Survey of Knight's Peak

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1) Introduction

Knight's Peak (NG471254) is in Section 17B of the list of Munros in the 1997 SMC publication of Munros Tables, where it is given as a Top of Sgurr nan Gillean. It is found on OS 1:50k Map 32 and 1:25k Map 411. Since its first inclusion in Munros Tables in 1997 there has been much controversy about its height. In the Tables it is listed as 914m, on the 1:25k map it is given a height of 915m and on the 1:10k map a height of 912m. Harvey's map records the height difference between Knight's Peak and Sgurr nan Gillean, which infers a height of 911m for Knight's Peak. From high resolution photogrammetry Ordnance Survey has quoted a height of 914.5+/-1m. The conclusion to be drawn from these results is that Knight's Peak is very close to 3000ft (914.4m) and probably well within the measurement uncertainty of photogrammetry, the technique used to determine all the values quoted above.

There are two summits on Knight's Peak which are rock tors set about 20m apart from one another; it is not known which is the higher.

The purpose of this survey was to locate the summit position and then determine the height of Knight's Peak accurately using the technique of differential GPS, which is capable of determining heights to less than 0.1m.

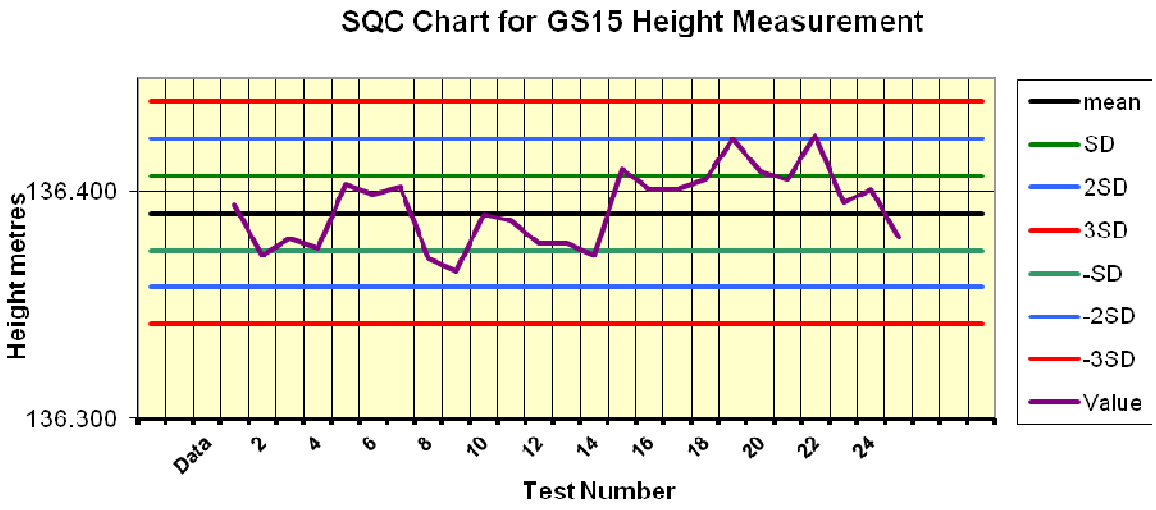
2) Equipment used and Conditions for Survey

The summit position of each tor was identified and an approximate height difference between them estimated using an Abney level. We usually use a Leica NA730 automatic level and staff for this purpose but for Knight's Peak this was not possible because of the steep nature of the terrain.

Absolute heights were measured using a Leica Geosystems Viva GS15 Professional receiver. This is a dual-frequency, multi-channel instrument, which means it can lock on to a maximum of 12 GPS and 8 GLONASS satellites and receive two signals (at different frequencies) from each of these satellites. The latter feature reduces inaccuracies that result from atmospheric degradation of the satellite signal. As a stand-alone instrument it is capable of giving position and height to an accuracy of about two metres and five metres respectively. Note that a hand-held GPS receiver can only receive up to 12 GPS satellites and each at a single frequency and therefore it has a poorer positional accuracy of +/-5m and a height accuracy of no better than 10 metres. Some recently produced hand held GPS Garmin receivers can also receive signals from GLONASS satellites which greatly improve the speed at which these units can achieve a satellite "fix". Despite the on-board features of the Viva GS15 receiver, there are still sources that create residual errors. To obtain accurate positions and heights, corrections were made to the data via imported RINEX files from Ordnance Survey which were post-processed using Leica Geo

Office 8.3 software. Heights were also determined by Ordnance Survey who processed the data using Bernese Software. This is state-of-the-art software and is recognised to produce definitive results, but the differences between results calculated by Bernese and by Leica Geo Office 8.3 are usually no more than 2-3cm for height measurements. Both ours and the Ordnance Survey results are given in this report.

