

Wellington etait-il geometre? RTK GPS revele Waterloo

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SUMMARY

Was the Duke of Wellington a land surveyor? A recent RTK GPS survey of Waterloo, for the Channel 5 television program "Battlefield Detectives", has revealed the secrets of the battlefield. The key battlefield area was mapped at an accuracy of 10cm from around the Lion Mound in the North to Hougoumont in the South. A volumetric analysis of the Lion Mound and current topographic surface was carried out from the measurements and is presented with a re-creation of a probable "virtual surface" at the time of the Battle in 1815. An assessment of the shape is also presented by a landscape archeologist, investigating the proposed topographic model of the battlefield from historical and archeological evidence. From this ground-breaking work, we show that Wellington's choice of ground at Waterloo was perhaps the most likely reason the battle was won. It is clear that Wellington had the skill, vision and understanding of terrain as possessed by the land surveyor.

RESUME

Le duc de Wellington était-il géomètre? Un récent levé par GPS-RTK, pour le programme "Battlefield Detectives" diffusé sur la chaîne de télévision britannique Channel 5, a dévoilé les secrets du champ de bataille de Waterloo. La zone clé de l'affrontement a été cartographiée avec une précision de 10cm, depuis les alentours de la butte du Lion au nord, jusqu'à Hougoumont au sud. Une analyse volumétrique de la butte du Lion et du terrain actuel a été réalisée à partir des données et le résultat est présenté sous forme d'une "surface virtuelle" re-crétant le terrain tel qu'au moment de la bataille en 1815. Cette reconstitution du champ de bataille est évaluée par un archéologue soumettant le modèle topographique proposé aux preuves historiques et archéologiques déjà établies.

Ce travail innovateur montre que le le choix par Wellington de l'emplacement de Waterloo a probablement été déterminant quant-à l'issue de la bataille. Il est clair que Wellington a su faire preuve d'une habileté, d'une vision et d'une compréhension du terrain dignes d'un géomètre.

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1. INTRODUCTION

During early summer 2002 Channel 5, a UK independent terrestrial television station, contacted various experts as part of a new documentary series. The programs proposed to 'scientifically' investigate the scene of several of history's most famous battles. They were particularly interested in high accuracy topographical survey techniques, although their knowledge of modern GPS survey technology was sketchy. The programme makers also believed that the actual battlefield landscape at Waterloo had been significantly changed in the decades following the battle by the construction of the Lion Mound, an enormous edifice of soil with an internal brick core. RTK GPS measurement was proposed to enable the most accurate large scale survey of the battlefield in history.

The significance of a properly understood landscape to both The Duke of Wellington and Napoleon is a factor not often commented upon by historians. Both men had displayed a consummate understanding of the nature of terrain, more properly called "ground" in modern military parlance. They were keenly aware of the potential for the landscape to dictate to them the composition of their forces and indeed, their intent in any campaign. Wellington had made himself the master of concealing his troops on the shallow reverse slopes of hills during the Peninsular War and his reputation for so doing would buy him a great deal of time in the Waterloo campaign. Napoleon's keenness for cartography left him in no doubt about the dangers of poor maps when he was planning his campaigns:

"I order that the map of Germany, which has been made at the Depot de la Guerre, be sent back. It is so bad that I cannot use it. I would rather have the first map captured in a library. This mixture of good and bad portions is fatal - worse than if all the parts were bad - for it serves only to jeopardise important operations. I know of nothing more dangerous....."

Napoleon to General Clarke, 19 December 1809

The nature of the soil, the angle of slopes, the undulations which provided opportunities for concealment, the agricultural usage to which the land had been put, were all known to both men, and yet it was these factors and the way in which they were used, which decided the outcome of Western Europe's most famous battle.

The Battle of Waterloo has generated a colossal amount of literature. Accompanying the thousands of re-constructions of the sequences of events of the campaign and the battle itself are the personal recollections of individuals who fought there. These observations are each made from what Keegan⁴ described as "the personal angle of vision". The battle of Waterloo, perhaps more than others is defined by a statement also made by Keegan, that "a few feet of elevation made the difference between the bird's eye and the worm's eye view".

It is to this notion that we address this paper. We do not propose another analysis of the events of the 18th June 1815. Instead, using modern survey technology, we strive to demonstrate that the choice of the site of the battle on the ridge at Mont. St. Jean was a choice made through the recognition on the part of the Duke of Wellington that the ground had the capacity to aid his defensive stance and confuse the approach of his enemy, putting them at a major disadvantage if they chose a frontal assault.

