

ST. PETER'S BASILICA – VATICAN CITY



ILLUSTRATED REFERENCE

| Nr. | DATE | OBJECT | OWNER |
|-----|------------|-----------------------------------|--------------------|
| 01 | 29/04/2026 | Illustrated Reference - Tender EU | Technical Director |
| 02 | | | |



Summary

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SURVEY & DIGITAL TWIN - ST. PETER'S BASILICA IN VATICAN CITY

Italdron Air Service S.r.l. is a company specialized in the digitalization of the built environment across all civil sectors.

The company was commissioned by Italferr S.p.A., a subsidiary of the RFI Group, to carry out the fundamental survey activities required for the detailed documentation of St. Peter's Basilica, with the objective of providing the main client, the Fabbrica di San Pietro, with the full know-how developed over extensive experience in digital design and infrastructure surveying of digital design applied to railway infrastructure, using the most advanced surveying and investigation techniques.

In this context, a Digital Model (Digital Twin) of the 17th-century structure of St. Peter's Basilica was developed, with **two primary objectives**:

- to create a structured repository capable of organizing and systematizing fragmented data collected over centuries;
- to develop a model serving as a basis for the design of a structural monitoring system, aimed at assessing the behavior of such a significant structure, both from an architectural and symbolic perspective, as the center of Christianity.

To achieve the final result, extensive expertise in surveying and digital modeling of civil works (bridges, dams, buildings, industrial plants, historical sites, etc.) was deployed.

Additionally, the project required the capability to process and manage up to **25,000 image files**, involving exceptional computational demands.

A total of up to **3 terabytes of data**—comprising digital imagery and point clouds—were acquired over two months of field surveys.

Subsequently, Italferr, with the support of IAS, carried out two additional months of data processing and modeling, involving up to 15 specialists, to produce the final digital model.

The resulting Digital Twin, based on textured 3D meshes and point clouds, represents a comprehensive virtual replica of the structure. It serves as a critical tool for all stakeholders involved in its management, including the Fabbrica di San Pietro, maintenance teams, and engineering and design firms. It also constitutes the foundation for the future implementation of a structural monitoring system, which represents the ultimate objective of the project.

This approach enables structured and integrated monitoring of the Basilica's structural behavior—particularly the 17th-century body—leveraging state-of-the-art technologies and international best practices.

Furthermore, within a sustainability and energy management framework, the Digital Twin functions as a dynamic data repository, capable of continuously integrating new information throughout the lifecycle of the structure. This allows for flexible use of data for various purposes, including maintenance, asset management, and specialized interventions requiring advanced digital information management, replacing traditional methods.

Beyond its technical and engineering purposes, the extensive dataset acquired through advanced technologies and made available to the Fabbrica di San Pietro also supports the Basilica's historical mission—namely, welcoming pilgrims and visitors—enhancing both its preservation and its cultural dissemination.



This project represents a benchmark case for the digitalization and integrated surveying of complex assets, combining multi-sensor data acquisition and advanced processing workflows.

The **methodologies applied** are directly transferable to infrastructure and engineering projects, including:

- transport infrastructure (bridges, railways, tunnels)
- urban and large-scale buildings
- energy and industrial assets

The **approach** enables:

- high-precision data acquisition for engineering surveys
- integration of heterogeneous datasets into unified digital environments
- development of digital twins supporting inspection, monitoring and maintenance planning
- scalable workflows applicable to large infrastructure networks

This experience demonstrates IAS's capability to operate in complex environments while ensuring safety, minimal operational disruption and high data reliability, in line with requirements of international and donor-funded projects.

A.1. EXTERNAL PHOTOGRAMMETRIC SURVEY BY DRONE

Photogrammetric surveying is a specialized land surveying technique performed with UAS (Unmanned Aerial Systems) – drones.

It represents the application of well-established high-altitude aerial photogrammetry methods (traditionally carried out using aircraft such as airplanes, helicopters, or gliders) to localized urban or building-scale areas, executed at low altitudes (typically ranging from



approximately 20/30 m up to 150 m above the surveyed surface).

Drone operations in Italy are regulated by multiple legislative frameworks, primarily the Italian Air Navigation Code and the SAPR Regulation issued by ENAC (Italian Civil Aviation Authority).

