

Measurement method, data, and calculations for the 2012 Olympic Marathon

Assembled by Mike Sandford during January 2013, Published on 31 Jan 2013 at coursemeasurement.org.uk/olympics2012/

Narrative Account by Mike Sandford: [Background](#) | [Measurement Rides](#) | [Data Analysis Summary](#) | [Data Analysis \(detail\)](#)

Reports



2012 Olympic Marathon Measurement Completed. (13/6/12)
David Katz, Organisers Mark Griffiths & Lisa Thompson, Hugh Jones, Mike Sandford.

Photo by Geoffrey Sandford

1. [The Length of the Calibration course in the Mall.](#) (Steel Tape method and Laser method.)
2. [Marathon Course Map](#) by Hugh Jones
3. Course Analysis Presentation by Nathan Jones - with 94 photos
4. Measurement report prepared by David Katz (24 July version)
5. [Measurement report prepared by Hugh Jones](#) (pdf)
6. [Measurement data for the marathon course obtained by Mike Sandford](#)
7. [Summary & Comparison of data from the 3 riders](#)
8. [Details of laser rangefinder method](#) (Measuring the Park Road Calibration Course in Abingdon) This gives full details with pictures of the laser method similar to that used for The Mall.

As an alternative to reading online the series of pages indexed here, I have prepared a pdf file (~7MB and 58 Pages) of this website *[this version compiled at 16:30 on 31 January 2013 The website may have been updated*

since this version of the pdf was prepared]. The Course Analysis Presentation is a separate pdf (~7MB 100 Pages)

History of Olympic Marathon Measurement 1984-2008

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The Map and Report By Hugh Jones and the Course Analysis Presentation by Nathan Jones which have been reproduced with the permission of the authors, and remain their copyright.

I thank David Katz and Hugh Jones for giving me the opportunity to participate and sharing their results, and Pete Riegel for his contributions after the measurement.

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Background:

The route preliminary work and selection, The test event, The Official IAAF Appointed measurer

When I first heard about the plans for the Marathon in the 2012 London Olympics the route was to be start with some loops in the city centre before heading out to finish in the Olympic Stadium. Hugh Jones was called in by the London Marathon Ltd to do some exploratory measures. The following is original route which I have found on wikipedia:

Originally the route was planned to start at Tower Bridge, run through Tower Hamlets and finished at the Olympic Stadium. It would have had a 580 m "run-in", three laps of 11.61 km circuiting central London and passing through or close to the Tower of London, the Victoria Embankment, the Palace of Westminster, Parliament Square, Westminster Abbey, Birdcage Walk, Green Park, Buckingham Palace, the Mall, Trafalgar Square, Strand, St Paul's Cathedral, and the City of London. After the final circuit, the route would then have headed east for 7.34 km, along Whitechapel Road and Mile End Road, towards the Olympic Park and a finish in the Olympic Stadium.

In August 2010 I read the one [David Katz had been appointed by the IAAF Council](#) as the Official measurer for the London Olympic Games Road races.

In September 2010 the route was changed to remain entirely within the city centre starting and finishing on the Mall. According to [The Guardian report](#) this was "because of the potential for traffic chaos and security issues" with the original route.

Hugh measured the new course and a test event was to be held over the new course on 31 May 2011. Hugh planned to make use of the opportunity of the closure of the roads for that event to get a more accurate measurement ride without traffic problems. The [39 test runners were scheduled to run together at 3 hr](#) marathon pace, and Hugh wrote that he planned to get a measurement ride as follows:

The timetable on Monday morning is very tight. We set up at 04.00 when the road closure comes in, and then I will start to measure as soon as I can, but unlikely before 05.15. I want to measure 1 small lap and 1 large lap in the running direction, although some parts of the course are disrupted by works, and will definitely be different a year from now. The test event starts at 06.00 - 50 runners going the full distance at 3 hour pace. I am only due to start duty on course at 07.50, to navigate the lead vehicle for the wheelchairs, as they set off on their one lap. They will rest a while and do a second lap. The Marathon test event will be finished at 09.00 and the London 10,000m starts at 11.00. There is a test for the walks course at 16.00. Not sure how we could do this. I would definitely be just riding at maximum pace to get the job done before the race starts, stopping at pre-noted points and scribbling the reading down. I attach my prompt list for these locations (different to that I have previously used, as this is the first chance I have had to do a measurement without worrying about traffic).

I chickened out of joining Hugh for the reasons explained in my reply:

Many thanks for the details - but I think on reflection I would be too slow and impede your measuring too much.

I understood your original plan had been to ride behind the test runners who would be doing 3hr pace for the marathon, i.e. 8.7mph. I can manage that since my electric bike can give maximum assist up to over 10mph, then the assist is steadily reduced, reaching zero at 15.5mph.

Riding above 15.5 mph I get no assistance, and in any case the gearing of the bike is deliberately rather low (for hills) so I have to pedal at an uncomfortably high cadence rate at speeds of 15 mph and above. Also the power needed to overcome air resistance goes up as the cube of the speed, and I have a completely upright riding position. This is no problem at all around 8.7 mph but at say 20 mph the air resistance pushes the power required to drive the bike up by 12 times, So what might be a requirement of about 30 watts at 8.7mph becomes 360 watts at 20 mph, and of course it all has to come from me rather than the motor at that speed!

I find the electric assist bike is very effective to help me measure at speeds typically between 8 and 12 mph.

..... So I wish you well on Monday morning, and I will be happy to remain in bed rather than turnout out very early and then just impede your challenging job.

On 16 May 2012 I got another message from Hugh:

The Olympic measurement (official) will likely be 13 June, just me and the official measurer (David Katz) - unless you want to join. Please let me know. It will likely be from 03.00.

Needless to say I jumped at the opportunity:

I would like to ride, provided my presence won't make the operation more complex to manage for David, whose work must take priority over hangers-on like myself.

Hugh got the go ahead from David:

After discussion with David Katz he is happy if you wish to join us for the official measurement. The riding order would be me, him in the middle and you. We would calibrate next to the start/finish line (350m) and David would like to re-calibrate mid-measurement, after having done the small lap [in two sections: i) from Embankment "wrong way" around down Northumberland Avenue, The Mall Spur Road, Birdcage Walk, Great George Street, Parliament Square (North side) and Bridge Street; ii) The 600m section down the Embankment (in the running direction)] We would measure the large lap from where it diverges from the small lap, just before the end of Northumberland Avenue and it is possible to measure right around the lap to Big Ben while only momentarily straying across the road into oncoming traffic (on Gresham Street/Princes Street near the bank of England and for 60m wrong way down King William Street near to Monument). We are still discussing arrangements with the police, but I think we will likely start around 02.30 on 13 June. The measurement should only take a couple of hours. Would you be able to join us?

So it was that I prepared to join Hugh and David for their ride. I have described what happened on the following page:

[The Olympic Marathon Measurement - Mike Sandford's Narrative Account](#)

The Olympic Marathon Measurement - Mike Sandford's Narrative Account

I set out for London with my son Geoffrey around Midnight. We had a traffic diversion and did not reach what I thought was the agreed meeting point - The bottom of the Duke of York Steps until about 01.45. There was no sign of Hugh and David. Eventually I saw lights about 300m away towards Buckingham Palace. It was Hugh and Dave with the London Marathon support van. They had completed the layout and measurement of the calibration course and were waiting for the police escort and an official photographer.

David presented me with a measurer's high visibility vest of excellent quality with lots of useful pockets, IAAF/AIMS logos, and my name and "International Course Measurer" neatly printed at the breast pocket. There were no London Olympics logos, but then we all know about the very close control kept over the use of the official Olympics logos. Nevertheless it is something I now very proudly wear when measuring. David also brought one for Hugh. Another generous present from David was a couple of packets of Mag Nails, arguably superior to the PK nails I normally use in measuring. Thank you David.

Before long police on motor bikes started to arrive, eventually about 8 in all. Finally the photographer from the Wall Street Journal turned up. While these were assembling, David and Hugh led me off to chalk a riding line 1.3 m from the cobbled strip around the Queen Victoria Memorial. They also marked a point we would aim for on leaving the Memorial where we would turn on to the right half of The Mall.

David's counter fails

At about 02:07, as we prepared for our first calibration ride, David announced his J-R counter was not turning. The tag was bent not engaging the spokes and also the large metal spur gear was seized. I removed his counter. It still would not turn. The slot for the gear spur gear had been some how clamped tightly on the spur gear. I tried to lever it apart with a screw driver to free the gear, without success. David's front wheel had a quick release mechanism which I always find slightly tricky. I suspected he may have had a 9mm hole counter and I thought it possible that tightening up the axle bolt he had clamped everything up too tight.

This was a considerable set back, since David being the official measurer had to have a working measuring bike. My first thought was to sacrifice my ride and offer David my bike. But then I realised he would be unfamiliar with the operation of my electrically assisted bike. So I removed the J-R counter with a 10mm axle hole from my bike and installed it on David's axle. It turned fine but the tag was too far from the spokes. I asked for some wire and Hugh went to look in his bag. Very fortunately Hugh discovered a spare old-style Jones-Oerth counter which he must have forgotten he had in the bag. So we installed this J-O counter. It needed its tags bending to engage the spokes by more than we could easily do by hand. My son Geoffrey who was accompanying me (not riding) came up with a pair of pliers on his all purpose pocket knife tool which did the job, and David then had a properly working counter. With considerable relief I put my J-R counter back on my bike. I would after all be able to measure.



David's Bike with Hugh's spare J-O Counter installed

It was not all clear to me how the gear had become clamped. I can only conjecture that when installing it on the quick release axle the counter's axle hole had been slightly misplaced so that tightening axle squashed the bearing plates onto the gear. At measurement seminars I have occasionally experienced problems when fitting a J-R counter to some bikes if wrongly placed on a quick release axle. It is certainly possible to have some resistance to turning if not optimally placed, but I have never had any counter clamp up solid to such an extent that it would need tools to free it.

Pre-Measurement Calibration

At 02:19 we were ready again for the calibration which then proceeded very smoothly. During their taping before I arrived, Dave and Hugh had stuck pieces of tape to the road at the end of each tape length and marked the exact position with a pen. My first reaction was one of a bit of concern that the course ends had not been nailed. What would happen if the tape became dislodged before we had completed our post measurement calibration. It was later pointed out to me that the end points were exactly in line with the East faces of the base of two lamp posts at the kerb about 30 cm to the side, so it would be possible to relocate the ends sufficiently well had the tape been disturbed. I imagine there might have been some caution about not having permission to bang nails into the pristine red tarmac of The Mall.

Small Lap measurement

We set off round the course at about 02.30, the police riding ahead and behind, blocking side roads and closing down the lane ahead when the SPR took us onto the wrong side of the road. The process they use is one of repeated leap frogging. Once our procession of 3 bicycles had passed, the police motor bike guarding the side road weaved past us and took up position on the next unguarded side road ahead. I imagined that this must be what it is like to be in a Royal or VIP procession around Central London. Although as the police motorbikes expertly weaved past we cyclists it made me think also of the TV images of the Tour de France.

We had numerous brief stops to record our readings at intermediate distances, and for the police to clear traffic problems ahead. Central London is surprisingly busy between 2 and 4 am. Hugh, of course knew exactly where we needed to stop. All I had to do was keep close behind Dave, noting exactly where he and Hugh had stopped to take the reading. Sometimes the reference point was away to the side, so I may not have exactly judged the right point to take the reading. I tried to note exactly where David stopped to take his reading rather than judge alignment with some more distant landmark.

At first Hugh appeared to be rushing off too quick for David who said that he felt that he was being hurried too much. But after a few miles we all settled down. I really enjoyed the ride - both the precision of the bike riding and glimpses of London streets which I did not know.

David's plan had been to do an intermediate calibration after completing the small lap, but when we reached the finish line after lap one we went straight ahead with measuring the large lap. I don't know if this was due to concern over the time which we had lost at the start, or whether it was just forgotten. In the event missing this intermediate calibration check did not make any impact on our calibration since there was very little temperature change during the measurement, and for all 3 riders the pre-measurement calibrations were very close to the post-measurement calibrations.

Large lap measurement

On our second lap down the 4 lane Northumberland Avenue, we were on the right facing a huge lorry stopped ahead of us. The police expertly shuffled the traffic around so the lorry could cross to its right in order to leave the shortest line clear for us to ride.

As we went west there was another hold up for several minutes due to road maintenance activities which closed the Victoria Embankment where it dipped under one of the bridges over the Thames (Blackfriars bridge I think.) I chatted to a [police lady on her motor bike](#). The Wall Street Journal photographer jumped out of the London Marathon support van and photographed us from every angle. He was strangely attracted by the glowing digits of the voltmeter measuring the state of the battery on my electrically assisted bike. I did explain that it was nothing to do with the measuring process, nevertheless [this photo](#) made it into a [slide show](#) on the WSJ web site to illustrate the [article by Joshua Robinson](#) which appeared in the WSJ on 20 June.

Once the road was clear we headed off under Blackfriars Bridge. [Here](#) I can be seen tracking David. Hugh is hidden in front.

I had my electric bike mostly on medium assist so I could easily cope with the slight incline up from the Embankment. Going though Paternoster Square after St Paul's Cathedral, Hugh missed his intended reference point for 20 km so he improvised another about 70 m further on.

At the North side of Paternoster Sq. there was a temporary works barricade in place. Hugh and David performed the classic measurer's maneuver - *with front wheel touching the barrier, note where the back of the bike is. Clamp front wheel list back to the noted point and wheel forward to the barrier again. Clamp wheel and carry around the barrier to start measuring again with the back of bike touching the barrier.* Seeing where they ended up riding on the other side, I judged I could just lift my bike sideways a couple of metres and ride a reasonably satisfactory line to the next bend.

When we reached the reference location for the Eastern turn round on Tower Hill, I noted that Hugh's description said end of central divide at Roman Wall. I thought that is interesting, I did not know that London still had Roman walls, and I wondered where the wall was. Only much later [via the web](#) I found out that it is still standing high on the North side of Tower Hill complete with a statue of the Emperor Trajan which I will have to go and view one day. I learnt some history as a result of the measurement ride!

The other occasion when we differed somewhat in line taken, was when dealing with 3 or 4 parked cars as we returned along the long bend of the Embankment travelling towards Big Ben. Hugh veered out gently over 50m + to pass around some of the vehicles. Whereas David stayed at the kerb and offset out and back immediately around each vehicle. I followed David of the first of these vehicle obstructions. But for the subsequent ones I judged that, since the the road was so nearly straight, Hugh's veer out and back was good enough and did not risk any small errors in judging the 90 degree of the offset if I had tried to use that method.

We reached Big Ben at 04:23, and arrived at the finish line soon after without further incident. So it took about 2 hours for a total of 10.2 miles to be measured so you can see we had spent quite a bit of the time stationary, waiting for the route ahead to be cleared, in discussion, or writing down our splits.

