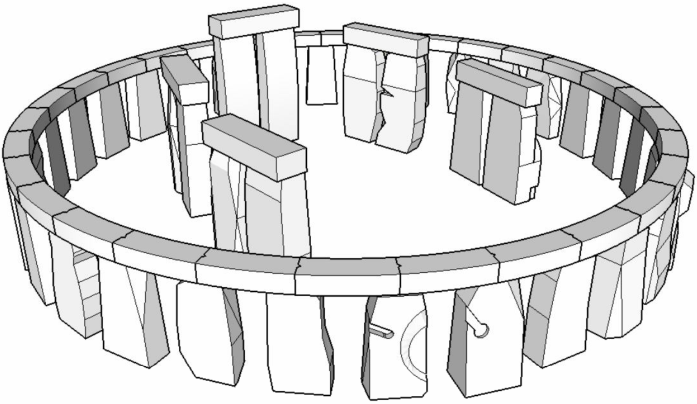
Thank you …

for choosing to download a preview of Dean Talboys' new book *The Stonehenge Observatory*. It includes the *Introduction* to Stonehenge together with large sections from the chapters dealing with the subjects of *Astronomy* and *Projection*, and a behind the scenes look at development of the 3D models.

THE STONEHENGE OBSERVATORY



Expand your experience of this remarkable book with access to the 3D model online at

http://www.stonehengeobservatory.com

Visit the site for a list of requirements

DEAN TALBOYS

Introduction

Nowadays you'd be hard-pressed to find a builder willing or able to construct you a house of natural stone blocks weighing upwards of 20 tons. If you did manage to find one but then said you wanted the stone brought from 30km (20 miles) away without the use of a truck he'd almost certainly think you were joking. When you told him he wasn't allowed to use any stone tools to cut, shape and finish the blocks, which had to be placed perfectly level on the side of a hill, he'd think you mad for sure, but that's what we're dealing with at Stonehenge. It's an ancient megalithic structure of unknown purpose standing in the English county of Wiltshire.

There is nothing like it anywhere in the world and, even more so than the Pyramids in Egypt, its origins pre-date all historical record. In this respect all we know for certain is that it existed before the Roman invasion of Britain as it was mentioned by Julius Caesar (2) in his account of the conquest of Gaul, the region now known as Western Europe. However, Caesar does little more than paint a picture of its (then) tenants, the Druids, who were involved in neither its design nor construction. It would be more than another fifteen hundred years before the condition of the stones was recorded by artists, and rather crudely at that. What they depict is a sight not too dissimilar to what we see today – the remnants of a ring of pillars topped by lintels, enclosing a horseshoe of five taller double pillars joined by a lintel (Trilithons), the entire site defined by a large circular Bank and Ditch and dotted with other stones of various shape, color and size.

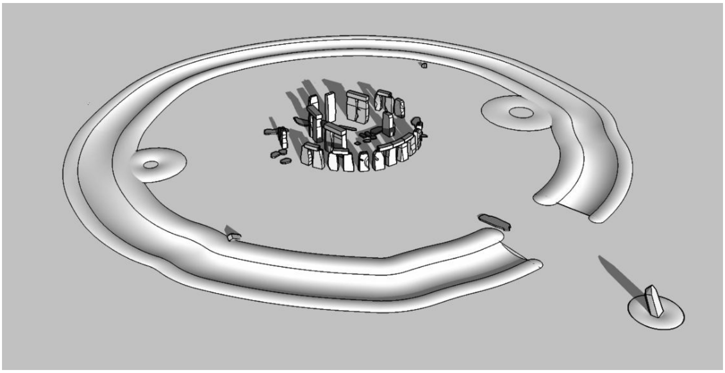
Efforts to make good stones fallen or leaning by the start of the 20th century were too little too late. Stonehenge has been the source of building material, so many of the more accessible and smaller stones from the lintel ring having disappeared it is fortunate that a few remain from which the original design can be reconstructed. And of all the stones only a handful stand in their intended positions, the others lying fallen, set upright or completely reset during restoration. A recent photograph shows the extent of this work, the view across the center of the site now obstructed by a restored Trilithon.

