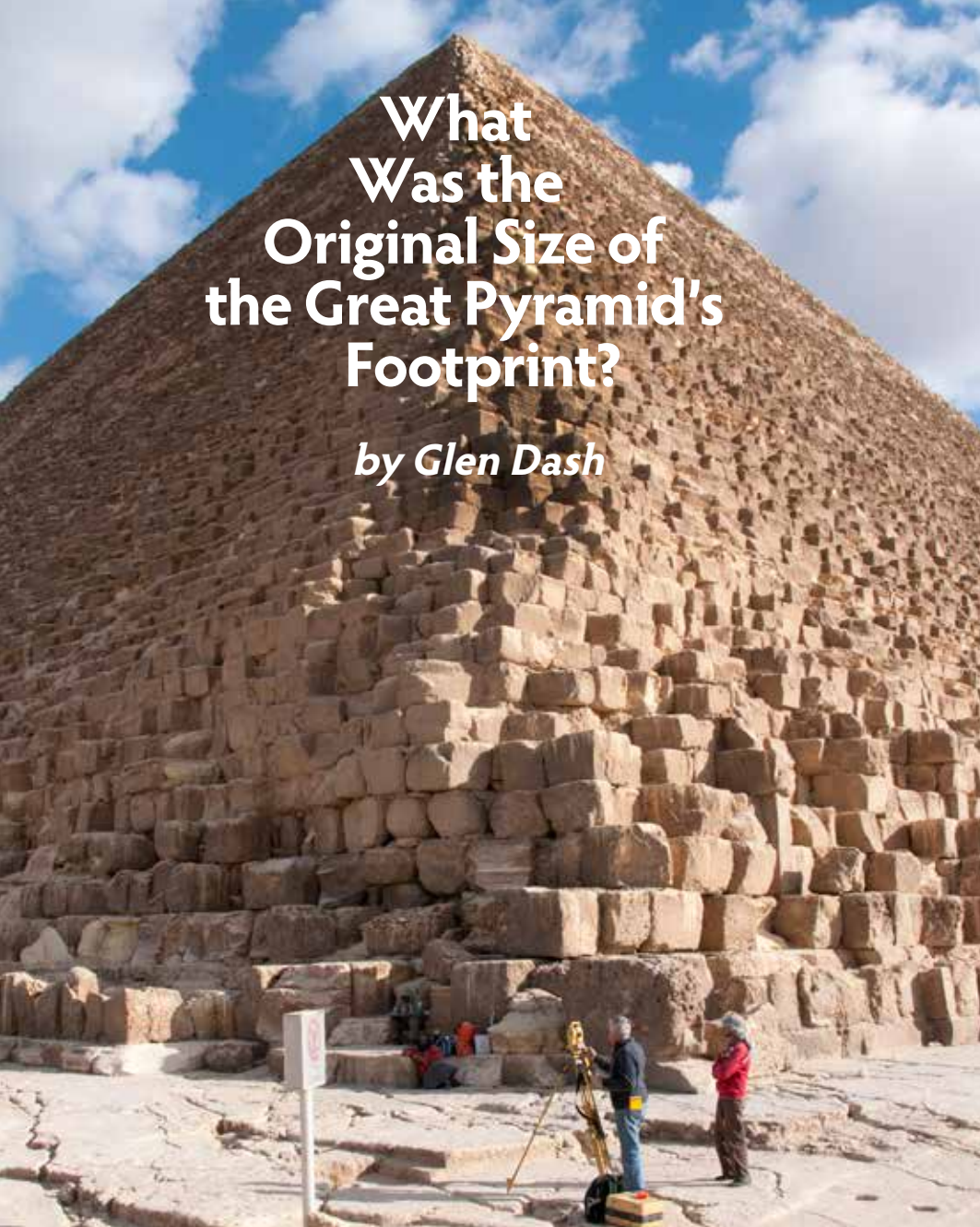


# What Was the Original Size of the Great Pyramid's Footprint?

by Glen Dash



*How large a footprint did the Great Pyramid make on the Giza Plateau when it was completed? It is not an easy question to answer, as most of the outer edge of the pyramid's base is long gone. Scholars have had to hunt for evidence of the ancient baseline and then extrapolate their findings to locate the original corners. Not surprisingly, the surveys that have been conducted to date do not precisely agree.*

*With the question of the Great Pyramid's footprint still incompletely resolved, another attempt seemed in order. So this past season, with the permission and cooperation of the Ministry of Antiquities, the Glen Dash Foundation and AERA undertook a new, comprehensive survey of the base of the Great Pyramid. Here Glen Dash presents a brief overview of that work.*

In 1880 and 1881, the noted Egyptologist Flinders Petrie<sup>1</sup> surveyed the base of the Great Pyramid, publishing his findings in 1883. His work was followed by J. H. Cole's,<sup>2</sup> J. Dorner's,<sup>3</sup> and E. Nell and C. Ruggles's,<sup>4</sup> published in 1925, 1981, and 2012, respectively.\* But none of these surveys seemed completely satisfactory. Therefore, last year I proposed that AERA and my foundation undertake our own comprehensive survey of the



Above left: Where is the corner of the Great Pyramid? Where is its outer edge? This photo of the northwest corner illustrates the problem a surveyor faces in trying to measure the sides of the monument or determine its precise alignment. The Great Pyramid, stripped of most of its outer casing stones in the Medieval period, is left with ragged edges and ill-defined corners. Photo by Mark Lehner.