Post Measurement Calibration

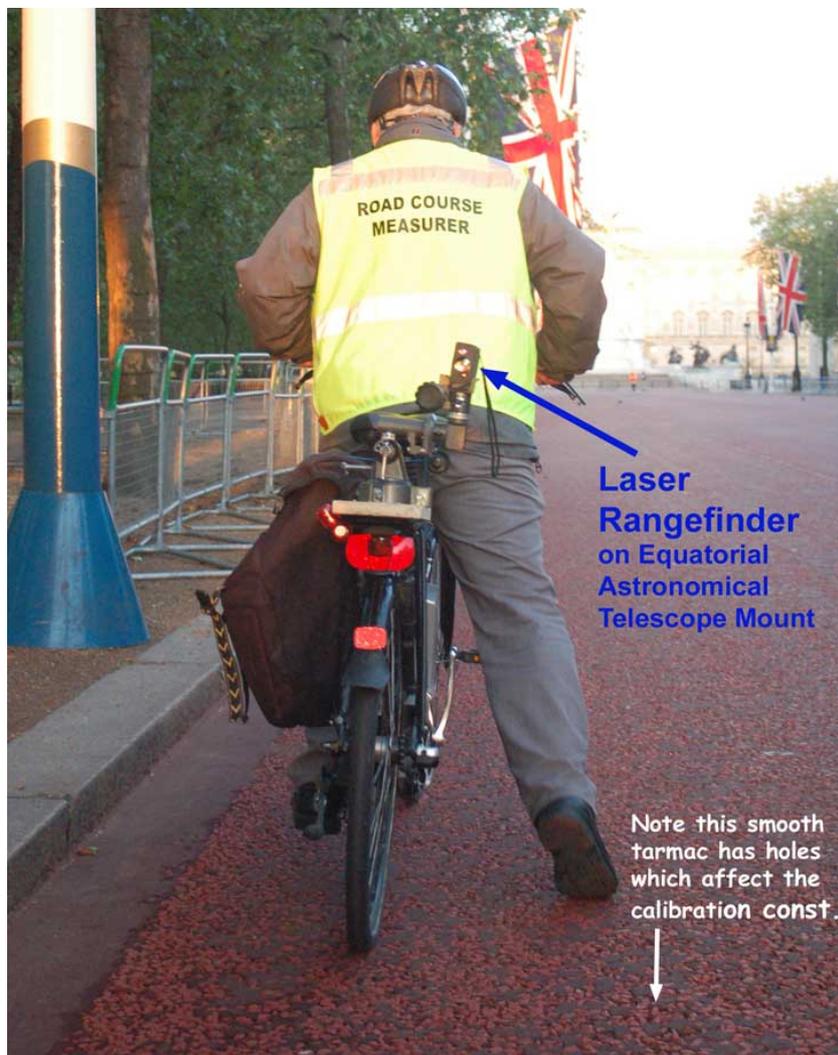
The police bikes were dismissed and we calibrated again without incident. The sticky tape was still in place. The temperature had dropped by 1.1C to 10C, and my calibration had barely changed. I was happy I had a good set of data. Likewise with David and Hugh who set about calculating their distances, while Geoffrey and I set up to use my laser to check the calibration course length.

Laser check of cal course

Here is how I transport to calibration courses my laser rangefinder with its ancillary equipment: a retro reflector and an equatorial telescope mount used for precise pointing over ranges up to the maximum of 250m



Below you see me on The Mall with laser in position about to pedal down to the Buckingham Palace end of the calibration course. The measurement is taken with the bike's kickstand deployed, so that the bike acts as stable tripod - overall an arrangement much better than the flimsy tripod and cheap alt-az pointing mount which came with the Bosch Laser Rangefinder



CLICK FOR A DOUBLE SIZE IMAGE

Laser
Rangefinder
on Equatorial
Astronomical
Telescope Mount

Note this smooth
tarmac has holes
which affect the
calibration const.

As you can see in the above photo the rising sun had just started to illuminate Buckingham Palace. A few minutes later when I was at the west end of the calibration course ready to take my first reading the rising sun was shining straight into the viewfinder of the laser, and I could not see my retro reflector to line up the laser spot. That was a new problem for me, but then I have not previously used this equipment firing towards the rising or setting sun. I decided to switch directions, moved the retro reflector to the west end and set up the laser on the bike about at about the midpoint of the calibration course 160 m to the east. I now had no trouble seeing the retro reflector in in the viewfinder and guiding the laser spot on to it using the slow motion knobs on the equatorial mount. Once on target, the retro-reflector can be seen with the naked eye to light up red even with the rising sun shining fully on the target.

I was very careful not to send the laser beam into the windows of Buckingham Palace behind, I did not want to get arrested by the Guards. I find the safe way to avoid such an accident with other road users or indeed residents is to make sure the laser beam in pointing towards the road before it is switched on, then carefully adjust the laser pointing controls so that the beam approaches the retro reflector from the road direction rather than the sky direction. The laser is Class 2, so eye safe provided you do not stare into the beam.

The first sign of confusion over the calibration course length started at this point. When we did the pre-measurement calibration I had been told one distance but later, while I did my laser measurement, David and Hugh recalculated and reported a revised value of 328.56 m (I did a quick on the spot calculation of of my laser readings but there were still some more corrections to apply and which I completed when I got it on a spreadsheet at home the laser gave 328.621 m. This was the start of a long saga during which the cal course length calculations were gradually refined and which I will describe in section on data analysis.

Hugh and David agreed very closely on their measurements ride distances. I put off doing my calculations until I had everything on a spreadsheet at home.

Geoffrey and I headed by car to David's hotel to collect some J-R Counters. Hugh and David cycled. We had a long wait at the hotel before they arrived. David had fallen off riding over a speed control bump (or sleeping policeman as they are commonly known). He had hurt his knee, but was still just about mobile. Not a good end to an otherwise memorable and successful night's work. We collected the counters and set off for home, stopping en route for coffee in order to keep awake.

Here is a [summary of the data analysis](#) which took place over the next three weeks or read [my detailed account](#).

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Analysis Summary

See [here for the detailed analysis narrative](#) [WARNING - long page] or use the links below to go directly to the section of interest.

Below, highlighted in bold are the comparisons between the steel tape and laser measurement of The Mall calibration course. They eventually converged to within 34 mm of each other once errors which had been made in applying corrections to the steel tape result were identified. - **a highly satisfactory outcome which demonstrates the capability of the laser method as an alternative to the steel tape method.**

- [First calculation results](#) - Mike: small lap 3.5679 km, large lap 12.8232 km (using 328.57m for cal course)
Hugh reported that with corrected NIST calibration steel tape result should be 328.56m.
Mall Calibration Course steel tape result was initially 328.57 m, changed to 328.56 m. Inital laser ranger result 328.621 m. LASER - TAPE = 71 mm
With 328.56 m for cal course, small lap: Hugh 3.56804 km David 3.56858 km, large lap: Hugh 12.8266km David 12.8263 km.
- [Question raised over the steel tape tension and the correct NIST calibration to use](#)
Tape was pulled at an estimated 10 lbs. However NIST calibration figures which had been first applied were for 10 kg tension
Mall Calibration Course steel tape result was changed to 328.517 m. Inital laser ranger result 328.621 m. LASER - TAPE = 104 mm
- [Hugh- Mike Interval Comparisons](#) - Analysis of both interval and cumulative differences between Hugh and Mike for the large lap
- [Wall Street Journal Article](#) - Interviews with David, plus 10 photos from the measurement
- [Effects of electric assistance on wobbles during my measurement](#)
Yes my wobbles may be reduced, especially on steep hills, but I calibrate with the same electric assist that I use to measure.
- [The laser ranger method for measuring calibration courses](#)
Mike investigates possible errors in his laser ranger method and makes a 10 mm correction to his inital value.
Mall laser ranger result was initaly 328.621 m, changed to 326.631 m. Latest steel tape calculation 328.517 m.
LASER - TAPE = 114 mm
- [Pete Riegel reviews David's data and reports finding an error in the calibration course length calculation](#)
Pete finds the tension correction has been applied in the wrong direction.
Mall Calibration Course steel tape result was changed to 328.597 m. Final laser ranger result 328.631 m. LASER - TAPE = 34 mm
- [Final Agreement on Measurement Result](#)

Olympic lap measurements (without the turnaround adjustments) using 328.597m for calibration course & Calculation of turnaround adjustments									
Lap measurements with turn rounds not moved				Calculation of turnaround adjustments					
	short lap	long lap	Course 1 short + 3 long laps		Km reqd for 8 miles	Length of 4.3m semicircle	centre move to make long lap 8 miles	Km reqd for 2 miles 385y	centre move to make correct short lap
david	3.5690	12.8280	42.0529		12.8748	0.0135	0.0166	3.5707	-0.0059
hugh	3.5684	12.8278	42.0517		12.8748	0.0135	0.0167	3.5707	-0.0056
mike	3.5683	12.8246	42.0422		12.8748	0.0135	0.0183	3.5707	-0.0055
							(lengthen)		(shorten)
fractional range	0.02%	0.03%	0.03%						
Mike Sandford's Recommendation: Since Hugh was most familiar with the course having ridden it a about 20 times take Hugh's values for the adjustment. Hugh's values are also the median values of the 3 measurements.									

- [Another Newspaper Story](#) Journalist from Long Island Newsday interviews the three measurers - The resulting article is hidden behind a paywall.

Analysis of the Measurement Data for the Olympic Marathon taken on 13 June 2012

I find I have 184 emails relating to the measurement and the subsequent analysis. This must surely be a record of some sort - it certainly is for any measurement I have made. It looks like I can extract bits from those emails which will tell the story of the post measurement data-analysis. The twists and turns during this analysis phase may make interesting reading for the dedicated measurer so I have selected here extracts from these emails which describe the key elements.

Warning this page is rather long. You may wish to view a [summary](#) before deciding to look further at the blow-by-blow detail below.

First calculation results

13 June: On reaching home I had a short sleep then calculated my results and at 15.31 sent them to Hugh and David

Dear All, Enjoyed the morning. Got back at 8 am, then to bed for 90 mins. Have now copied my data to a spread sheet (attached) My small lap was: 3.5679 km My large lap was: 12.8232 km My laser measurement of the cal course came out to 328.621 metres which is 61mm longer than the value which I wrote down from Hugh [i.e. 328.56 m]. Did that include the NIST calibration correction for the tape? I need to go through the small geometry corrections for the laser measurement again, but I will wait until tomorrow when I hope to have a clearer head after a good rest.

Hugh replied at 18.50

"I'm afraid these may need recalculation. David said the correction on his 100m tape was 16mm (so 3.28 x 16mm total). However, it seems it should have been 13mm, so the correction should have been 3mm x 3.28 less - that is, the calibration course should be 10mm longer than was given (ie 328.57m instead of 328.56m)

My figures, based on the 328.56 length of the calibration course, were: short lap: 3568.04m long lap: 12826.55m

David's were: short lap: 3568.58m long lap: 12826.27m

All extremely close"

Note: All the above distances were calculated using the two turn around references (the expansion joint on Westminster bridge for the small lap and the East end of the central divide at the Tower of London for the large lap.) So these distances do not include the length of the 4.3 metre radius turning sem-circles.

Measurement done, David caught a flight back to back to New York and on 15 June I wrote to David and Hugh:

Hope you had a good flight, and that the prognosis on the knee is OK. I have updated the spread sheet I sent you previously, and added more cal data from Long Tow, Abingdon, in the 24 hours after the London measurements. The sheets are:

1. My Cal data Long Tow and the Mall - also my laser check on the Mall Call course which makes it 5.1cm longer than the length which Hugh reported to me.
2. My Olympic Course measurements of the two laps.
3. Correction of My cal data for temperature and deflation using the coefficients for this tyre which I determined in June 2011. These are consistent with Long Tow being rougher than the Mall, But I am surprised the change is as large as 6 counts in 11200. I think I would have expected about 3 counts.
4. Summary of the results - Hugh's and David's values for the two laps were sent to me in an email from Hugh - I don't know if these are the final figures. I am about 9m shorter for the marathon. However it is an extremely twisty course.

Here is what I wrote in May: "Looking at the map on the web (version 9 -30/6/11) I have added up the equivalent of roughly 30 complete 360 degree turns in 42 km. So it will be equivalent to 30 laps of a simple oval loop of length 1.4 km. If the feet of the crowd control barriers are placed on the road way sticking out say 30 cm into the road beyond the kerb, then this will add 54 m to the length when compared with what would be measured if the measurers were to use the kerbs as the edge of the allowed route."

Using that estimate for the effect of mal placement of crowd barriers, then if my average line for the measurement was $9/54 \times 30 = 5$ cm closer to the kerbs than that of Hugh and David it would explain why I got a low value. I did try and not measure loosely but I would not have thought that I was more than 3 cm closer to the kerb on average than the nominal 30 cm. Of course the course surface was less smooth in places, and there were some flattish cobbles - this could produce slightly different effects on our different tyres.

Question raised over the steel tape tension and the correct NIST calibration to use

Later on the 15 June, after receiving my email, I got a phone call from David. He explained to me that he wanted no public discussion of the results. He said that the debates that had occurred in previous group rides of Olympic Courses were not helpful. Having followed some of the previous debates especially that on the measurement of the 1996 Atlanta Olympics marathon I understood what he meant. However there were a large number of measurers involved at Atlanta, all getting somewhat different results. So there was plenty of scope for debate as what to choose for the final distance. I agreed with David. For London 2012 we had just 3 measurers involved and our results were closely grouped.

I asked about the taping of the calibration course. David suggested that I be put in touch with NIST concerning the tape calibration. This I declined since I did not see any need - the NIST report appeared perfectly clear to me.

After reflecting on what he had told me I emailed back to David,

Have I got this right? On the phone did you say that your tape tension was an estimated 10 lbs? The NIST tape calibration was at 10 kg. So if you used the NIST table of tape length data at 10 kg, your real course length would be shorter than you worked out. In the attached spread sheet I calculate it would change 328.570 to 328.517. Please check if I have got the sign correct.

I am a bit concerned that it makes the tape to laser difference larger: 10.4 cm or 0.04% which is more than I would expect. Perhaps I made a mistake in the laser setup. For example if I had the

laser zero reference set to the wrong place on the device it could give a larger reading. The laser comes up by default with the reference as the back edge of the laser. But had it somehow got changed to use as the reference the end of the backwards extension arm, it would have added 45 mm to each laser reading, giving a total extra of 9 cm. I would be surprised if this happened since as I say I had planned to use the default reference, but I did not actually check the reference setting which is shown on the reading display. My raw laser readings without any corrections were West half: 159.539, 159.539, 159.539; and for the East half: 169.058, 169.055, 169.059, 169.054, 169.058.

16 June I wrote to David

My 50 m tape weighs 0.8 kg including its light metal case, so guessing 0.1 kg for the case, the tape weighs $0.7/50 = 0.014$ kg/metre. The NIST reports shows David's tape is 0.152 kg/metre so the two tapes must have nearly the same cross-section, and assuming steel of the same Young's Modulus they will stretch by the same amount under a given tape tension. Therefore my conclusion that David's tape has similar elasticity to mine is confirmed. This is actually not directly relevant to the question of the size of the correction. I was just interested to see how your tape's cross-section and therefore elasticity compared with mine.

Of somewhat greater importance and to reinforce what I sent in my spreadsheet yesterday yesterday evening about the length of the Mall Cal course. If David's tape was pulled at only 10 lb (4.5 kg), which is what I understood you tried to aim for, then the Mall Calibration length is 328.517 (not 328.570) and the marathon course measurement results should be reduced by 0.16% - just 7m in 42k. If of course you pulled twice as hard then you are correct in using the correction from the NIST table of 6.61 mm for 50 m. I am not sure why NIST pulled the tape at 10kg. The standard in Europe for Class II tapes is a pull of 50 N = 5.1 kg = 11.2 lbs. This is what I teach measurers to pull class II tapes at.