There has even been outrage that the stones were touched at all. Sir Edmund Antrobus, the 19th century "owner" of the site, believed it better left to nature. Regardless, work was undertaken, not only to restore but also to make safe the site during which archeologists have been allowed to excavate almost half of the ground to uncover even more of its mysterious past. For it emerged interest in Stonehenge *the location* started before the mighty Sarsen stones arrived. So numerous are the holes below ground it is impossible to discern any pattern, with the exception of a double ring of concentric holes which appear to have held the Bluestones –

smaller obelisks later distributed between the Sarsens. It's not as if the builders were short of space. Today you could still erect something on the scale of Stonehenge almost anywhere within a 10km (6 mile) radius of the current location. So what's the attraction? Perhaps it's the proximity to so many other unique ancient landmarks – the massive earthworks at Avebury, Durrington Walls and Silbury Hill, the superb chambered tomb at West Kennet Long Barrow, or the impressive timber holes at Woodhenge. Maybe it has something to do with the nearby River Avon. Or is it that Stonehenge lies at the vortex of so-called "ley lines"?

If Stonehenge is famous for anything it must be the alignment to that most important of annual events, the midsummer sunrise. Anyone who has spent time in England will appreciate just how easy it is to miss summer altogether, so what better way to ensure you don't forget than by building a massive reminder? It is on the "must see" list for thousands of tourists visiting England each year, not only during the midsummer festivities, and yet remains largely unknown outside of the United Kingdom. It is amazing how, on more than one occasion during research for this book, the reply from an astronomer, geologist or other authority in the field would begin "Though I am not familiar with the site ...", and at least one person contacted believed the site completely buried before discovery (presumably the entire surrounding landscape was excavated several meters as well to expose it!). Its exclusion from the Seven Wonders of the Ancient World could be excused by its geographic isolation (Greek historians didn't travel very far) and the much maligned *New Open World Corporation New Seven Wonders of the World* from which it is also absent turned out to be an online poll more indicative of cultural identity than true wonder, so much so that the Great Pyramid of Giza had to given an honorary candidacy. Though a finalist Stonehenge failed to get a placing, but what should England expect when the myth perpetuated by the archeological community is of a mausoleum built by Neolithic farmers in their spare time? Not that the winners were any more intriguing. The Taj Mahal, a true mausoleum commissioned by Emperor Shah Jahan in memory of his wife, was placed in the final seven along with several other national treasures from around the world, only one of which deserves to be labeled a “wonder”. Consequently, as with the Pyramids in Egypt, there is more interest in how Stonehenge was built rather than why, which is encouraged by the nation’s archeologists because proof of the ability to drag a slab around without the help of beasts or machines serves to reinforce the possibility that their ancestors alone were the builders. In this respect British archeologists should be careful. National pride led to the embarrassing episode of the Piltdown Man, once hailed by several British institutions as proof that evolution started in England but years later found to be nothing more than a collection of animal bones. Stonehenge is no archeological hoax, but neither is it a monument to British Neolithic ingenuity.

Throughout this book the various stages of the site’s development and redevelopment are illustrated using a 3D computer designed model. It has been created using information obtained from a wide variety of sources including modern maps, books, photos and personal accounts, and has been cross-referenced wherever possible to obtain as near perfect a representation within the limitations of data and software. This is a very important point. When a map is reproduced on paper and scanned into a computer the lines become pixilated and fuzzy. It becomes a matter of judgment as to exactly where a line starts and ends and a couple of pixels can affect positioning by a few centimeters. It may not sound like a lot, because it isn't, although some archeologists would like everyone to think otherwise in their arguments against any astronomical alignment at the site. The features of the site are so large and distances so great that errors of even 50cm (1½ft) have very little effect on results, and less so when you consider how inaccurate depictions of surveys at the site have been. Add the effect thousands of years has had on Stonehenge and arguing the precision of aligning the Heel Stone with a gap in the Sarsen Circle becomes almost as irrelevant as stating the age of the latter based on a single piece of antler radiocarbon dated to 2000BC – give or take four hundred years.

