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A Reexamination of the Substructure Inside the Castillo at Chichen Itza, Yucatan, Mexico

Dominique Rissolo [1], Scott P. McAvoy[1], Travis W. Stanton [2], Claudia Garcia-Solis [3], Jesus Manuel Gallegos Flores[3], José Francisco Javier Osorio León [3], Francisco Pérez Ruiz[3], Samuel S. Meacham[4], Falko Kuester[1]

[1] Cultural Heritage Engineering Initiative, University of California, San Diego, USA – (drissolo, smcavoy, fkuester)@ucsd.edu
[2] Department of Anthropology, University of California, Riverside, USA – travis.stanton@ucr.edu
[3] Instituto Nacional de Antropología e Historia, Mexico – (claudia_garcia, jesus_gallegos, jose_osorio, f_perez)@inah.gob.mx
[4]Centro Investigador del Sistema Acuífero de Quintana Roo, Mexico – sam@cindaq.org

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Abstract

The Castillo (also known at the Temple of Kukulkan) is one the most iconic structures in Mesoamerica. This temple-pyramid towers over the main plaza of the civic-ceremonial city of Chichen Itza, which once dominated the political and economic landscape of the northern Maya lowlands. Reported here are the preliminary results of a multimodal and multiresolution scanning campaign and fusion of 3D data outputs intended to more accurately record the physical attributes of the earlier temple-pyramid inside the Castillo, known as the Castillo-sub, and examine the spatial and architectonic relationships between the two structures. A focus of our scanning campaign involved the upper façades of the sub-temple and the Chacmool and jaguar throne sculptures inside the sub-temple itself. Structured-light scans of the upper façades now serve as the definitive representation of this portion of the Castillo-sub.

1. Introduction

The Castillo, also known at the Temple of Kukulkan, is one the most iconic structures in Mesoamerica (Figure 1). The civic-ceremonial city of Chichen Itza – a UNESCO World Heritage Site – once dominated the political and economic landscape of the northern Maya lowlands, and the Castillo towers over its main plaza. Although the chronology of Chichen Itza is the topic of much debate (see Ringle, 2017; Volta and Braswell, 2014), the rise and expansion of this enigmatic center roughly spans a period between AD 800 and AD 1050. A comprehensive overview or assessment of the structure, function, and meaning of the Castillo, as well as the century of scholarship focused on this temple-pyramid, is beyond the scope of this study. Reported here are the preliminary results of a multimodal and multiresolution scanning campaign and fusion of 3D data outputs intended to more accurately record the physical attributes of the earlier temple-pyramid inside the Castillo (known as the Castillo-sub) and examine the spatial and architectonic relationships between the two structures.

2. Past Documentation Efforts

The earliest detailed illustration of the Castillo, by Frederick Catherwood, was published in 1843 (Stephens, plate XXXVIII) and the earliest known photograph of the then brush-covered pyramid was produced by Déseré Charnay in 1860 (Charnay and Viollet-Le-Duc, 1863: Plate 32). Alfred P. Maudslay (1889-1902, vol.3) produced early plan and section drawings of the unexcavated pyramid and temple – which are remarkably accurate and detailed (plate 55) – and published excellent photographs (plates 56-58) of the cleared Castillo. Excavation and restoration efforts coordinated and conducted by Mexican archaeologists between 1927-1936 revealed the temple-pyramid's morphology and physical dimensions and made possible more accurate measurements.

In 1931, a tunnel excavated into the Castillo led to the discovery of an earlier, intact pyramid – with the temple on top encountered in 1935. Drawings of the Castillo-sub (both separate from, and superimposed onto, the overlaying Castillo) were published by Marquina in 1951 (figures 262, 263) in his grand tome, *Arquitectura Prehispánica*. An earlier, somewhat more artistic representation of both the Castillo and the substructure was illustrated by André Remondet (Figure 2). Detailed descriptions of the Castillo-sub and its temple were published by Erosa Peniche (1947), with a more recent study conducted by Miller (2018). The interior of the two-chambered sub-temple has been removed of debris, restored, and is well documented. However, since the sub-pyramid is only exposed along the narrow, excavated tunnels (center of the stairway and along the basal terrace riser of the SW corner), the structure's morphology remains largely hidden and difficult to parse.