2. RTK TECHNOLOGY AND METHOD USED FOR THE SURVEY

2.1 The battle of the survey at Waterloo

We did not know what to expect at Waterloo, certainly not the Lion mound which dominates the flat Belgian countryside and is visible several kilometres away. The extraordinary size of this monument made it clear to us that we should not have been surprised to learn that when the Duke himself saw the battlefield after its construction sometime in the 1820s, he is said to have remarked “My God, what have you done to my battlefield?”

As well trained land surveyors we immediately started work and Belgium being Belgium it rained and rained and rained for all three days of fieldwork. The soil stuck to our boots, quickly turned into liquid mud and the lettuce, potatoes and cabbages drenched us with rainwater from their leaves. The conditions were virtually impossible but “the show must go on....” Budgets had been spent and the television cameras were rolling.

Atkins Survey and Mapping coordinated the RTK survey. Trimble 4700 GPS instruments were selected for the survey with TSC1 dataloggers. The units worked perfectly as there are good sky views and hardly any obstructions, thus giving full satellite coverage. The base station for the RTK survey was established at the monument to Captain Mercer whose battery saw so much action in the front line and who left for posterity a personal journal of his observations on his own experiences in the battle. The system operated in a standard mode using a 458 MHz radio link. The two roving instruments were back pack mounted to cover the vast open field areas as rapidly as possible. The TSC1 loggers were set to automatically capture points at a 10m grid interval and then the walking started. Over the three days we pounded the battlefield covering over 150 Ha and collecting 3000 survey points. In addition there were certain staged survey events that required a halt to data acquisition and comments to the TV cameras. These caused delays and the Channel 5 crew were blissfully unaware that the survey was, at times, in danger of not being completed on time.

The fieldwork concentrated on the battlefield areas between the famous farms of Hougoumont and La Haie-Sainte, around the Lion Mound and the main crossroads. This specifically targeted the area that is believed to have been reduced in level by the construction of the mound. This area coincided with the Allied lines of defence, which historians believe originally contained the ridge used to great military advantage by Wellington. A typical picture of the team during the survey is shown in Figure 2.1 below.



Figure 2.1 The survey team and Channel 5 crew in action in the rain

2.2 Data processing methods

After completing the fieldwork data was downloaded daily from the GPS instruments. It was loaded to Trimble Geomatics Office software, quality checked for rogue points and poor initialisations, then output in ASCII format. This ASCII data was loaded to Trimble Terramodel software to form the ground model. Visualisation of the topographic surface was carried out using the 3D Visualizer part of the software package. This was undertaken daily so the ground area could be assessed as the survey progressed and to follow the tight timescales of the Channel 5 film crew. They stared in wonderment as the DTM built up before their very eyes. This allowed us to concentrate the mapping on critical areas of the battlefield. It was vital to complete all the fieldwork within the allotted 3 day window.

This interestingly resulted in a change to the originally planned areas for the survey. The visualisation showed that a previously unidentified area had to be measured as it was likely that some of the material used to construct the Lion Mound had come from that location. It was in hindsight an obvious area, being the main car park on the north side of the mound and museum!

3. RESULTS OF THE SURVEY

3.1 Current Ground Topography

From the final model created by the survey, a 3D model was visualised using two times vertical exaggeration, 2m coloured contours, custom light positions and shading. A fly-through model was then created using Camedia software and stored as a .avi movie file for later use by Channel 5. Several stills were also produced for publication purposes, an example of a still from the final model is shown below in Figure 3.1

