATION OF TERRESTRIAL AND AEROPHOTOGRAMMETRIC DATA FOR THE SURVEY OF THE VISCONTI TOWER

The architectural complexity of the structure surveyed, although modest in size, and of the surrounding space, covered by vegetation, made it necessary to use numerous topographic and aerial photography solutions to create, with various types of tools and software, both the interior and the exterior of the detected structure, a survey project - from a metric point of view - extremely detailed and precise, in order to obtain the digital twin of the cultural asset.

To do this, the range of Stonex laser scanners (X300, X150 and XH120) from which orthomosaics of the highest quality and a reliable survey from a metric point of view were obtained. Finally, an aerial photogrammetric survey of over 230 photos, carried out with a DJI drone, completed and integrated the territorial data with the aerial photogrammetric data obtained from the Remotely Piloted Aircraft System - SAPR.

Given the peculiarity of the structure - from an architectural point of view - which presents decorations and details of various kinds, the use of three different types of laser scanners proved to be extremely appropriate for the case study: each laser scanner of the Stonex it was used for a specific need, enhancing not only the properties of the instrument but also the possibility of collecting every essential detail with maximum precision for the purposes of digital reproduction of the structure. For example, the X300 laser scanner from the Stonex series, given its range of three hundred meters and its ability to generate extremely dense and precise point clouds, it was used to have an overall view and to capture details and decorations of the tower facades, in all its geometric and architectural interweavings, on

Fig. 2 - Aerophotogrammetric data processed in Cube-3d.

which to integrate more precise data coming from other scanners.
The X150 laser scanner is a light and easy to handle tool with a minimum range of 20cm and a maximum of 150m, particularly suitable for capturing portions of buildings and detailed elements. Multi-line Lidar technology and the ability to obtain complete coverage of the surrounding area allow you to process 3D models for a wide range of applications.
A perfect tool for quick topographic surveys, scans of building facades and data collection for floor plans. In fact, it was widely used to collect digital information about the interior of the Tower as well as some details of the exterior: the point clouds generated by the X150 laser scanner were then colored with a 360 HDR camera integrated into the instrument itself.
Finally, the XH120 portable laser with SLAM technology proved to be a reliable companion for providing a precision planimetry of the walls and for detecting the narrow spaces of the tower. The SLAM technology and the data derived from the portable laser XH120 have made it possible to carry out excellent integration and registration between the point clouds obtained from all the laser scanners used, providing an overall and integrated overview of all digital information collected and returned in that digital unicum which is its natural consequence and definition.
All the data collected by laser scans, whose elaborated and processed point clouds constitute the digital twin.

## PRECISION GEOREFERENCING WITH S990A GNSS RECEIVER AND R20 TOTAL STATION

No topographic survey can - nowadays - be carried out without precision georeferencing with a GNSS receiver and a cutting-edge Total Station. The topographic positioning was carried out with the S990A GNSS receiver from the Stonex range in harmony with the R20 total station, in order to be able to georeference all the data collected with maximum precision.
Stonex S990A is an 800-channel GNSS receiver characterized by an innovative functionality that improves the performance of field investigations. All GNSS signals (GPS, GLONASS, BEIDOU, GALILEO, QZSS and IRNSS) are included, at no additional cost.
The new IMU system allows tilt measurement (TILT) up to 60°: fast initialization, fast and precise detection.
The S990A receiver is equipped with: Bluetooth, Wi-Fi, dual frequency UHF radio 410-470 MHz and 902.4-928 MHz. The needs of each country are supported. And internal 4G modem that works with all signals in the world, a fast Internet connection is guaranteed.. The internal 10,200 mAh battery allows it to work for 9 hours and can be recharged via a Type-C connector. The color touch display and web user interface are a quick and easy way to have complete control of the receiver.
Thanks to the RTK function and the Atlas® correction service, Stonex S990A is also able to work in particularly difficult areas. Atlas® provides global centimeter correction data via L-Band.
The 1PPS port can be used in applications that require precise synchronization time to ensure multiple instruments work together.
Stonex S990A with IMU system makes all measurements reliable, both surveying and staking work, and makes the acquisition of points extremely faster: it is possible to save up to 40% of work time in the field.
The S990A GNSS receiver was also used to measure the GCPs (Ground Control Points) to be associated with the aerial photogrammetric data.
Field software at work in data collection: stonex cube-a, stonex reconstructor and Cube-3D
The Stonex Cube-a software was an excellent ally in field data collection thanks to its simple and intuitive interface.
All this data was processed in the office in the following days using Cube-desk and Cube-3d


Fig. 3 - Stonex S990A GNSS Receiver with IMU.

and Stonex Reconstructor software.

Stonex Reconstructor was used for filtering and recording the point clouds from Laser Scanner while with Cube-3d it was possible to create the final project of union of all the data collected since it is able to read a wide range of formats.

Cube-3d was able to:

- Manage the complete photogrammetric project (photo, 3D model, orthophoto)
- Import point cloud data from laser scanners (since it can handle clouds generated from any source)
- Import and manage topographic survey CAD data (points, polylines, etc.)

The final result confirms that the integration between TLS and SLAM data and from aerophotogrammetric survey allows to obtain a geometrically reliable digital 3D model enriched with color data, perfectly functional to the needs of the Villa Reale Park Consortium.

Fig. 4 - Stonex Cube-a Field Software.

## CONCLUSIONS

In recent years, new technologies have become precious tools for analyzing the state of conservation of historic and architectural buildings. In this sense, it is now widely established that geomatic survey techniques offer solutions that were unthinkable only a few years ago for integrated digital surveys and the documentation of the architectural and artistic heritage (point based methods, image-based photogrammetry and their combination) which, unlike a Traditional surveys allow you to save time and have a high level of accuracy even in cramped or poorly maintained structures.

For this reason, laser scanner and aerial photogrammetry surveys enhanced by GNSS and total station positioning systems can be used to produce detailed and excellently georeferenced 3D models.

**Abstract**

*In collaboration with the Consorzio Villa Reale, the topographic, 3D and aerial photogrammetric surveys of the Visconti Tower of the Monza Park were carried out. The surveys were carried out to obtain an extremely detailed, precise and georeferenced 3D model of the building in order to produce high-level internal and external elevations and floor plans and to obtain a digital twin of the structure. The survey is the result of different survey tools and techniques integrated together.*

**Keywords**

3D survey; GNSS; georeferencing; cultural heritage; digital twin

**Author**

Valentina Baratti
Valentina.baratti@stonex.it
Giada QuerciaGiada.Quercia@stonex.it
Gianluca Renghini
gianluca.renghini@stonex.it

REGGIA DI MONZA
VILLA REALE · GIARDINI · PARCO