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Underground Surveying of the *Porticus Minucia* as a Basis for the Georeferencing of a Fragment of the Marble Plan of Rome (*Forma Urbis marmorea*)

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***Abstract* – This study presents the results of a high-precision subterranean survey of the remains of the Porticus Minucia in Rome, conducted using advanced GNSS techniques and total station measurements. The collected data enabled accurately mapping the structure's foundations and alignment within the modern urban context. Crucially, this new dataset has made it possible to confidently georeference a previously unplaced fragment of the Forma Urbis Marmorea, the Severan marble plan of ancient Rome. By aligning architectural features visible on the fragment with the surveyed remains of the Porticus Minucia, we demonstrate a method for integrating archaeological fieldwork with historical cartographic reconstruction. This interdisciplinary approach not only enhances our understanding of the Forma Urbis but also contributes to the broader effort of reconstructing the topography of ancient Rome.**

I. INTRODUCTION

The urban area of Rome is built over up to ten metres of anthropic layers from the Early Bronze Age to today, recording events like buildings, demolitions, floods, and fires [1]. Most excavations are near or below modern structures, making them technically challenging [2-3]. A key difficulty is accurately placing uncovered structures within a three-dimensional framework to compare them with known features [4]. Since 2008, Rome's Superintendence has developed SITAR (Sistema Informativo Territoriale Archeologico di Roma), a webGIS based on the old Roma40 datum (EPSG: 102093) [5], to compile archaeological data. This paper proposes a workflow using geomatic methods to precisely locate ancient structures, demonstrated through a recent Roman excavation.

The study we will present builds upon a foundational survey, the methodologies and initial findings of which have been thoroughly detailed in previous publications . It is not the intention of the present work to reiterate the technical details of the survey, which have already been thoroughly described in the bibliographic reference [1]. Nevertheless, in order to facilitate the reading and understanding of the following discussion, it is worth recalling some essential aspects. The survey of the hypogeal area required the combined use of a total station and laser scanning technologies, following the descending path into the underground chambers where the remains of the Porticus Minucia—the subject of the current experimental investigation—were identified.

The survey, and in particular its geodetic framing and overall design, demanded the adoption of ad hoc strategies and carefully tailored solutions. This necessity arose from the peculiar geometry of the investigated area, as well as of the adjacent outdoor spaces. In fact, the GNSS framework proved to be highly problematic, not only because of the limited satellite visibility in the hypogeal context but also because the entire polygonal network had to be rigidly constrained to a small number of GNSS reference points. The positions of these points, in turn, were strongly conditioned by the visibility of the satellite

constellation, which introduced additional operational limitations.

A further critical aspect that emerged during the work was the sensitivity of the survey configuration: even very minor planimetric variations within such a network were capable of producing non-negligible angular rotations in the resulting dataset. This finding, in turn, highlighted the relevance of another issue, namely the lack of homogeneity among the different GNSS reference networks currently in use across Italy [1]. Such heterogeneity has important methodological implications, since it affects both the accuracy and the consistency of the integration between terrestrial and satellite-based surveying techniques in complex archaeological contexts. While those earlier works established the parameters of our original survey, the innovative core of the current research lies in its integrative approach: specifically, how the initial survey data was not merely supplemented but profoundly enhanced by the insights gleaned from the surviving fragments of the Forma Urbis.

This ancient marble plan of Rome, despite its fragmentary state, offered invaluable historical and topographical context. its available details to complement and cross-reference the information gathered during our on-site survey. This initial integration allowed for a more nuanced understanding of the urban fabric we were studying. Subsequently, the relationship became reciprocal: the precise geometric data obtained from our comprehensive survey proved instrumental in refining the positioning and interpretation of these very marble fragments. By superimposing our accurate geomatic measurements onto the historical evidence, we were able to propose more precise locations for the fragments within the grander scheme of the Forma Urbis, and in turn, derive more accurate interpretations of the urban features they depict. This dynamic, iterative process—where historical data informs geomatic analysis and vice-versa—exemplifies how the strategic combination of historical scholarship and advanced geomatic information can dramatically improve both the accuracy and interpretative clarity in reconstructing ancient urban layouts. This powerful synergy not only contributes to a more faithful digital reconstruction but also offers a more robust framework for understanding the spatial organization and evolution of the ancient city.