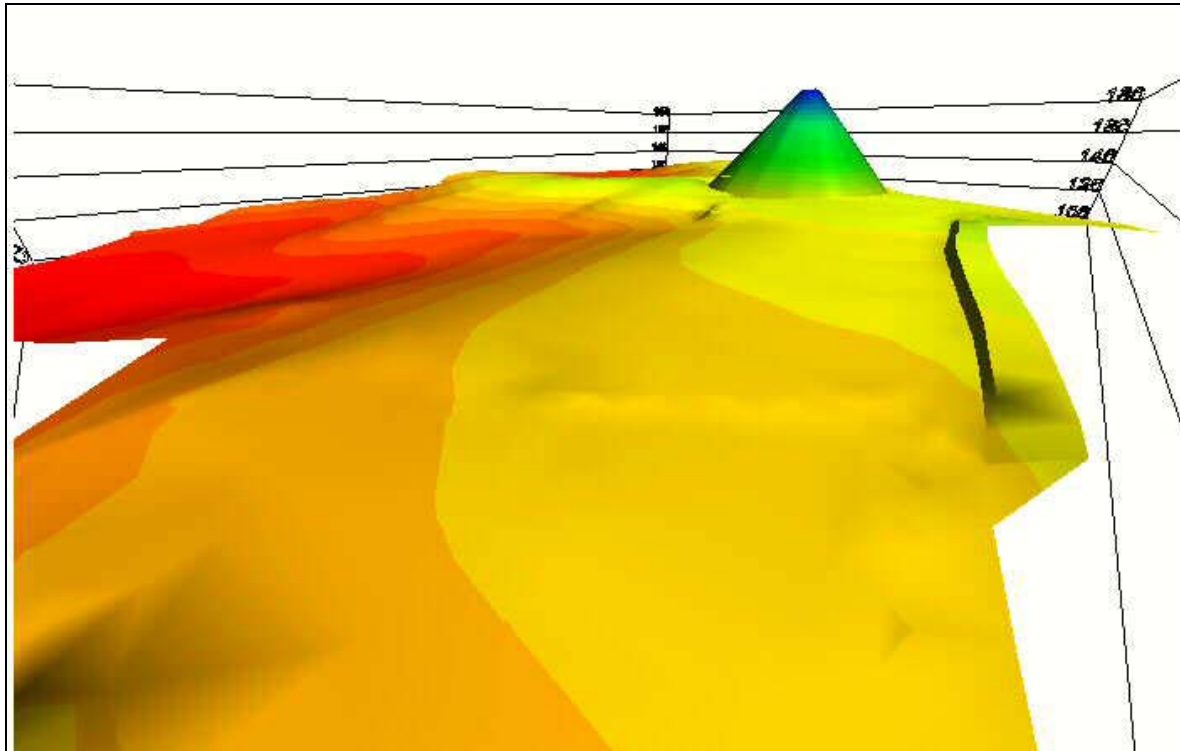


Figure 3.1 Current battlefield shape in Terramodel 3D Visualizer software.

From the exaggerated model there are some interesting and noteworthy parts of the battlefield surface. To the south west of the Lion Mound, in an area of the site which is currently a potato field, an amphitheatre shape exists. The above view in Figure 3.1 is from the crossroads on the main Brussels-Charleroi road to the immediate north of the farm at La Haie Saint, looking west towards the Lion Mound. This amphitheatre area is to the rear at the left hand side of the figure. Here, at the top of this ridge Byng, Maitland and Halkett awaited the onslaught of the Imperial Guard late in the day.

Interestingly, due to the high precision nature of the survey further small undulations were also found to exist in the plane of the up/downhill slope. This area is shown at a five times exaggeration in figure 3.2. The additional exaggeration of this area clearly shows ridges that

run up/down the slope. These number five or six and run around the curve of the amphitheatre area.

