THE GUERNSEY LIBERATION MONUMENT

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THE CONCEPT

During World War II the Channel Island of Guernsey was occupied by German armed forces. Liberation came on the 9th May 1945 - one day after VE Day, and Liberation Day is now celebrated as a public holiday. The Island government, the States of Guernsey, decided that the 50th anniversary of the Liberation, 1995, should be marked by the erection of a monument of a distinctive and appropriate design.

The site chosen for the monument was at St Peter Port Harbour, the place where islanders met the liberating British forces in 1945 and rejoiced at their freedom. Today it is a popular spot where people can relax whilst waiting for a ferry to the outlying islands, or just sit and soak up the sun.

The Guernsey Liberation Monument provides a convenient place to sit and enjoy the sunshine [Photo: P. McMahon]

3,000 years ago, Neolithic man erected great stones on the Island, placing them as precisely as they could, using the best technology then available. The States of Guernsey resolved that the Liberation Monument should combine the idea of a standing stone with a pleasant place for people to sit.

The challenge facing Guernsey international artist Eric Snell, who was commissioned to create the Monument, was to relate such a simple concept with the one special day. His inspiration was to form 30 metres of stone seating into a curve defined by the path which the tip of the shadow of a 5-metre stone obelisk would follow on the 9th May.

Thus the Monument is a kind of giant sundial, designed for only one day each year - Liberation Day.

THE DESIGN

The obelisk is composed of 50 layers of polished Guernsey granite - one for each year of freedom. The top layers are sheared away to represent the years of occupation. The seating and platform are off-white French granite, which enhances the visibility of the shadow cast by the obelisk. Inscriptions carved on the seating record the major events of the 9th May 1945. The tip of the shadow falls a few centimetres up on the back of the seating, and points towards each inscription at the appropriate time: the signing of the surrender of the German forces at 7.15am, the landing of the British Liberating Force at 8.00am, and the unfurling of the Union Flag at 10.15am. Also recorded is the announcement by Winston Churchill: *Our dear Channel Islands are also to be freed today.*

The design of the Monument is not just specific to one day each year; it is also unique to Guernsey - in fact to this precise spot. Nowhere else would the Sun cast a shadow exactly on the curve of seating at the times marked by the inscriptions.

THE CALCULATION OF THE SHADOW PATH

As a member of the Astronomy Section of La Société Guernesiaise, the local studies society, and familiar with astronomical computation, I was asked to carry out the calculations required to determine the curve of the seating. Because of the Monument's large scale, and the fact that the shadow has to be significant for one day only, considerable precision is possible. I aimed for a maximum tolerance less than 30 seconds in time, and achieved an accuracy of about 5 seconds.

The problem was essentially that of a sundial calculation (horizontal dial with a vertical gnomon), with the difference that:-

- Only one day each year was being considered.
- The length of the shadow, as well as its direction was required.
- A high accuracy was needed.

I carried out an analysis of the prediction accuracy required, and found that a precision of $0^{\circ}.01$ in the position of the Sun would suffice. I then wrote a computer program called *SunShadow* to calculate the following:-