A recent ERT (electrical resistivity tomography) geophysical survey provides a holistic, three-dimensional view of the Castillo interior, including the Castillo-sub (Tejero-Andrade, 2017). However, precise dimensions of the Castillo-sub, and details regarding its spatial relationship to the overlying Castillo, have largely been estimated (from the aforementioned remotely-sensed data) or hypothesized. Stories in popular media do reveal or suggest efforts to scan (presumably via TLS) the north-side tunnel and sub-temple; however, the results of these scanning efforts remain unpublished, and the scans themselves are not publicly available.

Figure 1. The Castillo (viewed from northwest). The principal stairway and the main entrance to the temple face north towards the Sacred Cenote. The entrance to the tunnel system that accesses the stairway of the Castillo-sub as well as the sub-temple is located on the west side of the main Castillo stairway. (UAV-based photogrammetry by S. Meacham).

The dimensions of the Castillo itself are readily observable and have been established via a range of techniques over the decades. In short, the base measures approximately 55.5 m on a side and is 24 m high (with the temple on top being 6 m in height). It should be noted that exact terrace and stairway geometries are largely the result of 20th century consolidation and restoration works, while the pyramid height and basal extent (as well as the general dimensions of the temple on top) reflect the structure's pre-abandonment morphology. Again, the focus here is on the physical characteristics of the sub-pyramid and sub-temple, and what has been revealed by – and what can be inferred from – the most recent digital documentation campaign.

Figure 2. Illustration depicting both the Castillo and the Castillo-sub by André Remondet, ca. 1938 (Peabody Museum of Archaeology and Ethnology, Object #58-34-20/27777).

3. Digital Documentation Methodology

The scanning campaign reported here was conducted as part of the Proyecto Arqueológico de Investigación, Conservación y Mantenimiento Mayor de la Zona Arqueológica de Chichen Itza – a project of the Instituto Nacional de Antropología e Historia (INAH). All scan data and associated derivatives are currently being integrated into the online, open-access Chichen Itza 3D Atlas (which is a collaboration between the University of California and INAH).

Data capture of the exposed surfaces of the tunnels (inside the Castillo and along the Castillo-sub) involved LiDAR and photogrammetry (Figures 3 and 4). The northside tunnel was scanned using the Hovermap 100 – a SLAM-enabled mobile LiDAR system well suited to capturing both the risers and treads of the stairway and awkward spaces not easily reached by TLS. The horizontal excavation tunnels on the south and west sides were scanned with a Leica BLK360 – a compact TLS. Scanning included exterior Castillo surfaces so that we could align the interior scans with the overlying pyramid, for which exterior TLS data are publicly available through Open Heritage 3D (https://doi.org/10.26301/2atk-cq42). This scanning campaign was conducted by CyArk and partners in 2007.

All tunnels were also scanned using the Looq qCam – an integrated multi-view mobile photogrammetry system. The resulting colorized point clouds were co-referenced with the mobile-LiDAR and TLS point clouds (recognizing inherent variations in resolution and accuracy) and visualized in Potree. The Chacmool and jaguar throne as well as the upper façades and select portions of the sub-temple were scanned using an Artec Leo structured-light scanner (SLS) with sub-millimeter resolution in HD mode. The Leo was also used to scan portions of the Castillo itself (see McAvoy et al., 2025).