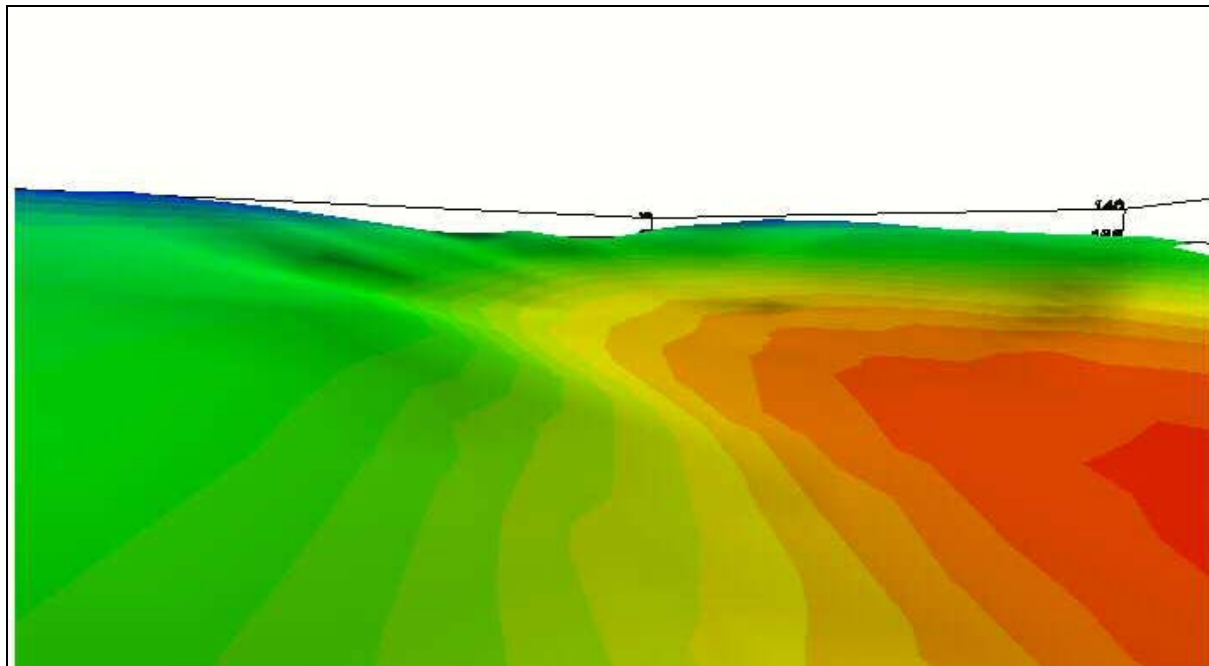


Figure 3.2 Exaggerated 3D view showing small undulations in the up/downhill slope

The existence of these undulations begins to explain some of the theories historians have had about this area of the battlefield. Five battalions of the Middle Guard formed the first wave which entered this tricky landscape. But it seems that this assault may not have landed in the intended place. The crossroads above La Haie Sainte was the crucial area on the battlefield. The farm was captured and could provide supporting fire for fresh French forces assaulting a battered defence; an attack here could win the day. If the centre of Wellington's line fell, Napoleon could be in Brussels. Instead of assaulting here, the guard curiously veered to the west, dictated in their westerly incline by the very nature of the landscape as revealed in our survey.

There is a natural tendency even for the best trained troops to incline to the left (as experiments in the television programme have shown) and the undulations on the slopes would have further channelled the Guard's approach. The undulations might also explain some of the problems we found when surveying the area. It was very difficult to walk in a straight line during the survey as one was consistently veering off down the slope. The undulations, which are invisible when negotiating the ground, make it appear that one always is climbing up hill especially when attempting to traverse across the slope.

It would appear that when climbing the slope one is "pulled" into the gully of the undulation and thus one is always in a low point. To escape to the right or left, traversing across the slope one still has to climb. Cut to the scene of the battle and imagine the undulations filled with fallen men and horses and the situation is compounded. The attackers of this main ridge

would have been disoriented by the shape of the ground, not to mention the confusion caused by the horror of the battle.

This amphitheatre can be seen as a killing ground. Although the landscape did not encumber the French to the extent that their perfect order was not in evidence (the British later recalled the awesome sight of professional soldiers advancing in formation), in less than a minute the first volleys of the British had accounted for 300 casualties at the front of the enemy line. Because of the noted ability of the British for rapid fire and reloading, the second and third volleys produced a scene of carnage from which the landscape denied any safe means of escape. With slopes all around them and no way to prosecute the frontal assault, the Guard could only go backwards, falling-out of formation, as is usually the case, from the rear.

3.2 Volumetric Analysis

From the survey measurements the gross volume of the Lion Mound was computed. The shape of the mound was delineated around the base and the interior volume computed using the Terramodel Software. However the Lion Mound also contains a central brick column which supports the statue at the top of the mound. From early engineering drawings held the museum in the centre of Waterloo town, approximate dimensions were taken to allow a computation of the column volume. This was subtracted from that of the mound to give a net earth volume. No correction was applied for compaction. As the mound has been in existence for approximately 180 years the soil is now as compact as when it was scraped from the adjacent ground. It could be argued that the soil in the centre of the mound is in fact of a higher density, notwithstanding this, the final earth volume from the mound was assessed at 287,500 m³

This volume was, therefore, the minimum amount of earth removed from the locality of the battlefield to create the Lion Mound. In simple terms, it equates to a volume that could be described by a square with sides of 1/3km that is 3m thick. This is a substantial amount of soil and assessing the techniques that were available to construct the mound in 1819, it is most likely to have come from the area immediately around the mound.