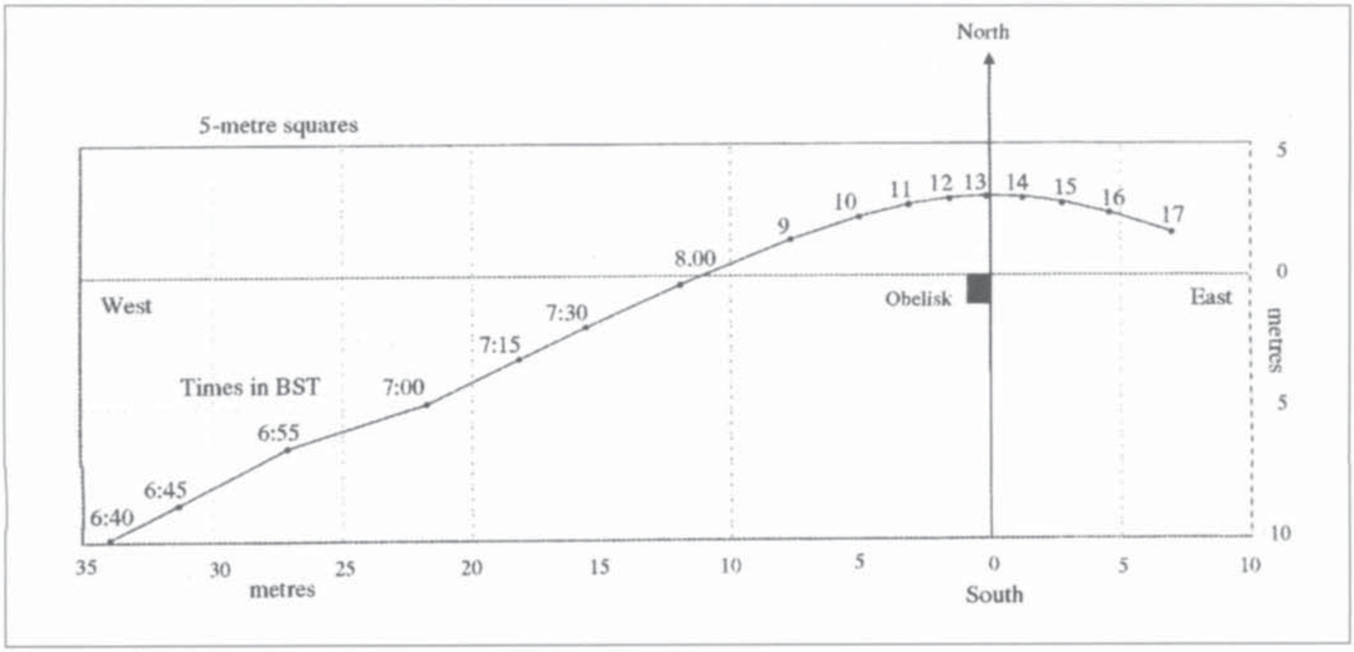

Fig. 1 The path of the tip of the shadow on the 9th May. The bend in the curve between 6.55am and 7.00am is where the shadow moves from the base to the seating

For the Sun:	Right Ascension (to 0°.01)	
	Declination (to 0°.01)	
	Altitude (to 0°.01)	
	Azimuth (to 0°.01)	
For the shadow:	Length (to 1 mm)	
	Azimuth (to 0°.01)	
	E-W distance of tip (to 1 mm)	
	N-S distance of tip (to 1 mm)	

All data refer to the centre of the Sun's disc. The E-W and N-S distances of the tip of the shadow from the base of the gnomon were required to lay out the path of the seating. The inputs are: latitude, longitude, date, time (UT), and gnomon height. The time output can be in UT or BST.

SunShadow uses Meeus's method[1] of calculating the solar coordinates, and includes a correction for atmospheric refraction by Bennett's formula[2]. Thorough checks were carried out into the accuracy of the program, including the use of the US Naval Observatory's *Floppy Almanac*[3] and *Mica*[4]. Reference was also made to Dr Peter J Andrews of the Royal Greenwich Observatory, who confirmed that the method and results appeared sound.

An initial experiment was then conducted, in order to identify any gross errors. I was assisted by Daniel Cave, a member of the Astronomy Section. The experiment was carried out in early August 1994, when the Sun's declination was similar to that in early May, using a one-metre vertical rod as a gnomon, It demonstrated the need for a high degree of accuracy in the construction of the Monument.

SunShadow was run for 1995 May 09 at 5-minute intervals for the required times, from 0640 BST to 0655 BST with a gnomon height of 5.55 metres (the height of the top of the obelisk above paving leading up to the seating), and from 0700 BST to 1700 BST with a gnomon height of 4.75 metres (the height of the top of the obelisk above the seating). Figure 1 shows a rectangular plot of the path of the tip of the shadow.