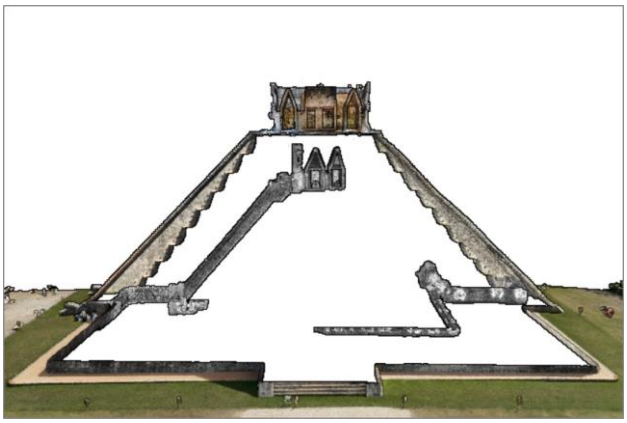

Figure 3. Section view of the scan data – revealing the north (left) and south stairways and temple of the Castillo and the excavated tunnels and sub-temple inside the Castillo. The tunnel leading up to the sub-temple follows the center-line of the Castillo-sub's only stairway (north side).

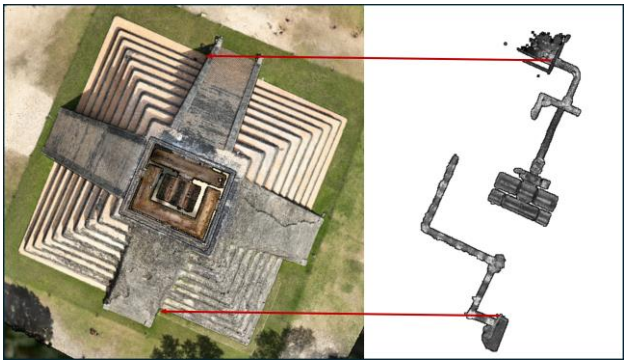

Figure 4. Plan view of the Castillo (left) and the scanned tunnel system (right). Red arrows indicate alignment.

4. Preliminary Results

4.1 Configuration and Dimensions of the Sub-Pyramid

The Castillo-sub was laid out with the same orientation as the Castillo (determined by the rising sun of the summer solstice and the setting sun of the winter solstice). Unlike the radial configuration of the Castillo, however, the Castillo-sub has a single stairway (facing north towards the Sacred Cenote – like the principal stairway and temple of the Castillo). There is some conjecture regarding the precise history of constructions beneath Castillo, as there appears to be an early iteration of the pyramid in addition to the Castillo-sub. Also, it is difficult to reconcile the relationship between the plaster floors revealed by early excavations into the Castillo and the base or basal terrace risers of each of the two pyramids. The implications, with respect to construction history (and site chronology), are addressed in other studies (e.g. Bey and Ringle, 2007; Braswell and Peniche May, 2012).

Measurements of the sub-pyramid extracted from the tunnel scan data are consistent with those derived via other techniques: 33 m on a side, and 17 m high. The south-side tunnel exposes the center-line of the basal terrace of the sub-pyramid and follows this terrace to the southwest corner of the structure. As measured from the aligned TLS and photogrammetry point clouds, this distance is 16.5 m (which, when multiplied by two, equals 33 m). An additional measurement of interest (which was

otherwise difficult to make prior to the scanning campaign) is the distance between the base of the Castillo stairway (north side) and that of the Castillo-sub: 12.72 m. (Note that the tunnel that accesses the north side of the Castillo-sub was not excavated via the center-line of the Castillo north stairway, but rather it entered the pyramid from the side of balustrade).

4.2 Characteristics and Dimensions of the Sub-Temple

Following its discovery, the interior of the relatively intact two-room sub-temple was removed of fill and debris and stabilized. The only exposed portions of the sub-temple's exterior are the doorway and upper façade (on the north side) and the upper façade (on the south side). The interior dimensions of the two rooms are readily observable and have been published elsewhere (e.g. Erosa Peniche, 1947; Miller, 2018). The room containing the Chacmool sculpture is 10.60 m long and 2.36 m wide, and the room with the jaguar throne is 10.60 m long and 1.84 m wide. The exterior dimensions of the sub-temple itself could be estimated from the scan data. Assuming an average wall thickness of .90 m (based on the thickness of the walls at the exposed entrance), the exterior width of the temple is approximately 12.40 m.

