Introduction
This report presents results from measurement studies of distances and angles between mounds and other circular features appearing on photogrammetric imagery and their correspondence to intervals of 86.6 meters. This distance was determined by John Clark (2004) as a Standard Measurement Unit (SMU) in North America derived from his study of Middle Archaic mound complexes (ca. 6950-3750 cal B.C.) in the lower Mississippi River region of North America. In a related study at Poverty Point, Louisiana, Sassaman (2015) demonstrates that one, and possibly three Archaic mounds, along with later constructed mounds both use this unit of measurement as does the concentric elliptical earworks constructed some 2,000 years later.

The juxtaposition of dissimilar monuments using the same unit of measurement over an expansive time period, led to considering if such a scenario existed at Serpent Mound. Here the site is dominated by a ~ 1,427 foot earthen serpent sharing an elevated plateau with an undetermined number of mounds, most of which are not discernible by casual observation. The three used in my study are quite prominent and are located south of the effigy. Two are circular and attributed to the Adena culture (ca. 800 BCE-1 CE). The third is elliptical or vesica shaped and dated to the Fort Ancient Period (c. 1000-1650 CE). While still being debated, current thinking attributes the Serpent effigy to Adena and may have been repaired and/or modified during Fort Ancient.

It became incrementally apparent the triangular array is deceptively complex due to the correspondence of numbers defining distance, diameters, angles and azimuths, to numbers related to Venus and Lunar orbital motion, and to Universal Transverse Mercator zones at the equator. It was also determined the mound siting is based upon Venus tables appearing in extant Postclassic codices, and is a physical representation of the Tzolkinex Eclipse Cycle. This expanded research into matters relating to archaeoastronomy and Mesoamerican calendrics.

Given the amount of inter-related topics, I am including only results regarding: (1) the process of developing an accurate as possible geometric model, (2) the array’s scalar and calendric

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relationship to UTM zones and to other ancient sites, (3) and demonstrate the method by which likely affiliated archaeological sites are established in the landscape surrounding the site proper.

Methodology
My results are based on the software linear and angle measurements between center points and tangential to circular features on diagnostic quality scaled and unscaled imagery of Serpent Mound and other sites in the Western and Eastern Hemispheres available from the internet. It was a highly visual based process producing considerable empirical data acquired overtime by simply recognizing repeating shapes, patterns and recurring numbers. In some respects, the method can be described as reverse-engineering, or in other words, finding an explanation for a length or angle.

First, the native image matrix was scaled to correspond with the scale index appearing on the image and software linear measurement tools were set to read in meters or kilometers. A circle transparency (500 x 500 pixels) was then placed on the circular features and adjusted to fit. Invariably, the diameter will correspond to a SMU interval and thus registers as the horizontal size of the transparency. The diameter is then verified with a linear measurement. Because of the spacing between intervals, in most cases there was no ambiguity as to the diameter.

Circular features were divided into two categories. Those which are obvious by their appearance or being a known archaeological structure, and those which are less obvious. The latter are those which presented a sufficient partial continuous margin, or segmented margins, on which a transparency could be placed with confidence.

The angular position and distance of these features are then measured. If these measurements produce numbers which were known recurring numbers, the feature is accepted. A listing of these numbers is too lengthy to include, but are numbers based on intervals of 13(13i), 20 (20i) and 86.6, with 13 being a product of the Earth-Venus orbital resonance and as a basic period in the Mesoamerican calendar along with 20. Two other geometric shapes of interest were the elliptical or vesica, and the reuleaux equilateral triangle. They are formed from the overlapping of two and three circles respectively.

The inherent limitations of my method was principally a result of the often nebulous center points of a feature which was particularly troublesome in determining the overall geometry of the array. The triangle transparency used in this report was refined over a period of about one year as distance-time relationships, astronomical and other information was acquired. It represents a model which is accurate as possible.
Triangle Morphology

The geometry of the triangular mound array conforms to an asymmetrical pentagram whose shape is derived from Venus data appearing in the Mesoamerican Mayan Dresden Codex. This pentagram differs from a geocentric pentagram having five equally sized points, which is typically used to illustrate the Venus orbital pattern and the 5 inferior conjunctions occurring during its 13 orbits in 8 Earth years, after which time it returns to its starting point.

