MULTIMETHODOLOGICAL APPROACH TO STUDY THE AREA
OF S. GIOVANNI IN LATERANO BASILICA (ROME, ITALY)

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Introduction. The San Giovanni in Laterano Complex. An exceptional building in its own right, the Constantinian basilica of S. Giovanni in Laterano holds the title of *caput et mater* of the churches of Catholic Christendom. The basilica is the Pope’s own church, a pioneering structure and a site of remarkable archaeological importance. Extensive excavations beneath the complex have revealed not only the remains of the first powerfully influential basilica and baptistery, but also structures from still earlier periods. Chief among these are the barracks of the imperial horse guards, substantial palatial buildings, a bath house, and a street with houses. These areas are remarkably well preserved and a substantial number of frescoes and mosaics remain *in situ.*
Extensive research by Prof. Paolo Liverani (Florence University) has enriched our understanding of the complex, but a major collaborative project is required to interpret the remains unearthed by previous excavators. The earliest recorded excavations took place in 1730, the deepest lie 5.5 m below ground level.

The Lateran Project is undertaking an intensive scientific survey of the entire structure to integrate information from standing buildings, excavated structures and sub-surface features through the collaboration of Newcastle University (UK), Florence University (Italy), the Institute for Technologies Applied to Cultural Heritage (ITABC-CNR, Italy) and the Direction of Musei Vaticani.

**Research design.** The Lateran Project aims to undertake a fully integrated 3D survey of the excavations under San Giovanni in Laterano.

A particular concern is to find an approach that will not only allow collaboration between researchers using a range of established and innovative methods, but also a method that allows an integrated approach to the three-levels of structural data that form the complex (Gaffney et al., 2008). There are the standing features on the modern city surface, as seen in Fig. 1. These can only be fully understood in relation to subsurface features and vice versa.

There are also the extensive and inter-cut structures that form the opened area of excavations. Finally, there are the unexcavated deposits that lay either beyond the immediate confines of the site or beneath the area opened to date.

Ground penetrating radar (GPR) was used to map standing and sub-surface structures. The aim of these surveys is to identify Roman and high-medieval age remains which could enhance understanding of the ancient topography and the urban evolution of the studied area. The main goals of this survey are the following:

1. to determine the limits of *Castra Nova Equitum Singularium*, the barracks of the imperial horse guards established by the emperor Septimius Severus;
2. to locate the remains of the buildings of the Lateran Patriarchy. These are known from renaissance plans but up until now it has not proven possible to locate them all on the ground;
3. to determine the full plan of the Santa Croce oratory, built by Pope Ilaro (V century) and destroyed by Sixtus the Fifth; part of this building has been identified by Olof Brandt within the excavated area adjacent to the Baptistery;
4. to determine the full extent of the palatial housing found below the western part of the Basilica.

**Ground penetrating radar. Data acquisition.** For The measurements a GPR SIR3000 (GSSI), equipped with a 400 MHz (GSSI) bistatic antenna with constant offset and a 70 MHz (Subecho Radar) monostatic antenna were employed. Some signal processing and representation techniques have been used for data elaboration and interpretation. GPR surveys were performed, employing the SIR3000 (GSSI) to survey the selected areas outside the Basilica in the S. Giovanni in Laterano square, in front of the Basilica and inside in few internal parts.

The horizontal spacing between parallel profiles at the site was 0.50 m, employing the two antennas. Radar reflections along the transepts were recorded continuously, with different length, across the ground at 40 scan s⁻¹; horizontal stacking was set to 3 scans.

In the area outside the Basilica a total of 777 adjacent profiles across the

![Fig. 1 – Basilica di San Giovanni in Laterano, Roma.](image)
site were collected alternatively in forward and reverse directions employing the GSSI cart system equipped with odometer. All radar reflections within the 90 ns for 400 MHz antenna and 195 ns for 70 MHz antenna (two-way-travel) time window were recorded digitally in the field as 16 bit data and 512 samples per radar scan.

A nominal microwave velocity of about 10 cm/ns was determined from fitting hyperbolas to the raw field data. This was used in estimating a penetration depth from the GPR survey.

_data processing and presentation._ All the GPR data were processed in GPR-SLICE v7.0
Ground Penetrating Radar Imaging Software (Goodman, 2015). The basic radargram signal processing steps included: i) post processing pulse regaining; ii) DC drift removal; iii) data resampling, iv) band pass filtering, v) migration and vi) background filter.

With the aim of obtaining a planimetric vision of all possible anomalous bodies the time-slice representation technique was applied using all processed profiles (Goodman et al., 2008a, 2008b; Goodman and Piro, 2013; Leckebusch, 2008; Piro et al., 2008, 2012; Utsi 2006). Time-slices are calculated by creating 2-D horizontal contour maps of the averaged absolute value of the wave amplitude from a specified time value across parallel profiles.

Time slice data sets were generated by spatially averaging the squared wave amplitudes of radar reflections in the horizontal as well as the vertical. The squared amplitudes were averaged horizontally every 0.25 m along the reflection profiles 3 ns (for 400 MHz antenna) and 6 ns (for 70 MHz antenna) time windows (with a 10% overlapping of each slice). The resampled amplitudes were gridded using the inverse distance algorithm with a search radius of 0.75 m. In addition pseudo three-dimensional volumes of the reflections were generated to produce isosurface images.

In Fig. 2 the time-slices (in the time windows from 58 to 61 ns twt for 400 MHz antenna) for the investigated area are shown. On this map the individuated anomalies are visible and in particular the reflections obtained in the area N-E to the basilica can be related to the remains of the early Christian bishop’s palace (high medieval period).

Fig. 3 shows, the time-slices at the time-window 112-118 ns (for the 70 MHz antenna) obtained in the same area.

Ground Penetrating Radar (GPR) survey at the Lateran has produced significant and fruitful results. The use of two different antennae has enabled to reach depths of up to 6÷7 m.

All the obtained results are presented in 3D animation using real time Open GL graphic displays in which isosurface rendering, 3D time slice fence diagram are mixed with the filtered radargrams.

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