IAS has been authorized for several years to operate, both in terms of UAS platforms and certified pilots, in all risk scenarios under applicable regulations, and is fully capable of managing any required authorization processes for conducting flight operations in regulated or restricted airspace scenarios.

A.2. INTERNAL PHOTOGRAMMETRIC SURVEYS – TRIPOD-BASED ACQUISITION

Internal photogrammetric acquisition is performed using stabilized tripods, capturing all interior areas of the church from the ground upwards. The methodology includes both radial image capture and perpendicular shots relative to walls and spatial volumes. This approach can be used independently for the reconstruction of high-detail photogrammetric models, or in combination with laser scanner acquisitions to achieve enhanced geometric detail and preserve the optimal color fidelity of the surveyed objects.



A.3. INTERNAL PHOTOGRAMMETRIC SURVEYS – AEROSTATIC BALLOON-BASED ACQUISITION

Internal photogrammetric surveying is carried out using an aerostatic balloon equipped with a stabilized gimbal supporting a high-resolution RGB camera. This solution is particularly suitable for minimizing the risk of damage to structural elements, decorative features, and artworks inside the church, while ensuring excellent maneuverability and operational duration not constrained by battery limits, as is typically the case with drones.



The system can be powered via cable when required, extending operational time beyond standard camera battery life. It can also be equipped, if necessary, with LED lighting to ensure adequate illumination in upper areas of naves or chapels with low light conditions.

A.4. INTERNAL PHOTOGRAMMETRIC SURVEYS – UAV-BASED ACQUISITION

Internal photogrammetric surveying is complemented by acquisitions carried out using non-intrusive UAVs in areas where tripod-based or aerostatic balloon surveys present limitations due to restricted fields of view or inaccessibility.



A.5. INTERNAL AND EXTERNAL SURVEYS USING LASER SCANNING

Laser scanning surveys were carried out to metrically capture the as-built condition of the Basilica, including interiors and exteriors, underground spaces, corridors, halls, and spiral staircases, in order to enable subsequent CAD 2D / CAD 3D / BIM reconstructions.

From a performance standpoint, the integrated internal and external scans—constrained and georeferenced through dedicated control networks—allow the generation of a point cloud model that serves as the primary reference dataset for the entire survey.



A.6. INTERNAL AND EXTERNAL SURVEYS USING TOTAL STATION



The use of this instrument is aimed at the topographic surveying of temporary targets placed both inside and outside the church, in order to establish a control traverse network to which the laser scanner datasets can be rigidly referenced. This also provides an additional verification method alongside cloud-to-cloud registration.



A.7. EXTERNAL SURVEYS USING GNSS (GPS)

GNSS (GPS) technology is well suited for the execution and integration of topographic surveys, ensuring both accuracy and efficiency in detailed surveying activities as well as in all staking-out operations.

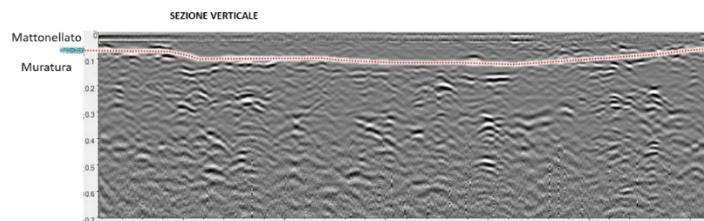
The GPS system enables the georeferencing of acquired survey data and allows direct operation within various cartographic projections, making it possible to determine on-site coordinates in multiple formats.



A.8. GROUND PENETRATING RADAR (GPR) SURVEYS

The survey was complemented by targeted investigations on selected areas using Ground Penetrating Radar (GPR), in order to identify and characterize potential deteriorated zones and the presence of through-stones within the masonry structure.

The equipment used was a Hi-Bright VV multi-channel system, operating at a frequency of 2 GHz with vertical polarization, with dipoles spaced at 5 cm intervals. The system provides an investigation depth of approximately 2 meters.





CONCLUSION

The project confirms IAS's capability to deliver advanced geospatial data acquisition and digital modeling services in complex environments, supporting engineering decision-making processes and long-term asset management.

The experience gained is directly applicable to international infrastructure projects requiring high-precision surveying, data integration and digital twin development.