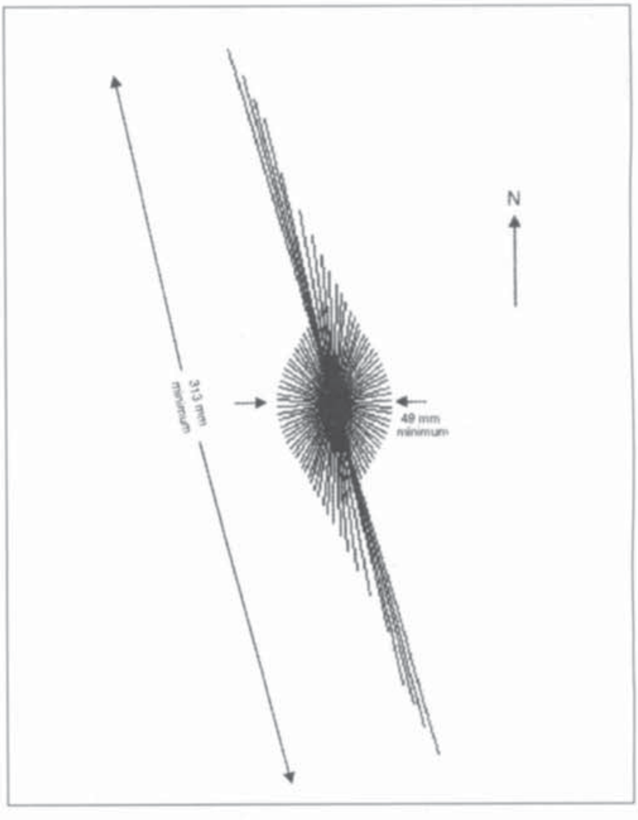

Fig. 2 Schema of top of obelisk

SHAPE OF THE TOP OF THE OBELISK

Dr Andrews pointed out that the shape of the top of the obelisk is important insofar as it affects the appearance of the shadow, and therefore the accuracy of the Monument[5]. The top of the obelisk as seen from the tip of the shadow must subtend an angle of at least the angular width of the Sun, ie $1/2^\circ$, so that the shadow tip has an umbral core. It cannot be a point.

The required dimension *d* is dependent upon the distance *L* from the top of the obelisk to the tip of the shadow. It is therefore dependent upon the altitude of the Sun, and varies during the day. It is given by the formula:-

$$d = 0.00873\,L$$

(since $1/2^\circ = 0.00873$ radians).