Not getting any response, on the 19 June I followed up to David with:

Do you have any thoughts about the tape tension? See my email.... It would make 7 m difference to the marathon length if your tape was pulled at about 10lb as you said to me, rather than the 22lb which NIST used for their calibration readings. Do you have a copy of the raw readings for yourself and Hugh? I would like to put them into my spreadsheet which I sent you last Wednesday because I am keen to see if any of my intervals were badly out, perhaps because of a wrongly written down number. Alternatively I would be interested to see if the small difference in our results built up gradually over the whole course, or was perhaps worse in specific areas perhaps with certain types of surfaces, e.g. the cobbles.

Hugh who had been copied into the correspondence sent me his results and I replied to him

Hugh, Many thanks. I will do the comparison tomorrow. Did you make any notes on the calibration course layout? Particularly what tape tension do you think you used?

David was busy he replied

Dear Mike, I have been non stop traveling, working events over the past week and hope to be able to send you the data over the next few days. David

Next morning (20 June) Hugh emailed

Mike, I nowadays use just the "firm pull", but it was David who tensioned the tape from his end. We measured 6 tape lengths westbound and then 28+ metres. Going back we found 3 mm of

difference. We did the temperature correction for 11C and also compensated for the laboratory verification of David's tape (he at first said this was 16 mm over the 100 m tape length, but later corrected that to 13 mm, causing the calibration course length to increase from 328.56 m to 328.57 m (3 mm /100 m x 328.5 m) Hugh

I replied

Hugh, Thanks for that. The exact tension wont change the overall conclusion that the course was well measured, but it does make me slightly worried about my laser technique because if David pulled at only 10 lb then the difference is a little larger than I can account for from what I presently understand of the errors in the laser technique. I will do more study of my laser errors.

I have compared my data with yours. I will send a spreadsheet later to you and David when it is complete, but here is an image of the current status showing one point, marked in yellow, where I may have stopped 0.5 m out of position, and 3 intervals, marked in red, where I seem to have ridden a bit tight through the very twisty parts. Perhaps the cobbles also had an effect on two of these intervals. It will be interesting to see in due course how David's intervals compare.

Hugh-Mike Interval Comparisons

Later on 20 June I sent out a draft assessment of the interval differences between Hugh and my counts for the large lap ([5 MB pdf](#)). The final version of the comparison of intervals, including the data from David which I received later is shown in the [graphs on this page](#).

Wall Street Journal Article

21 June

We heard from David that the [Wall Street Journal article](#) had appeared. David said that much had be written from an interview he gave before he headed to London for the measurement with updates from a post measurement interview.

I replied,

David, I was delighted to see the smashing article which is excellent PR for measuring. Obviously we can link to that article. Can you get a contact for the photographer Gareth Phillips. I would like to seek permission for reproduction of his photographs. I would particularly like to ask him for a photo showing he whole measurement procession complete with the police blue lights. I think it might provide a good general impression of the procedure, which I might be able to use in our course measurement website over here.

Geoffrey had been supposed to get such a picture for me, but he was not able to get his new camera into the right mode to get really good pictures in the gloom. We clearly should have practised properly beforehand but it was all rather a last minute plan.

I was amused to see Geoffrey and myself in the background of this picture of yourself. We are engaged on my attempt at laser measuring the calibration course. It nicely shows my reflector box.

I am still keen on ironing out the practical procedures for this laser measuring, despite the comment in the article implying that lasers at present have no place in course measurement.



David poses for the

Photographer. Mike and Geoffrey at work in the background

Months later I did a web search to find the photographer for the WSJ who had accompanied our measurement ride in order to ask for a photo of us riding surrounded by police motor bikes with blue lights flashing. I thought it might be nice to use it on the strictly non-commercial UK course measurement web site. The photographer replied offering a "discounted rate" of £50 for use of one of his photos. Now I understand that photographer has to make a living, but I was surprised that an unpaid volunteer who had been featured in his photos was being asked to pay. Presumably he had already been paid handsomely by the WSJ for the photos which they had used. Did I have any privacy right to ask for photographs of myself not to be used in his commercial/journalistic activities? Probably not.

Effects of electric assistance on wobbles during my measurement

I was asked about my use of electric assistance on my bike:

I don't know how much electrical assist you used, but I suspect it produces less wobble than does pedaling. If you didn't use it when calibrating, but did use it while measuring, the front wheel would not have to compensate for the back-and-forth forces caused by pedaling.

22 June - I replied:

I used medium electrical assist although the ride was not challenging and minimum assist (an extra 50% on top of what I provided into the pedals) would have been sufficient to keep me close. When at the back you tend to need to accelerate to catch up from a stop hence I chose medium (100% addition to what I provided)

You could well be correct that I wobble less with the benefit of extra power. It is on steeper hills where I really notice the reduction in wobbling. But of course Hugh is an excellent rider and I expect he wobbles very little even when accelerating hard or going up slopes.

I have gone over the map adding the angles turned through. The large lap has about 9.1×360 degrees of turning. So if on the large lap the 3 m, which Hugh and I differ by, is all due to me riding a tighter line on bends, then I rode 5.2 cm closer to the kerb on average than Hugh. So if Hugh rode the perfect 12 inches, then I would have had to ride at 10 inches - just about possible I

suppose since Hugh is very familiar with the corners whereas I was seeing them for the first time. To be sure of a perfect 12 inch ride I would have wanted to stop and check the distance in a few places to help judge it right.

Probably the difference is a mix of many effects including this one. We shall never know. The great number of turns help to make it a challenging ride which would test a poor rider.

The laser ranger method for measuring calibration courses

Because of the unexplained difference between my laser ranger measurement of the Mall calibration course and that reported by Dave and Hugh from their steel taping, I carefully looked at my laser calculations and procedure.

Firstly I found that my initial calculation of the laser distance was in error by 10 mm. I had not allowed for the fact on the second step the plumb bob was aligned 12 mm SHORT of the calibration course marker position. I also made some minor corrections for the fact that the effective reflection point of the retro-reflector was not at its surface. This changed my laser measurement from 328.621 to 328.631.

It was now 114 mm longer than the figure we had at this point in time for David's steel tape result. The difference was now 0.035% far more than the specified accuracy of the Bosch laser which is given by Bosch as 0.013% in unfavourable conditions and 0.005% in favourable conditions.

I decided to document fully the method which I had used. When on the Mall in London I had not made a photographic record of my method, I decided to repeat the method on another calibration course and photograph each step. I chose Park Road in Abingdon to lay out a 286 m course. My procedure and the calculations are fully described [here](#).

At this point, on 23 June 2012, it appeared from the Mall data that I had proved that the laser was not as accurate as specified. However, I could not square that with [earlier comparisons](#) which I had done on 29 March 2011 between my own "Silverline" steel tape and the laser on a 249.906 m calibration course. I then found that the laser gave 249.955 m. So the laser gives a result 49 mm longer than the steel tape. So in this test my laser gave about 0.02% more than my "Silverline" steel tape.

I know my own Silverline tape reads very slightly less than the true distance because on 23 April 1998 I had been able to compare it against Pete Riegel's Brazilian made "Stanley" tape which he had had calibrated by Stanley in the USA. In fact [the result from this 1998 check](#) was that my Silverline tape read low by 2.2mm in 30m relative to the Stanley calibration. Thus my Silverline was then reading 0.007% low. If the laser reads 0.013% high - the limit of the Bosch specification - this would be exactly predict my March 2011 result. However, I could not understand 0.035% difference found in the Mall comparison with David's NIST calibrated tape.

The solution to this conundrum was revealed on 2 July when Pete Riegel found an error in the sign of the NIST calibration when it was applied to David's tape. This discovery is described in the following section. Once we had corrected the tape calibration error for David's tape, the laser result on the Mall was only 0.01% high. This is a highly satisfactory result which leads me to conclude that my laser ranger properly used is entirely acceptable method for measuring calibration courses as an alternative to the recognised steel tape method.

Pete Riegel reviews David's data and reports finding an error in the calibration course length calculation.

On 29 June David sent Pete Riegel a copy of his and Hugh's data and asked,

" Please see attached data for myself and Hugh. The final report will contain more including photos of split locations, drop & separation data, etc. Please look over it with your microscope and let me know of any typos or errors. I am having a few others look this over for accuracy. Obviously this draft is not ready for publication."

On 2 July Pete replied to David, copying the correspondence to me,

I'm operating on generator power for the last few days. I hope for restoration in the next 2 to 4 days. Meanwhile, we roast.

I think there is an error in your calculation of the length of the calibration course. Also, I see only one measurement of the cal course. If two were taken, the other one should be included in the report.

I suggest you contact Mike Sandford, a world-class measurer and calculator, and see what he says. I am buried in dealing with the present power outage and cannot focus properly. He may also be helpful in integrating whatever data he has with that of you and Hugh. His data should appear in the report, whatever choice you make as to whose is "official."

I emailed David

2 July - Dear David, I am happy to help look at the calibration course length calculations. I remember you did suggest on the phone that I might make contact with NIST, but I said at that time that I thought fully understood the NIST report and no contact with NIST was needed.

As you know I have been studying the cal course length question rather closely when I found a somewhat larger than expected difference between your value of 328.570 and my laser value of 328.631. What disturbed me about my laser result was that the difference would increase still further if you pulled the tape at 10 lbs rather than 10 kg which the tape was calibrated at.

I have since then checked my laser technique very carefully - I have laid out another calibration course in Abingdon [[see my report on the Park Road Calibration Course](#)] using the exactly the same laser method as for The Mall. I have not found anything wrong with my laser methodology, although I have found out something unexpected about my bike tyre : it behaves like a solid tyre on rough/smooth surface even though it is a pneumatic tyre, ie on smoother surfaces it gives a smaller constant. This easily explain the difference between Hugh and me over the cobbled sections.

I did hear from Hugh that you and he made two tape measurements of The Mall and that these differed by 3 mm, which sounds fine. But Hugh did not mention the raw values, so if you send me these over I will be very happy to carefully go through the cal course length calculation.

Please call me on Skype if you want to discuss. I hope you have not suffered in the storms as Pete has in Ohio.

David sent me his data:

Mike, Please see attached data. Please respond to me only. I had another individual check my data as well, but it's easy to make errors. Thank you David

I responded:

David, I have quickly looked at the calibration course calculation You wrote:

June 13, 2012 00:45-01:15 Calibration course- On the Mall east face of Ip -18 & 30 raw measurement: 328.645 meters (6 tape length x 50 + 28.645 meters)

NIST correction: @0.013m/100m $0.013m \times 3.28645 = 0.0427238m$ $328.645 - 0.0427238 = 328.60228m$

Temperature Correction 11C @0.0000115* = 0.034m $328.60228m - 0.034m = 328.56828$ (*AIMS uses 0.0000115)

Calibration Course Length=328.57 meters

The NIST correction is in the wrong direction. The NIST report (table on page 1) says that under 10kg tension the 0 to 50 metre interval was measured by NIST to be 50.00661m, with a tiny uncertainty (negligible for our purposes). So the tape is actually longer than the scale on the tape says. You have to add the 0.0427metres which you calculated. So the length (before temp correction) ought to be 328.6877.

Now when you apply the temp correction by subtracting 0.034 m you get 328.6537 m round to 328.654 (the sign of the temperature correction is right because with a tape colder than 20C it will contract and so give a larger reading than it should).

Now when I compare 328.654 with my laser value of 326.631, my laser is now in much better agreement, Laser - Tape = - 23 mm. which I am now very pleased with since the laser error is now only 0.007%.

However caution is still required over the actual tension which you used. If the tension was only 10lb rather than 10kg, there will be hardly any tension correction required, just the temperature correction. Here is the actual calculation which I sent previously.

Tension	Tape length 40m-100m	
10kg	60.00776	NIST report p2
20kg	60.02946	NIST report p2
4.54 kg (10lb)	59.99791	

I see I made a small mistake in that calculation I think it should be at 4.54 kg true length tape length= $60.00776 - (60.02946 - 60.00776) * (10 - 4.54) / (20 - 10) = 59.99569$ So the 60 m of the tape is 4.3 mm short at 10 lb pull. 328 m of the tape will be short by 23 mm. At somewhere close to 14 lbs pull the tape will be exactly right!

When you come over again can you bring your tape so that the we can get together and compare the laser and the tape over 100 m and 10 kg pull? I think it would enable me to get a really good check on my laser - traced back to NIST standards! Since I started writing the above Pete copied to me his calculation which is for a 10 lb pull, not 10 kg.

328.645 minus the 23 mm which I calculate above= 328.622 this is close enough to the value Pete gives of 328.6227 - So Pete and I agree!

Final Agreement on Measurement Result

I then updated my summary of the three riders' measurements including calculation of the turn round adjustments and I recommended:

Since Hugh was most familiar with the course having ridden it about 20 times take Hugh's values for the adjustment. Hugh's values are also the median values of the 3 measurements.

David agreed, in an email to Pete:

As discussed with you and Mike (and suggested in Mike's email), I will be going with Hugh's landmark notations.

Throughout much of the period since our measurement on 13 June, David had been on duty at other events including the US Olympic Trials which were held in Eugene between 21 June and 1 July, and therefore he had to rely on others to spend time checking the results. However, he kept in touch even while working with his Blackberry in airports and while on the plane home on 2 July:

Thank you for the very prompt work. I'm flying back from Eugene, Oregon (yes, inflight internet). There's a ton of data!

3-5 July,

Over the next three days I had a round of discussion mainly with Hugh who regretted the fact that he had not checked the cal course with a certified Japanese tape which he had. Hugh also made the interesting point that it might be better to go with the manufacturer's calibration of the tape scale rather than try to apply corrections for tension. During this exchange Hugh gave me the actual raw lengths that he and David obtained, and the average of the two. I replied:

Hugh, Thanks for this, with the two actual measurements values for the cal course - first time I have seen the 328.648 figure - you told me your reading was 3 mm different but I did not know which way! The normal protocol is to take the average, as you have done 328.6465, as the base to which the corrections must be applied..... David asked me to write a one or two page summary of the tape calculations for his report, and to include mention of the laser check, which of course now confirms the properly corrected value which was obtained from the taping.

I sent my final summary of the calibration course length calculations which appears [here](#)

Hugh, Yes, except I have now recalculated using the average tape value which you gave of 328.6465 so it gives (after rounding) a value 2 mm greater 328.597. In the next email I am sending a draft for David's measurement report as he requested. Mike

Then I updated my overall measurement spreadsheet with this final value 328.597 (see [here](#))

Dear David, I have updated my spreadsheet with the latest value for the cal course 328.597 (2 mm more after taking the average of your and Hugh's taping, which I think will give the best estimate of the cal course length). I have left out the sheet where I did temperature corrections for my calibrations taken over two weeks, I did that when I was still trying to understand how all the numbers fitted together. But now that we have a clear, clean story for the taping and the laser check of it, I don't want to go into the complexities of my tyre's changes on different cal courses. It would not in anyway assist your report, which should obviously focus tightly on the job in hand. I think I have now done everything you asked for. Let me know if there is anything further.

Hugh revised his report using the finally settled calibration course length 328.597.

Mike, David, I attach my amended report, based on 328.597 m being the calibration course length. This is the third version (previous lengths having been 328.56 m and 328.57 m) Hugh

On 6 July Hugh sent to The Race Organisers the final version of his calculations

Lisa, I attach what I have done myself. there was some discussion over the length of the calibrations course (depending upon corrections for the laboratory test of the tape we used, and this added a few centimetres to our 328.56 m first used. The agreed figure is 328.597 m. I re-calculated using this as the basis yesterday (as in the attached report). David Katz will be submitting his own report, using these same figures (and therefore specifying the same course). I think he is near completion but was delayed by his duties at the US Trials over the last weeks. Hugh

And David told the Race Organisers to use Hugh's numbers.