Left: Our first task was to find those places where the original casing of the Great Pyramid met its platform. Here on the north side is one of the few places where well preserved casing stones survive. Photo by Mark Lehner.

This portion of the west side of the pyramid exhibits some of the best evidence of where the casing stones once met the platform. The circles, drawn on the photo, indicate where Mark Lehner identified two such points. Photo by Mark Lehner.



base of the Great Pyramid using the best available technology and personnel. We carried out the survey in February 2015.

### How Do You Measure the Base of the Pyramid?

The ancient Egyptians clad the Great Pyramid in more than 21 acres of hard, white casing stones that they hauled over from quarries at Tura across the Nile. The lowest course of casing stone was set on a carefully sculpted platform which once extended 30 to 50 centimeters (12–17 inches) outwards beyond the casing’s outside, lower edge (the casing’s “foot”). The photo at the bottom of the facing page shows the relationship between the platform stones and the casing stones. Behind the casing stones sits the rougher masonry that makes up the bulk of the pyramid as we see it today.

We define the base of the Great Pyramid as the place where the foot of the casing stones met the platform. However, we find few casing stones *in situ* today; most were removed centuries ago for building material. The Great Pyramid is approximately 230 meters (755 feet) to a side, but along its 920-meter (3,018 feet) periphery we now find only 54 meters (179 feet) of casing stone in place, and much of that is badly eroded. To determine the pyramid’s original lines, we needed more information than we could get just by examining the surviving casing stones. We needed to carefully examine the platform for signs as to where the missing casing stones once stood.

The marks on the platform that could supply that information can be subtle. In setting out the goals for this project, I felt that only someone like Mark Lehner, who has worked at Giza for more than 30 years, would be able to reliably identify where a particular missing casing stone’s foot once met the platform. To find those points, Mark started with the casing stones that remained, looking for places where the casing’s foot met the platform. This leading edge, however, was almost always worn back. Sometimes there was an etched or cut line in front of it representing the original edge. More often, Mark looked for



The casing’s lower edge, or foot, is worn back making the original lines of the pyramid difficult to identify. For the 2015 survey, Mark Lehner identified those points representing the pyramid’s original lines using the knowledge and experience he has gained in working at Giza for more than 30 years. Here he locates points on the west side. In the background, Glen Dash observes Mark at work. Photo by Rebecca Dash.

Joel Paulson, surveyor for the Glen Dash Foundation Survey, sets up a survey reflector over one of our control points. Joel, of NV5, Inc., (San Diego, CA) is an Egyptologist and professional surveyor. Amr Zakaria, surveyor with the Egyptian Ministry for Antiquities, holds the base of a tape used to measure the height of the survey reflector. Photo by Ashraf Abd el-Aziz.



\* Glen Dash’s article “New Angles on the Great Pyramid” in *AERAGRAM* 13-2, pages 10–19, Fall 2012, reviews the history of efforts to map and survey the Great Pyramid. Glen also presents the data that Mark Lehner and David Goodman collected in 1984 when they surveyed the Giza Plateau and gives the dimensions and orientation of the pyramid based on an analysis of that data. All back issues of *AERAGRAM* are available for free download at our website: aeraweb.org.

more subtle clues, places where the surface of the platform had been worn or eroded due to the presence of the now missing casing stone or edge.

### Finding the Points

At the project's outset, Mark walked the survey team around the pyramid, pausing to identify points where the casing's foot might have fallen. Each side of the pyramid presented its own challenges.

**The North Side.** The best-preserved casing stones are on this side. Here Mark found the evidence of where the casing's foot once met the platform at 16 points. These spanned a length of 51.3 meters (168 feet).

**The West Side.** The west side of the pyramid has more casing stones than the north, but they are badly worn. In some places Mark found a cut line in front of the casing stones demarcating the original edge. In other places, a subtle line formed by wear or erosion yielded clues as to its original location. Mark identified 30 points along 49.4 meters (162 feet) of casing that were worthy of measure. These flank the midpoint of the west side.