3.3 Re-creation of the probable surface at the time of battle in 1815

To re-create the shape of the battlefield at the date of the battle in 1815, the first assessment was to incorporate the current historical knowledge, using documented information about the original battlefield shape. For example, the height of the ground at the Gordon Monument is generally accepted to have been that of the original ground level in 1815, although being so close to the road, it is likely only to have reflected the ground level in that particular area where it would have been higher than the ground level which fell away to the west. This historical fact was used with others, such as the cutting that was known to exist along the road to the west of the Haie-Sainte crossroads.

The second step in recreating the probable surface at the time of the battle was to digitally remove the Lion Mound from the current landscape. This was simply done by removing the measured points from the top of the mound and regenerating the DTM surface.

Due to the substantial reduction in relief, this surface was then viewed using a four times vertical exaggeration in the Terramodel 3D Visualizer software. Various still images were also produced for publication purposes, and in the example shown below in Figure 3.3 a depression area is clearly visible.

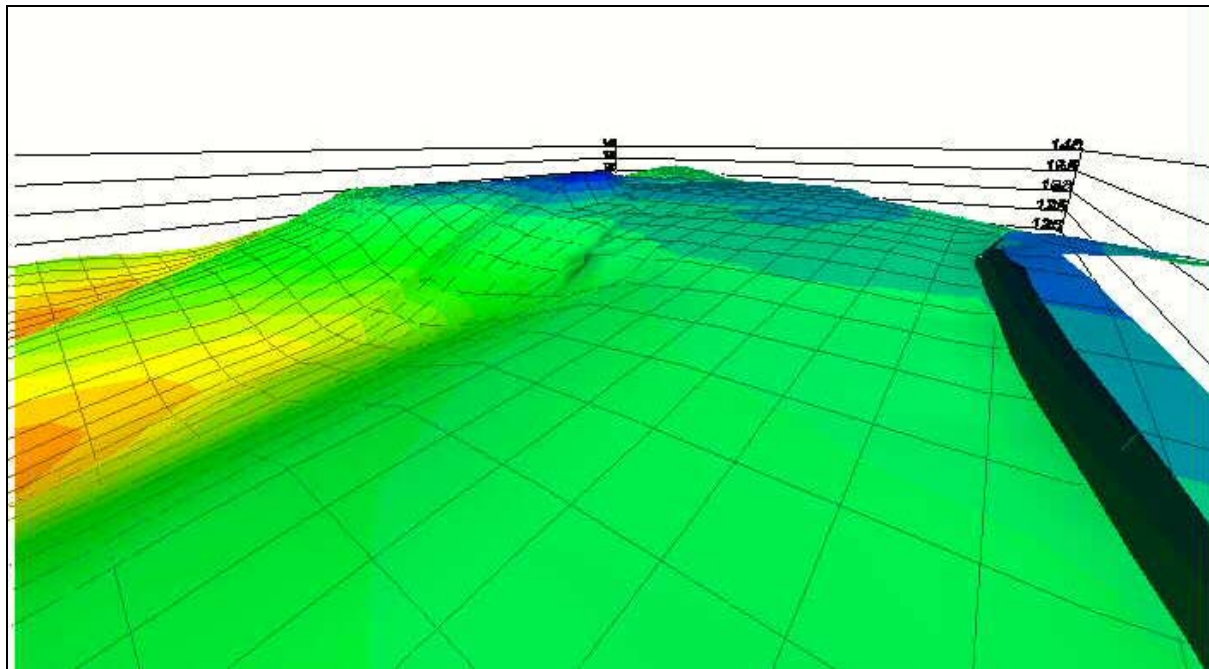


Figure 3.3 Depression area in ground model with Lion Mound removed

The third and final step was to digitally add the soil volume back on to the ground model without the Lion Mound. The technique used a contour matching process from all points on the battlefield that were almost certainly original ground. Using these reference points and the natural pattern of the ground contours, new height points were added to the model. This elevated the ground in areas where there were clear depressions; in particular around the base of the Lion Mound and in the northern car park area. It also filled in a key area to the east of the Lion Mound, termed the “Billiard Table Area” during the Channel 5 filming.

The landscape archaeology of this area was assessed to be a truncation of the original slope from evaluations made during the filming. The extraordinary flatness of this area was visible to the naked eye and especially reveals itself when observed from the top of the Lion Mound. The angle of slope to the south of the ridge can be seen to be much steeper on the east side of the main Brussels-Charleroi road than it is on the western side whence some of the material for the Lion Mound is supposed to have been extracted. The unnatural truncation of the top of the ridge is a clear indication of human interference with the natural lie of the land.