We regularly check the functioning of the Leica Viva GS15 against Statistical Quality Control (SQC) charts generated for a marked position. The chart associated with height measurement is shown below. The mean height above Ordnance Datum Newlyn (ODN) for a fixed point (measured on 20 different occasions for 30mins of data collection at each time) was calculated to be 136.391m. Further height measurements have been made at this point on separate occasions over a period of 12 months using the same process parameters. The last and penultimate measurements were carried out after and before the mountain surveys described in this report. The results shown on the graph are all within a range of +/- two SD (Standard Deviation), in this case one SD is +/-0.016m. This demonstrates that our Leica Viva GS15 receiver is giving consistently precise results within the expected range of uncertainty for the measurements.



In addition, we check the instrument periodically by taking measurements on an Ordnance Survey Fundamental Bench Mark, processing the data and comparing it with the OS derived values. Height should agree within about 0.05m. The latest two measurements are given in the table below.

Processing	Height(m)
OS measurement	73.24
JB/GVJ GeoOffice 7	73.22
JB/GVJ GeoOffice 7	73.22

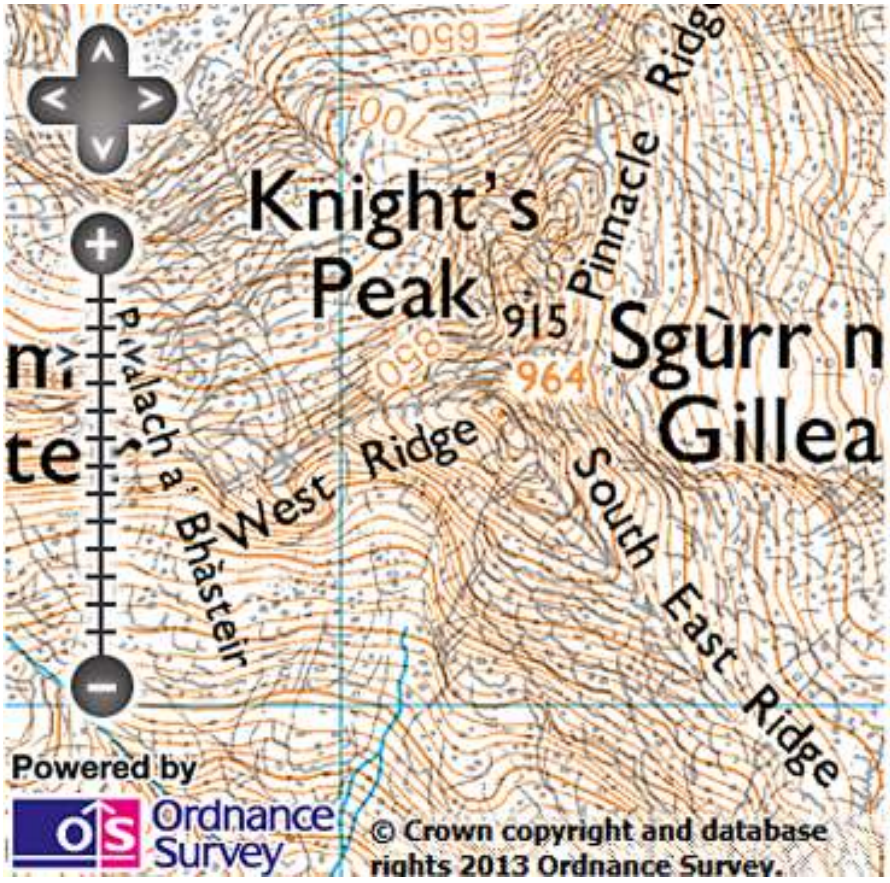
Conditions for the survey, which took place between 14.15hr and 16.40hr, were fair. Mist covered the upper regions of the mountains, the temperature was about 12 degrees Celsius and crucially the wind was light. Even moderate winds would have curtailed the survey because of the exposed positions in which the GPS receivers were placed.

3) The Survey

3.1) Character of the Mountain

Knight's Peak is part of the Black Cuillin of Skye, a 12km long ridge of black gabbro which provides excellent rock climbing and arguably the finest mountain scenery in Britain. The rock is magnetic and the terrain complex and consequently route finding can be a major problem in mist for those unfamiliar with the ridge.