The sub-temple lacks feathered serpent columns flanking the entrance or warrior imagery – either carved on the jam stones or painted on the interior walls. Overall, from an iconographic perspective, the period that witnessed the construction of the sub-temple has been described as "transitional" (see Marquina, 1951:852; see also Bey and Ringle, 2007:412; Volta et. al, 2017:52). The walls and ceilings of the two rooms (in their stabilized state) are unadorned. However, the south wall of the inner room (behind the jaguar throne) is unique in that human long bones (thought to be femora) once protruded from this surface (see Miller, 2018:186 for a discussion). All have been broken off (essentially flush with the wall), but remnants of the bones can be seen inside the holes. This entire wall surface was scanned using a structured-light scanner.

The Chacmool and jaguar throne inside the sub-temple are among the more celebrated sculptures at Chichen Itza and have been well photographed, measured, and drawn (see Miller, 2018). SLS scans of the Chacmool and jaguar throne provide an unprecedented level of detail, in terms of geometry and texture. These high-resolution 3D scans were also co-referenced with the mobile LiDAR and photogrammetry data from the sub-temple scans (Figures 5 and 6). Together, they provide a more accurate representation of the sub-temple interior. Once the digital atlas of Chichen Itza is online, scholars will be able to access and download the highest resolution 3D data of these sculptures (as the Castillo-sub is not accessible to the public).

Figure 5. SLS scans of the Chacmool (lower left, inset) and jaguar throne (upper right, inset), and their locations.

Figure 6. Closeup views of the SLS scans of the Chacmool (left) and jaguar throne (right).

4.3 Upper Façade of the Sub-Temple

Similarities between the sub-temple of the Castillo and the Upper Temple of the Jaguars at Chichen Itza have been noted (Miller, 2018:179). In this case, along the upper front façade of the Temple of the Jaguars, eight jaguars are depicted (four on each side of the doorway), each pair separated by three shield-like elements. Unlike the rather cherubic felines (possibly pumas) of the Castillo-sub temple, those on the Upper Temple of the Jaguars are quite lean and spry. As mentioned above, most notable is the absence of feathered-serpent columns supporting the lintel of the sub-temple.

A focus of our scanning campaign involved the upper façade of the sub-temple (above the sub-temple entrance, on the north and south sides). At least six, vaguely similar reconstruction drawings of the upper façade have been published (see Miller, 2018: figures 6.3, 6.4). On the north side, the plaster and stone mosaic panel depicts a least four visible felines facing intertwined elements (which have been identified elsewhere as serpents), crested by a reed motif and flanked by tasselled shields. The scene is extremely difficult to photograph given the narrowness of the excavated space between the façade and the consolidated fill of the overlying Castillo. On the upper façade of the south side of the sub-temple, only the central two felines have been exposed (and are visible). Based on our measurements, it is likely that the north and south upper façades each support eight felines – four on each side of the intertwined elements (facing the center of each side of the temple). Note that the east and west sides of the exterior of the sub-temple were not exposed by excavations. Our structured-light scans (using the Artec Leo) now serve as the definitive representation of these portions of the Castillo-sub (Figure 7 and 8).

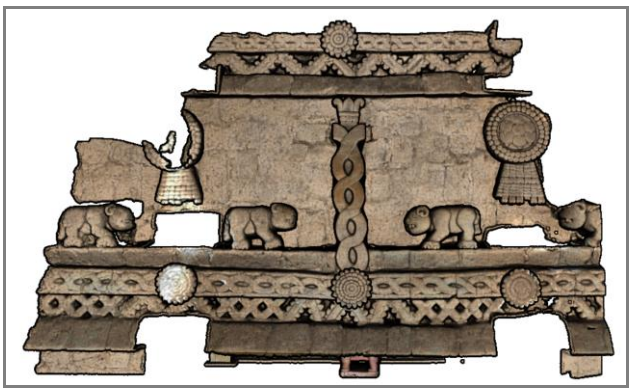

Figure 7. SLS scan of the upper façade of the sub-temple, north side. Note the similarities and differences between the scan and the reconstruction drawings in Figure 9.