**The East Side.** The casing line on the east side was poorly preserved. Only two casing stones survived *in situ* and since the foot of both was broken away, neither provided useful data. All the points Mark found were south of the midpoint and consisted of little more than wear marks on the platform. Mark identified 25 points spanning a distance of 15.6 meters (51 feet).

**The South Side.** We found no direct evidence of where the casing stones once met the platform on this side. All we could do was measure the top outer edge of the casing stones and project where the casing stones once would have fallen on the platform below (top photo on facing page.) Fortunately, we found the top outer edge of the casing stones reasonably well preserved and, once again, Mark selected the points. He identified 13 points along 38.4 meters (126 feet) of casing.

In total, we identified 84 points along 154.7 meters (508 feet) of platform and casing well-preserved enough to record and utilize. Since the pyramid is about 230 meters on a side, 155 meters amounts to about 17% of the pyramid's total periphery.

### Survey Control

Our next task was to recover our survey control monuments at the four corners of the pyramid. These are our reference markers and without them we would be unable to locate where our survey equipment was placed on the plateau, and likewise, where the features we wanted to record were located. Two of these survey control monuments consist of bronze markers which were set in place outside the northeast and northwest corners of the pyramid by Royal Astronomer David Gill in 1874. We found them in place and relatively undisturbed (photo of marker at the northeast corner on facing page). One



For a photographic record of each point we surveyed, Joan Dash holds a board with the point number, while Mohammed Abd el-Basset, surveyor with Egyptian Ministry of Antiquities, holds a rod with a reflector mounted on its top over the point. This point is on the pyramid's platform on the south side just to the west of the surviving casing stones. Photo by Ashraf Abd el-Aziz.

more marker, at the southeast corner, was set in place by the Survey of Egypt's J. H. Cole in 1925. Cole had found an empty socket here where one of Gill's markers once had been and set a new monument in place. Presumably, the Gill monument had been stolen by vandals. We found Cole's monument covered in debris and sand, which we cleared. We then discovered that the control monument at the southwest corner, originally set by Gill in 1874 and reset by AERA surveyor David Goodman and Mark in 1984, had been stolen as well. Fortunately, one of Flinders Petrie's nearby control monuments, consisting of a hole drilled in the rock and filled with blue plaster, did survive, so we used that as our southwest reference marker.

### Surveying the Great Pyramid's Sides

With our survey control monuments identified, we could proceed with the survey. To record points, Joel Paulson trained his total station on a target held by either Mohammed Abd el-Basset or Amr Zakaria. Joan Dash kept track of the points being surveyed, writing a unique point identification on a white board she held (photo above). Ashraf Abd el-Aziz, AERA archaeologist and inspector with the Egyptian Ministry of Antiquities, took a photograph of each point as it was being recorded.

We assigned each point a number from AERA's point registry, and, following standard survey methods, recorded its position on a coordinate system established by Mark and David in 1984

known as the Giza Plateau Mapping Project (GPMP) control network.<sup>5, 6</sup> Eventually, we plan to publish the location of each point we measured along with Ashraf's photograph of it.

The map on the lower right shows the points where we found evidence of the pyramid's original baseline. Using statistical techniques, I will be working on finding the best fit lines that match these points and then extrapolating these lines to the corners. Where the extrapolated lines cross will indicate the approximate positions of the original corners of the pyramid. Once the corner locations have been identified, I can estimate the original size and orientation of the pyramid.

Because of the pyramid's current state we will never know its exact dimensions. However, from my preliminary analysis, I can say that we will be able to locate its corners to within a few inches with a 95% certainty.

### More Survey Data

Along with recording places where the casings fell on the platform, we also recorded and photographed more than 1,200 points on and around the Great Pyramid. All this evidence should help us better understand this last surviving wonder of the ancient world. I will be reporting on our survey findings in future issues of the *AERAGRAM*.

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Right middle: Bronze marker set in place outside the northeast corner of the Great Pyramid by Gill in 1874. This one and markers at the other three corners of the pyramid served as reference markers for the Glen Dash Foundation Survey. The total station tripod stands over the marker as Glen crouches, pointing out a feature. In the background, Rebecca Dash photographs Glen at work, and beyond, tourists meander about the pyramid. Photos by Ashraf Abd el-Aziz.

Right bottom: The points we located and mapped for the baseline survey are shown as blue dots on the GPMP survey grid for the Giza Plateau. In setting out the control network, the center of the Great Pyramid was assigned a location of North=100,000 meters and East=500,000 meters. Our control markers at the corners of the pyramid are shown as orange dots.



On the south side of the Great Pyramid there was no direct evidence of where the casing stones met the platform. In order to project where the casing stones once would have fallen on the platform below, Glen Dash measures the top outer edge of the casing stones, assisted by Rebecca Dash. Photo by Mark Lehner.