Knight's Peak is situated on Pinnacle Ridge, the north ridge of Sgurr nan Gillean. It was first climbed in 1873 by Professor W Knight and his guide Mr MacPherson. Excluding Sgurr nan Gillean itself, there are four pinnacles on the ridge and Knight's Peak is the highest and nearest to Sgurr nan Gillean. Indeed it is only 150m north of Sgurr nan Gillean in horizontal distance. The summit comprises two rocky tors about 20m apart with the southerly one being the more awkward to climb and the flanks of the peak are precipitous and rocky.



There are four possible routes to Knight's Peak and all involve exposed scrambling and two are graded Difficult rock climbs. We were advised by Noel Williams, author of the SMC guide Skye Scrambles, that the most straightforward route was via the 'tourist' path to Sgurr nan Gillean, which starts near the Sligachan Inn on the Portree road. The route crosses the Allt Dearg Mor near the start and then winds its way south crossing the Allt Dearg Beag at about 130m in height. The path is finally left at a height of about 600m and the gully between Knight's Peak and Sgurr nan Gillean then followed. There is a Difficult but short rock climb at the head of the gully to gain the bealach

after which it is a stiff scramble to the summit. Andy Nisbet offered to set up a rope to protect the climb up the head of the gully and Alan Dawson was familiar with the route, having taken it two years ago. Consequently this was the route that was chosen for the survey.

Other possible routes are via Pinnacle Ridge or from Sgurr nan Gillean, both of which are more serious undertakings with heavy and delicate equipment, or up the gully between Knight's Peak and Sgurr nan Gillean from Coire a' Bhasteir.

3.2) Summary of Survey Method

On reaching the summit our first task was to assess the options open to us in the limited space available. There was no suitable platform on which to set up the automatic level and consequently the only option open to us to determine the higher of the two summit tors was to use a small hand-held Abney level. Fortunately there was sufficient space to set up the GPS receivers immediately by or on both tors and the wind was very light, less than 10mph, which meant this could be done without risk to the equipment.

3.3) The Survey of Knight's Peak

The exact summit position of Knight's Peak was quickly determined with the hand-held Abney level and is the north rock tor. It was found to be approximately 0.1m higher than the south tor. In order to confirm this we had the use of the two GPS receivers so one was set up on each summit and the results would provide a check on the Abney level measurements. On the south tor the Leica RX1250 receiver was set up on the summit rock itself, while on the north tor, the Leica GS15 receiver was set up on a small tripod and the Abney level used to align it with the summit. Finally, the tripod legs were stabilised with heavy stones in order to provide stability in the event of a gust of wind. The horizontal distance between the summit and the set-up position was about 0.5m.

The summit position of both tors was very obvious and did not require use of the Abney level in order to determine them.

In all, 2hr of data were collected on both summit tors of Knight's Peak.

The ten-figure grid reference for the north tor and summit using hand-held GPS is:-

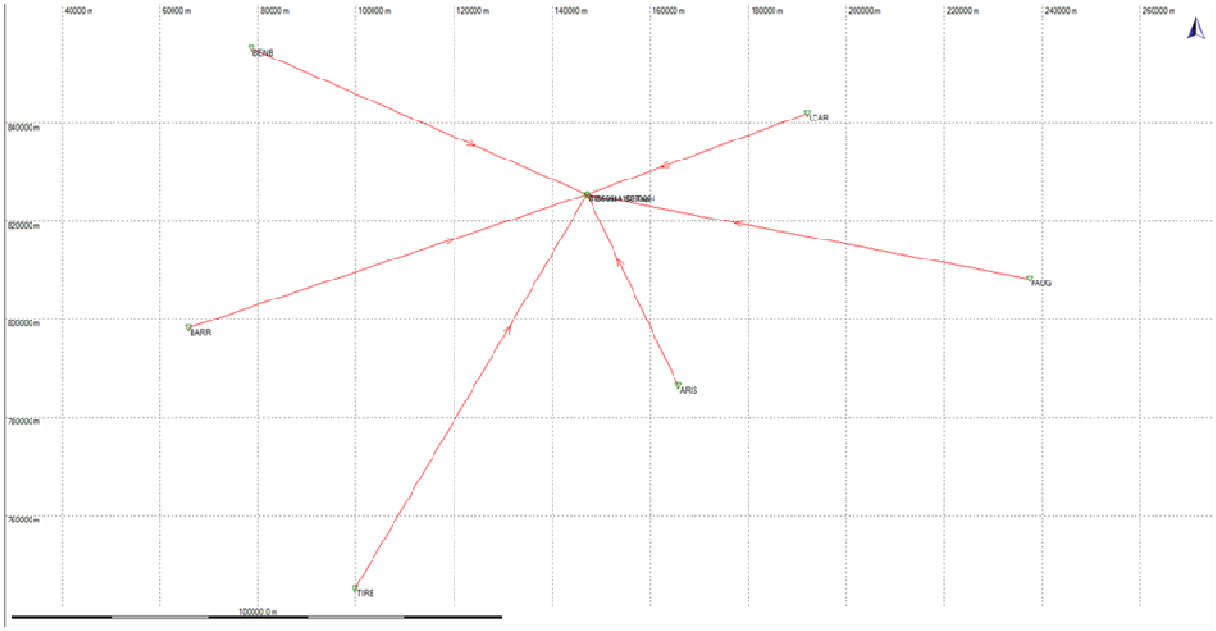
Garmin Etrex 20	NG 47185 25414	Accuracy 4m Height = 917m
Garmin Montana	NG 47185 25416	Accuracy 4m Height = 914m
Garmin Oregon 450	NG 47186 25416	Accuracy 4m Height = 921m