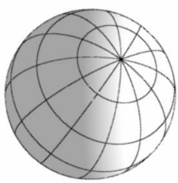


As the artist it is also easy to fall into the trap of presuming features related because they are aligned to another, a celestial event or something else on the landscape. For this reason the origin of any angles has been undertaken "blind", that is to say, once a stone has been aligned on the ground plan the reference map is then hidden while a line is extended. Any possible origins become apparent only when the map is made visible, but none have been doctored to coincide with another feature such as a missing stone. That is not to say the model is without artistic license. Many features are so badly weathered that their original size and design is lost forever. Missing pillars of the Sarsen Circle are an example. Though it may be safe to assume an original setting of thirty, the seventeen that remain upright are so irregular that a simple block design has been adopted as the basis for the others for the purpose of illustrating the original design. Those available for inspection on site are presented in sufficient detail in the model to highlight the quality of finishing between inner and outer faces. The relative height of stones is also open to interpretation. Heights stated in references as “above ground” are of no use when the site is on an incline, and with no GPS survey or cross-section available a datum had to be assumed. To avoid giving too much away early on in the book a full discussion on factors used to determine the sizes and positions of all features is left to the Appendices.

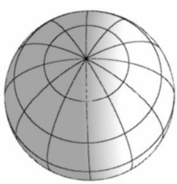
Having gone to all that trouble of ensuring accuracy it soon became obvious how characteristics of the design that survived the test of time (and all too often overlooked) were more important than the number of stones, their size, shape or distance apart. The conclusion is stunning in its simplicity.

6. Astronomy

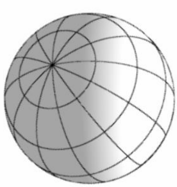
If you’ve ever seen models of the world (globes) you can’t help but notice how they are invariably tilted on their stands. This is a reflection of the Earth’s rotation about an axis inclined around 23.5° from the vertical (called “obliquity”) and accounts for our seasonal variations, for as the Earth maintains this inclination on its orbit around the Sun it is at one extreme leaning directly into the Sun’s rays and at the other directly away from them. These two points are the summer and winter solstice respectively. Around the time of the summer solstice the Sun rises over the horizon earlier than on any other day.



Summer Solstice
The Earth tilts towards the Sun producing the longest day and shortest night

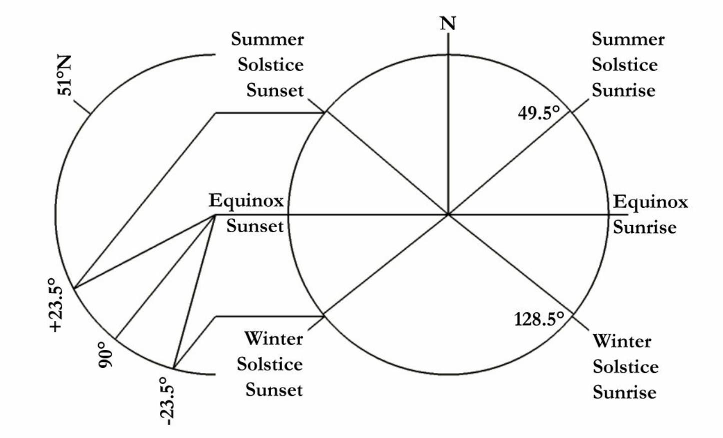


Equinox
The Earth's tilt is perpendicular to the Sun's rays producing equal day and night



Winter Solstice
The Earth tilts away from the Sun producing the shortest day and longest night

It also sets later than on any other day giving us the longest day of the year. The reverse is true on the winter solstice during which we experience the shortest day of the year. The spring (vernal) and autumn equinoxes occur at the midpoints of the solstices at which point there is equal day and night. Astronomers refer to the solstices and equinoxes as the start of the seasons whereas the familiar British terms “midsummer” and “midwinter” suggest otherwise, but are actually the same events (though in England summer and winter appear physically interchangeable!). The point on the horizon where the solstices occur can be derived from an orthographic projection.



At midday on an equinox the altitude of the Sun is at 90° to the latitude (this is altitude in the astronomical sense, i.e. the angle the object appears above the horizon, otherwise referred to as its elevation). At the summer solstice its altitude is higher than at the equinox by a value equal to the tilt of the Earth, and at the winter solstice its altitude is lower by the same amount. In practice the Sun is seen to rise slightly before (and set slightly after) the calculated value due to the refraction of light caused by water in the Earth's atmosphere. In effect the observer is able to see below the horizon. In each of the diagrams the calculated values are represented by markers on the outside of the circle and corrected values by lines inside.