d was calculated for 45 times during May 09. A schematic

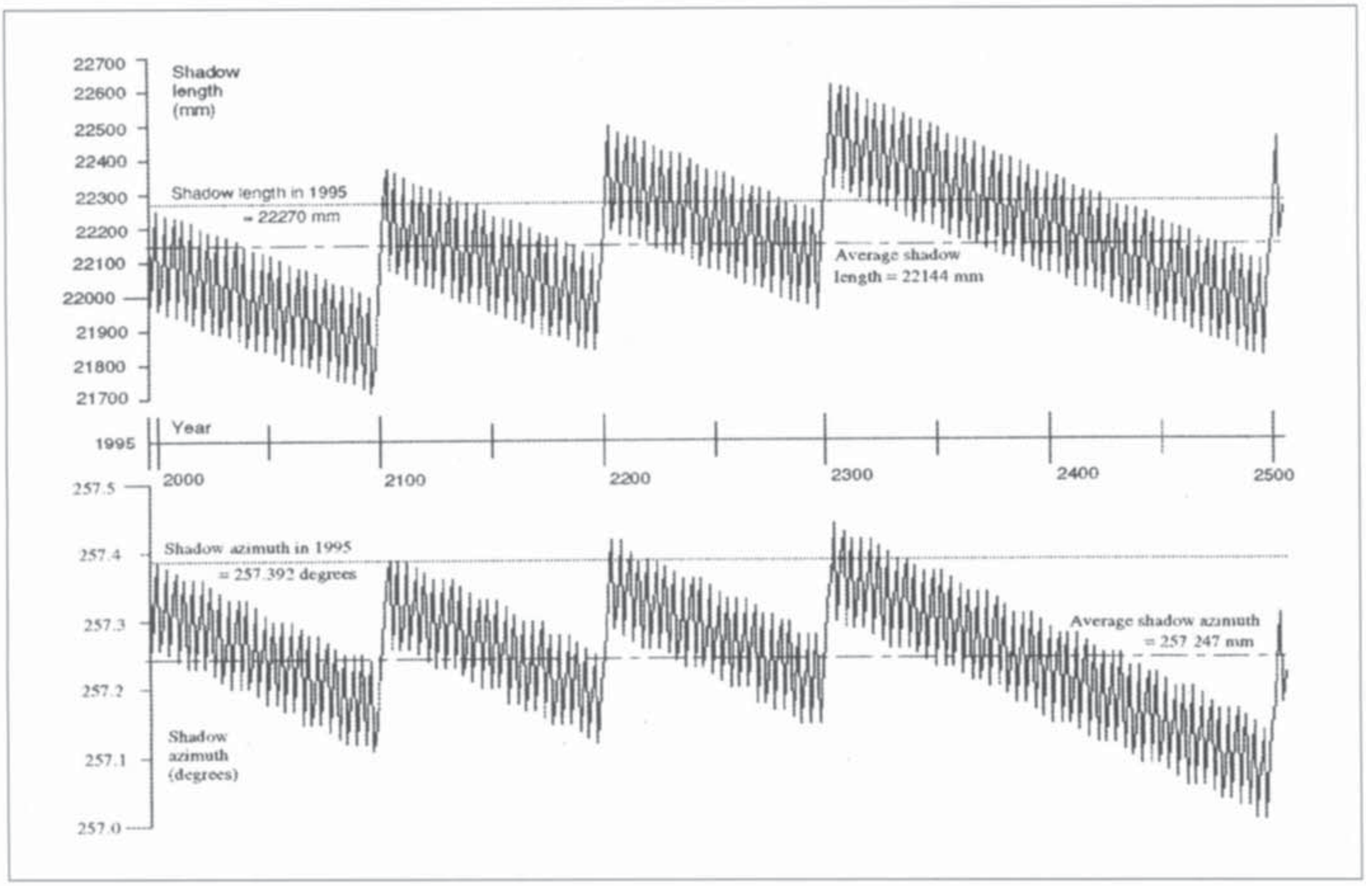

Fig. 3 Shadow length and azimuth for gnomon 4.75m high, 0600UT, May 09, 1995-2505