Lisa, Sorry for the delay. The "nerds" of the world (including myself) have been fine tuning the numbers! I will be preparing the "official" report over the next week which will recommend that you use Hugh's landmark notations for all required marks along the course (miles, 5k's, etc.). This weekend I will review the report that Hugh emailed you today for any inconsistencies (typos) so your team can move forward with their preparations. David

Another Newspaper Story

On 9 July a journalist called Nicholas Spangler emailed me:

Dear Mr. Sandford, I'm a reporter for Newsday, a U.S. newspaper covering Long Island. I'm doing a story on your colleague, David Katz. Do you have time for a quick phone interview this week, or the patience to answer questions over email? Regards, Nicholas Spangler

We later spoke on the phone and I reported back to David:

David, This reporter phoned me this afternoon, asked some of the usual sort of questions, e.g. how many times does the bike wheel go round for a marathon, etc. But there was also a wider range of questions, some unexpected.

Do measurers have different styles? Answer: For good measurers the important thing is consistent riding and calibrating, but style may differ in how they deal with race directors.

What is it like being an anonymous measurer giving interviews to the media. Answer: we have experience of media enquiries when runners complain a course is short and we have to work out whether the race director sent the runners along the measure route.

I referred a question about how our 3 measurements compared to David, saying he was in charge of the official report on the measurement. Regards Mike

By means of a web search I found out that [Spangler's article appeared on 4 August](#) but unfortunately it is hidden behind a paywall. I am not going to subscribe, so I don't know if anything I said got published. After my run in with the WSJ photographer described above I decided not to plead for free access. Perhaps I had better draft an access

and fair non-commercial use contract ready in case I ever encounter these journalist types again.

A further web search revealed a [facebook page](#) containing what appears to be a cut and paste of the Long Island Newsday article.

Finally the web search brought up an [article on The Runners World Website](#) about Hugh Jones's preparatory work for the official measurement.

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Measurement of Calibration Course: The Mall

Calibration by NIST of the tape used to measure the course

The tape was a 100m steel tape which had been calibrated by NIST. (See REPORT OF CALIBRATION, NIST Test No: 683/282295-12 April 24, 2012. Scans are available on David's website [page1](#) [page 2](#)) The NIST test measurements showed:

At 10KgF tension and 20C, the true distance between the zero and 50 m marks on the tape was found to be 50.00661 m. This means that for every 50m tape length 6.6mm has to be added to the tape readings get the true distance.

The true distance at other tensions can be worked out from the following NIST test result from the distance between the 40m and 100m marks on the tape:

At 10KgF tension true distance = 60.00776 m; At 20KgF tension true distance = 60.02946 m

The standard tape tension pull specified by most tape manufacturers is 50N which is approximately 5.1 KgF (or 11lbF). Experienced measurers are able achieve sufficiently close to 50N by giving the tape a firm but not excessive pull.

One can calculate the true distance for 5.1 KgF tension from the 20KgF and 10KgF test results above:= $60.00776 - (60.02946 - 60.00776) \times 4.9/10 = 59.9971\text{m}$.

So the reducing the tension from 10KgF and 50N for 60m section of the tape is true distance is reduced by 10.66mm. This is a factor of $59.9971/60.00776 = 0.999822$

Applying this factor to the 0 to 50m true distance of 50.00661 m we get a true length at 50N tension of 49.9977 m, so at 50N the tape markings are very nearly exact, we have to subtract just 2.3mm for each 50m tape length (at 20C).

Correction for temperature of 11C experienced during the taping of the Mall Course

NIST give an assumed temperature coefficient for a steel tape of 0.0000115 C^{-1} .

At 11C correction to give the true distance for the 50m length is $-50000 \times 9 \times 0.0000115 = -5.2\text{mm}$.

Final corrected tape length for 50N and 11C

So at 50N and 11C the true distance from the 0 to 50m tape marks is $50\text{m} (-5.2 - 2.3)\text{ mm} = 50\text{m} - 7.5\text{ mm} = 49.9925\text{ m}$.

Details of calibration course and its measurement by the steel tape

A temporary calibration course was laid out next to the straight kerb on the South side of The Mall between the start/finish line and the

Queen Victoria Memorial.

The endpoints used were in line with the East Faces of Lamp Posts No 18 and 30. Pieces of sticky tape were used on the road and these were marked to show the exact locations of the end points. The taped intervals were also marked in the same way.

David Katz and Hugh Jones carried out the course taping between 00:45 and 01:15 on 13 June 2012 immediately before calibrating the bikes and undertaking the measurement of the marathon course. The temperature was recorded as 11C.

On the first run with David marking the tape lengths and applying tension and Hugh holding the zero mark to the road marking, there were 6 x 50m tape lengths plus 28.645 m giving a total of 328.645 m before applying the corrections calculated above.

For the return measurement with roles reversed Hugh obtained a total length of 328.648 m

Average of two tapings= 328.6465 m. Correction is $-7.5 \times 328 / 50 \text{ mm} = -49.2 \text{ mm}$

The Mall Calibration Course Corrected Length = 328.597 m

Independent Check Using a Laser Ranger

Mike Sandford carried out a check on the calibration course length around 05:00 after the marathon measurement had been completed.

The laser was mounted 104 cm above the ground and aligned with the calibration course end marker by means of a plumb bob. The laser beam was aimed at retro-reflector placed on the ground. The reflection spot was approximately 10 cm above the ground.

A correction was deducted for the slope of the laser beam (worked out using Pythagoras) The plumb bob hung from a point 16mm behind the laser reference point. The course was measured in two steps, on the second step the plumb bob was aligned 12 mm SHORT of the calibration course marker position).

LASER READINGS (metres)

Laser Readings (average of 3)	Deduct extra arising from slope of laser beam	Plumb line to laser ref point	Reflection to front face	Plumb to cal end mark	After correction
159.539	-0.0029	+0.016	-0.0015	0	159.551
169.057	-0.0027	+0.016	-0.0015	0.012	169.081
			Corrected laser total =		328.631

So the laser gave a measurement which was $328.631 - 328.597 = 34\text{mm}$ larger

As a percentage this is a difference of 0.010%

The specification for the laser, a Bosch Professional GLM 250VF, is as follows:

*In unfavourable conditions (e.g. at intense sunlight or an insufficiently reflecting surface), the maximum deviation is $\pm 20 \text{ mm per } 150 \text{ m}$.
In favourable conditions, a deviation influence of $\pm 0.05 \text{ mm/m}$ must be taken into account.*

This spec is 0.013% in unfavourable conditions and 0.005% in favourable conditions.

Therefore, within the laser accuracy range stated by Bosch, the laser measurement confirms the measurement made with the calibrated tape .

The value of 328.597 m derived from the NIST calibrated steel tape measurements was taken as the calibration course length for the purpose of Olympic Marathon measurement.

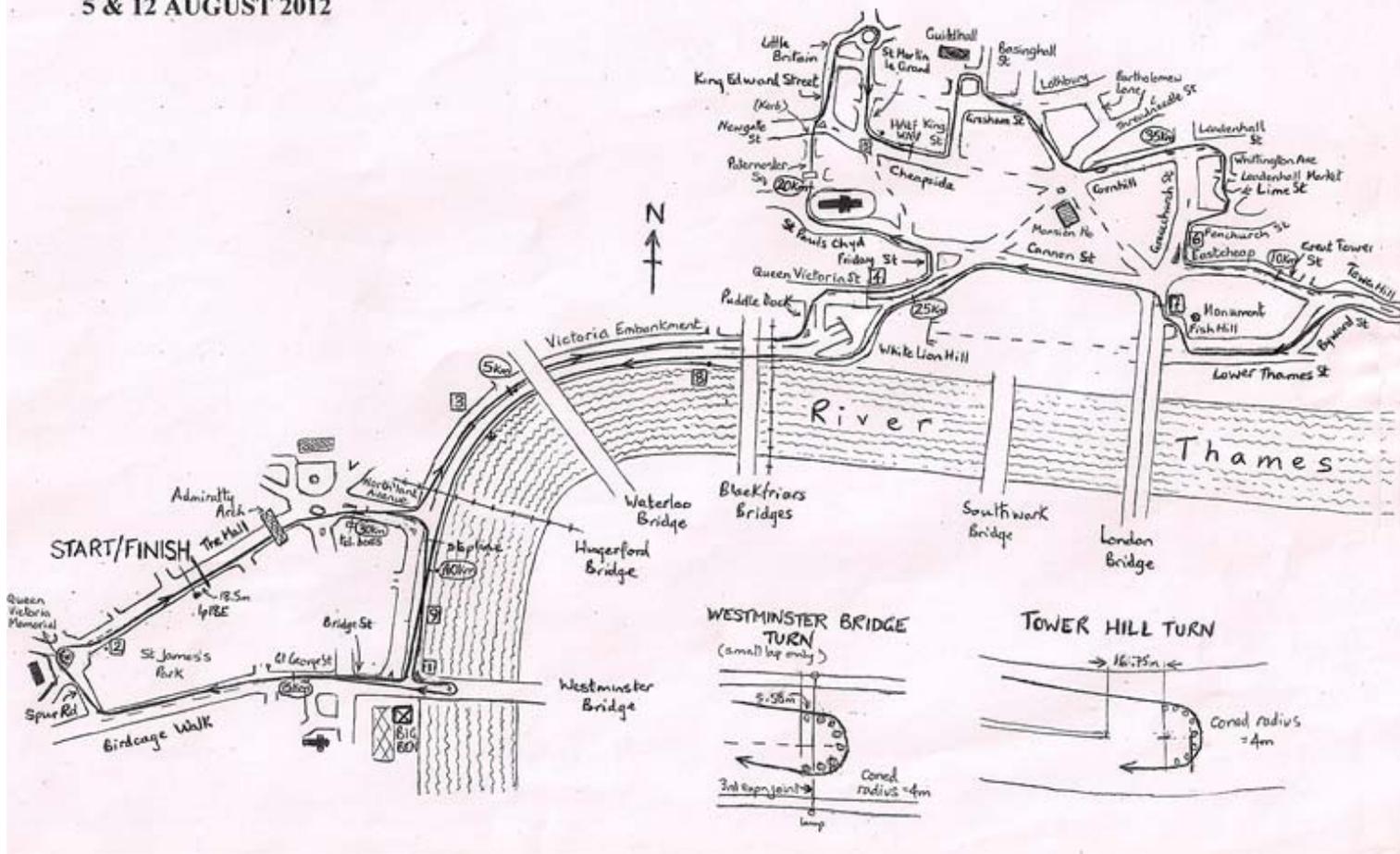
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OLYMPIC MARATHON COURSE MAP

MARATHONS OF THE XXX OLYMPIAD

LONDON, UK

5 & 12 AUGUST 2012



[click](#)

[for larger map](#)

Course Map ©Hugh Jones 2012

This is the course map drawn by Hugh Jones for the official measurement on 13 June 2012. Previous versions had existed prior to the test event held on 30 May 2011, after which the last significant changes were made to the course, including:

1. At the extreme north point of the course, the test course turned right from King Edward Street into Little Britain and right again at the the junction of Little Britain and St Martin Le Grand. The final route was changed to continued along King Edward Street (this section is actually also called Little Britain), and Montague Street before going clockwise around the roundabout at the Museum of London and turned there into Aldersgate Street, becoming St Martin Le Grand.
2. At the east end of Gresham St the course used for the test event continued along Lothbury, turned right into Bartholemew Lane, and right again at Threadneedle Street to reach the west end of Cornhill. The final route missed out this loop around the Bank of England: the runners turned right from Gresham St/Lothbury into Princes St to reach the west end of Cornhill.

The final offsets for the two turning points are also shown. These are based on Hugh's measurement data from our [final measurement rides of 13 June 2012](#).

There are five details not shown on this final map:

1. Around the cobbled perimeter of the Queen Victoria Memorial cones were to be placed with their outer edge 1m from the function of the cobbles with the smooth tarmac. For our measurement we marked the running line with chalk 1.3 m from the cobbles.
2. As shown in the map the runners are guided into the right half of The Mall. At the pedestrian crossing at the West end of The Mall, we marked a point with chalk where the runners leaving the circle of the Queen Victoria Memorial would pass as they turned on to a line immediate to the right of the centre line of the Mall. I did not record the details of the exact positioning of this chalk mark.
3. At the entrance and exit of the Guildhall Courtyard, the rising bollards were to be retracted and the runners were to pass through this section. The fixed bollards on either side would be barriered to prevent runners passing between the fixed barriers and the adjacent buildings.
4. At the right turn from the eastbound half of Leadenhall St into Wittington Avenue a 4.4m radius was measured and marked by Hugh and David to be coned off in order to create a gentler turn.
5. At the junction of White Lion Hill and the Victoria Embankment there is a removable metal kerb on the left hand side to guide the traffic. It

was agreed that this would be removed for the a marathon so we measured the very slightly shorter route across the metal kerb.

I watched the TV pictures of the race very closely and I am able to confirm that all the above 5 points were correctly marked on the race days and the runners followed the route we measured. Hugh and David of course were on the spot during the preparation of the course for the race and during the actual events and they obviously can provide official confirmation that the course available on the day and run was that measured.

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COURSE MEASUREMENT SUMMARY SHEET

EVENT **MARATHONS OF THE GAMES OF THE XXX OLYMPIAD**

LOCATION: **LONDON, UK**

DATE: **5 & 12 AUGUST 2012**

Promoting Organisation: **LOCOG 2012**

Name & Address of Road Events Manager:

Terry Colton

Tel:

Email:

Distance: **not less than 42,195m** Measured by: **Hugh Jones**

Dates: 2012-06-13

Measurement method: **Jones counter mounted on bicycle wheel**

Elevation, if not same, of: START 7m FINISH 7m

Distance, in a straight line, between start & finish: **identical**

Description of the Course

- i) Terrain: **mainly flat: sharpest rise 9m in 200m, sharpest descents - Byward St (7m in 150m) & White Lion Hill (9m in 250m)**
- ii) Race surface: **tarmac city streets**
- iii) Course configuration: **short lap of 3570.75m then 3 laps of 12874.75m**

Measurement Details

- i) Section of road available: **entire width of road or carriageway but keeping to north half of Birdcage Walk.**
- ii) Line to be taken at turns: **shortest route, with defined turnaround point (see map detail)**

SIGNED:

DATE: 2012-07-05

MARATHONS OF THE GAMES OF THE XXX OLYMPIAD

LONDON, UK

5 & 12 AUGUST 2012

This official measurement was based upon many preceding measurements of the course, which had identified landmarks from which it would be easy to reference all splits required. Some small modifications of the route had been made in Queen Victoria Street and White Lion Hill, but the main change was a decision to fix the running line around the Queen Victoria Memorial at 1.3m offset from the cobbled strip (ie coned 1m out from the cobbles).

The official measurer David Katz was already familiar with the course after a visit in January 2012. We also rode the course the afternoon before the official measurement.

On the evening of the measurement we rode to the start line early to tape-measure (with a calibrated tape, certified as 13mm shorter than the advertised length of 100m) between permanent landmarks on a section of The Mall which would remain accessible throughout the duration of the Games. This was between the west faces of lamp-posts 18 and 30, and was measured at 328.57m

Mike Sandford, measurement secretary for the South of England, joined us at 02.00 and we calibrated soon afterwards (02.30), after a delay caused by the jamming of David Katz's new model Jones counter and replacement by an old model.

We rode with 8 police motorbikes as escort, who enforced a "rolling closure" along with a London Marathon vehicle following up, driven by Mark Griffiths and in which course manager Lisa Thompson was a passenger.