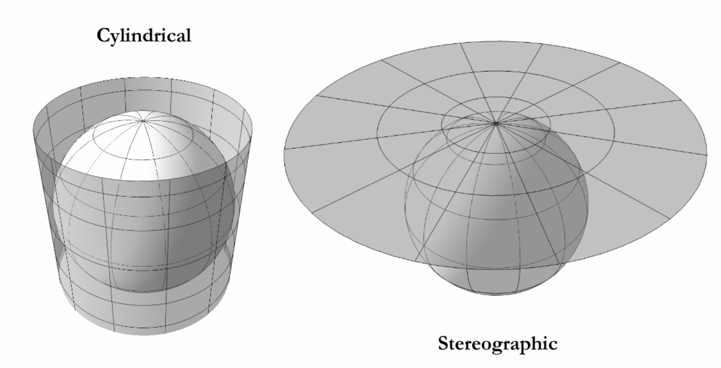
The Earth's Wobble

An effect known as *precession* affects the point in the Earth's orbit at which the solstices occur. If we return to our globe as an example, precession has the effect of turning its stand clockwise ever-so-slowly. Because the Earth orbits the Sun in an anticlockwise direction this rotation causes the solstices to occur increasingly earlier each year. Not that you'd be aware of it. Precession takes around 25,700 years to turn the globe's stand one full circle, so the solstices regress by one day every 71 calendar years. The point at which the Sun appears over the horizon on the longest day is not affected and any monument oriented towards the summer solstice *should* always point to it, only not on the same day unless the calendar you are using is adjusted for precession. It would if not for another effect caused by cyclic variations in the obliquity that can be likened to rocking the globe on its stand, which does affect the point on the horizon at which the Sun rises and sets. This takes around 41,000 years to go from 22.5° to 24.5° and back again, the last maximum calculated to have occurred in 8700BC and the next minimum occurring 20,500 years later in 11800. The present tilt is very close to the mean value and is decreasing, so the sun is rising around 2/100ths of a degree to the right every 100 years as far as Stonehenge is concerned.

(continued)

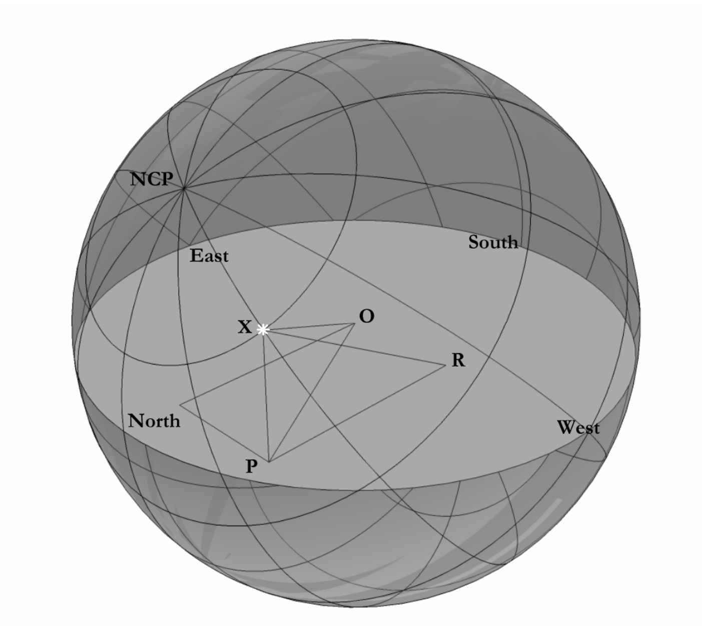
8. Projection

We're used to viewing the Earth as a flat map although we know it to be a sphere. The reason is the cylindrical projection developed by Gerardus Mercator in the 16th century which stretches the surface of the sphere so that the lines of longitude (from north to south) appear parallel, forming a grid with the lines of latitude, which are naturally parallel. In doing so the area of land is exaggerated the farther away it is from the equator to the extent that the map is all but useless above latitude 70° north and south, but the bearing between points on the map are preserved making it ideal for maritime navigation. Mercator's method has been improved upon in non-maritime applications including the pseudo-cylindrical maps used to depict the world in atlases. Essentially in any method properties like area, shape, direction, distance and scale are compromised and mapping the stars is no different.