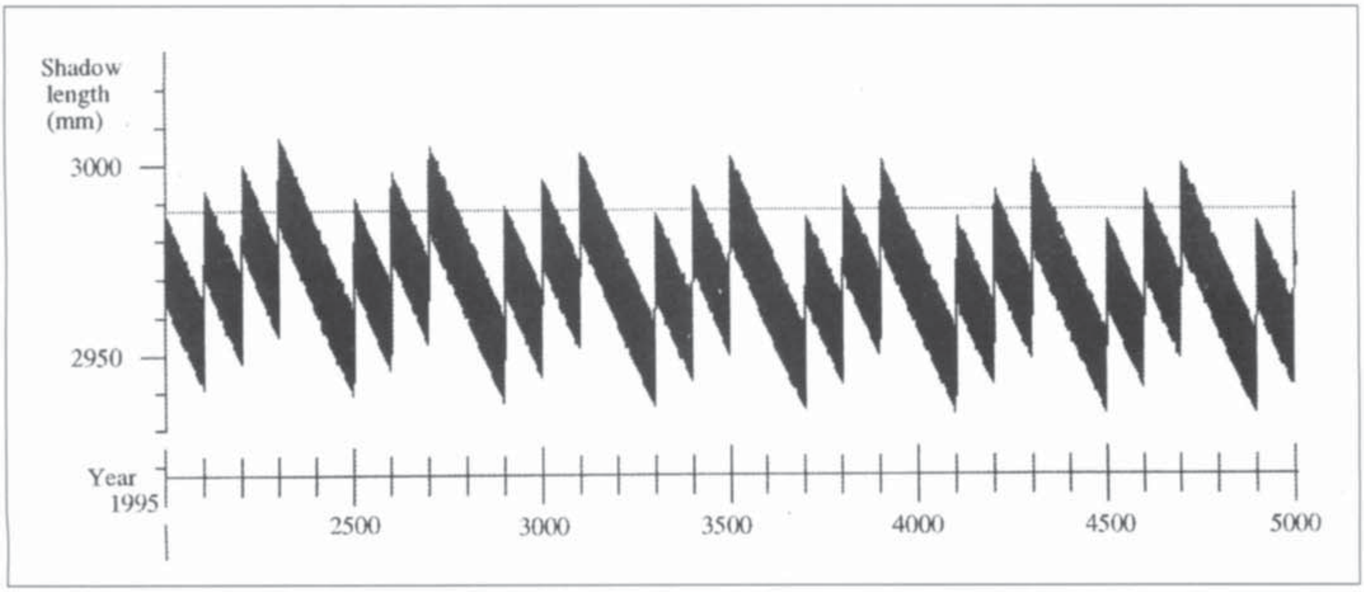

Fig. 4 Shadow lenth for gnomon 4.75m high, 1200UT, May 09, 1995-5005

representation of the top of the obelisk, based on the azimuths and minimum widths necessary to cast an umbra, is shown in Figure 2. It is not the shape of the top of the obelisk, but a mathematical plot from which a possible shape could be derived. It shows that the width of the top of the obelisk must be at least 313 mm at 0640 BST, 199 mm at 0700 BST, and 49 mm at 1300 BST.

The top of the obelisk therefore had to have a *bulk* in order to cast an umbral shadow at the required distance. It was also desirable to take into account the effect of this bulk on the apparent shadow length, as the shadow should properly be measured from the edge casting the shadow.

The tip of the shadow at the 10.15am inscription

It was concluded that the best shape for the top of the obelisk could only be determined by experimentation. The designer, Eric Snell, used my calculations to create a life-size model of the top metre of the obelisk, with the top few centimetres shaped in plaster. We carried out the experiments on a bowling green - the flattest area available - with the assistance of a States of Guernsey surveyor, Sean Harvey (also a member of the Astronomy Section). This exercise was necessarily done in the winter, and the low altitude of the Sun, compared to May 09, did not help. However, sufficient data was gathered to establish a probable best shape. In the event, two alternative tops were created, one higher than the other. The final shape chosen has a triangular cross-section (looking from above), and works well.

THE SHADOW IN FUTURE YEARS

In view of the fact that the Liberation Monument may well last several hundred years, I was interested in the behaviour of the shadow over that period of time. I therefore used SunShadow to calculate the shadow length and azimuth for a period of over 500 years. The results are shown in Figure 3. The 4-year, 100-year and 400-year cycles of the Gregorian calendar are apparent.

For academic, rather than practical interest, I also calculated the shadow length for a period of 3,000 years (Figure 4). The long-term trend of the calendar is shown. The Gregorian calendar gives an average year of 365.24250 days, compared with the tropical year of 365.24218 days, a difference of 0.00032 days, or one day in 3,125 years.

THE HEIGHT OF THE OBELISK

The long-term shadow length data shown in Figure 3 indicate that the length of the shadow on May 09 in 1995 was longer than the average shadow on that date over the next few hundred years. Indeed, the shadow will be shorter until the year 2103.Consideration was therefore given to increasing the height of the obelisk slightly, in order to allow for these long-term effects. In addition, it was recognised that the mathematical calculations of shadow length represent an ideal situation, which was unlikely to be attainable in practice. In particular two further effects could result in the shadow being shorter than the ideal.