Even around 03.00 there were some traffic problems, most notably in Northumberland Avenue, but with patience and police direction we were able to stick strictly to the shortest possible route throughout the course, measuring sequentially the one small lap and the first of three identical large laps. We stopped and noted references at all locations required for split points (known approximately from previous measurements), although at 20km I overshot the mark by 70m and had to improvise a new reference landmark.

For the turn points we rode to the reference points and returned directly. The prescribed turn radii for both short lap and long lap turn points is 4m, so the turn path is $(4.3\text{m} \times \pi =) 13.5\text{m}$. Adding this distance, the adjustment is made by retracting (small lap) or extending (long lap) the centre of the turn circle from the reference point so that the lap becomes the required length. Accordingly, the centre of the small lap turn is 5.58m before the 3rd expansion joint on Westminster Bridge; for the large lap it is 16.75m past the end of the divider on Tower Hill – which is just over a metre beyond (east of) the Roman Wall.

We recalibrated at 04.40 with small calibration change (1C change of temperature).

counts distance adjusted dist.(m) location

$c = 11.266302/m$

00000	0.0m		The Mall, finish Gantry position
18166	1612.4m		Embankment, traffic light at Westminster Bridge
19226	1706.5m		Westminster Bridge, 3 rd expansion joint

--- retract by 5.58m (x 2) and add turning path of 4.3m x pi – total addition 2.34m ---

36043	3199.1m	3201.5m	The Mall, near (west) side of pillar
40203	3568.4m	3570.75m	The Mall, finish Gantry position

LONG LAP: Started with 3570.75m elapsed

40203	3568.4m	3570.75m	The Mall, finish Gantry position
54276	4817.5m	4819.8m	Embankment, level with centre of Cleopatra's Needle
56486	5013.7m	5016.0m	Embankment, last lp on left before Waterloo Bridge
72501	6435.2m	6437.5m	QV St, start of permanent divider before White Lion Hill
90674	8048.2m	8050.5m	Cheapside, 1 st lp on left (opposite New Change)
08855	9662.0m	9664.3m	Fingerpost at start of Eastcheap (opp. Fish Street Hill)
12875	10018.8m	10021.1m	Great Tower Street, start of divider approaching Tower Hill
16608	10350.1m	10352.5m	Tower Hill, before turn

--- Extend turn by 47.0m (16.75 x 2 and add turn circle of 4.3 x pi) – adjust overall by +49.34m ---

16608	10350.0m	10399.5m	Tower Hill, after turn
26220	11203.3m	11252.6m	London Bridge, lp2 on divider
44263	12804.8m	12854.1m	Embankment, traffic light on left opp. Temple Ave
62537	14426.8m	14476.1m	Embankment, far side of Battle of Britain Memorial
68293	14937.7m	14987.0m	lp6, Great George Street
80566	16027.0m	16076.4m	The Mall, west face of pillar
84724	16396.1m	16445.5m	The Mall, finish Gantry position after ONE long lap

ON SECOND LARGE LAP (add 16445.5m):

40203	+ 0m	16445.5m	The Mall, finish Gantry position after ONE long lap
81114	+ 3631.2m	20076.7m	Paternoster Sq, far side of pillar to Chop House
92543	+ 4645.7m	21091.2m	Cheapside, level with east kerb of Bread St (on right)

=> plus Tower Hill adjustment of 47.0m from here to end of lap

36030	+ 8505.6m	24998.1m	Q V Street, ped light on left at Millennium Bridge
84724	+ 12827.7m	29320.25m	The Mall, finish Gantry position after TWO long laps

ON THIRD LARGE LAP (add 29320.25m)

40203	+ 0m	29320.25m	The Mall, finish Gantry position after TWO long laps
47786	+ 673.0m	29993.2m	level with middle of 2 tel boxes on right, entering N'land Ave
03849	+ 5649.2m	34969.4m	Traffic light, Leadenhall St (before turn into Whittington St)

=> plus Tower Hill adjustment of 47.0m from here to end of lap

59906	+ 10624.8m	39992.1m	Embankment lp90, before Horse Guards Avenue
75693	+ 12026.1m	41393.3m	Birdcage Walk, lpC88
84724	+ 12827.7m	42195.0m	The Mall, finish Gantry position after THREE long laps

List of split mile and 5km positions

START	The Mall, 18.5m east of lp18E
1 mile	Embankment, 3.0m before traffic light at Westminster Bridge
TURN	Wstr Bridge, 4m coned radius centred 5.58m before 3 rd expn joint
2, 10, 18 & 26 miles	The Mall; west end, 17.1m past west side of pillar
3, 11 & 19 miles	Embankment, 8.2m past centre of Cleopatra's Needle
5km	Embankment, 16.0m before last lp on left before W'loo Bridge
4, 12 & 20 miles	Q Victoria St, 0.1m before start of permanent divider at W Lion Hill
5, 13 & 21 miles	Cheapside, 3.8m before first lp on left (opposite New Change)
6, 14 & 22 miles	Eastcheap, 8,3m before fingerpost opposite Fish Street Hill

10km	Great Tower St, 21.0m before start of divider approaching Tower Hill
TURN	Tower Hill, 4m coned radius centred 16.8m past end central divider
7, 15 & 23 miles	London Bridge, 12.8m past lp2 on divider
8, 16 & 24 miles	Embankment, 20.6m past traffic light opp. Temple Ave
9, 17 & 25 miles	Embankment, 8.0m past south face of Battle of Britain memorial
15km	Great George St, 13.0m past lp06

On second long lap:

20km	76.7m before far side of column o/s “Paternoster Chop House” OR: 7.3m before angle of last metal tree apron before turn thro arch
HALFWAY	Cheapside, 6.2m past east kerb of Bread Street
25km	Q Victoria St, 1.9m past ped. light on left at Millennium Bridge

On third long lap:

30km	N’land Ave, 6.8m past centre of two tel. boxes OR 8.6m before lp55
35km	Leadenhall St, 30.6m past traffic light at Gracechurch Street
40km	Embankment, 7.9m past lp90, before Horse Guards Avenue
800m to go	Birdcage Walk, 1.7m past lpC88
400m to go	The Mall 30.9m before west side of pillar OR 7.8m past lp32E
300m to go	The Mall, 13.1m past lp28E
200m to go	The Mall, 18.0m before lp24E
100m to go	The Mall, 3.4m past lp22E
FINISH	The Mall, 18.5m east of lp18E (St James’s Park side)

On 328.597m steel-taped calibration course on south side of The Mall, 2012-06-13

Pre-measurement, 02.30			Post-measurement, 04.40		
start	end	reading	start	end	reading
82000	85699	3699	85000	88698	3698
85699	89398	3699	88698	92396	3698
89398	93096	3698	92396	96094	3698
93096	96795	3699	96094	99792	3698
Average – 3698.75 (x 1.001/328.597m)			Average – 3698 (x 1.001/328.597m)		
Working Constant: 11.267445/m			Finish Constant: 11.265159/m		
Constant for the Day (Average) = 11.266302/m					

Calibrations

Specialized All Cond Armadillo 700x25 tyre pumped ~ 110psi on 9 June at 10.00													
Date	Time	start R1	end R1	end R2	end R3	end R4	CONSTANT	Ride 1 count	Ride 2 count	Ride 3 count	Ride 4 count	avtemp C	
				Long Tow, <u>Abingdon, Cal</u> length =			595.283 m						
10 Jun 2012	07:00:00	20925.5	27594.5	34262	40929.5	47597.5	11212.6	6669	6667.5	6667.5	6668	11.1	dry
11 Jun 2012	05:30:00	86300	92970	99639.5	6508.5	12978	11215.1	6670	6669.5	6869	6469.5	11.4	very wet – rain
12 Jun 2012	04:45:00	47009.5	53680	60349.5	67021.2	73691.8	11216.9	6670.5	6669.5	6671.7	6670.6	10.6	wet -no rain
13 Jun 2012	19:56:00	5747	12414	19081	25748.3	32415	11210.9	6667	6667	6667.3	6666.7	15.3	dry
14 Jun 2012	05:12:00	66417	73088.5	79759.2	86480.5	93101.5	11217.9	6671.5	6670.7	6721.3	6621	8.8	dry
N.B The Mall is very smooth but with holes, Long Tow was resurfaced with tar and small stones last summer, and is much rougher. For a pneumatic tyre The Mall should give a larger constant.													
				The Mall <u>Cal</u> Length =			328.597 m						
Date	Time	start R1	end R1	end R2	end R3	end R4	CONSTANT	Ride 1 count	Ride 2 count	Ride 3 count	Ride 4 count	avtemp C	
13 Jun 2012	02:07:00	25247	28930.5	32613.5	36297	39980.8	11220.84	3683.5	3683	3683.5	3683.8	11.1	dry
13 Jun 2012	04:37:00	26645	30328	34012	37695.5	41379	11220.99	3683	3684	3683.5	3683.5	10	dry
average used for Olympic Measurement=							11220.91						

Measurement Ride

Hugh led with David following. Mike rode close behind Dave and stopped at the places indicated by Hugh and Dave. Hugh had supplied a list of location numbers and descriptions at which intermediate readings were to be taken. Mile recorded his own brief note of the location to be later matched up with Hugh's definitive reference point description

Mikes Ride			Constant	11220.9	ctskm		
Hugh's measurement schedule	Hugh's l/o.	MCWS location note	Count	count inc	Dist inc km	Cum dist km	
Small lap							
Start/Finish	1	LP	42213				
Traffic light Westminster br	2	?????unclear note	60307	18094	1.6125	1.6125	
3 rd expansion joint	3	Joint on N side	61364.5	1057.5	0.0942	1.7068	
3 rd expansion joint	3	Joint on S side	61570			1.7068	
Ped light at start Mall	4	dashed line	78314	16744	1.4922	3.1990	
Start/Finish	5	Mid point between Tarmac join lines	82458	4144	0.3693	3.5683	
8 MILE LAP							
Start/Finish	5	Mid point between Tarmac join lines	82458				
Between Telephone Boxes	6	Between Telephone Boxes	90011	7553	0.6731	0.6731	
Cleopatra's needle	7	R	96473	6462	0.5759	1.2490	Temp=11.8C
Last LP before Waterloo Bridge	8	LP on L	98680	2207	0.1967	1.4457	
WL Hill – start divider	9	Start Divider on R	14624	15944	1.4209	2.8666	
Paternoster Sq Tree apron	10	Paternoster Sq;N edge Column on L	23193.5	8569.5	0.7637	3.6303	
1 st LP Cheapside	10a	Lp on L	32714	9520.5	0.8485	4.4788	
bread St E Kerb	11	level with kerb of road on R	34575	1861	0.1659	4.6446	
TL Leadenhall str	12	Post on R	45834	11259	1.0034	5.6480	
finger Post Eastcheap	13	finger pole on L	50812	4978	0.4436	6.0917	
Start is. Before Byward St	14	First edge divide in centre	54816	4004	0.3568	6.4485	
Tower Hill turn	15	Turn at divider near Tower	58533	3717	0.3313	6.7798	
London Br LP2	16	LP centre on L	68100	9567	0.8526	7.6324	
Ped light at Millennium Br	17	TF LP on L	77867	9767	0.8704	8.5028	
TL opp Temple Ave	18	Pole on L	86066	8199	0.7307	9.2335	
LP90 (Before HG Ave)	19	Centre LP on L	01644	15578	1.3883	10.6218	
Far side BoB memorial	20	S face Block on L	04266	2622	0.2337	10.8554	Time=04:23
LP 6 George St	21	LP on R	09998	5732	0.5108	11.3663	
LPG92 Birdcage Walk	22	C88 on R	17367.5	7369.5	0.6568	12.0230	
Ped light The Mall	23	dashed line	22220	4852.5	0.4325	12.4555	
Start/Finish	24	Start/finish	26362	4142	0.3691	12.8246	

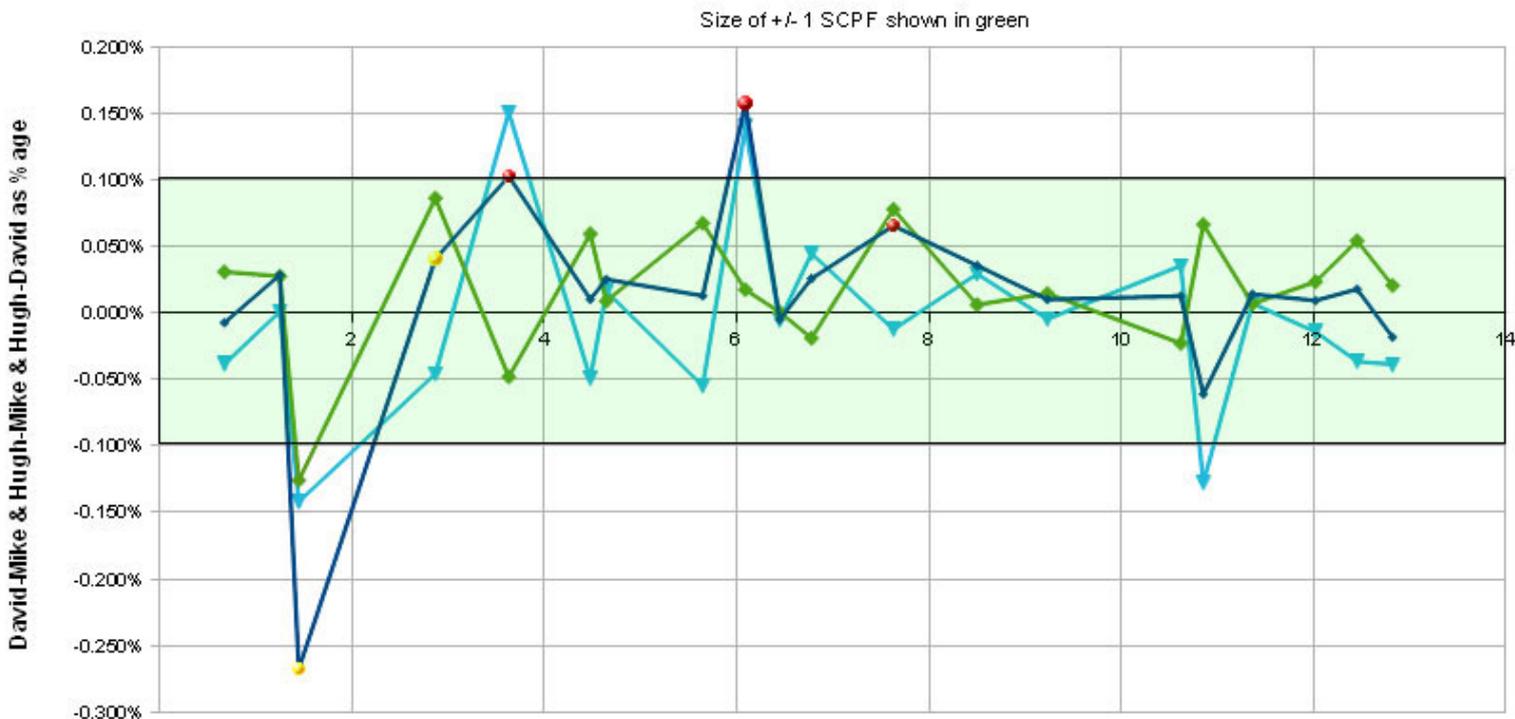
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Summary and Adjustments required