II. THE FORMA URBIS MARMOREA: A MONUMENTAL FRAGMENT OF ANCIENT ROME'S TOPOGRAPHY

The *Forma Urbis* marmorea (Latin for "Marble Plan of the City"), represents one of the most remarkable and invaluable surviving topographical records of ancient Rome. Dating to the early 3rd century CE, during the reign of emperor *Septimius Severus* (203–211 CE), and probably in 211 CE itself [6], this colossal marble plan originally adorned a wall within the *templum Pacis* (Temple of Peace). This wall is still preserved but now it's the external side of Santi Cosma e Damiano church (Fig.1). Its creation underscores the sophisticated administrative and cartographic capabilities of the Roman Empire.

Fig. 1. The wall on which the Forma Urbis Marmorea was installed

Carved onto approximately 150 marble slabs (Fig.2), the *Forma Urbis* depicted the entirety of Augustan Rome at an approximate scale of 1:240. Unlike modern maps, it was oriented with southeast at the top.

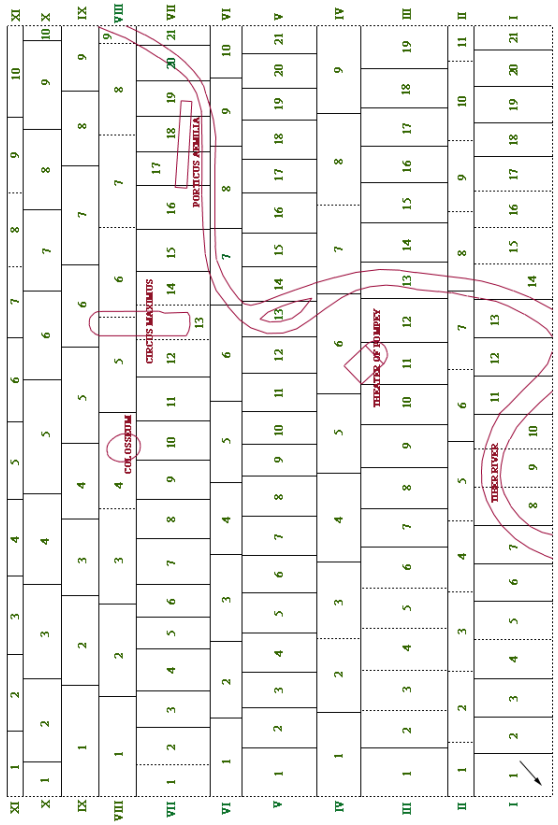

Fig. 2. Map showing the 150 fragments of the Forma Urbis Romae (from [9])

The plan meticulously rendered the ground plan of virtually all buildings within the city, including public monuments, private residences, temples, porticoes, baths, and commercial establishments. Crucially, it depicted internal architectural features such as columns, stairs, and even the layout of individual rooms and courtyards. This unparalleled level of detail provides an extraordinary glimpse into the urban fabric of Imperial Rome, offering insights into its density, spatial organization, and the intricate connections between various structures [7].

The plan can hardly be regarded as an official document, nor as one intended for general public display, since its structure shows no orientation toward bureaucratic, administrative, or fiscal purposes. With the exception of a few private properties, the captions are in fact restricted to monuments and public spaces.

Tragically, only a fraction of the original plan survives today. Following the decline of the Roman Empire, the marble slabs were largely repurposed as building material or reduced to lime. The vast majority of the surviving fragments were discovered between 1562 and 1939, primarily in the vicinity of the Santi Cosma e Damiano church, which occupies the former site of the *templum Pacis*.

Fig. 3. Detail of the wall on which the Forma Urbis marmorea *with the holes of the removed metal clamps*

Today, these approximately 1,186 known fragments [9],

ranging from tiny slivers to larger sections, are now (since 2024) housed at the Museo della *Forma Urbis* within the Parco Archeologico del Celio in Rome.