The inherent diffuseness of the shadow because of atmospheric effects, creates a shortening effect. The main effect, however, is caused by the fact that the Sun is not a point source. The calculations were made using the centre of the Sun's disc, but light from the upper half must be taken into account.

One might, therefore, think that the reference point should be the top of the solar disc, rather than the centre. However, the shadow appears longer than that calculated using the top of the disc, because the additional disc area contributing light decreases with increasing radial distance from the centre.

Is there a point between the centre and the top of the disc which can be used as the light source?

Experiments to answer this question were carried out, first using a two-dimensional representation of the top of the obelisk, and then with the full-scale mock-up of the top metre, used on the bowling green.

However, it was not until the precisely level platform of the Monument itself was in place, that a one-third scale model of the obelisk gave a more definitive solution. The platform was used essentially as large-scale graph paper, with the north-south and east-west gaps between paving slabs being used as guides for those directions. Metal scale tapes were used to measure north, east and west distances, and shadow lengths.

These experiments gave an average light source just 0.093 degrees above the disc centre, with a range of 0.06 to 0.12 degrees, dependent upon the time of day. The wide range of the results demonstrated the subjectiveness of shadow observations, especially where the shadow was not very distinct.

As the Sun's azimuth moves towards the west, the edge of the top of the obelisk which "casts" the shadow is east of the reference point on the obelisk top. Thus, in theory, the shadow is lengthened by the amount of the displacement of the edge in the direction of the shadow, and a correction should be made for this effect. (On the one-third scale model this displacement, and therefore shadow lengthening, was about 12 mm for the late afternoon observations.)

However, in practice the requirement that the top of the gnomon must have a certain bulk to cast an umbral shadow means that the correction is largely nullified. Indeed, this was why the particular position of the reference point was selected.

It was also noted that, although the observed umbral shadow was shorter than the predicted shadow length, as expected, the penumbral shadow was clearly visible as an extension of the "true" umbral shadow for all but extreme shadow lengths. The eye, therefore, took into account this extension, and it could be easily seen that the shadow was really longer than just that indicated by the umbra.

A conflict occurred, however, because the above effect is less evident for long shadows, when the shortening effect of the light from the top half of the Sun is greatest. In selecting the obelisk height, therefore, there must be a compromise between having an umbral shadow which is long enough in the morning and late afternoon, and an umbral+penumbral shadow which is not too long at midday

I therefore calculated these effects for various obelisk heights for 1995 May 09 and for 1996 May 09, assuming the light source to be 0.093 degrees above the centre of the Sun's disc, and ignoring the dimensions of the top of the obelisk for the reasons described above.

The data are plotted in Figure 5. They appear to indicate that the best compromise for the umbral shadow would be a gnomon height of 4.77 m or 4.78 m. This would give an umbral shadow closest to the line of the seating.

However, three other factors had to be taken into account:-

1. It was desirable that the shadow tip was slightly (a few centimetres) above the seating line, so as to "point" to the inscriptions on the back of the seating.