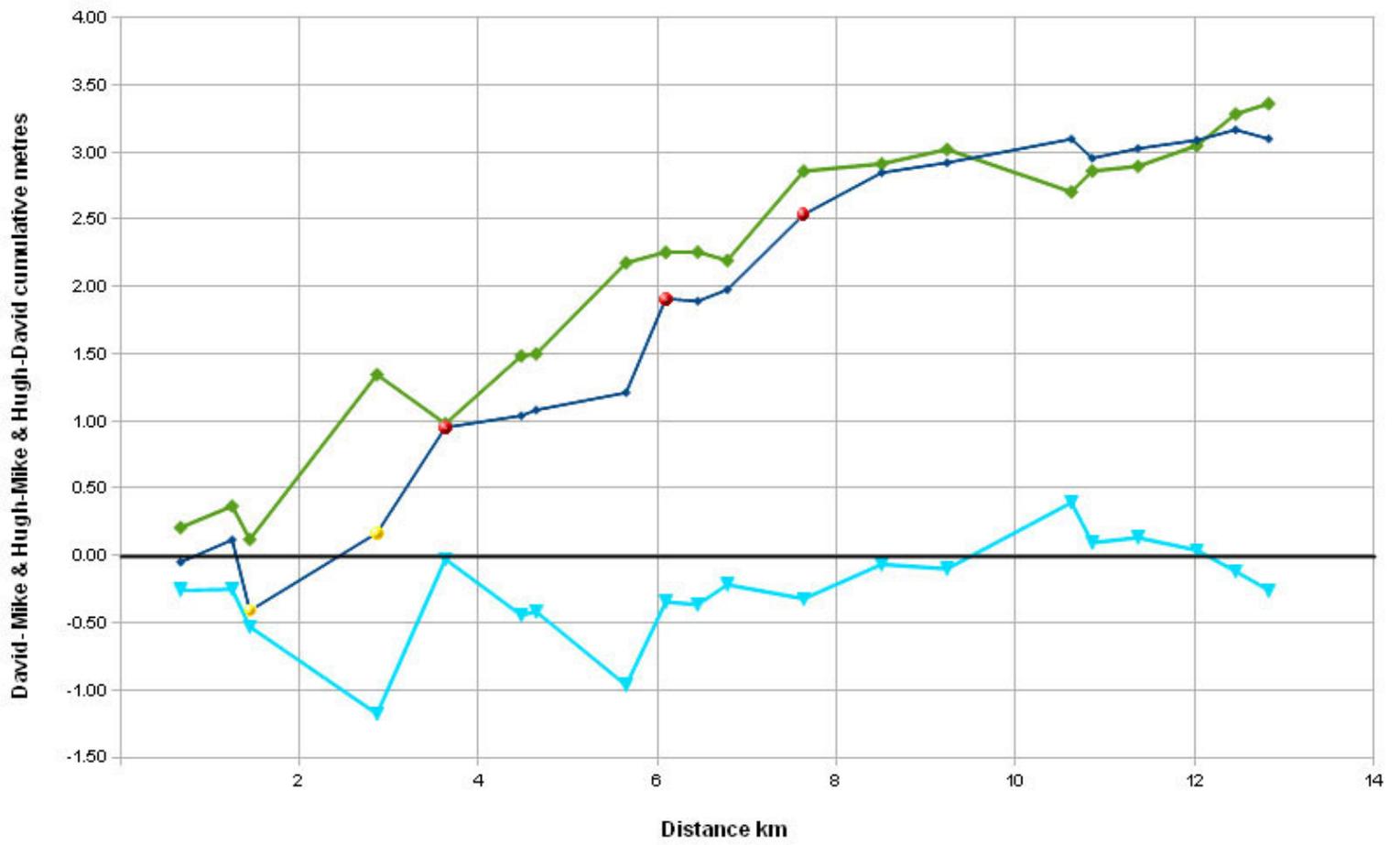
Olympic lap measurements (without the turnaround adjustments) using 328.597m for calibration course & Calculation of turnaround adjustments									
Lap measurements with turn rounds not moved				Calculation of <u>turnround</u> adjustments					
	short lap	long lap	Course 1 short + 3 long laps	Km reqd for 8 miles	Length of 4.3m semicircle	centre move to make long lap 8 miles	Km reqd for 2 miles 385y	centre move to make correct short lap	
<u>David</u>	3.5690	12.8280	42.0529	12.8748	0.0135	0.0166	3.5707	-0.0059	
<u>Hugh</u>	3.5684	12.8278	42.0517	12.8748	0.0135	0.0167	3.5707	-0.0056	
<u>Mike</u>	3.5683	12.8246	42.0422	12.8748	0.0135	0.0183	3.5707	-0.0055	
						(lengthen)		(shorten)	
fractional range	0.02%	0.03%	0.03%						

Mike Sandford's Recommendation: Since Hugh was most familiar with the course having ridden it about 20 times take Hugh's values for the adjustment. Hugh's values are also the median values of the 3 measurements.

12.8 km loop Hugh-David (in turquoise) Hugh-Mike (in dark blue) & David-Mike (in green) as a % age of each interval



12.8 km loop Hugh-David (in turquoise), Hugh-Mike (in dark blue), David-Mike (in green)

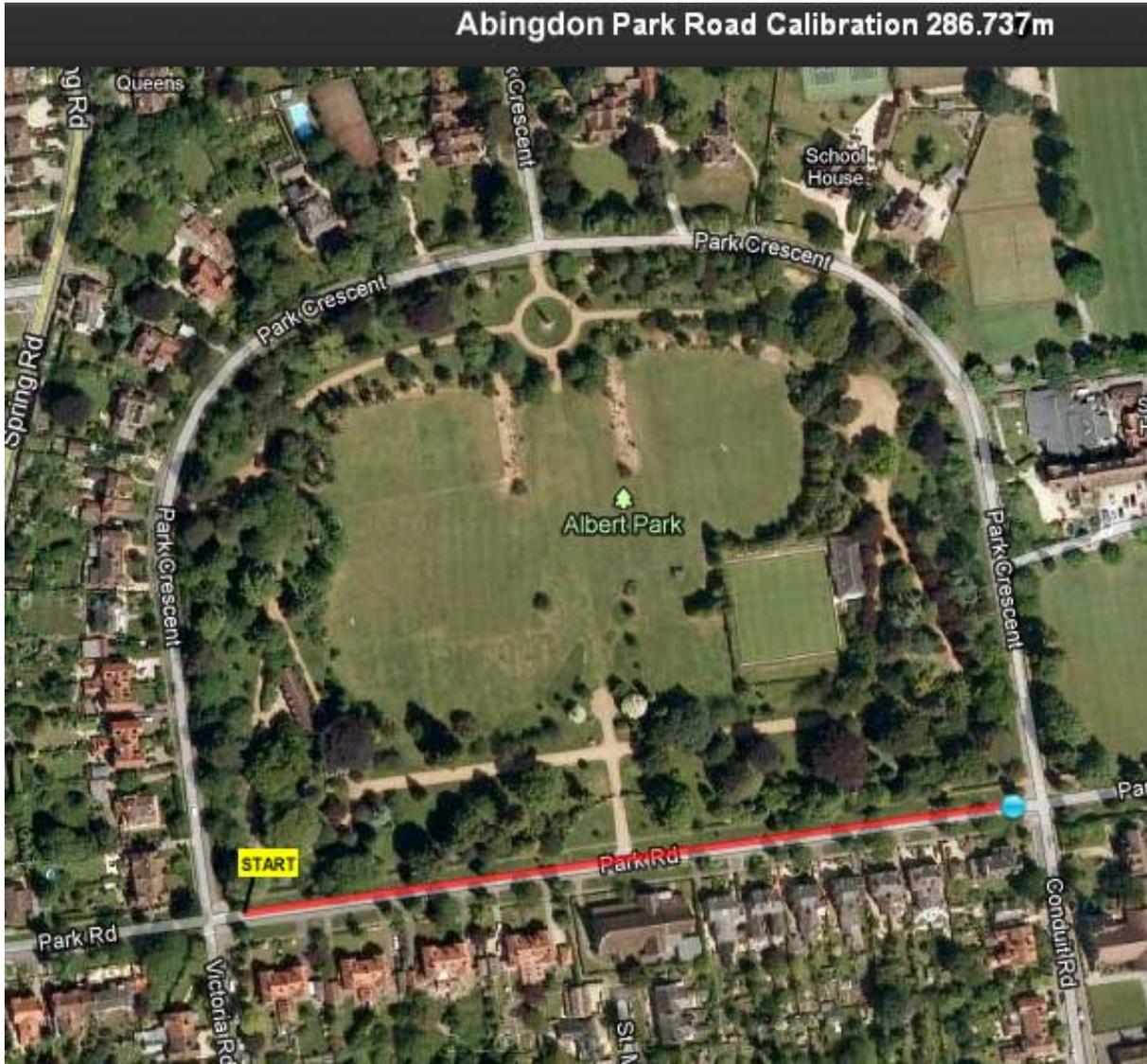


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Calibration Course Measurement Report: Park Road, Abingdon

The laser rangefinder measurement method by M.C.W.Sandford, 23 June 2012

The North side of Park Road Abingdon is normally clear of parked vehicles, since it is a private road with no parking allowed for the public. Two way riding is possible at quiet times of the day. When there are traffic movements at busier times it may be necessary to abort East to West rides and repeat them later when the traffic has cleared.





The road surface is smooth and the tarmac is in very good condition.

Between 0505 and 0520 on 23 June with a temperature of 11C I carried out the measurement using my Bosch GLM 250VF Professional laser range finder.

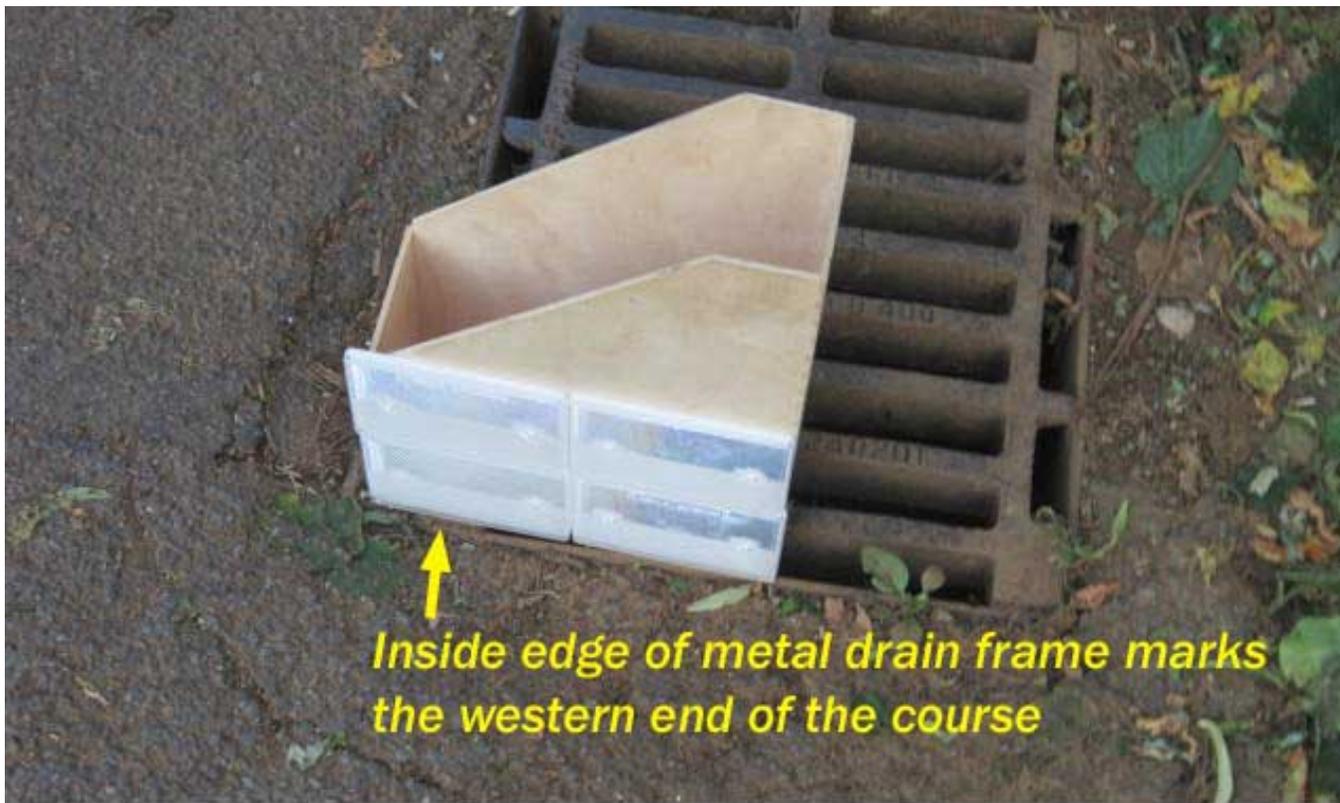
The specification of the range finder includes the statement:

In unfavourable conditions (e.g. at intense sunlight or an insufficiently reflecting surface), the maximum deviation is ± 20 mm per 150 m. In favourable conditions, a deviation influence of ± 0.05 mm/m must be taken into account.

I consider the conditions were favourable, and with the use of a good retro-reflector I would expect a maximum error of $0.05 * 286 \text{ mm} = 14\text{mm}$.

Since the length of the course was greater than the 250m maximum range, the measurement was carried out in two steps.

1. The reflector was placed at the west end and the bicycle carrying the laser was ridden just less than 250m along the course.



Laser Reflector at West end of Park Road cal course

2. A temporary red tape was placed on the road to mark the position of the plumb bob suspended from the laser. The plumb bob position was 2mm East of the West edge of the tape, which was to be used as the reference therefore 2mm would need subtracting from this measurement. This close up of the road surface shows how smooth the finish is.



Plumb Bob location 2mm from West side of tape when measuring the West section of course.

3. The 3 readings of the western section all gave 246.336 metres.

3 identical laser readings for western 246.336m of Park Road calibration course. The laser is on the equatorial pointing mount on the back of the bike



4. Next the reflector was moved to the red tape



Reflector positioned on West edge of tape
in order to measure the east section of the
calibration course

5. For the 40m which remained the laser removed from the mount on the back of the bike and was placed directly on the road. This was done to reduce the correction for slope which would be quite large over 40m. Since the laser is about 96cm above the reflector spot this would have given a slope addition of 11mm. Over the short distance it was possible to aim the laser by means of small hand adjustments until the reflected spot was visible on the target.



6. Here are the 4 readings obtained at the west end. The first reading was disregarded since the laser was moved when the button was pressed. The average good reading of 40.392m was used.



Laser measuring eastern 40.392m of calibration course
 The initial reading 40.387m was discarded since the laser position was slightly disturbed when pushing measure button. The 3 good readings are within +/-1mm

The above picture also shows the point of attachment of the plumb bob behind on the extension behind the rear face of the laser. The rear face of the laser is the default reference point for the readings and this setting can be seen indicated in the small icons on the lower left corner of the laser LCD screen near the B of Bosch. This provides positive confirmation that the intended reference point was in fact being used.

Separate measurements with a ruler of the distance of the plumb bob cord from the rear face reference gave a value of 16mm which needs to be taken into account when the plumb bob is used.

Laser Reading	slope correction*	PLUMB TO LASER REF	PLUMB TO ROAD MARKER	REFLECTION SURFACE**	CORRECTED DISTANCES
246.336	-0.0018	+0.016	-0.002	-0.0015	246.347

40.392				-0.0015	40.391
				TOTAL	286.737

*Slope correction: Laser height = 1.04 m, Height of laser spot on retroreflector = 0.10 m.