Furthermore, to the north of the ridge, the southern most bank of the holloway is completely missing, as are the banks which would have surrounded the area of the vital crossroads 200 yards to the north of La Haie Sainte. For the truncated area itself (that is, the land between the

Lion Mound and the crossroads, an initial rough guess of around 2m was put forward as the extent of truncation.

A final DTM was then generated for this proposed surface at the time of battle in 1815. Again this was viewed using a four times vertical exaggeration in the Terramodel 3D Visualizer software. The still image shown below in Figure 3.4 shows a plan view of the complete recreated battlefield surface. The coloured contours are shown at a 2m interval and in addition, the ridges in the amphitheatre areas are also made visible using grey level shading in the depressions.

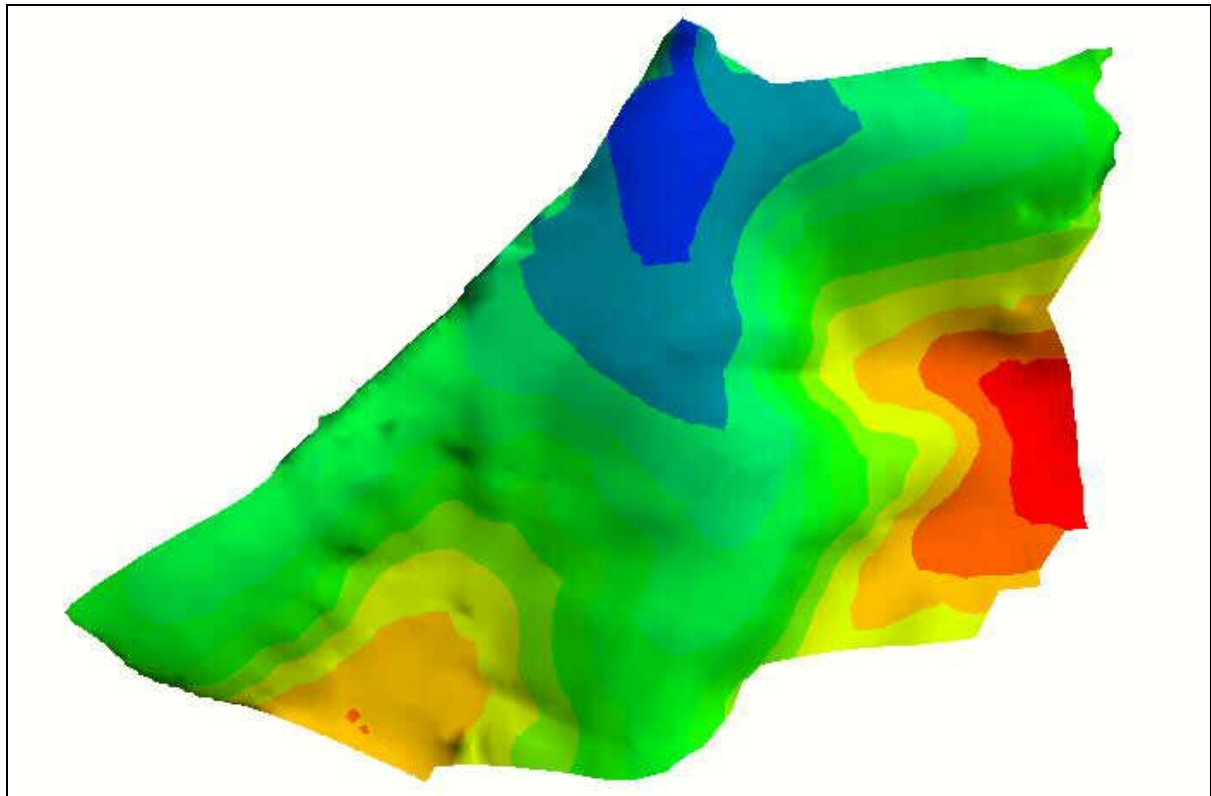


Figure 3.4 Final model of the probable surface at the time of battle

A final volumetric analysis was also carried out by subtracting the proposed surface from that of the current ground with the Lion Mound removed. This was done using a common set of boundary points to compute the volume of earth added back to the battlefield. The volume difference was found to be within 68,250 of the soil volume of the Lion Mound. It is most likely that this missing soil was from an area to the north west of the Lion Mound, behind the main visitor centre car park in an area inaccessible for survey and could not be measured at the time of the filming. The other possibility is that the main ridge, seen in blue in Figure 3.4, was even higher in the area immediately to the north east of the Lion Mound.