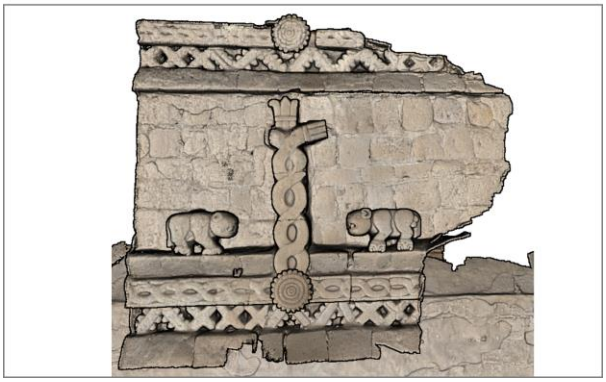

Figure 8. SLS scan of the upper façade of the sub-temple, south side. Note the tassel-like element at the end of the one of the intertwined elements.

These scans enable us to reevaluate the earlier reconstruction drawings, which vary significantly in accuracy. Again, this is likely the result of scholars not being able to gain a clear view of the upper façade on the north side, in particular. A ladder or scaffolding is required to accurately record or document this tableau. Though often cited and reproduced, the illustration by Remondet (Tozzer, 1957: fig. 86) is especially inaccurate and misleading (Figure 9, left). Notably absent in our scans are heads terminating the intertwined elements, which have been commonly attributed to serpents. An illustration that appears in Cirerol Sansores (1948) also depicts serpent heads. While it is conceivable that these are in fact serpents, and their heads have since been broken off (intentionally or otherwise), there are no residual features at the distal ends of these elements that are suggestive of serpent heads. Moreover, one of the intertwined elements on south side exhibits something that could be better described as a tassel (see Figures 8 and 10). Finally, the scales depicted on Remondet’s “serpents” are entirely absent in the scans.

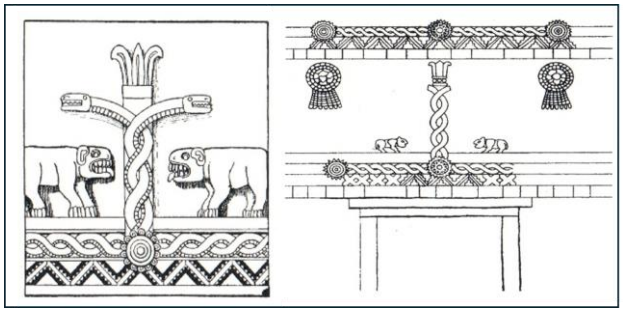

Figure 9. Reconstructions of the upper façade of the sub-temple, north side. Left, after Tozzer, 1957: fig. 86. Right, after Erosa Peniche, 1947.

Upon close inspection of the ends of the intertwined elements – the two on the north façade and the one without the tassel-like element on the south façade – it appears that carved stones or stuccoed pieces were once attached to the walls (Figure 10). It is reasonable to assume that elements matching the intact one on the south façade (Figure 10, right) were attached here. However, it is difficult to know whether these elements completed the scene. Regardless, there is no visible evidence of serpent-like heads.

In many respects, Erosa Peniche’s 1947 reconstruction is more accurate (Figure 9, right). Captured in this drawing (and not in Remondet’s, for example) are three circles associated with the reed bundle. Bey and Ringle (2007:412) suggest that the reed motif, in this context, is emblematic of Tollan. It should be noted that rosettes are located above and below each tasselled shield across the façade, though they are either absent or misplaced in other reconstructions – including the full-scale reproduction in the Gran Museo de Chichen Itza (personal observation, 2024).

Figure 10. Closeup SLS scan of the termini of the intertwined elements (often interpreted or described as serpents). North façade (left): note the surface where it appears that a carved stone or stuccoed element was once attached. South façade (right): note the intact tassel-like element.