Slope correction (by Pythagorouos) = $246.336 - \sqrt{246.336^2 - 0.94^2} = 0.0018$

**The reflection surface correction is my estimate of half the optical path the laser beam undergoes during reflection by means of the 2mm hexagonal pyramids in the retro-reflector. Effectively the reflection surface is about 1.5mm behind the front face of the retro-reflector.

Conclusion

The calibration course length is 286.737m. The manufacturer's stated error is +/- 14mm, an allowance of 4mm needs to be added to cover my errors in measuring positions and corrections so the total error should not exceed +/- 18mm.

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History of Olympic Marathon Measurement 1984-2008

The following measurement reports are available in Pete Riegel's [archive of course measurement articles](#) :

1984	Measurement of 1984 Olympic Marathon	LA84.pdf	10 MB	Letson, Robert & Baumel, Bob
1988	Measurement of 1988 Olympic Marathon	Seoul88.pdf	7 MB	Letson, Robert
1992				
1996	Measurement of 1996 Olympic Marathon	Atlanta96.pdf	22 MB	Riegel, Pete
2000	Measurement of 2000 Olympic Marathon	Sydney00.pdf	1 MB	Jones, Hugh & Williamson, Norrie & Cundy, Dave & Wickiser, Mike
2004	Olympic Marathon Athens 2004	OlympicMarathon2004.pdf	19 MB	Grall, Jean-Marie
2004	Olympic Racewalks Athens 2004	OlympicRaceWalk2004.pdf	6 MB	Grall, Jean-Marie
2008	Olympic Marathon & Walks - Beijing, 2008	Beijing 2008.pdf	1 MB	Cundy, Dave

Analysis of reports:

Olympic Marathon year	No of riders	range of results	
1984	13	13 m for a 31km distance	
1988	13	8 m for a 31km distance	
1992*			
1996	25	91 m	
2000	7	60 m	
2004	3	18 m	
2008	5	26 m	
2012	3	9 m	

*An interesting article "Measuring the 1992 Olympic Marathon" by Bob Baumel appeared on page 17 of [Measurement News No 41](#), May 1990. It reviewed the history of Olympic Marathon Measurement and made a proposal for the IAAF measurement of the 1992 Barcelona Olympic Marathon. I have not seen any report of what was actually done for Barcelona.

First Olympic Marathon Measurement using an Electrically Assisted Bicycle and the Oldest Olympic Marathon Measurer

Please forgive inclusion the following personal contribution to Olympic Measurement History.

Looking at the previous Olympic Marathon Measurement reports it is clear that nobody has used an electrically assisted bike or pedelec as my Kalkhoff Agattu is known in Europe. So I can claim the honour of being the first. Although the London course was mainly flat (sharpest rise 9m in 200m 4.5%), I would not have been confident about keeping up with Hugh and David without a little supplement to my pedalling from my electric motor. I had first used it in April 2011 and it had enabled me to keep up with Hugh Jones and Dave Cundy on a [much tougher measure of that year's London Marathon](#). This type of electrical assistance is certainly of great benefit to older measurers who are less fit. My bike still feels like an ordinary bike and I can ride it up hills with less wobbling than would be the case for an unassisted bike.

On the 15 June 2012 after I had posted a [short account](#) on the RRTC's Road Course Measurement Bulletin Board I had an email from our defacto historian, Pete Riegel:

Thanks for posting your experience on the BB. Looks like your electric bike propelled you to "oldest Olympic marathon measurer" status. Well done!

A bit investigation confirmed that at the age of 70 I had just beaten John Disley who was 67 when he measured the Atlanta course in 1996.



ROAD COURSE
MEASURER

Laser
Rangefinder
on Equatorial
Astronomical
Telescope Mount

Note this smooth
tarmac has holes
which affect the
calibration const.

2012 London Olympic Measurement rides 13 June 2012

Work-in-progress: Comparison of raw measurement data from Hugh Jones and Mike Sandford

This draft was written 20/6/2012 by M.Sandford

1. Raw Data

I transmitted by raw data xls file to Hugh and David on 13 June at 1521. I received a quick reply from Hugh correcting the calibration course length to 328.57m and an indication that my measurement was in close agreement his for lap 1 but 3m shorter than his for lap 2. So this would make my measurement for the 1 short lap + 3 long laps about 9m shorter. David's and Hugh's results were very close.

Although the agreement between these overall results is certainly good enough that the course can be satisfactorily adjusted to the marathon distance, I wanted to explore my data more closely to see if there were any mistakes in my readings or other explanations of the 3m difference on the long lap of 12.8km. Therefore, when on 19 June Hugh sent me his draft measurement report (dated 14 June) I set about comparing Hugh's measurements of the individual splits with mine.

Hugh's data were presented in the form of accumulated distances over the marathon course of 1 short lap plus 3 long laps. He calculated the necessary adjustments for the the 2 turn round points. His presentation is in a form suitable for a measurement report for certification.

2. Comparison of interval distances

The spreadsheet which I had prepared is in a simpler form. It presents in order of riding the counter readings we took during one short lap followed by one long lap. I decide to use this form of presentation to compare my ride counts with Hugh's. I copied Hugh's raw counts onto the corresponding cells in my format of spreadsheet, then calculated the incremental and cumulative distances for each lap. Finally I took the difference between distances calculated for Hugh and for me.

The result is shown on the following page.

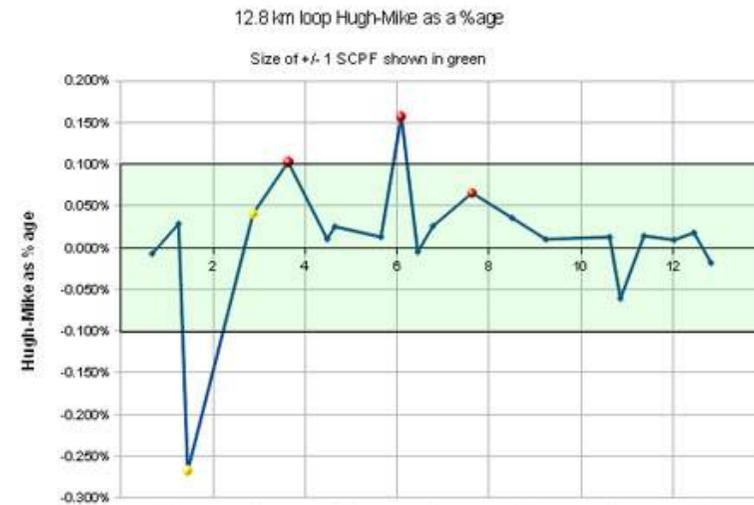
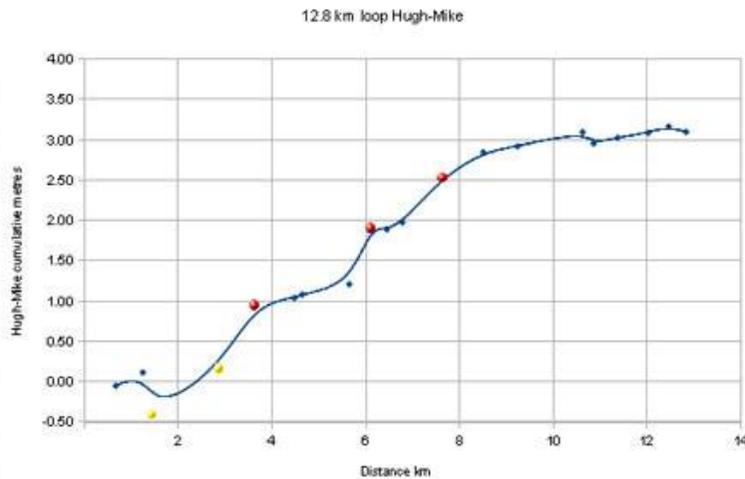
Agreement was good for the small lap.

For the large lap Mike measured 3.1m less than Hugh. For 5 intervals there was an appreciable difference between Mike and Hugh's results:

The pair of intervals marked in yellow, could be due to Mike making a 0.55m error in locating his bike to take the reading at the reference location "Last LP before Waterloo Bridge". This has caused the preceding interval to be short and the next interval long – both by about 0.55m. Alternatively, this could be caused by an incorrect reading of Mike's counter, however the value recorded, 98680 would need to be changed to 98686. This is clearly not one of the occasional digit transposition errors. It is possible that six could have been read as a zero, although visibility was quite good.

For the 3 intervals highlighted in red Hugh – Mike was more than 0.5m. Together these 3 intervals account for 2m of the 3.1m difference in overall ride length. These intervals are considered in detail on subsequent pages.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
3	Hugh's measurement schedule	Hugh's No.	MCWS location note			Mike accumulated dist km	Hugh-mike accumulated dist m	Hugh -Mike interval m	Hugh-Mike interval %age									
4	Start/Finish	1	LP															
5	Traffic light Westminster br	2	????unclear note			1.6124	-0.11	-0.11	-0.007%									
6	3rd expansion joint	3	Joint on N side			1.7066	-0.26	-0.16	-0.167%									
7	3rd expansion joint	3	Joint on S side			1.7066	-0.26											
8	Ped light at start Mall	4	dashed line			3.1987	0.20	0.47	0.031%									
9	Start/Finish	5	Mid point between Tarmac join lines			3.5680	0.14	-0.07	-0.018%									
10																		
11																		
12	Start/Finish	5	Mid point between Tarmac join lines															
13	Between Telephone Boxes	6	Between Telephone Boxes			0.6731	-0.05	-0.05	-0.007%									
14	Cleopatra's needle	7	R			1.2489	0.12	0.17	0.029%									
15	Last LP before Waterloo Bridge	8	LP on L			1.4456	-0.41	-0.53	-0.267%									
16	WL Hill - start divider	9	Start Divider on R			2.8664	0.17	0.58	0.041%									
17	Paternoster Sq Tree apron	10	Paternoster Sq N edge Column on L			3.6300	0.95	0.78	0.103%									
18	1st LP Cheapside	10a	LP on L			4.4784	1.04	0.09	0.010%									
19	bread St E Kerb	11	level with kerb of road on R			4.6442	1.08	0.04	0.025%									
20	TL Leadenhall str	12	Post on R			5.6476	1.21	0.13	0.013%									
21	finger Post Eastcheap	13	finger pole on L			6.0912	1.91	0.70	0.157%									
22	Start is. Before Bynard St	14	First edge divide in centre			6.4480	1.89	-0.02	-0.005%									
23	Tower Hill turn	15	Turn at divider near Tower			6.7792	1.98	0.09	0.026%									
24	London Br LP2	16	LP centre on L			7.6317	2.54	0.56	0.066%									
25	Ped light at Millennium Br	17	TF LP on L			8.5021	2.85	0.31	0.036%									
26	TL opp Temple Ave	18	Pole on L			9.2327	2.92	0.07	0.010%									
27	LP90 (Before HG Ave)	19	Centre LP on L			10.6209	3.10	0.18	0.013%									
28	Far side Bob memorial	20	S face Block on L			10.8546	2.96	-0.14	-0.061%									
29	LP 6 George St	21	LP on R			11.3653	3.03	0.07	0.014%									
30	LP92 Birdcage Walk	22	C88 on R			12.0221	3.09	0.06	0.009%									
31	Ped light The Mall	23	dashed line			12.4545	3.17	0.08	0.018%									
32	Start/Finish	24	Start/finish			12.8236	3.10	-0.07	-0.018%									



In the following pages we show

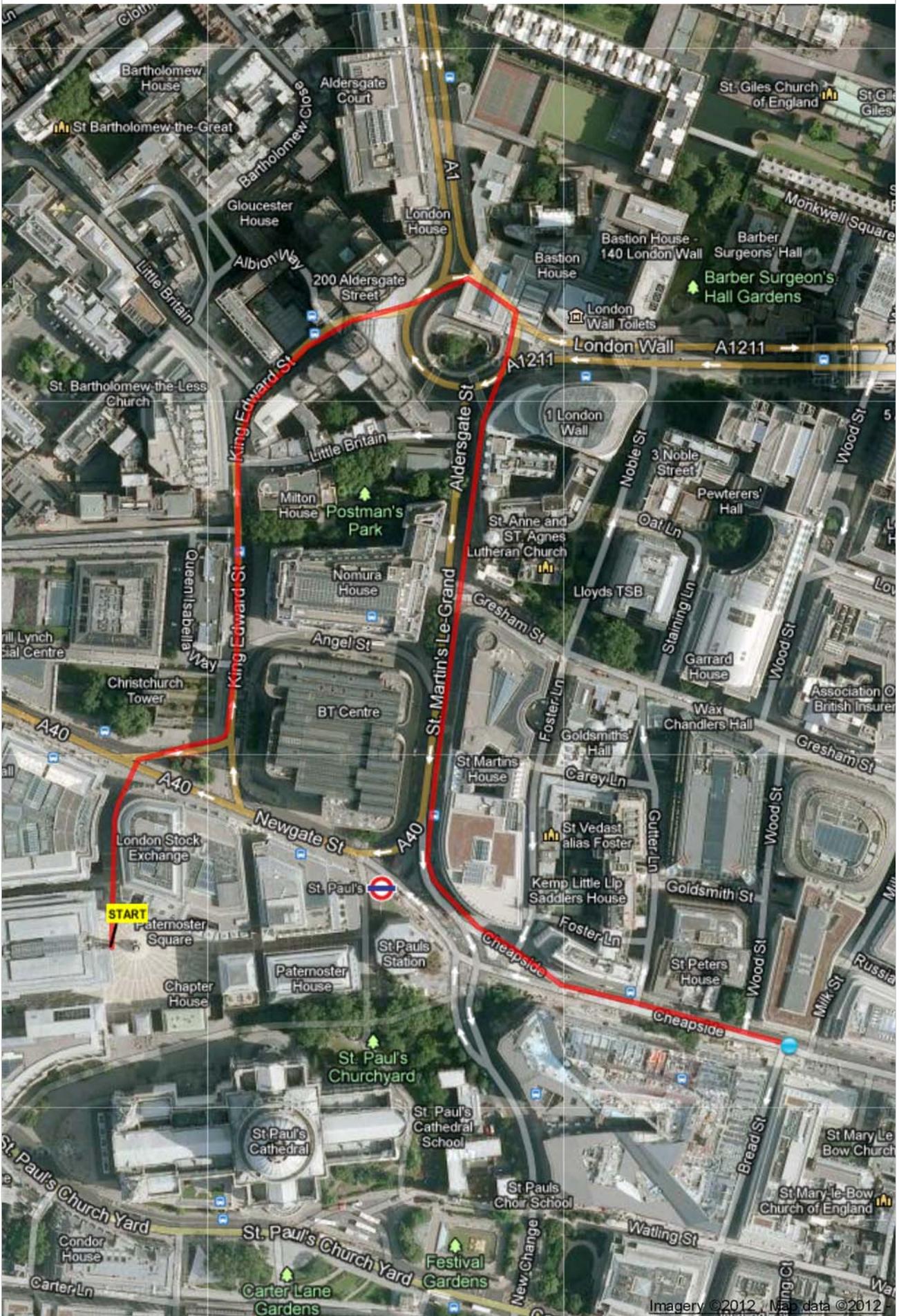
1. The route of the interval from Paternoster Sq to 1s LP in Cheapside and on a further 70m to the next interval at Bread Street East Kerb. This is a very twisty section. Perhaps Mike rode so several of the corners too tight. In a number of places the kerb height was reduced to zero on the corners although the stones marking the kerb were still visible laid flush with both pavement and road, so the intended route was clear and I tried to follow that ridden by Hugh and David.
2. The route from the traffic light Leadenhall Street to then fingerpost East Cheap. This starts with a coned radius into Whittington Avenue, which Hugh and David measured with a tape and chalked on the road. Part of this interval is on small partly round rectangular paving slabs which provide an uneven surface somewhat similar to rounded cobbles. Tyre calibration could be changed on this surface by a small amount, and the change could be different for different tyres.
3. The route from the Tower Hill turnround reference to London Bridge Lamp post 2. The first part of this route is straight forward but the final 150 m or so had 3 sharp right angle bends (with lowered kerbs, and a section of cobbles).