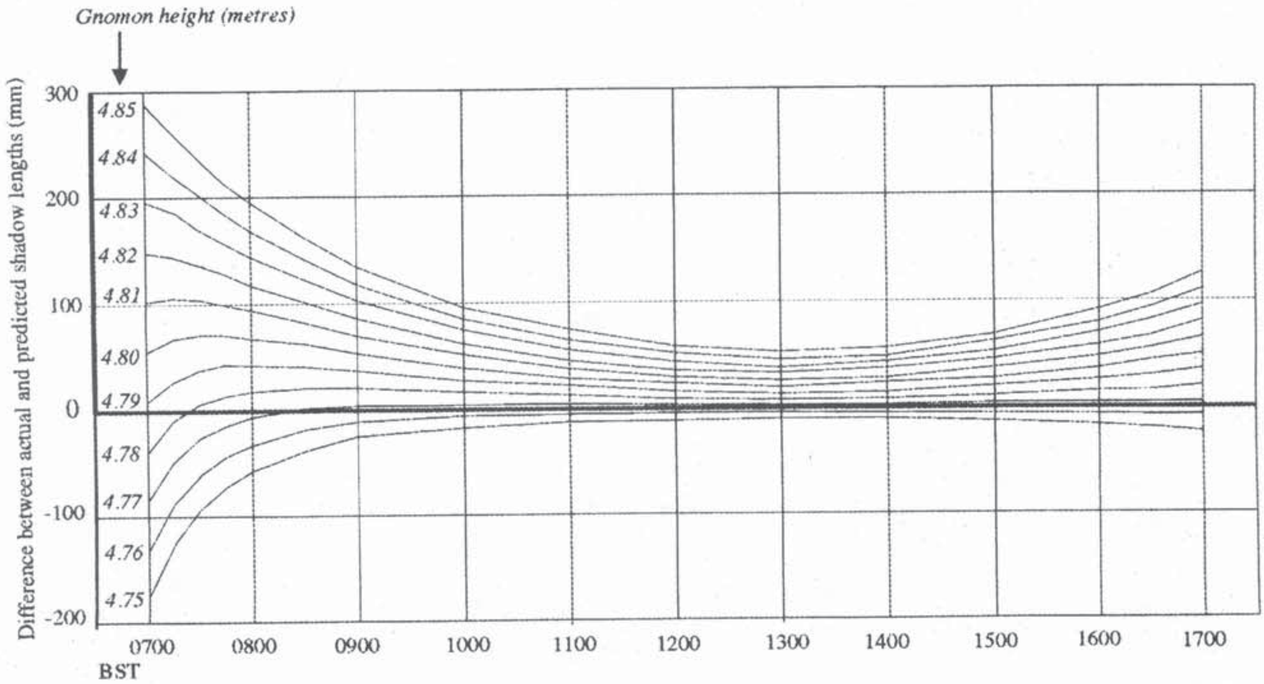

Fig. 5 Differences between actual and predicted shadow lengths for gnomons of different heights

2. The shadow in future years will be shorter, because of the higher altitude of the Sun[3]. The shadow before 0700 BST had not been taken into account.
4. The seating was built 5mm higher than planned.Further studies into these effects concluded that the gnomon height should be 4.825m, giving an obelisk height of 5.325m.

CONSTRUCTION TOLERANCES

A detailed analysis was made into the tolerances allowable in the construction. The analysis concluded that the following tolerances should be adhered to:-

	Maximum tolerance	*Preferred tolerance*
Obelisk height	6 mm	1 mm
Obelisk tilt	4 arc-mins	1 arc-min
Platform and seating levels	6 mm	1mm
Direction of True North	7 arc-mins	1 arc-min
Laying out of shadow path and manufacture of Monument		1 mm

Checks made by the architect and builders during the construction of the Monument indicated that the preferred tolerances were, in fact, achieved.

However, there remained the possibility that differential subsidence (especially because the Monument is constructed on an old land reclamation site) might affect the accuracy, as the obelisk is not tied to the seating or platform. The architect resolved this potential problem by installing three jacking points in the base of the obelisk, so that, if necessary, its height and tilt can be adjusted.

DETERMINATION OF TRUE NORTH

It was necessary, of course, to determine the direction of True North to an accuracy of 0.01 degrees. Several methods were considered:-

1. An accurate compass bearing on magnetic north, with a correction for magnetic variation. Extrapolation from data given on Admiralty charts does not give sufficient accuracy. A more accurate extrapolation could perhaps have been made from the magnetic field model recalculated by the British Geological Survey every five years, with one due in 1995.
2. A bearing related to the Universal Transverse Mercator Grid, with a correction for the convergence of the meridians.
3. The stellar method used by astronomers for aligning telescopes with the North Celestial Pole, as described, for example, in Norton's 2000.0[6]. Some modern telescopes provide for accurate polar alignment through computer methods.
4. A bearing of the Sun, or the position of the shadow of a suitably sized, vertical gnomon, could be made at the accurately predicted time of local noon, when the Sun is due south.
5. O. Neugebauer has suggested a possible method by which the Great Pyramid of Giza may have been accurately orientated to the cardinal directions[7]. This involves observations of the shadow of a small pyramid, and its re-orientation on a trial and error basis until it is correctly aligned. It seems doubtful that this would give the accuracy required for the Liberation Monument, but the method could be analysed and a minimum pyramid size determined for the required accuracy to be established.