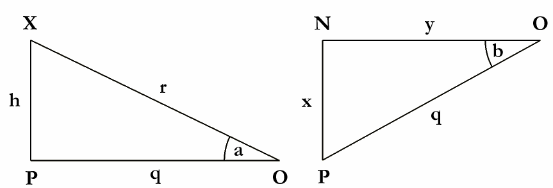


At Stonehenge the observer is in the center of a celestial globe tilted at 45° representing both the latitude of the site and the altitude of the North Celestial Pole (NCP) above the horizon.

In the following examples an observer (O) looks towards object (X) to the west of north (N).

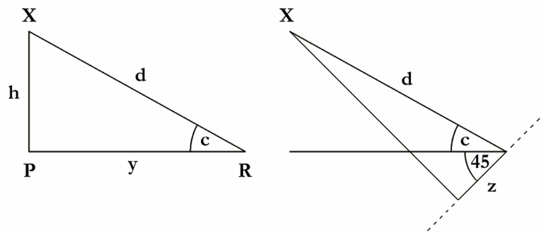


For a sphere of radius (r) the object (X) at altitude (a) is perpendicular to the ground at point (P) which is at a distance (q) from the observer at (O). At a bearing (b) point (P) is at a distance (x) east or west and (y) north or south of the observer.



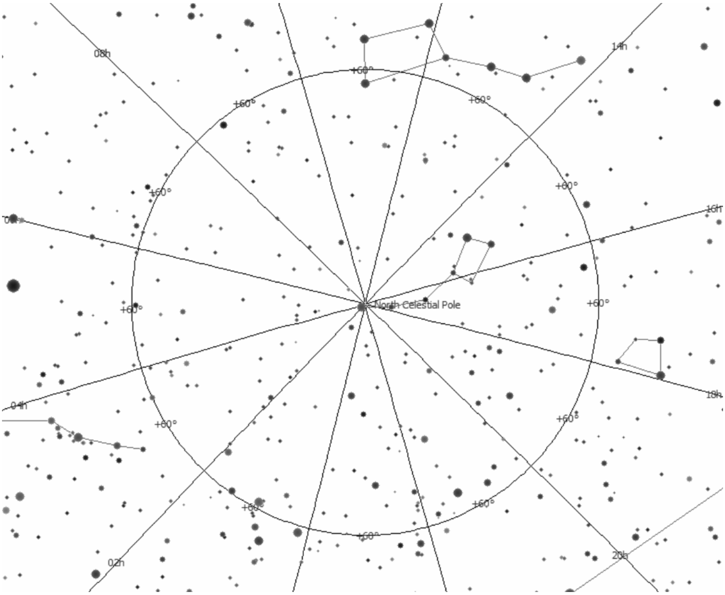
$h = r \sin(a)$, $q = r \cos(a)$ $x = q \sin(b)$, $y = q \cos(b)$

The (x) component is correct but (y) must be adjusted for the tilt of the globe. Object (X) is at altitude (c) from point (R) on the axis of tilt (i.e. east-west). The object (X) is then perpendicular to the plane of projection at a distance (z) north or south of the observer and its position can be plotted orthogonally.