3. Conclusion

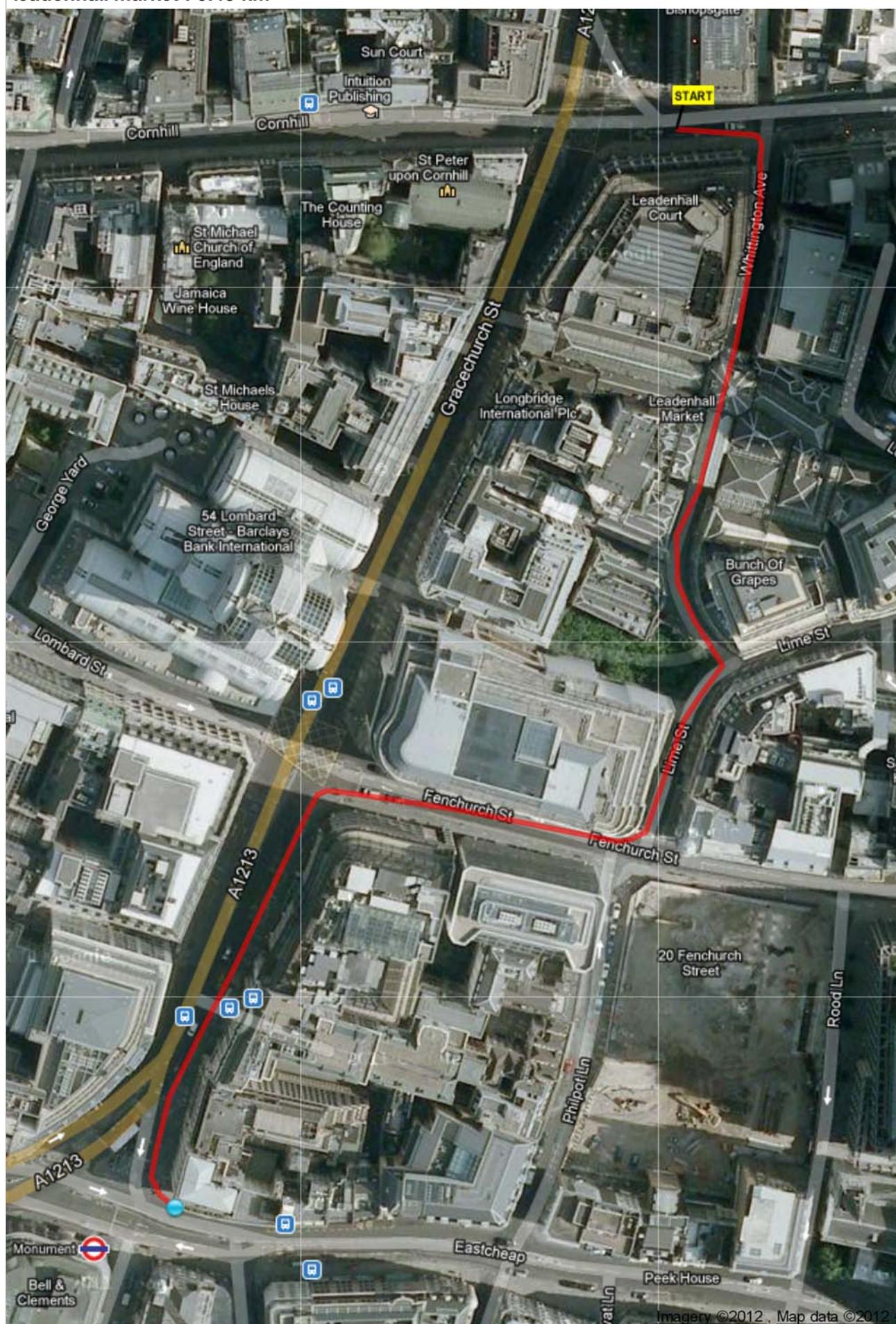
It is possible that Mike cut corners slightly less than 30cm from the edge of the course. Hugh with his great familiarity with the route is likely to have ridden a better line. The effect of cobbles on the calibration could also have contributed to the difference.

It will be interesting to add David's raw figures to this analysis, as his intervals are in close agreement with Hugh's as his overall distance was then it would lend weight to the view that Mike rode rather close on some corners.

paternostersq : 1.03 km



leadenhall market : 0.43 km



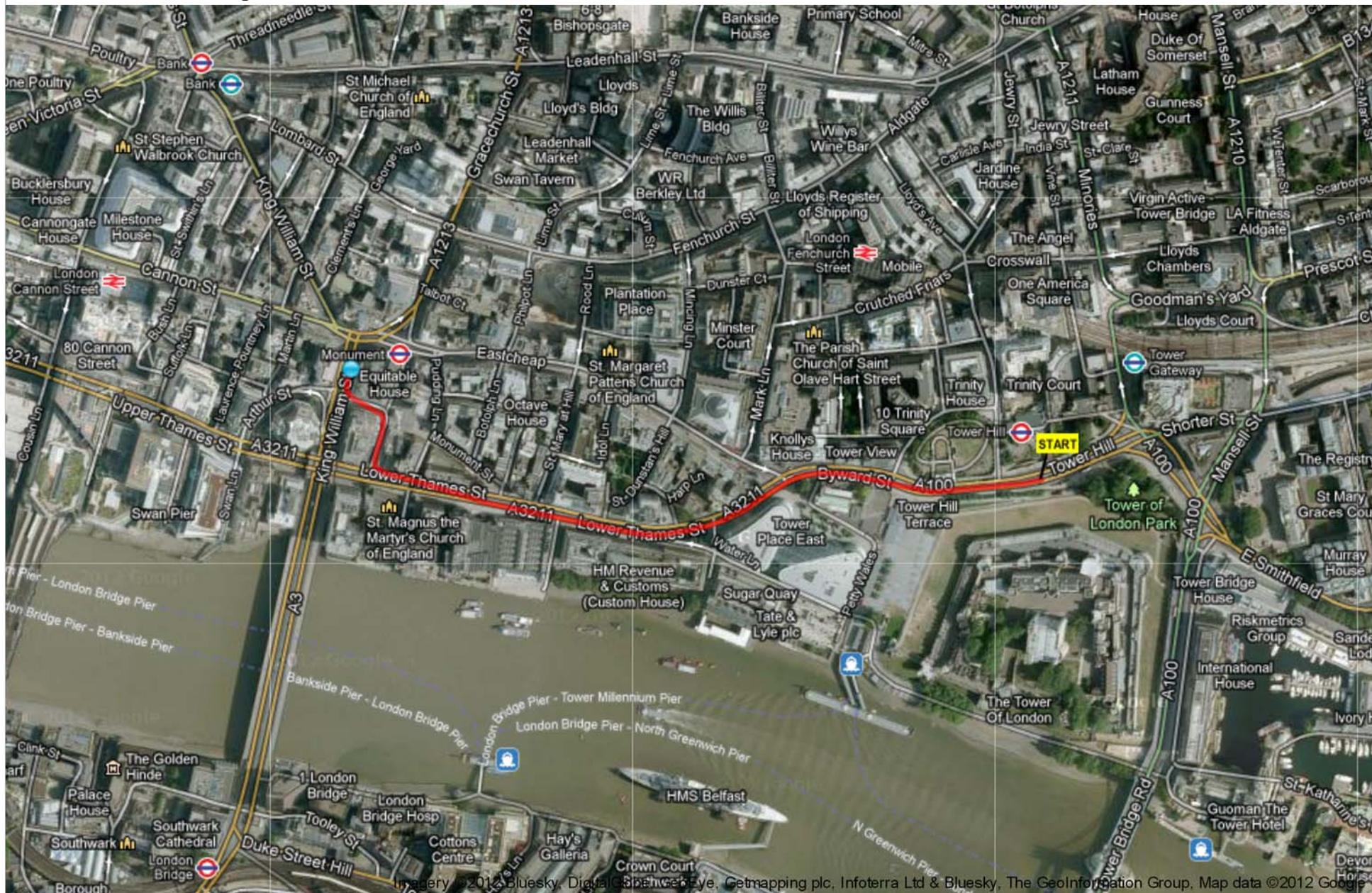
**Entrance to Whittington Ave &
Leadenhall Market
Coned off to provide radius**



***Cobbles in Whittington Ave
at Junction with Lime Str.***



towerhillturn-londonbridge : 0.85 km



VERIFICATION OF STEEL TAPE LENGTHS (1998)

We compared three steel tapes on 23 April 1998:

Mike Wickiser's 60m IRWIN,
Pete Riegel's 30m Brazilian STANLEY,
Mike Sandford's 50m RABONE SILVERLINE.

Inspection of the Irwin showed that although the tape had many very small patches of paint removed at the edges of the blade, this was largely cosmetic and there was no evidence of thinning caused by dragging the tape along the ground which would only be serious if large areas of paint and the metal underneath were removed. The paint on the other two tapes was in very good condition.

PK nails were placed at the following approximate separations: 10m, 30m, 50m. All the tapes were stretched with a tension of 10lbs measured by a Salters 11lb spring scale. The temperature was 19C in the shade and 21C in the weak sun. For each measurement two readings were taken with Pete and Mike interchanging roles. The greatest difference between our readings with the same tape was 0.5mm, the reading resolution. Pete's Stanley Tape had not been used since its calibration at the Stanley factory in Nov 1996 (see MN Jan 1997 page 5). The factory calibration report showed it to be 9.7mm long, and the error to be uniformly distributed along the tape.

Two nails about 30m apart:

Stanley (PR) = 29.8645m after correction (+9.7mm) as per factory calibration = 29.8742m

Irwin (MW) = 29.873 m

Silverline (MS)= 29.872 m

All tapes agree to within 2.2 mm. The Irwin is only 1.2mm different from the Stanley which was factory calibrated in Dec 1996.

Two nails about 50m apart:

Irwin (MW) = 49.8655 m

Silverline (MS)= 49.864 m

The difference between these tapes is now 1.5 mm in 50m. It was 1 mm in 30m. The two differences are consistent with a very slight change of scale between the two tapes.

We realised that the final 10m of the Irwin had not been checked. We therefore carried out the following between nails about 10m apart:

Irwin 50m to 59.976m = 9.976m

Stanley 0m to 9.9742m = 9.9742m after correction (+2.8mm) as per factory calibration =9.977m

Over this 10m interval the tapes were tensioned by feel since we did not have a convenient attachment point for the spring scale, so this comparison may be slightly less accurate but nevertheless it shows that the final 10m of the Irwin tape is not significantly stretched. Noting the 200 foot point on the reverse of the tape was just beyond the 60m point and might have been used at some time by Mike Wickiser, we checked with the foot scale between 200 foot and 167ft 3.25in = 32ft 8.75in = 9.9758m, which agrees with the metric scale on the other side of the Irwin. We concluded that the Irwin was pretty much spot on. Mike S thanks Mike W for a good tape! Discussing the results, we felt it was probable that the Irwin tape had been inside spec when manufactured and was unchanged in length since manufacture. We regard the debate on *[the stretching with time of]* steel tapes as closed, at least as far as it affects calibration courses.

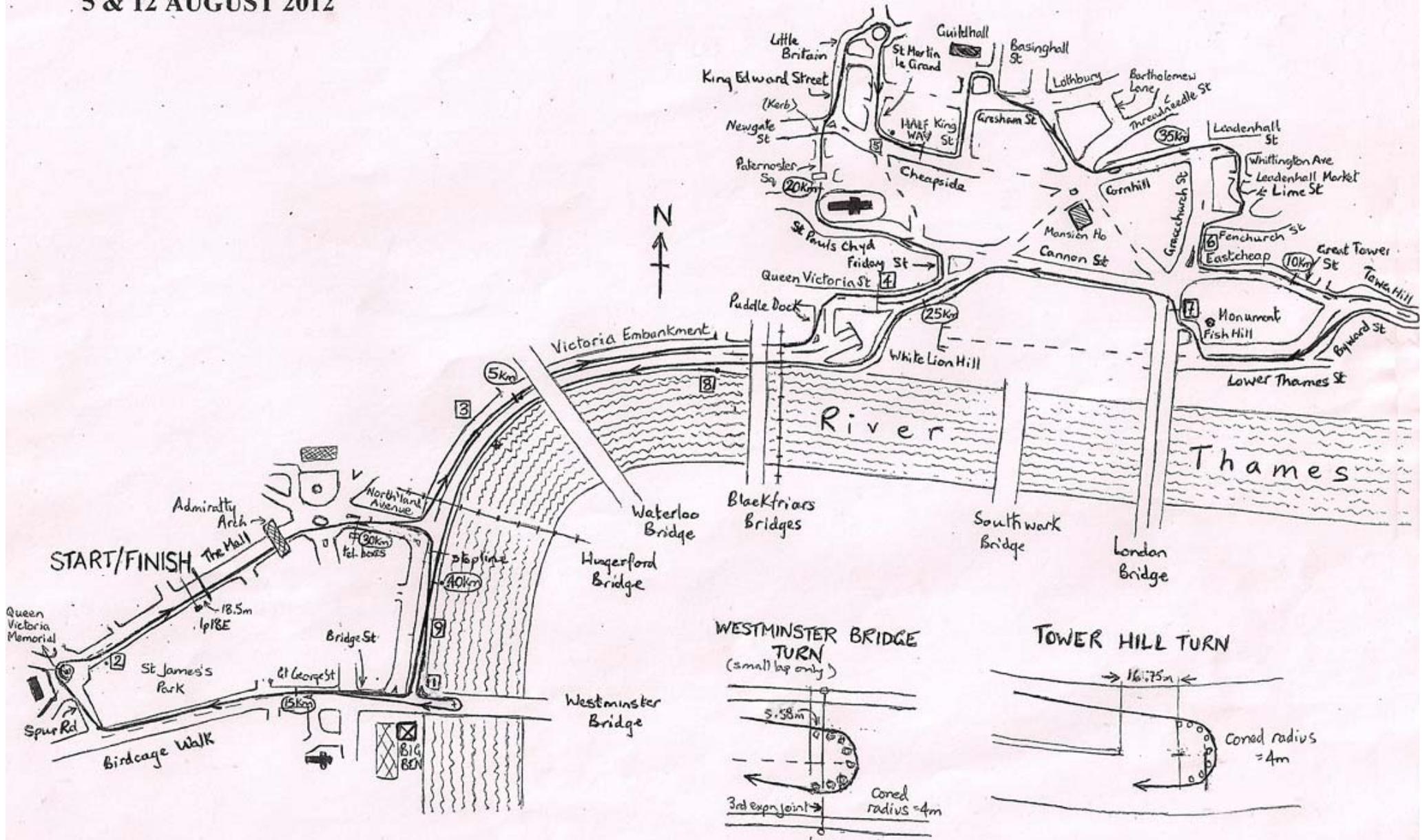
Mike Sandford and Pete Riegel. *From Measurement News Forum 25 April 1998*

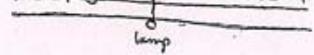
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MARATHONS OF THE XXX OLYMPIAD

LONDON, UK

5 & 12 AUGUST 2012





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