Attempts were first made with method 4, using a tall (15m) lamppost, with corrections for "lamppost lean". Unfortunately, the results were inconsistent, probably because the lamppost was telescopic, and its lean changed from day to day. Method 3 was tried with an 8-inch, computerised Meade telescope. This proved insufficiently accurate for the purpose.

Resounding success was scored, however, with a combination of method 2 and observation of Polaris, the Pole Star. Sean Harvey, the surveyor, laid out a north-south line across the Harbour of St Peter Port, based on the Universal Transverse Mercator Grid Zone 30 coordinates. This was then checked using a Topcon GTS-6B Total Station, with due offset from Polaris, as predicted by Mica, and confirmed with reference to other stars. The results were consistently within 5 to 10 arc-seconds of the surveyed direction.

THE CONSTRUCTION

Construction started in September 1994, and continued concurrent with the experiments and activities described above, until May 1995, under the supervision of the States Architect, Patrick Reade.

Local company LeRoy Limited were contracted to build the Monument, with the Managing Director, Phil Sebire, responsible for seeing it to a successful conclusion. Regular progress meetings were held with all persons involved. Because of poor weather conditions during the experiment phase, the final decisions as to the shape and height of the obelisk were not made until a few days before the unveiling. Two stones for the obelisk top were made, with different heights and shape. In early May 1995, Eric Snell and I decided to use the taller of the two, and this was duly installed.

The construction of the Monument. Designer Eric Snell and the author David Le Conte examine the foundations. [Photo: Guernsey Press Co. Ltd.]

The cost of the project (not including the neighbouring pedestrian improvements) was £130,000. This was defrayed by public subscription, but the bulk of the cost was met by the States of Guernsey.

THE PERFORMANCE AND UNVEILING

HRH The Prince of Wales unveils the Monument on the 9th May 1995, the 50th Anniversary of the Liberation of the Island from Occupation by German armed forces.

In the early morning of the 50th Anniversary of the Liberation Day, the 9th May 1995, a small group, including all those involved in its design and construction, gathered to observe the shadow's progress. Final washing of the Monument made the early shadow difficult to discern, but when it did appear, shortly before 7.00 am, it was right on course, and progressed exactly as planned along the line of seating, pointing to each inscription in turn.

It was uncanny, seeing the tip of the shadow trace out the predicted path, almost as if the shadow itself was tied to the seating.

At 1.40 pm, in front of thousands of people, His Royal Highness, the Prince of Wales, unveiled the Monument, to the accompaniment of a fly-past of military helicopters. I was honoured to be asked, at the last moment, to describe sundial-like qualities of the Monument to the Prince.

Immediately after he left the site, and police allowed the public onto it, it was swamped by hundreds of people, the shadow totally lost amongst all the heads and bodies.
The Monument continues to serve both its commemorative function and its utilitarian one, being a popular spot for people to sit and enjoy the sunshine, and occasionally the shadow. Many may be indifferent to the fact that they are sitting on a piece of the Island's history, but the unique design of the Liberation Monument creates tremendous interest and acknowledgement of Guernsey's troubled past, and that wonderful moment of freedom celebrated at this very spot over 50 years ago.

On the 17th April 1997 the Civic Trust announced that the Guernsey Liberation Monument had won a coveted Civic Trust Award, recognising its outstanding contribution to the environment of the town and harbour, and stating: "This is a work of austere beauty that captures a moment in the island's history with power and precision". *The Liberation Monument has its own web page,*

at:http://www.guernsey.net/monument

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