$\tan(c) = h / y$, $d = y / \cos(c)$ $z = d \cos(c \pm 45)$

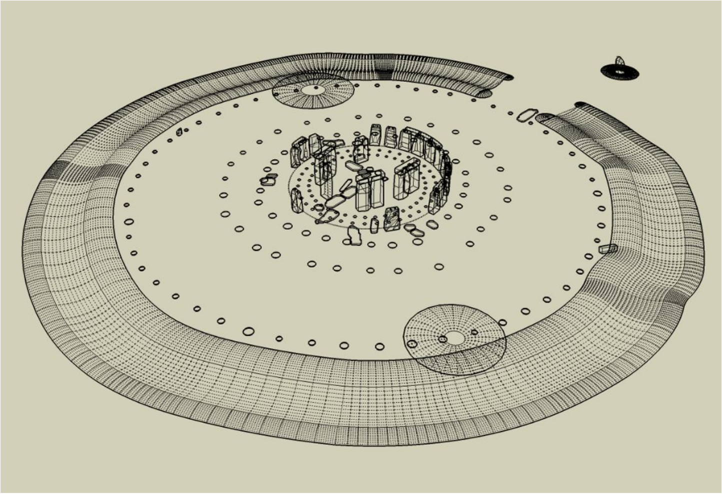
However, azimuth and altitude alone are not sufficient to map the stars. Because the sky is constantly moving overhead the star's position needs to be recorded against the known position of another or the time. Every 24 hours the stars make a full circle around the North Celestial Pole, a point in the sky which is, at present, occupied by Polaris, the Pole Star. When you know what position a star close to Polaris occupied on a certain date it's possible to calculate the current time by observing how many hours it has rotated around the sidereal "star" clock. For example, there are two stars in the constellation Ursa Major (aka The Plough or Big Dipper) that point towards Polaris and help synchronize the sidereal and regular clocks by appearing directly overhead Polaris, i.e. at 12 o'clock, at the start of March each year. The sidereal clock rotates anticlockwise at the rate of one hour per 15° of arc, half the rate of the hour hand on your regular clock or watch which completes two full circles every day, so you can approximate the time of day from the position of the two stars in Ursa Major. If they are to the left and level with Polaris the sidereal time is 90/15° or six o'clock in the morning, but only at the start of March. The solar clock which we use to tell the time of day runs about 28 minutes slower every week than the sidereal one, or, to put it another way, if you checked the time on your watch the stars in question would appear directly overhead Polaris about 28 minutes earlier every week from the beginning of March, but would be correct after one year as they are a full day earlier. If you know the current date you can compensate for the "error" by subtracting about half-an-hour from the sidereal time for every week since the start of March.



(continued)

The 3D Model

The software used to create the models was Google Sketchup Pro 6. All models were drawn to scale on a metric (mm) template. The basis for the main model is an Ordnance Survey (OS) map of the site that was scanned, imported and scaled as accurately as possible. More accurate information was obtained from texts and photographs. Additional models were created to illustrate possible methods of construction and the destruction of the site. All models are available to view in 3D online using the Hypercosm Teleporter plugin.



Topography

The site has been drawn flat with no attention to the slope of the land and oriented towards north as defined in the OS map. The immediate terrain is not as significant in sighting objects as is the horizon, and neither affect the measurement of altitude or azimuth at the Observatory. However, given more time and data it would be useful to provide relative heights of the horizon at least to better illustrate some of Gerald Hawkins' work.

The Center

A cursor of 30 markers 1m in length set at 12° intervals on a circle of radius 14500mm was superimposed over the scanned OS image. The cursor was manually positioned so that each marker lay between two pillars and the distance from the center of the cursor to the inner face of each pillar recorded. The cursor was then repositioned to adjust for differences in distances. This process was repeated until it became visibly impossible to adjust the cursor further. The center was recorded and the entire process repeated twice more. The difference between the three results was within 150mm from which the origin of the Sarsen Circle was established. It is 234mm from the center of the circle according to the OS map. The reason why the OS value was not used in the first place is that the method by which it was derived is unknown but was probably based on the symmetry of the Sarsen pillars described by Atkinson (1:38). When the lintel ring is generated with the OS value at its center the lintels are set inside the inner faces of pillars on the southeast of the circle by as much as 200mm and outside faces of pillars on the northeast by a similar amount. This deviation is all but eliminated with the origin used in the model.

Central Axis

A ring of 30 lintels was generated at a radius of 14651mm from the Center. The Central Axis is the line from the Center through the midpoint of the lintel straddling pillars 30 and 1 of the Sarsen Circle. It runs almost parallel to the axis of phase 3 on the OS map.

Bank and Ditch

The point at which the outside of the Bank meets the inside of the Ditch has been drawn as a circle of radius 50500mm from the Center to coincide with the OS definition of the outer edge of the Bank. It must be appreciated that this feature is the least defined of any at the site and the original Bank and Ditch featured in the Observatory is for illustration purposes only.