4. HISTORICAL SUBSTANTIATION OF THE RECREATED SURFACE

4.1 Troop deployments on the battlefield

It is likely that the final decision to fight on the ridge at Mont. St. Jean was not taken until dawn on the 18th June, despite what had transpired between the Duke of Richmond and Wellington on the evening of the 16th. In fact, the ridge was not the first position which the Duke had earmarked Glover¹. He had initially thought that the ridge at La Belle Alliance, where Reille and D'Erlon would soon be deployed, would suit the British as a defensive position. It had all the characteristics which Wellington favoured, but he was advised by William de Lancey (acting as Quartermaster General) that the ridge was too extensive to accommodate the small British force. It was a wise decision and Wellington, who had always shown a deep concern about having his flanks turned, opted for Mont St. Jean. At Albuera in 1811, he had chosen a similar defensive position on a ridge for Beresford who had a great misfortune on the right flank and it must have prayed upon Wellington's mind.

Still troubled enough by the notion of a French advance from Mons that might turn his right flank, Wellington stationed 17,000 Netherlanders and one British and one Hanoverian brigade at Hal and Tubize. Then, he waited at Mont. St. Jean for what he hoped would be a frontal assault that he must withstand until relieved by Blücher's Prussians. On hearing of the long awaited promise of Prussian support, Wellington is said to uttered a phrase which gets to the heart of this modern analysis of the battlefield:

"Now Buonaparte will see how a general of Sepoys [Indian troops] can defend a position"

His decision to fight there was a brave one, however, and Napoleon knew that if he could break him there, then Wellington's retreat through the Forest de Soignes would be a bloody affair indeed. In fact, it seemed to Napoleon that it was a strange decision to fight with such a large physical encumbrance to the allied rear. But, both generals were, it seems, quite prepared to fight in the rippled amphitheatre of Waterloo. And so, the two armies stared at each other over rain-soaked undulating fields of Rye which stood to the girths of their horses until trodden down.

4.2 Geology and topography of the battlefield

The nature of the soil here is also of crucial importance. The area is covered by a silty loam derived from loess, an extremely fine-grained wind blown material. This gives rise to a soil which produces a slippery mud when it gets wet. When it is dry, it brushes-off quite easily, being so fine. The cannon fire upon which Napoleon relied so heavily on the day was noted to land straight in the mud, as opposed to the desired effect of ricochet. If the top of the slopes were slippery, then the accumulated colluviums, characteristic of this kind of a landscape, which gather at the foot of the slopes produced a further problem for the troops: It was extremely sticky. However gentle this landscape might have appeared in its undulations, it concealed its treachery very well.

Wellington described his deployment at Waterloo as having his right wing thrown back to a ravine near Merbe-Braine and his left extended to a height above the hamlet of Ter la Haye, an occupied farmstead. The ridge is three miles long from west to east but crucially at the western end it curves forward giving a concave front to the British lines. It is in this crucible that our survey took place. In the extreme east of the battlefield the ridge is at its steepest, sloping away southwards from the farms at Papelotte, La Haie, Frischermont and Smohain. From the evidence shown in the diagrams above, it is clear that the area of land bounded by the triangle created by drawing a line from the Lion Mound to the crossroads and then down to the farm at La Haye Sainte is much changed from what it was on the day. The difficulties of ascending the slope here are still in evidence today, but were greatly exaggerated on the day of battle.

5. WELLINGTON'S USE AND UNDERSTANDING OF LANDSCAPE

5.1 Use of concealment in landscape

We have noted that Wellington's reputation for using the landscape preceded him at Waterloo. This reputation had been built over years of him having to find ways of spreading his manpower resources (always a key problem for the British) over wide areas of land. On a strategic level, Wellington had masterminded the defence-in-depth system to the north of Lisbon in Portugal of fortifications known as the Lines of the Torres Vedras. It is these which were designed to protect British interests at Lisbon and free-up the main British army for other operations, being manned by a militia force (Hill and Wileman³, Haythornethwaite²). However, on a tactical level, Wellington's use of concealment was unsurpassed. The placement of troops on the reverse slope of a ridge had a two fold advantage over time. Firstly, it reduced the amount of casualties that one would expect from enemy artillery fire, and secondly it would give the element of surprise to an enemy who mounted the ridge to find troops standing on order and opening fire at close range.