The ten-figure grid reference for the slightly lower south tor using hand-held GPS is:-

Garmin Etrex 20	NG 47193 25401	Accuracy 4m Height = 916m
Garmin Montana	NG 47193 25398	Accuracy 4m Height = 916m

The GPS data were processed with the Leica GeoOffice Version 8.3 Software. RINEX correction data were imported from the Ordnance Survey Website for the 6 nearest Active Base Stations (Loch Carron – LCAR 48km, Arisaig – ARIS 43km, Fort Augustus – FAUG 92km, Tiree - TIRE 93km, Barra – BARR 85km and Benbecula – BENB 75km). We used Broadcast Ephemeris data received by the GPS during the survey rather than Precise Ephemeris data, since we have found this makes little difference to the height results. The computed Tropospheric model was chosen for the

calculations to suit the data collection times and the wide difference in height between the base stations and the summit of the mountain.



The results are tabulated below for our result (GeoOffice) and that determined by Ordnance Survey for this dataset.

Source	Easting	error(1SD)	Northing	error(1SD)	Height(m)	error(1SD)
GeoOffice GS15 N Tor	147180.146	0.002	825426.436	0.002	914.236	0.007
GeoOffice RX1250 S Tor	147187.287	0.002	825412.389	0.002	914.125	0.013
OS result N Tor	147180.148		825426.441		914.244	
OS result S Tor	147187.281		825412.393		914.161	

Thus the height of the north tor is 914.24m and that of the south tor 914.16m, confirming that the north tor is the summit of Knight's Peak and it is 0.08m higher than the south tor.

4) Discussion of Results

Since the summit positions of both tors of Knight's Peak were identified very precisely and both were rocks, then the height uncertainty in their respective locations is very small and of the order of 0.01m. The largest error in this determination lies with the GPS measurement itself. For absolute height and with two hours or more of data collected this is +/-0.06m (to three standard deviations)

as determined by numerous measurements we have previously made and as has been reported in the literature. So we can be confident that the absolute height of each tor is accurate to within +/- 0.06m. The difference in heights between the two summits is 0.08m with the north tor being the higher. This result is also supported by the Abney level measurement.

5) Summary and Conclusions

The **summit** of Knight's Peak is the north tor at grid reference *** NG 47185 25415**. Its height is **914.24m (2999.3ft)**.

The **south tor** is at grid reference *** NG 47193 25400** and its height is **914.16m**.

The survey has shown Knight's Peak to be below 3000ft.

* NB for the convenience of walkers using a hand-held Garmin/Magellan GPS, grid references quoted in the summary are from these instruments.

John Barnard, Graham Jackson and Myrddyn Phillips, 19 September 2013.

Acknowledgement

Thanks are due to Ordnance Survey and especially Mark Greaves for processing our data files through Bernese software to give us the most accurate solution to the datasets. We are also indebted to Andy Nisbet whose leadership and expertise on the climb made the survey possible and to Alan Dawson for joining the survey and using his receiver to record data on the S top.

Appendix 1 – Photographs of the GPS receivers set up on the north top and south top of Knight's Peak

Leica Viva GS15 on North Top of Knight's Peak

Leica Viva GS15 on North Top of Knight's Peak

Leica RX1250 on South Top of Knight's Peak

Leica RX1250 on South Top of Knight's Peak

The Team

The Gully

Pinnacle 3 from Knight's Peak