Fig. 4. The fragment 35 dd (from [8])

Despite its fragmentary state, the *Forma Urbis* marmorea remains an indispensable resource for scholars of Roman topography, urbanism, and archaeology.Extensive efforts have been made since its rediscovery to catalog, identify, and digitally reconstruct the plan. Researchers meticulously analyze architectural details, epigraphic evidence, and the physical characteristics of the marble fragments to piece together the ancient city's layout.

This ongoing work, often employing advanced photogrammetry, laser scanning [8] and geographic information systems (GIS), allows for a deeper understanding of Roman urban planning principles, the evolution of specific sites, and the daily life of ancient Romans. The *Forma Urbis* marmorea continues to be a reconstructions of the *Forma Urbis*, shedding light not only on its physical structure but also on the technical methods employed in its installation.

III. THE PRESENT EXPERIMENTATION RESULTS.

Many fragments of the marble Forma Urbis Romae have been repositioned through the recognition of architectural features that correspond to known ancient monuments still partially preserved in the modern urban fabric, such as the

Fig. 5. The excavated part of Porticus minucia *(from [10])*

Colosseum, the Circus Maximus, and other prominent landmarks. These identifications have provided reliable anchor points for the reconstruction of specific sections of the map. However, a significant portion of the surviving fragments correspond to structures that are either no longer extant or have not yet been securely identified. In such cases, the absence of correlating archaeological or topographical evidence makes it impossible to determine their original placement, even approximately in some instances.

Recent work has been greatly aided by the precise architectural survey of newly exposed remains of the *Porticus Minucia*, as previously documented in [1]. This detailed documentation has made it possible to confidently georeference at least one fragment, number 35dd, with a high degree of spatial accuracy (see Fig. 5). The correlation between the architectural features depicted on the fragment and the preserved remains of the *Porticus* allows for a reliable placement within the overall layout of the *Forma Urbis*. Furthermore, the same dataset has enabled the tentative identification of the likely position of two additional fragments. However, due to the less distinctive nature of their preserved features and their limited correspondence with the surviving remains, their placement is necessarily more speculative.

In the specific case of fragment 35dd, the precise survey of the original wall of the *Porticus Minucia* has proven particularly valuable.

It permits a confident alignment of the fragment with the documented wall line, thus reducing uncertainty in its orientation. Nevertheless, one degree of freedom remains unresolved: while the fragment can be aligned with the correct axis of the wall, its exact position along that line—i.e., the longitudinal placement of the slab relative to the full extent of the boundary wall—cannot yet be determined with certainty. In this specific case, the achievement of an

accurate georeferencing is unfortunately subject to two major preconditions that inevitably constrain the entire process. The first concerns the alignment observed with certainty during the excavation: although this alignment is clearly detectable in the archaeological record, it cannot, at the present stage, be unambiguously identified with either of the alignments visible on the surviving fragment of the Forma Urbis Marmorea. This circumstance introduces a fundamental indeterminacy at the very basis of the correlation between the archaeological evidence and the cartographic document.

The second limitation arises from the particular characteristics of the fragment itself. On the marble fragment, one of the vertices of the Porticus Minucia is indeed represented with clarity (Fig.4). However, within the excavated portion of the monument this same vertex is not observable (Fig.5). As a consequence, the alignment between the fragment and the excavated remains can at present only be constrained to a line for which the planimetric equation may be written, but which in fact generates an infinite set of possible solutions for the rigorous positioning of the fragment. In other words, the absence of a directly observable vertex prevents us from definitively anchoring the fragment in its exact location, and obliges us to accept a degree of translational indeterminacy along the axis of alignment.

Future excavation campaigns may, should the missing vertex eventually be uncovered, provide the decisive evidence needed to resolve this ambiguity. The identification of such a point would allow us to fix the translational degree of freedom and thus establish an unambiguous correspondence between the archaeological remains and the fragment of the Forma Urbis. Until that moment, however, the current state of knowledge allows us “only”—and we deliberately stress the word only—to determine and constrain the correct alignment, and therefore the orientation with respect to true north, of the fragment under examination. Further discoveries or comparative analysis may, in the future, help to resolve this remaining ambiguity.

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