The felines in the Erosa Peniche reconstruction (Figure 9, right) are rather diminutive, and we would argue that none of the drawings or reconstructions are particularly representational with respect to these cats. Again, the SLS scans provide an exceptionally high level of detail and allow for closer examination of these feline sculptures (Figure 11). It is interesting to note that among the five complete felines captured in our scans, only one (on the south façade) lacks obvious testicles (see Figure 8, feline on the left side). As a final observation, it is possible that the felines were originally painted and may have had spots (characteristic of jaguars). Perhaps due to their current unadorned state, they are thought to be pumas.

Figure 11. Closeup of SLS scan of a feline, south façade. Note the pronounced testicles, which indicate the cat is male.

It is likely that four tasselled shields adorned both the north and south upper façades of the sub-temple, though none are visible on the exposed portion of the south façade. The most complete tasselled shield is on the right side of the north upper façade (see Figure 12). Seven U-shaped motifs appear on the shield. In terms of style and decoration, the shields (possibly represented as feathered) bear a strong resemblance to those found on the Upper Temple of the Jaguar and exhibit Toltec affinities (Bey and Ringle, 2007:412).

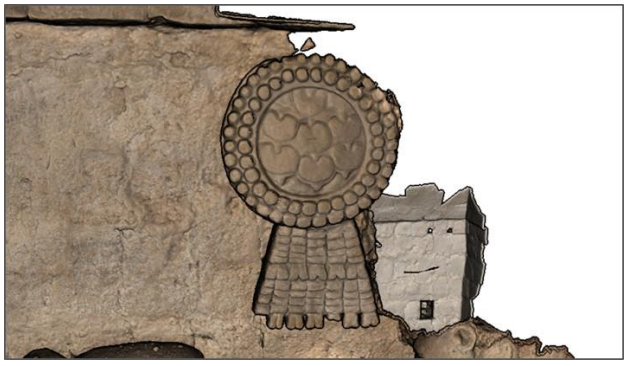

Figure 12. Closeup of SLS scan of a tasselled shield, south façade. This the only complete example on the sub-temple.

5. Concluding Remarks

The scanning campaign reported here affords researchers and conservators an opportunity to better visualize and evaluate the relationships between the Castillo and the Castillo-sub. The structured-light scans of the Chacmool, jaguar throne, south wall of the inner sub-temple, and the sub-temple upper façades offer the highest resolution and most accurate geometry and texture data to date. Our multimodal and multiresolution approach was designed around the unique environments and access challenges of the Castillo-sub and the need to capture specific features in greater detail. Nevertheless, we would advocate for a comprehensive and systematic follow-on survey and scanning campaign that would employ a high-end TLS for capture of all available Castillo and Castillo-sub exterior and interior surfaces and spaces.

Our near-term goals involve additional spatial and contextual analyses based on the scan data featured here as well as the completion and launch of the online, interactive 3D atlas of Chichen Itza, which will afford users open access to all the original datasets and derivatives produced by our project. This larger effort involves the digital documentation of the carved stone mosaic façades, sculptures, architectural features, and monuments of the civic-ceremonial center of Chichen Itza. Ambitious in scope and scale, this ongoing campaign continues to respond to the 3D documentation priorities of INAH and its partners.

Many of the carved stone architectural elements, sculptures and monuments have been removed from the site over the decades and can be found in museums, labs, and storage facilities at or near Chichen Itza and across Mexico. As well, numerous sculptural components, like those of the celebrated serpent columns of Chichen Itza, lie scattered around the site. As they cannot be easily moved and repositioned or reassembled, working with their digital counterparts has proven to be empowering and revealing (see McAvoy et al., 2025). Such efforts are contributing to a more comprehensive and complete picture of Chichen Itza.

The story of Chichen Itza is, in part, writ large in the iconography of its buildings. By scanning the carved stones located on- and off-site – as well as the building façades themselves – it is possible to digitally recontextualize these pieces and complete the architectural tableaus. By providing access to the growing corpus 3D data, we can enable researchers and conservators to participate in this iterative and collaborative process.

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