Briefly explained, the unique shape is derived by transferring tabular codex day sign sequences to a von Koch fractal square matrix and then connecting the points (Illus.1). Each day sequence produces the pentagram in a different orientation. The developer, Stan Cizek⁵ argues that in addition to providing data for the 260 day ritual calendar, the pentagram represents “the actual projection of the Venus orbit considering not only the different planet positions, but also, different distances when observing from the Earth. In other words, an Earth centric observation tool/method preserving correct measuring proportions”⁶. (emphasis added)

Absent any pentagram geometric data, a transparency model was created from Cizek's graphics using graphic software. Experimentation showed that only one of the pentagram's interior angles of 114⁰, will conform to the angle located at mound 2 (M2). This measured angle is presumed accurate because of the relationship of the adjacent 66⁰ angle (141+66=180) to the 666 km width of a Universal Transverse Mercator (UTM) zone at the equator and being embedded in SMU 86.6 (86.6 / 13= 6.66. This is discussed later.

Refining the intended orientation to 1/10th of a degree and the celestial used was problematic. Because only M2 presents a well defined margin on which a 6.93m (SMU 693.04) circle transparency precisely fits, it served as the “pivot point” to rotate the triangle over the broad top of M1. Rotation is limited to several ± 0.1⁰ before the point at M3 moves off the mound and the M2-M1 azimuth visually does not look centered on M1. Because it is doubtful if the human eye would be able to differentiate a tenth of a degree or so at the horizon, this provided no solution.

⁶ From personal correspondence.
Azimuthal Projections

The orientation question was decided by extending azimuths to the equator using Google Earth in the Universal Transverse Mercator mode. As mentioned earlier, there is a numerical relationship of the pentagram’s 66 degree angle and the 666 kilometer width of a UTM zone at the equator. A line extended from M2 at 110.4 degrees terminates at the junction of UTM zones m26 / m27 and the projection from M1 at 246 degrees arrives 19 kilometers west of junction m8 /m7 (Ills. 4, 5). Please note the embedded 104 which is a 13i or SMU 103.9.

Illustration 3: Site plan showing triangular Adena mound array representing the Tzolkīnēx Eclipse Cycle and it’s position within a pentagram, with intermediate trajectories, derived from the Dresden Codex. Note the pentagram’s intermediate dotted extension relative to the rectangular feature in upper right. Image: Ohio Valley Archaeology

Illustration 4: Various inter-hemisphere azimuthal projections. Credit: Google Earth
The following calculations demonstrate the distance-time relationship:

19 UTM zones x 666 km = 12,654 km + 19 km = 12,673 km.
12,654 / 346 = 36.5 = 1/10th Solar year
12,654 / 365 = 34.6 = 1/10th Eclipse year
Difference = 1.9 = 1/10th of 19, the difference between the two years in days.
12,673 / 73 = 173.6 = the 173.26 m distance between M2 and M3
173.3 = ½ Eclipse Year

A mathematical correspondence to Venus is implied with the numbers 73 and 0.13 (246°-245.87°).

73 x 5 = 365
73 x 8 = 584 days in synodical period (583.92)
5 Synodical cycles (5 x 584) = 2920 days
8 x 365 = 2920 days
2920 / 13 = 224.6 day orbital period (224.7) also = M2-M3 azimuth

Another indication of the model's accuracy is its correspondence to the Tzolkinex Eclipse Cycle. Briefly explained, the cycle is one of a number of eclipse cycles relating to the recurrence and periodicity of lunar or solar eclipses. The name is derived from the cycle's duration of 2598.69 days being closely equal to 10 Mesoamerican Tzolk'ins (10 x 260 day periods). The average Eclipse year is 364 days. Expressed by formula:

2 Saros cycles – 1 Inex cycle
6585.3211 x 2 – 10571.95 = 2598.69

with:
- 1 Saros = 6585.3211 days = 18 years = 223 lunar synodic months.
- 1 Inex = 10,571.95 days.
- 1 Tzolkinex = 95.497 Draconic months with each month consisting of 27.21222 days (95.497 x 27.21222 = 2598.69).

7 An important Mayan calendric ceremonial period.
This indicates the 173.26m side corresponds to ½ Eclipse Year, which is also the number of days between eclipse seasons. The 223 azimuth corresponds to 223 lunar synodic months of the Saros cycle, and the 95.5m side equals 95.497 Draconic months.