Post Holes, Stone Holes and Pits

All holes have been drawn as circles estimated from the OS map. In each case the center and size of the circle has been chosen to reflect as much as possible the location and minimum width. For example, the Y and Z holes are described as similar to bathtubs in their design but are depicted by circles in the same way the Aubrey Holes are represented at the actual site.

Sarsen Pillars

These have been drawn to scale and as accurately as possible given the information available and designed to be representative of any obvious feature (e.g. a significantly large chip or hole). A height of 4100mm was assumed for each pillar, however, no allowance has been made for the slope of the land, so pillars towards the southeast sector of the Sarsen Circle will appear shorter than they are actually and those towards the northwest taller. The footprint of a stone on the OS map was cross-referenced against data from site excavations and a solid block created onto which the profiles could be mapped using images from site excavations and actual photos. In each case the end result was viewed in relation to neighboring stones in an attempt to recreate the actual scene at the site. Exceptions to the rule are Sarsen Circle pillars 8, 9, 12, 14, 15, 19, 25 and 26, and Trilithon pillars 55 and 59, which are present but have fallen and broken or deteriorated to such an extent that they cannot be used to recreate an original. All of these together with pillar 11, which looks to have been replaced at some time by a stone much smaller in stature than the original, have been replaced in the model by a generic block (see below). Pillar 55 of the central Trilithon has been replaced by a duplicate of its partner, pillar 56.

Sarsen Lintels

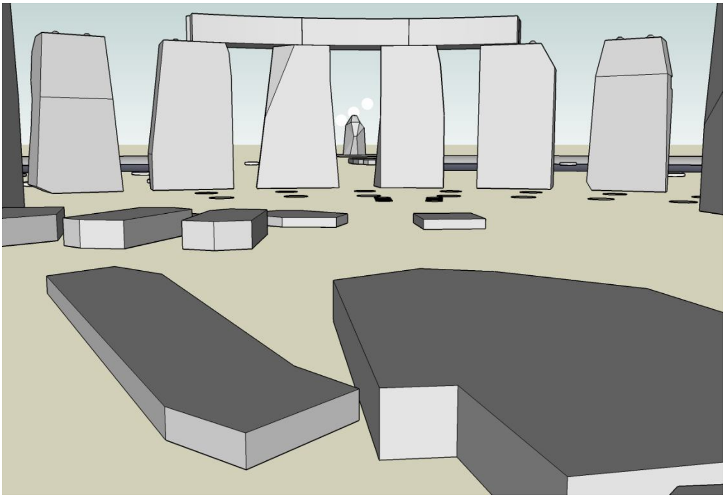
The lintels of the Sarsen Circle are all designed on a generic block of 750mm depth as part of a perfect circle of 30 blocks. Each has a tongue on one end and groove on the other although it should be noted that at least one of the original lintels has a tongue on each end. Trilithon lintels are also based on a generic block of 1000mm depth. The lintel spanning pillars 53 and 54 has been tapered as per the original, however, the numerous grooves on the lintel spanning pillars 51 and 52, which might be construed as a deliberately marked scale to measure the Moon’s transit, are absent.

Fallen Stones

Stones that have fallen and are evident on the OS map are depicted in the model by their raised profiles without actual reference to their present height above ground.

Absent Stones

A generic block has been designed to represent the missing pillars of the Sarsen Circle placed with their center at the precise location based on a 12° angle of separation. Other stones presumed missing are depicted as short circular pillars, basically for illustrating Gerald Hawkins' alignments (it should be noted that existing Station Stones are depicted as upright short square pillars and the Heel Stone has been placed erect for the same purpose).



Alignments

All angles are drawn to the closest 0.1°. The software used to confirm altitude and azimuth values for celestial events is CyberSky™ 4 by Stephen Michael Schimpf. It was selected over similar products for its ability to map the sky at any point in time and the immense amount of information provided. The software allows for atmospheric refraction so the orthographically derived values for the solstices were verified with this feature turned off. In all cases the dates of the solstices for a particular year were calculated by the software.

If you want to unlock the secrets of Stonehenge . . .

You don’t have to wait to read the rest of

The Stonehenge Observatory

because it’s available for immediate download online in PDF format (requires the Adobe reader) at:

http://www.stonehengeobservatory.com

***