In the Waterloo campaign, such concealment is well recorded. At Quatre Bras on the 16th, Reille and Ney had paused. They had seen a reverse slope position to the north of the Nivelles road and had presumed that Wellington's forces would be behind it as they had been so many times in the Peninsular, and yet they were not there. The Duke's reputation of using the landscape to the best effect, bought for him a crucial two hours in the campaign, thus replacing some the time that Napoleon had stolen from him in his remarkable strategic manoeuvres.

5.2 Wellington's involvement with surveyors

It is well documented by Keay⁵ that Wellington (and latterly, Wellesley) was greatly involved with Lambton, the founder of the Survey of India and one of the greatest geodesists to have ever lived. Lambton travelled with Wellington during his campaigns in Mysore (Karnataka) in the late 1790's giving navigation and mapping advice.

It is generally believed that during these campaigns Lambton conceived the idea of the Great Arc and the survey of India. Subsequent to Wellington's involvement Wellesley's full support, and more importantly that of his brother Richard Wellesley (Wesley), Earl of Mornington and Governor General of Britain's fledgling Raj, allowed the famed Survey of India to develop. The need to properly map newly acquired territories for the purposes of defense and exploitation was well understood by both Wellesley's. With the Mysore survey of 1800 becoming the model for the Great Arc and detailed survey of India itself, the Wellesley family essentially bankrolled this pioneering work of geodesy.

6. CONCLUSION

From the results of this survey it is absolutely clear the shape of the battlefield today is different to that at the date of the battle in 1815. The ridge running due east from the Lion Mound is some 3m lower than it was at the time of the battle. In addition, the extension of this ridge to the north of the Lion Mound is likely to be some 4m to 5m lower today. The original shape of the ridge, coupled with the undulations in the amphitheatres below it, would have created a ground which was virtually impregnable. Add to this the sticky mud, rye grass and confusion of battle and the result is certain defeat for an advancing force that has to climb the ridge. Therefore, it is clear that the Duke of Wellington carefully chose his position on the ridge at Mont St. Jean.

It is true that the stakes were high and it is also true that the defence of the ridge was desperately close fought affair. If Napoleon had had the time, he may have succeeded in smashing through the centre of the British line. But the key to understanding the choice of terrain from the point of view of Wellington is in the promise of support that he received from Blücher and his Prussians who were to arrive on Napoleon's easterly flank late in the day. Wellington knew that he had to hold this ground until that support came. He must have calculated that the landscape held enough secrets to confuse his enemy's approach. Our survey proves that the ground he chose was more treacherous than any first glance might suggest, but the Duke's noted involvement with military surveyors, including one of the greatest of that age, and the advice he received early on from William de Lancey, ensured that his choice was not made out of desperation or whimsical fancy.

It is very likely, if not certain, that the choice of his position at the Mon St Jean ridge won him the Battle of Waterloo. He may not have been a land surveyor but he possessed all the land surveyors skills, understanding and ability to visualise a landscape. Napoleon did not stand a chance against such a man and such a choice of ground.

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BIOGRAPHICAL NOTES

Dan Schnurr is a Chartered Land Surveyor and works as a survey project manager within the Atkins Survey and Mapping group. He is widely respected in the UK as one of the most expert GPS surveyors in the commercial sector. He is broadly experienced in land and hydrographic surveying throughout the world having worked in Europe, the Middle East, Australia, West Indies and United States. Dan currently manages some 15 staff located across Europe working on a wide range of different survey and mapping projects. He also is a member of the RICS Mapping and Positioning Practice Panel and is the UK delegate to FIG Commission 5.

James Kavanagh is a professional Land Surveyor and graduate of DIT Bolton St, Dublin and University of East London. He has worked on some of the largest engineering projects in Europe including Canary Wharf and Broadgate, London and spent several years mapping refugee camps in the Middle East whilst working for the United Nations. He has broad experience of land survey in many countries around the world including the Seychelles, Philippines, Syria, Egypt and of course, Belgium. James is currently a staff member of RICS with direct responsibility for geomatics.

Paul Hill is an archaeologist and author specialising in military archaeology and history. He has recently published a book Landscapes of War – The Archaeology of Aggression and Defence with Julie Wileman, a fellow archaeologist. Published by Tempus Publishing Ltd. 2002.

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