As noted in illustration 4 were the results of other vectors drawn from Stonehenge and the City of Mecca to the equator. These in summary are:

- 260° from Stonehenge Barrow 94, England (Ill. 8), converges with a 173.26° line from M2, with 173.26° being the distance between M2-M3 in meters converted to degrees.
- 260° from Mecca, Saudi Arabia terminates at m26-m27 and a 52°, 11,099 km line to M2. Dividing 11,099 km by the synodic period of Venus (584) equals 19 = number of days between the Eclipse and Solar years and the number of UTM zones representing 346 days.

Not shown are lines drawn from Stonehenge to Poverty Point (Ill. 7) and Serpent Mound (SM) at 291.6° and 291.73° respectively. These closely correspond to SM's 290.4°. Other measurements, including the Mississippian Cahokia complex, produce similar results.

The specifics of how this occurs is not understood at this time, but the general concept can be portrayed on a regional scale by rotating and scaling a triangle transparency to align with three locations (Ill. 6).
Affiliated Complexes

Azimuth projections from Serpent Mound and other sites into adjacent landscapes showed likely affiliated sites whose locations are based upon an SMU interval. One of the more striking examples is shown below. When a line is extended from M2 across the 173.26 meter triangle leg 1.73 kilometers, it terminates in a grove of trees on a plateau presenting numerous circular features. Historical Google Earth images show the grove and several other close by obvious features.
circular features have not been tilled in recent times in an otherwise farmed area. Others appear to have been tilled, but still retain a circular shape.

Similar appearing depressions along the Brush Creek plateau at the Serpent site proper have been reported as possible Karst sink holes. Those located within the Serpent effigy design itself, give the impression the Serpent was designed around them (see Herrmann 2014). The implied cosmological association as an entrance to the underworld would support such an interpretation.

Nevertheless, the cluster of these features at 10 times distance from and on the azimuth projection from M2 strongly suggests they are non-coincidental.

As with all distance measurements, this azimuth produces numbers associated with Venus and the Moon.

The 223.3 azimuth when extended from M2 to the equator arrives 12 kilometers west of of UTM zones m12 \11, is 5333.88 Kilometers in length.

- 5,333.88 / 73 = 73.066, a number associated with Venus.
- 5,333.88 / 666 = 8 years, the time for Venus to make 13 orbits, the moon 104 orbits, or SMU 1039.56.
- The distance between azimuths 110.4 and 223.3 at the equator = 10,002.07 kilometers 10,002.07 x 73 = 130026.9 / 1000 = 130.03 x 2 = 260.06 which be viewed as 260 days or degrees, an interval of 13, or SMU 259.89.
- 365 days / 13, the number of Venus orbits in 8 years, = 28.076923 x 8 = 224.6, which is close to the 224.7 day orbit of Venus around the Sun. 224.6 days – 223.3° = 1.3.
- 13° = lunar motion in one day and 130° marks the Maximum Southern Moonrise.

Closing Comments
At this time there are many unresolved questions requiring additional study. As such, drawing any clear-cut conclusions would be premature. It is analogous to a large jigsaw puzzle where enough pieces have been assembled to get a general idea of what it represents, but to many pieces are missing to be specific.

It is clear however, the Adena had command of knowledge far exceeding basic alignment techniques and were seemingly Venus centric. Though corresponding to a later in time 13th century codex, the earliest evidence of the Venus cycle in Mesoamerica can be traced to Protoclassic Veracruz, Mexico (2000 BCE-250 CE) contemporaneous with Adena. My interpretations of Poverty Point and the inter-site positioning of regional Middle Archaic complexes, suggest this knowledge preceded the Veracruz Olmec time period. Similar results from Stonehenge Neolithic mound and circular monuments and ongoing analysis of sites in

8 Herrmann, Edward, etal. (2014) www.researchgate.net/publication/264161570_A_new_multistage_construction_chronology_for_the_Great_Serpent_Mound_USA
Western Eurasia and South America, suggest wide spread use of these conventions extending even further back in time.

A following report will address astronomical alignments focusing on Venus and how the array, along with proposed intermediate azimuths, can be used for tracking the 260 and 365 day calendars. I will also address the positional relationship of the Serpent effigy and mound array.

Jon R. Haskell, 2019

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Stan Cizek whom I discovered was approaching a similar subject but from a different perspective. Chancing across his asymmetrical pentagram was pivotal in understanding the geometry of the array.